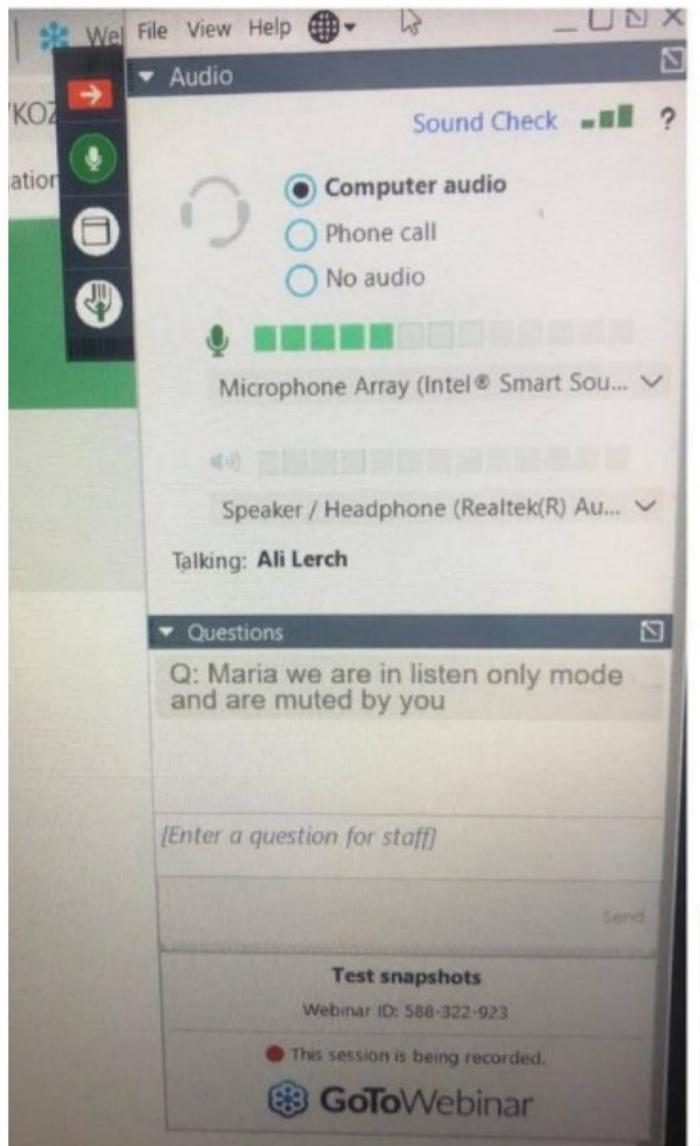


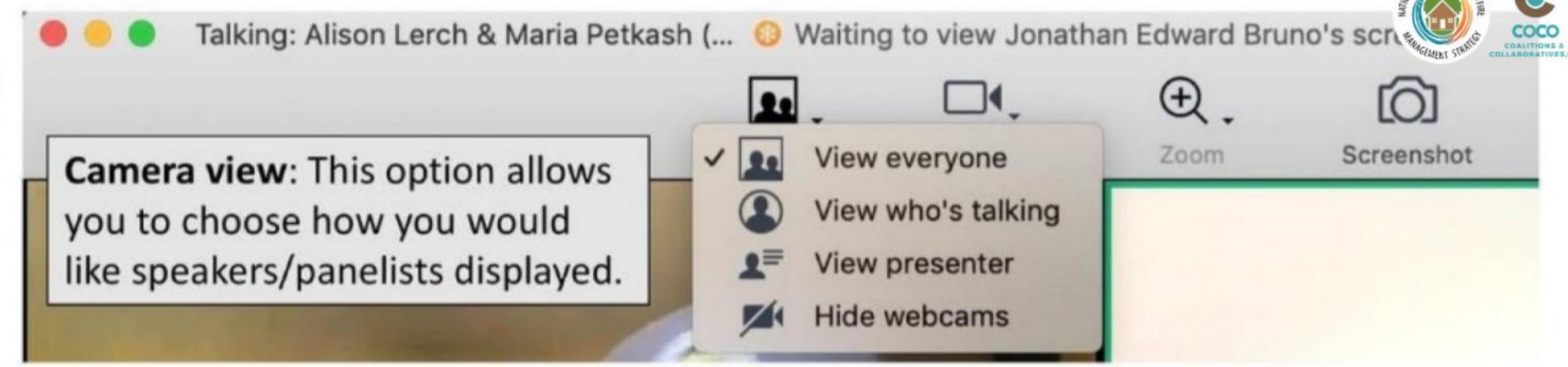
Welcome → ATF Webinar Series: Post-Fire Water Quality Impacts This session will begin shortly. > Thank you for your participation!



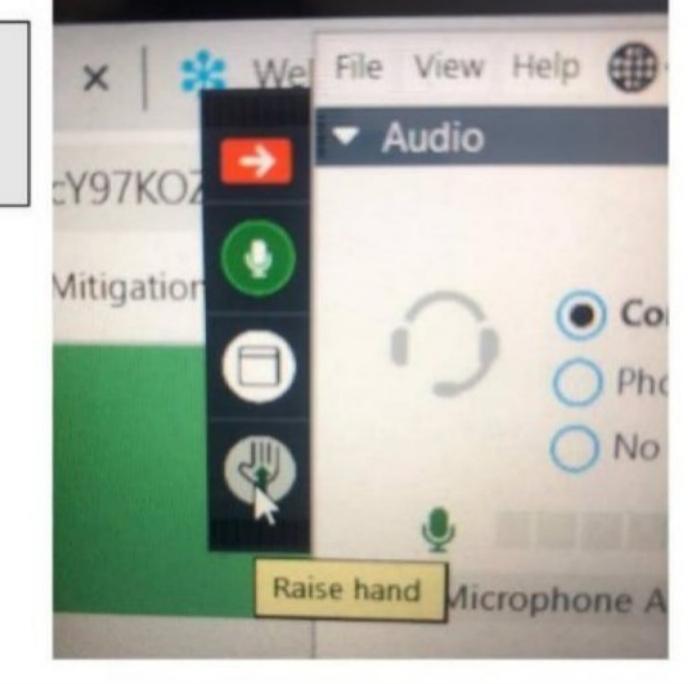
Welcome from Coalitions & Collaboratives, Inc.

- Carol Ekarius, Chief Executive Officer, COCO, Lake George, CO
- Thank you, National Cohesive Wildland Fire Management Strategy, for sponsoring today's webinar!





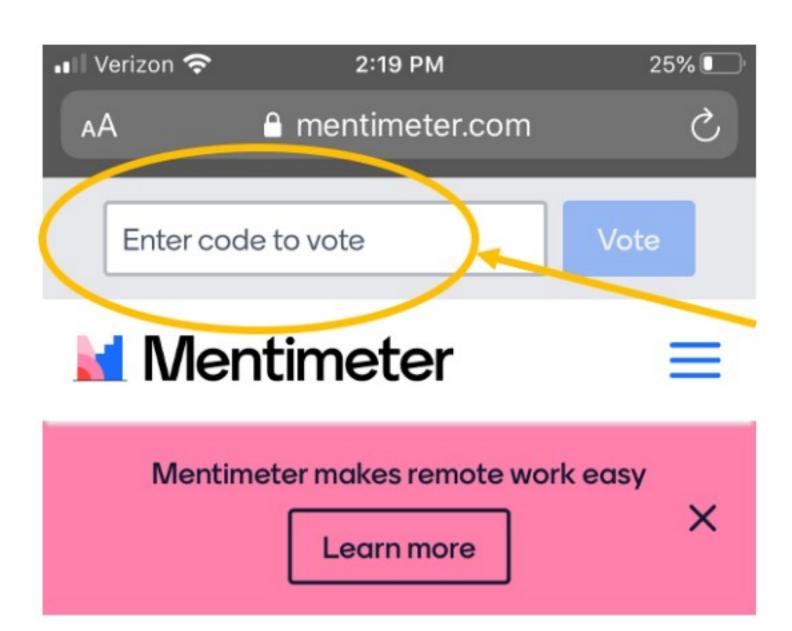
Raise hand: If you need attention from tech support, can raise hand.



Question Area: Questions only goes to hosts/tech support.
Use this to ask for tech help or other conference support.

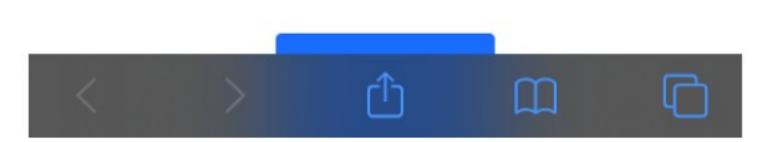






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Using Mentimeter

- Type Menti.com into your phone or computer's web browser
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- Follow along & participate in the webinar

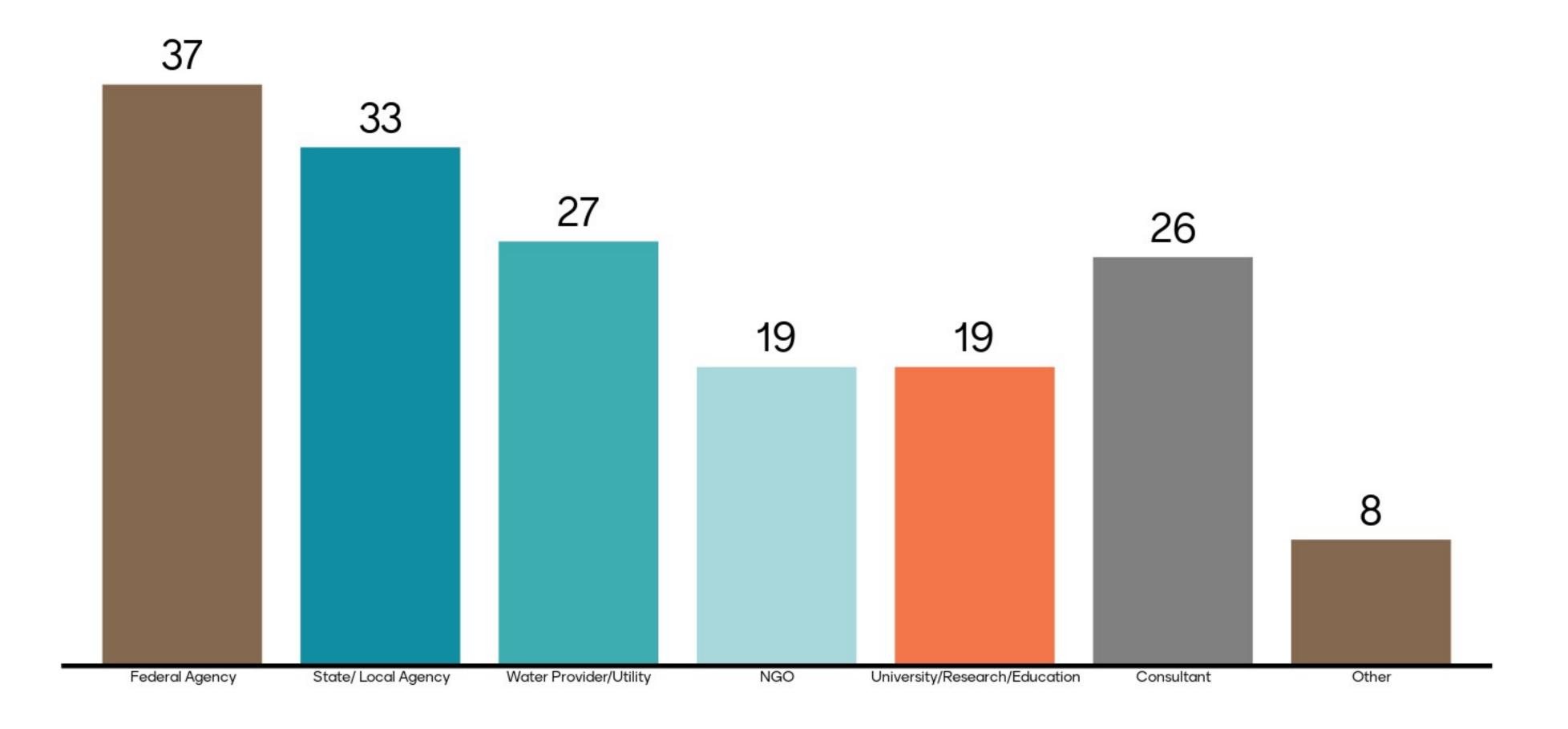


Panel Discussions, Q&A, Polling

- > Polling is anonymous. Please be respectful & professional.
- → Please reserve GoToWebinar's 'Question' box for technical issues & 'Chat' box for resources.
- → We have a fixed time for questions. Unanswered questions will be addressed in a post-webinar report.

What sector best represents you?

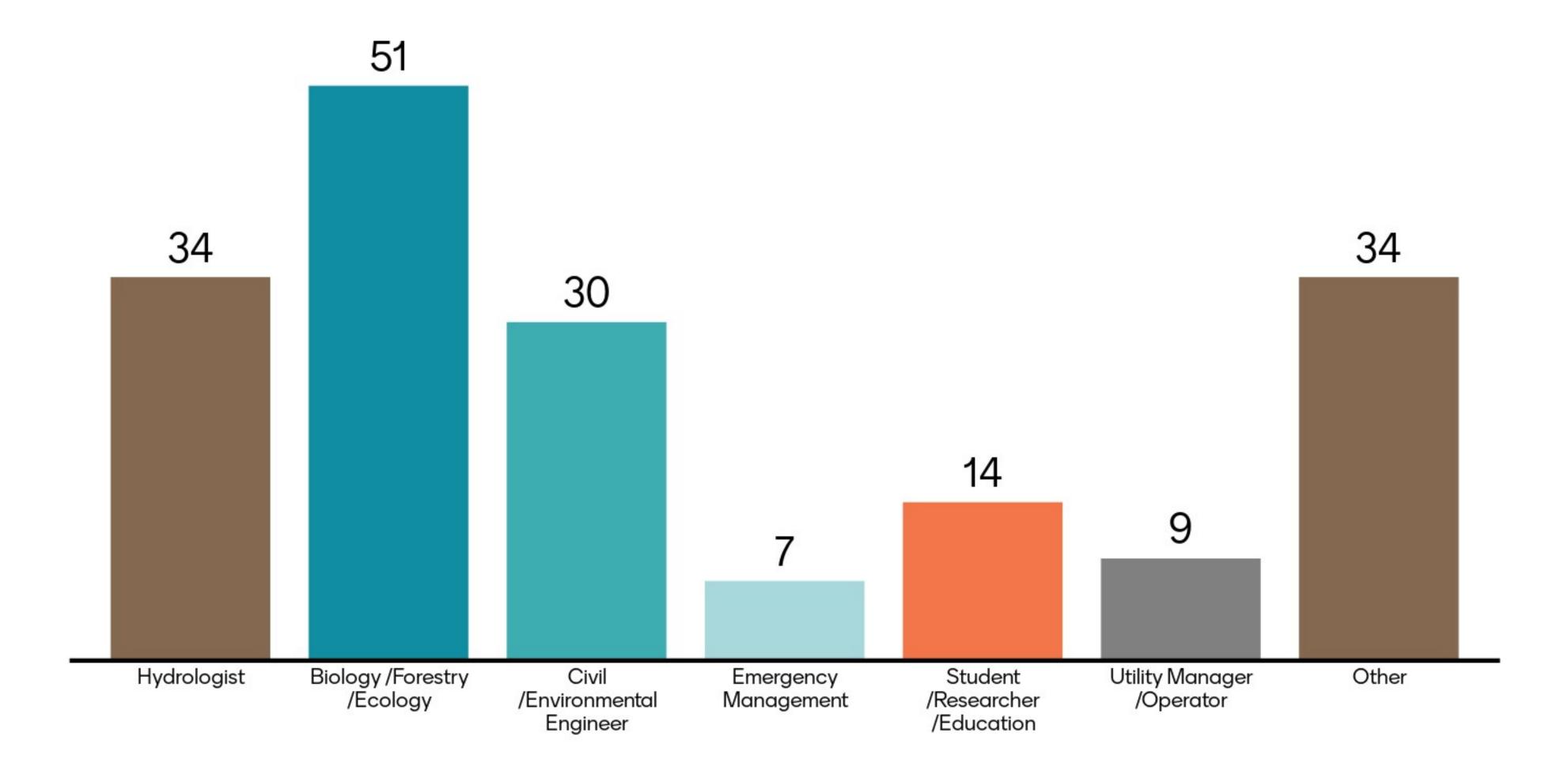






What field best represents your expertise?

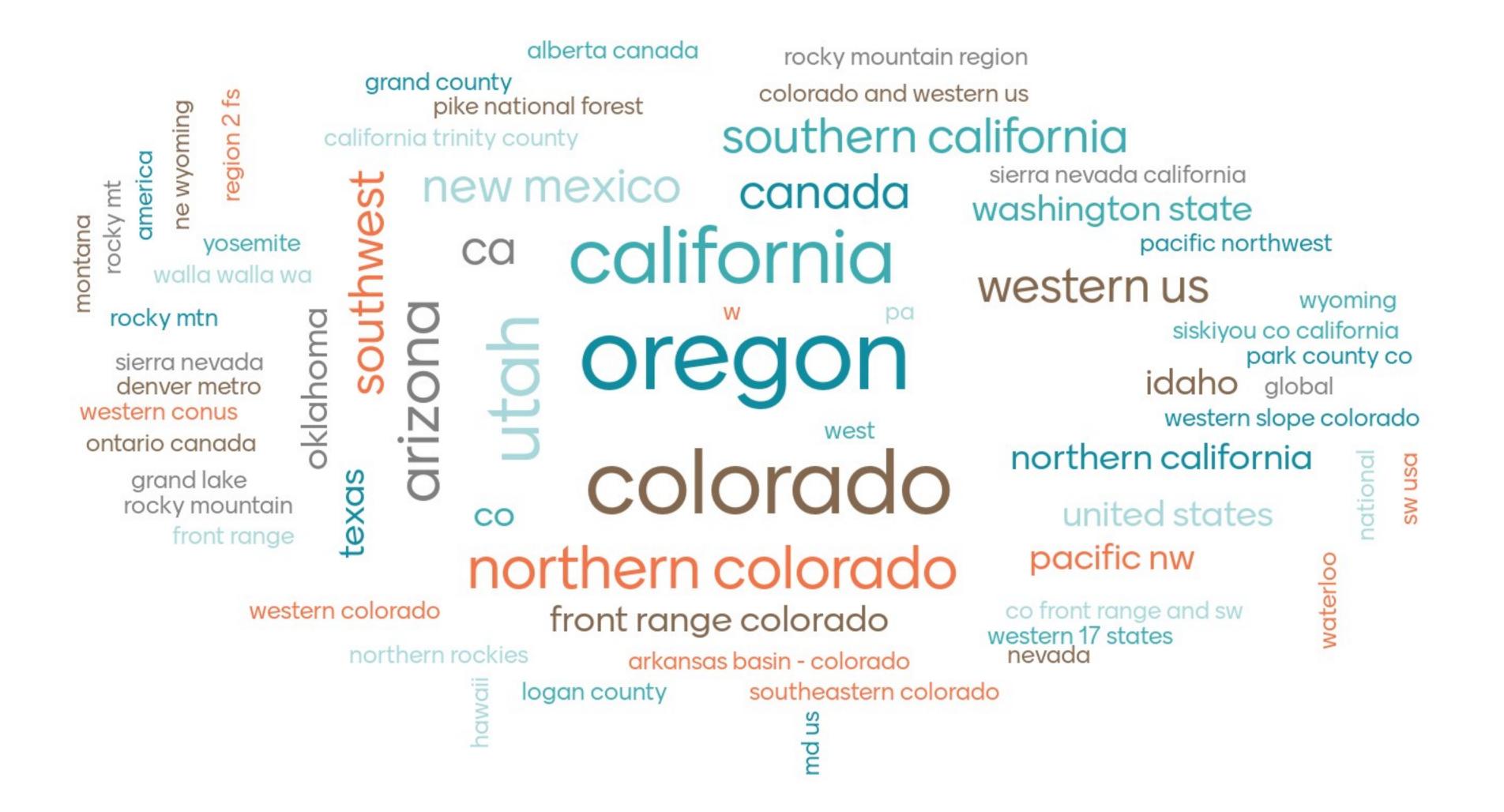






In what country, state, or region do you conduct the majority of your work?









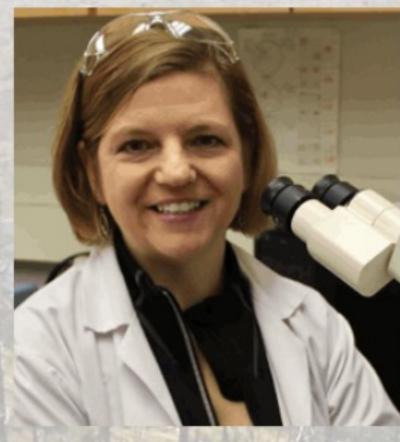














Post-Fire Water Quality Impacts

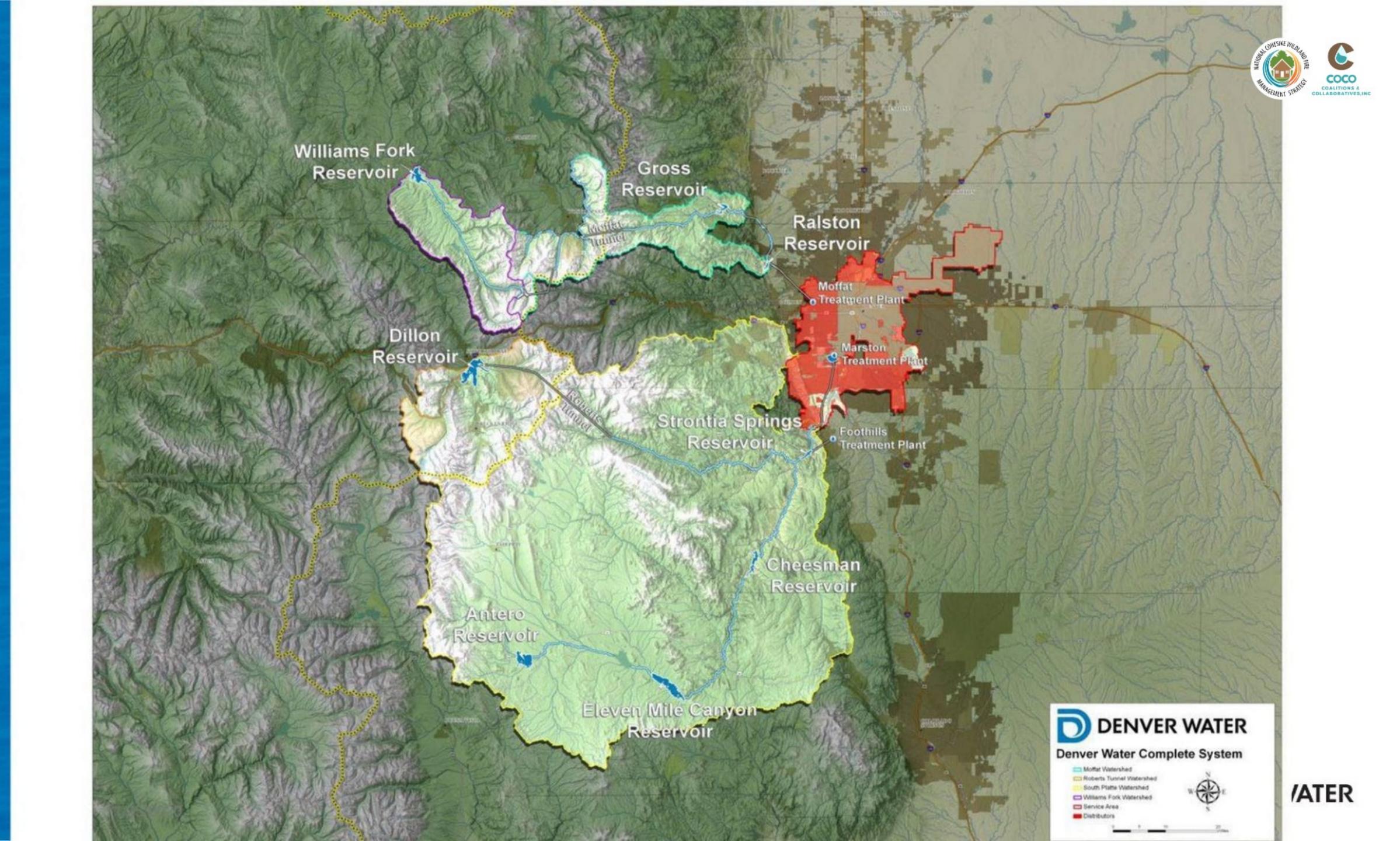
- Christina Burri, Watershed Scientist
- Monica Emelko, Drinking Water Treatment Engineer & Director of the Water Science, Technology & Policy Group
- Chuck Rhoades, Watershed Scientist

Denver Water Post Fire Lessons Learned



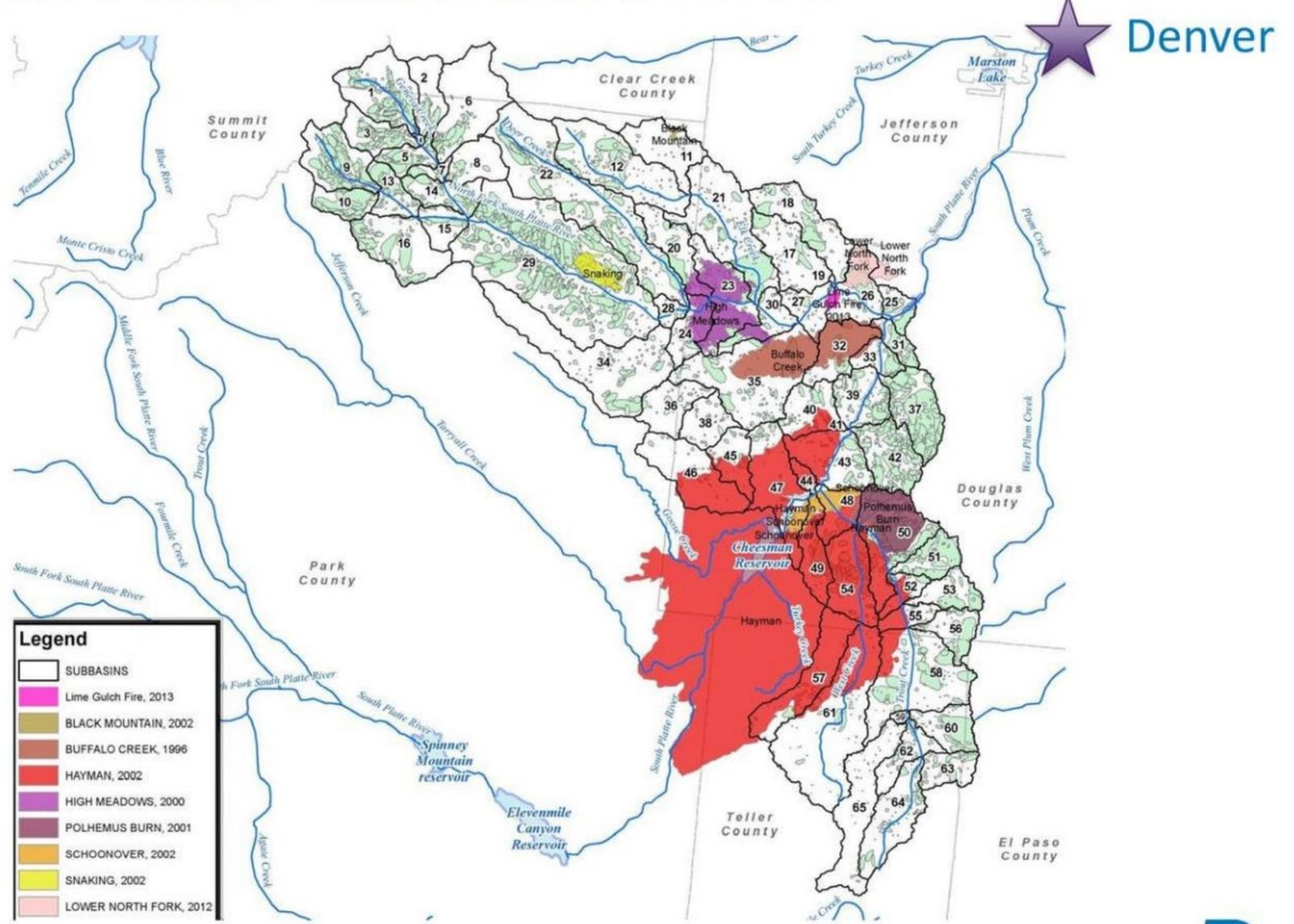
Christina Burri, Watershed Scientist





South Platte Watershed Fires

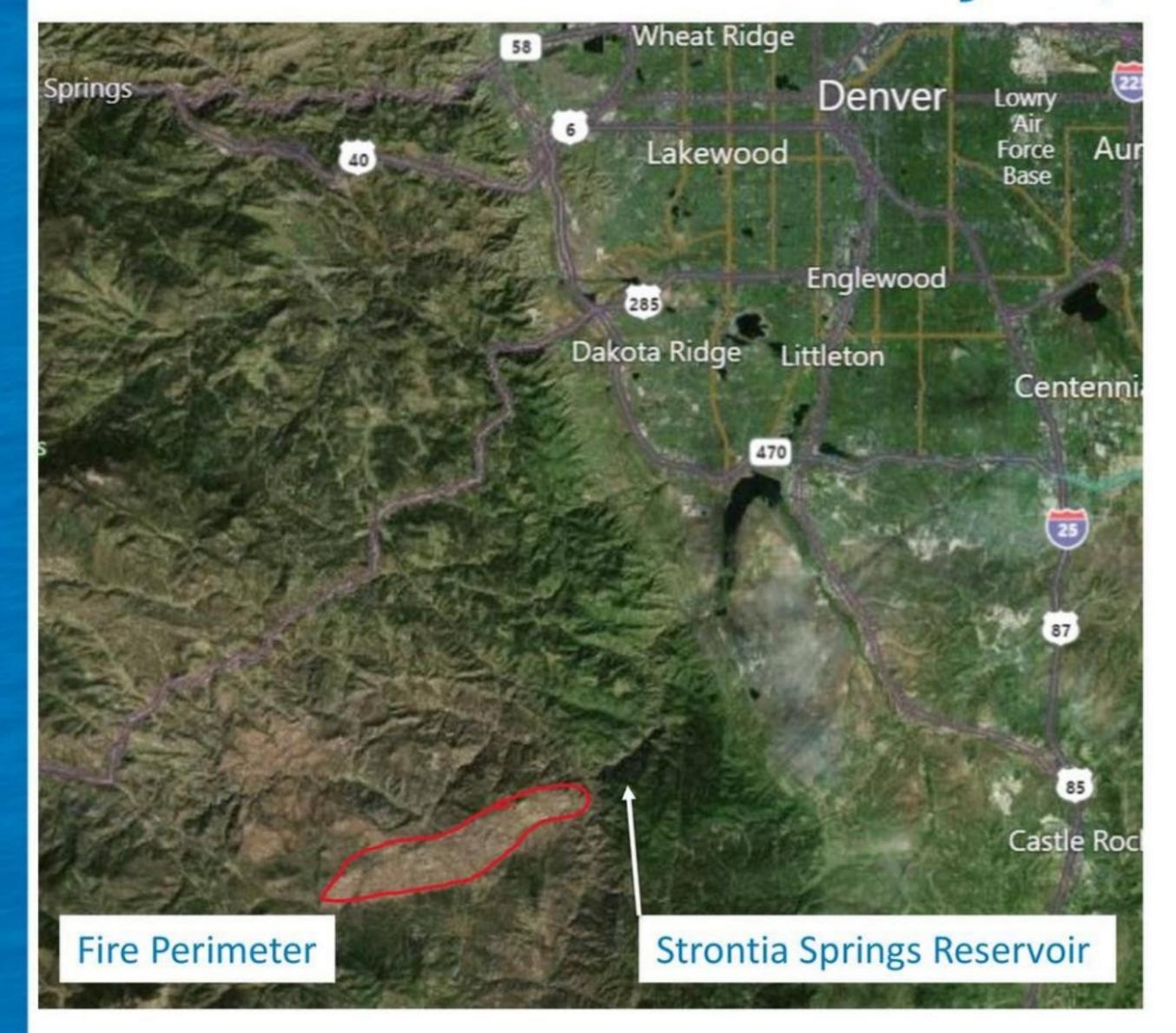


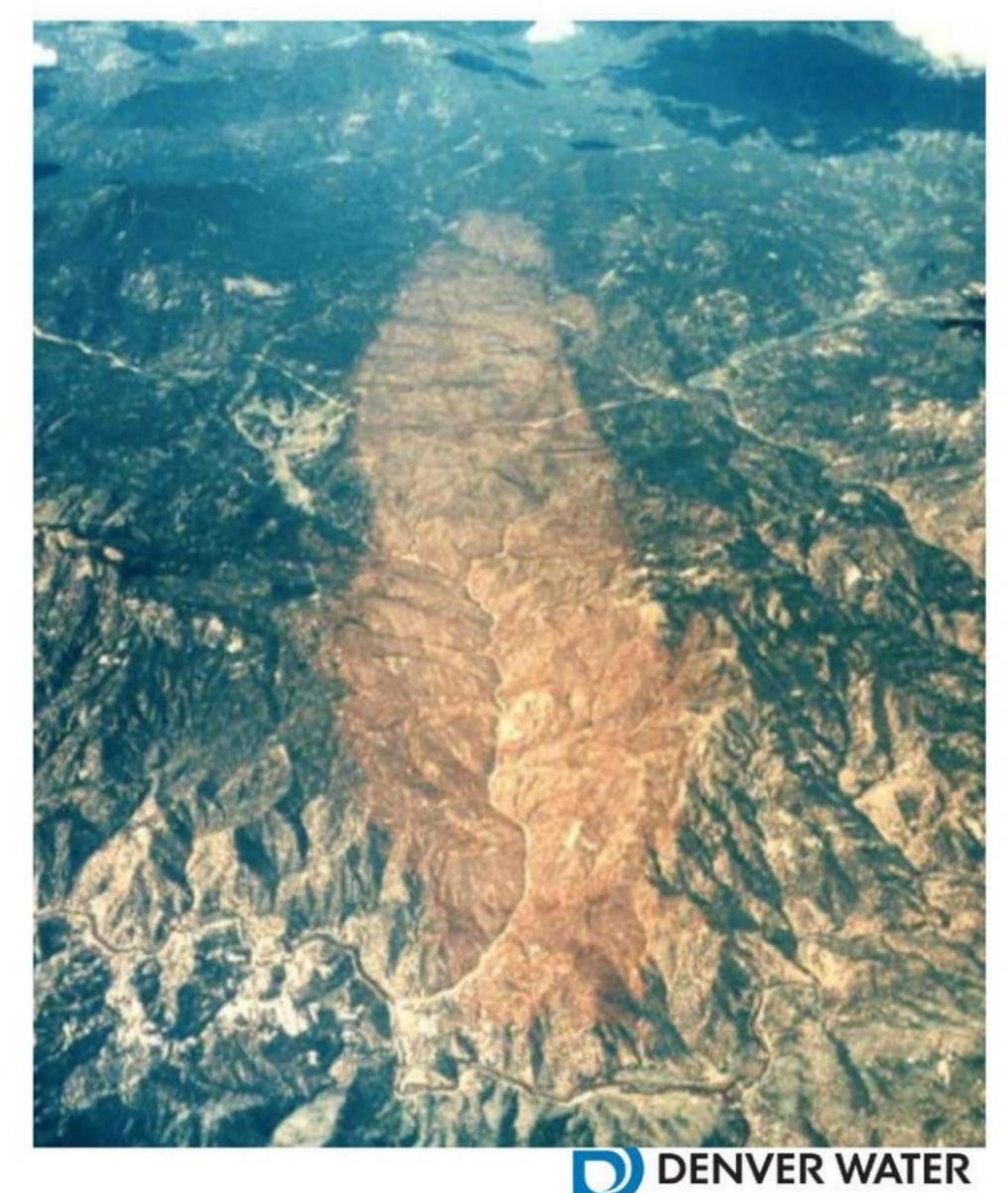




Buffalo Creek Fire: May 18, 1996



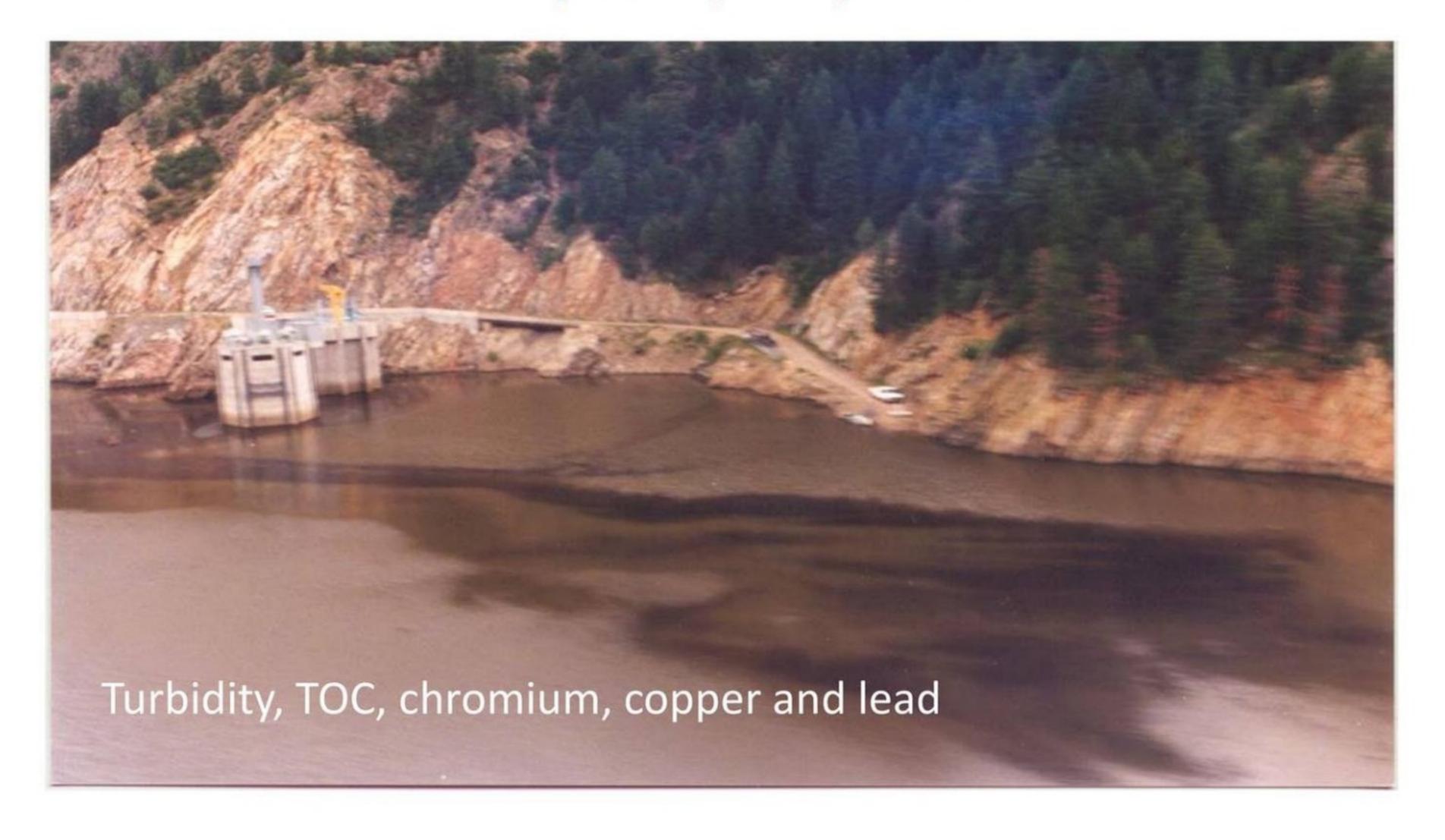






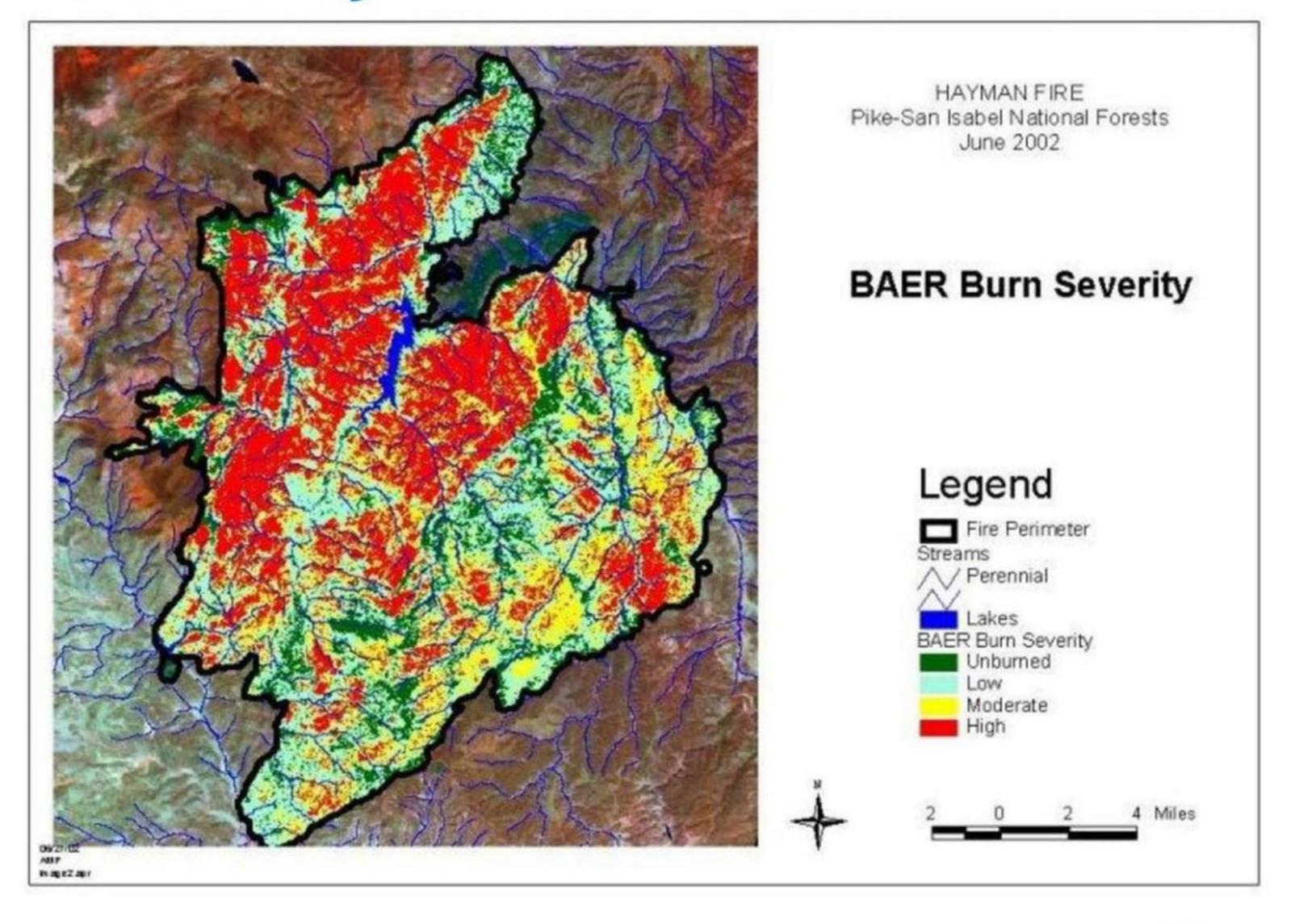
Water quality impacts





Hayman Fire Severity









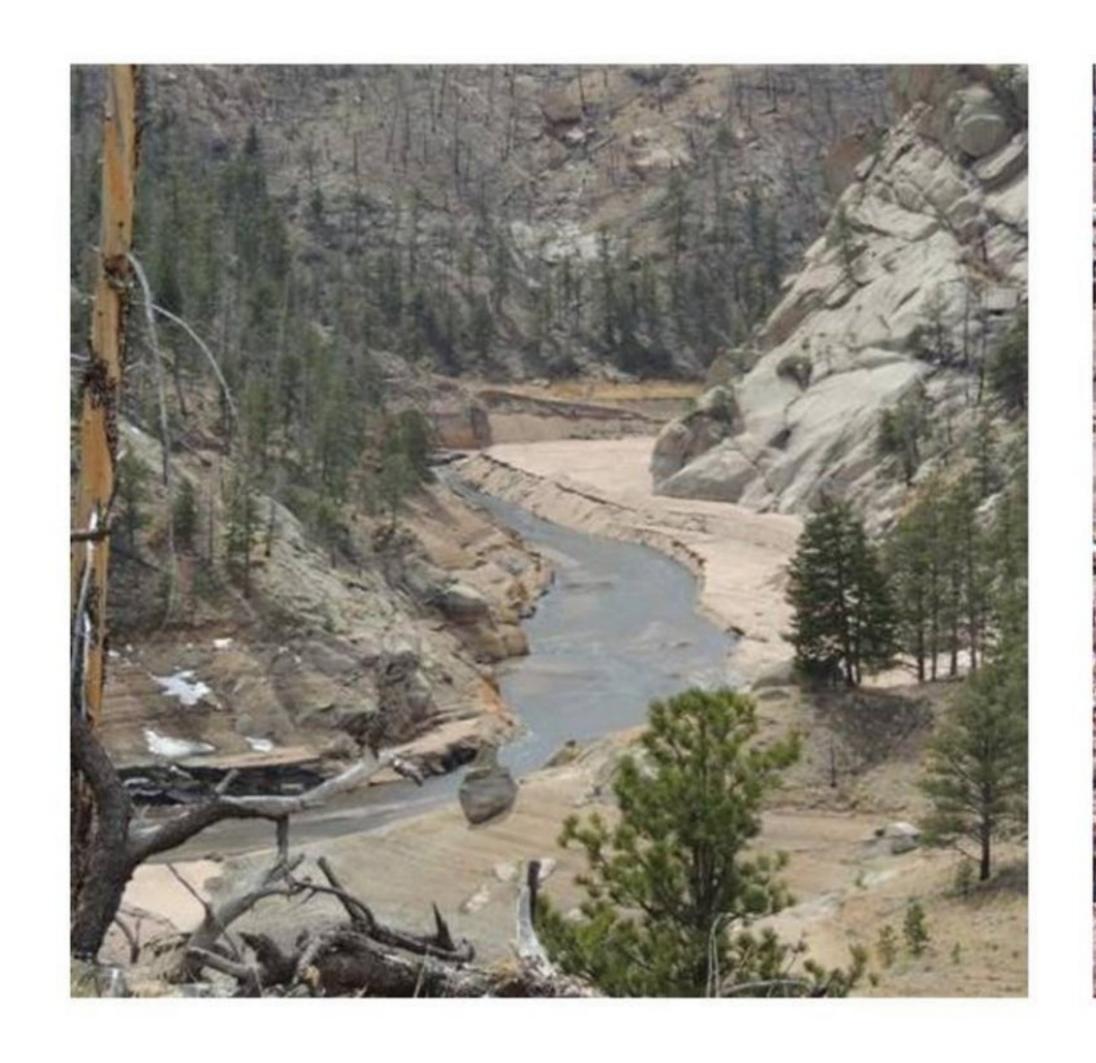
Watershed Management

- Immediate sediment response
- Mid-range sediment response
- Long-range watershed strategies





Immediate Post Fire Sediment









Straw Sediment Traps









Log Sediment Traps – Small Drainages







11

Mid-range sediment management

















Long-Term Sediment Strategies

- Hiring Watershed Scientists and establishing a Watershed Planning Program.
- Proactive investments in forest health and partnerships.
 - DW only owns 2% of the 2.5 M acre watershed. Need to collaborate.
- Inventory, Assessment, and Prioritization (IAP) for investments
 - Strontia Sediment Task Force
- Frequent and consistent internal communication
 - Watershed Steering Committee
- Don't put all your eggs in one basket.
 - Wildfire Readiness and Recovery Framework





Denver Water Watershed Values







Drinking Water Treatability

Provide high quality water at an affordable rate

Infrastructure Protection

Protect collection system, watershed assets, and access to assets

Community & Environmental Stewardship

Foster partnerships to sustain healthy and resilient watersheds





Denver Water partnership commitments

From Forests to Faucets

- \$66 million investment 2010-2021 Denver Water committed \$33M.
- Partners include DW, CSFS, NRCS, USFS and USPP.
- Proactively improve the health and resiliency of forests and watersheds.
- Focus in areas critical for providing and delivering water to Denver Water customers.



Photo credit: denver.com

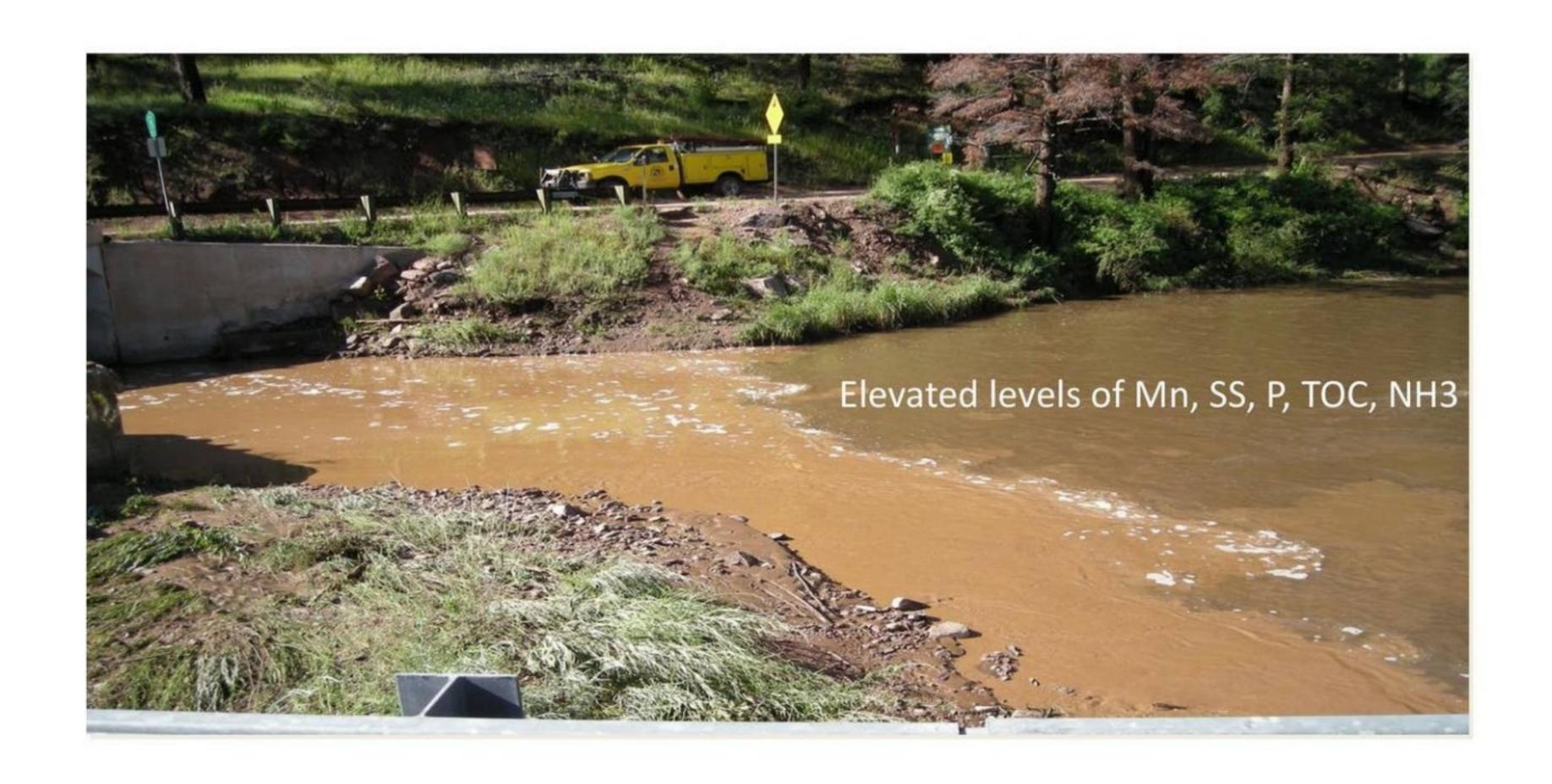
Partnerships with CUSP Horse Creek Stream Restoration





Horse Creek water quality Horse Creek confluence with South Platte

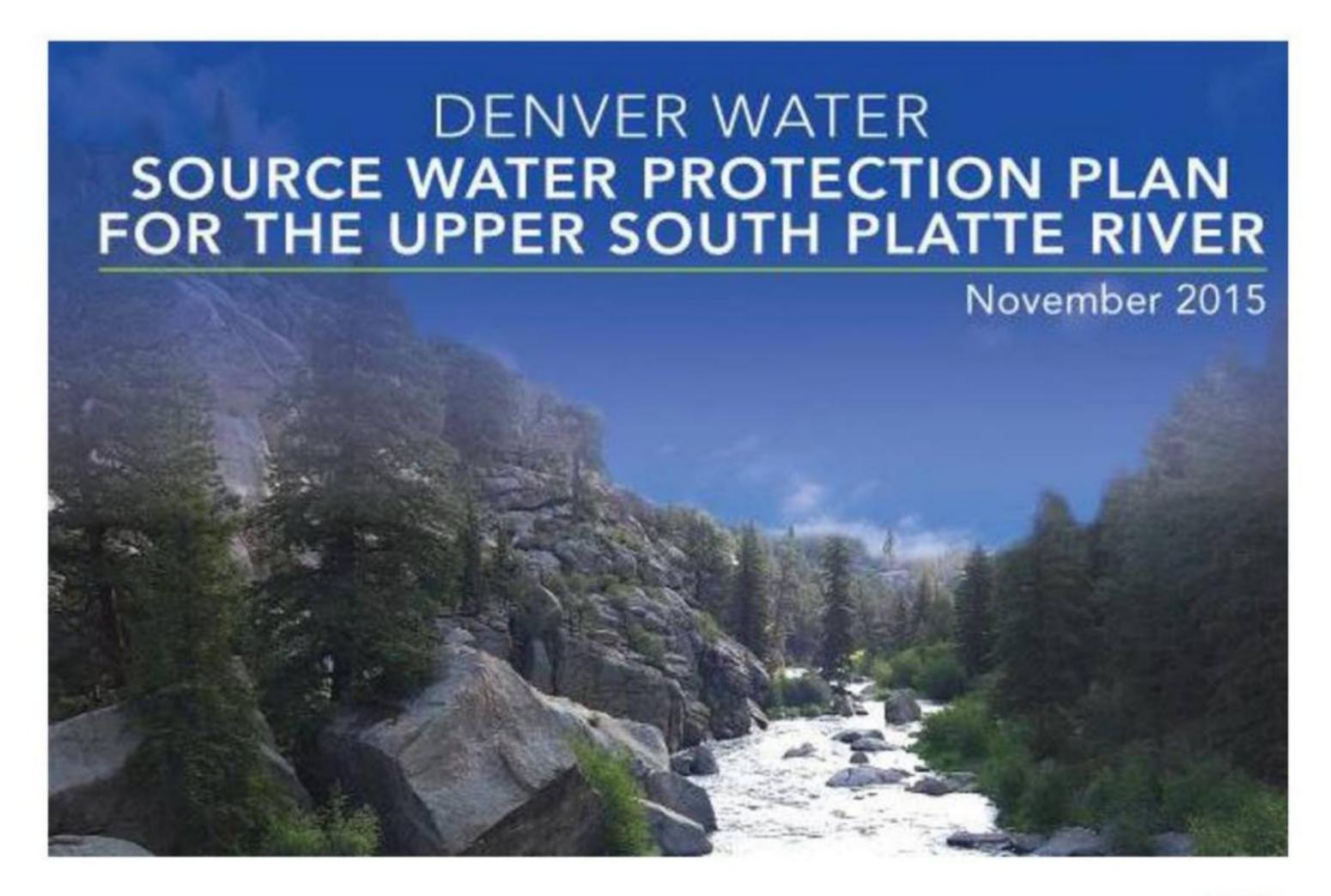






Source Water Protection Planning:

http://www.denverwater.org/SupplyPlanning/WaterSupply/watershed-protection/









INVENTORY

Identify risks and threats, actions implemented and planned, and compile monitoring data (water quality, biologic indicators, etc.).

EVALUATE

Determine the ROI on the actions and the impacts to the prioritized areas and threats. Estimate future budget needs. Adapt action planning as needed.

ONGOING

Monitoring Implementation

ASSESS

Use inventory to assess state of the watershed and progress or impact made. Frequency and level of detail based on audience and needs.

PLAN

Use IRP Watershed Toolbox and other existing and new actions that will target prioritized areas and threats. Identify partners and stakeholders for watershed actions.

PRIORITIZE

Identify geographic areas and categories of threats to focus implementation efforts.





Adaptive Management Framework

INVENTORY

Identify risks and threats, actions implemented and planned, and compile monitoring data (water quality, biologic indicators, etc.).

EVALUATE

Determine the ROI on the actions and the impacts to the prioritized areas and threats. Estimate future budget needs. Adapt action planning as needed.

ONGOING

Monitoring Implementation

ASSESS

Phase 1

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PLAN

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PRIORITIZE

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Adaptive Management Framework

Phase 1

Phase 2

INVENTORY

Identify risks and threats, actions implemented and planned, and compile monitoring data (water quality, biologic indicators, etc.).

EVALUATE

Determine the ROI on the actions and the impacts to the prioritized areas and threats. Estimate future budget needs. Adapt action planning as needed.

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PRIORITIZE

Identify geographic areas and categories of threats to focus implementation efforts.



In one or two words, what strategies can water utilities use to implement projects when they don't own the source area?







Water Quality & Treatability after Severe Wildfire: Planning for Water Supply & Treatment Resilience

M.B. Emelko, M. Stone, K.M. Müller, U. Silins, J. Skwaruk, T. Shardlow, C.A. Emmerton, C. Cooke, & P.J. Schmidt







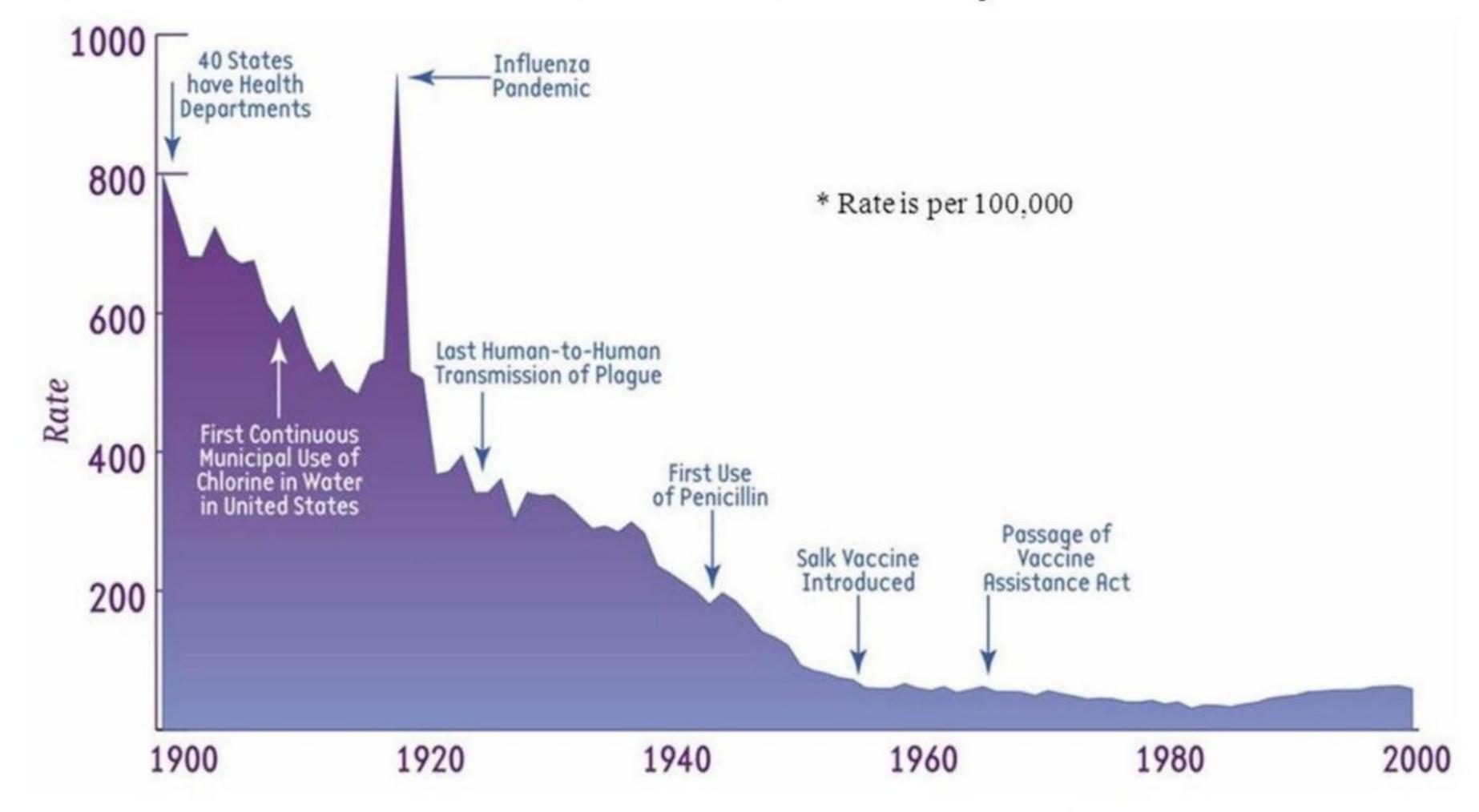
After the Flames:
Post-fire Water Quality Impacts & Mitigation
WEBINAR

December 3, 2020



U.S. infectious disease crude death rate, 1900-2000

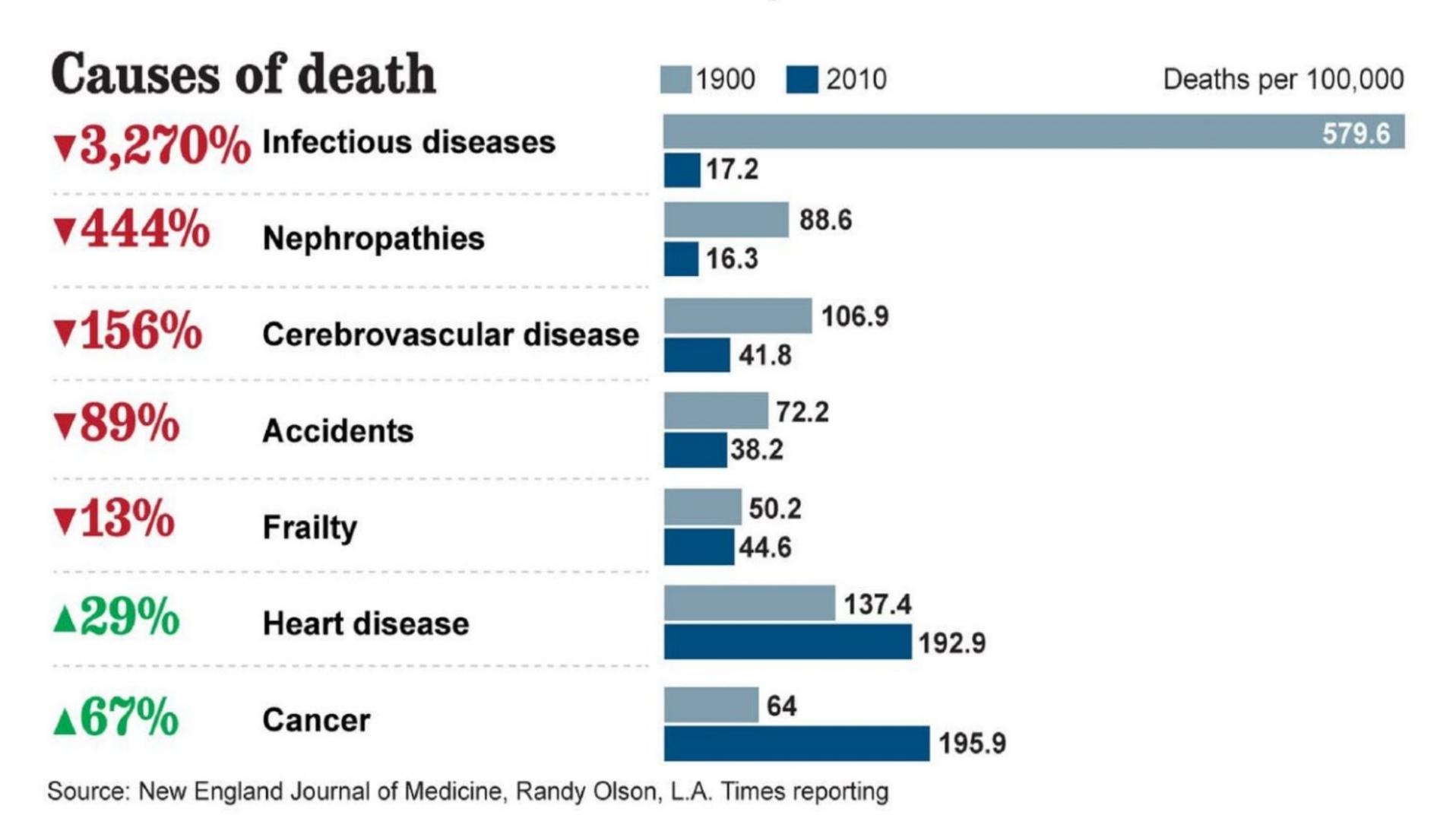






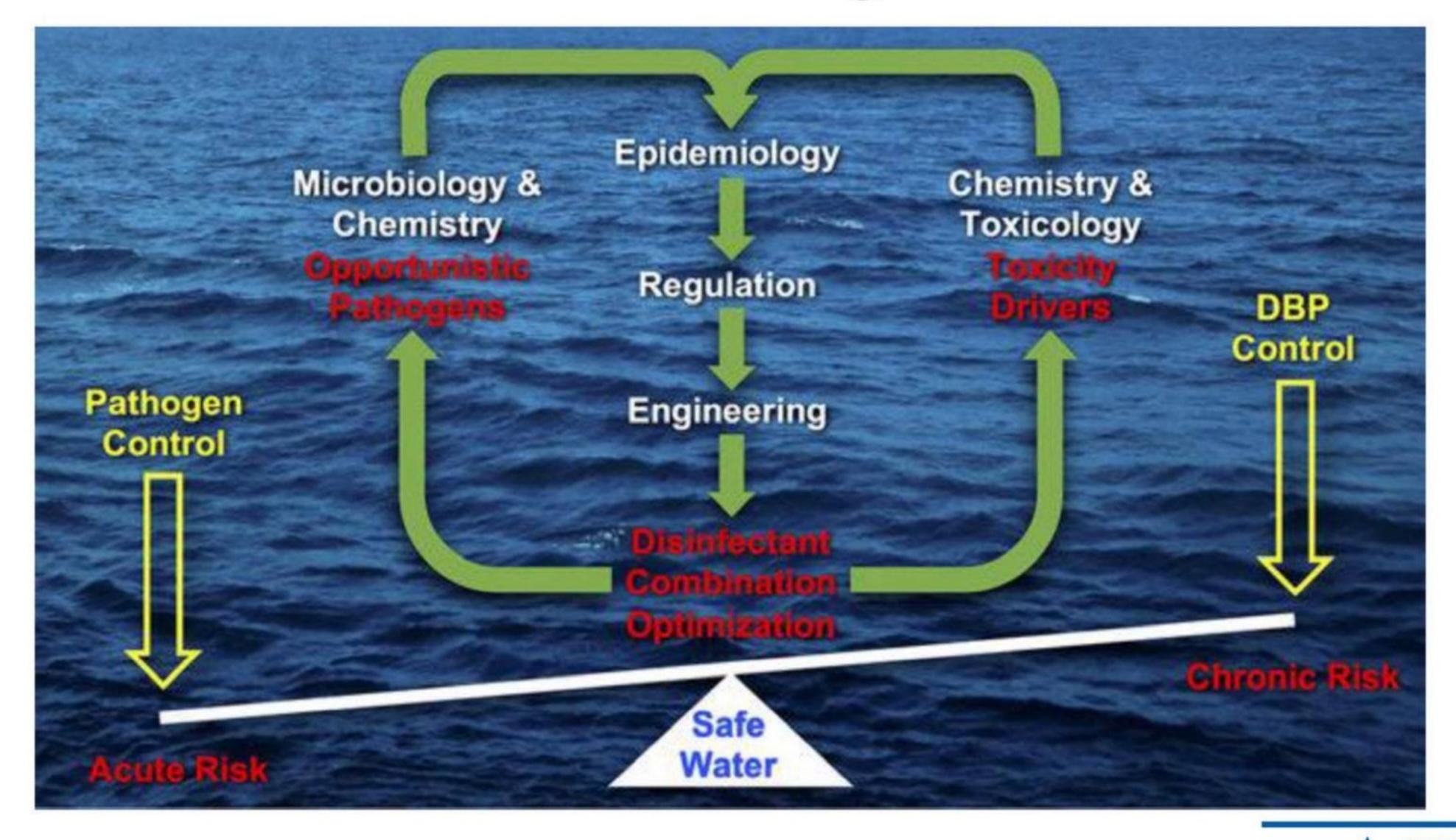
Major causes of death in the U.S., 1900-2010





Contaminant threats to safe drinking water

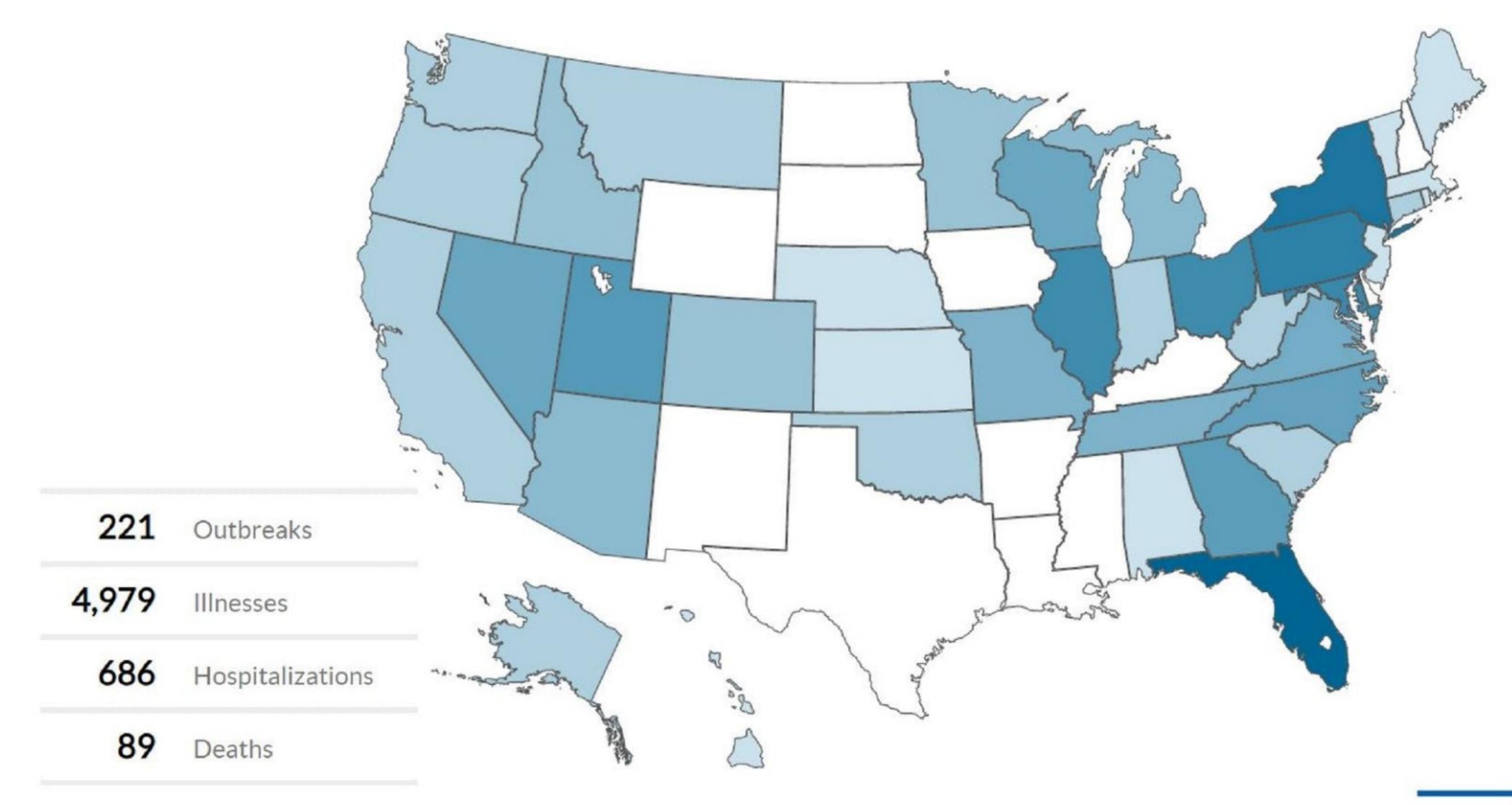






Recorded drinking water outbreaks of disease (2008-2018)





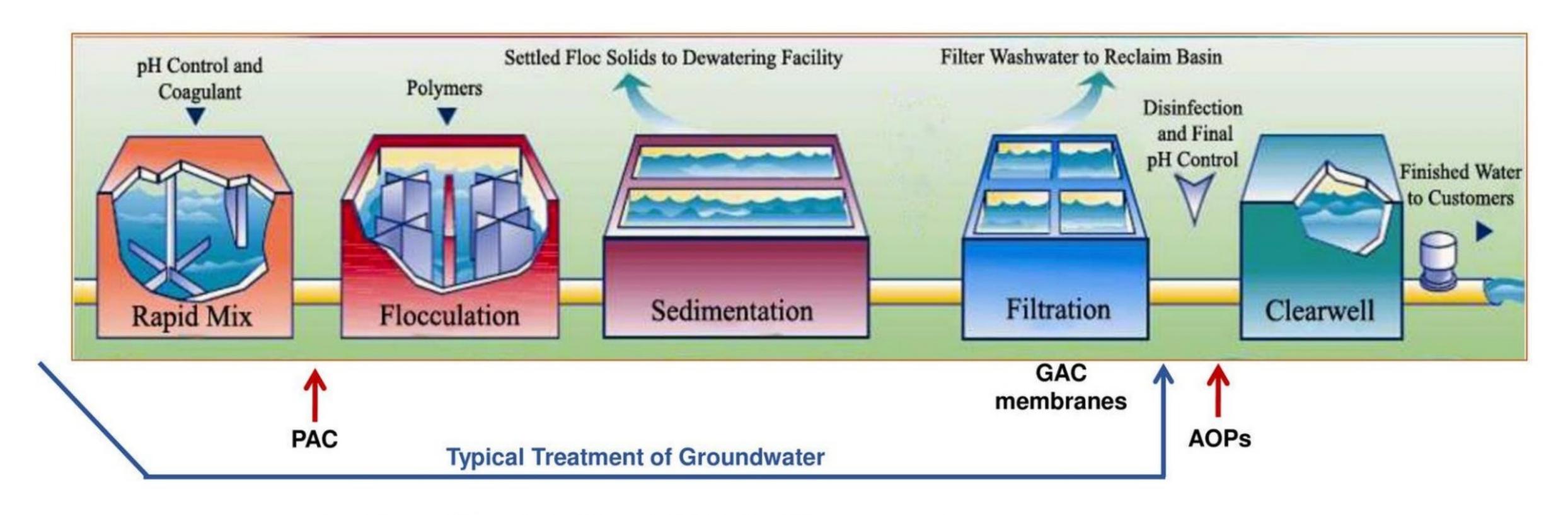
Key water quality drivers of drinking water treatment



Process	Turbidity	Color	TOC
Conventional	high	high	high
	>20 NTU	>20 c.u.	>4 mg/L
Direct/Inline	low	moderate to low	low
Filtration	≤15 NTU	≤20 c.u.	<4 mg/L
Microfiltration	low	moderate to low	low
	≤10 NTU	≤10 c.u.	<4 mg/L

Drinking water treatment overview





Solids/Turbidity & NOM Removal

Pathogen Removal



COC COALITIO

Wildfire threats to drinking water treatability

Parameter Impact on Treatment	Turbidity and SS	TP	DON and TKN	Hg	DOC	Chla
need for solids removal (C/F/S)	✓				✓	✓
† coagulant demand	✓				✓	✓
† sludge production	✓				✓	✓
† oxidant demand	✓		✓		✓	✓
† potential DBPs	✓		✓		✓	✓
† fluence required for UV			✓		✓	✓
↑ potential microcystins		✓				✓
taste & odor concerns					✓	✓
compliance concerns	✓			✓	✓	✓
† operating costs	✓	✓	✓	✓	✓	✓

...can lead to service disruptions or outages



Key water quality drivers of drinking water treatment



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Conventional	high	high	high
	>20 NTU	>20 c.u.	>4 mg/L
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Microfiltration	low	moderate to low	low
	≤10 NTU	≤10 c.u.	<4 mg/L

- Microbial risk management is <u>always</u> a top priority.
- Parameters of health consequence are <u>NOT</u> the most significant threats to <u>treatability</u> of surface water!
- More variable water quality can be a game changer!



Wildfire can significantly impact water

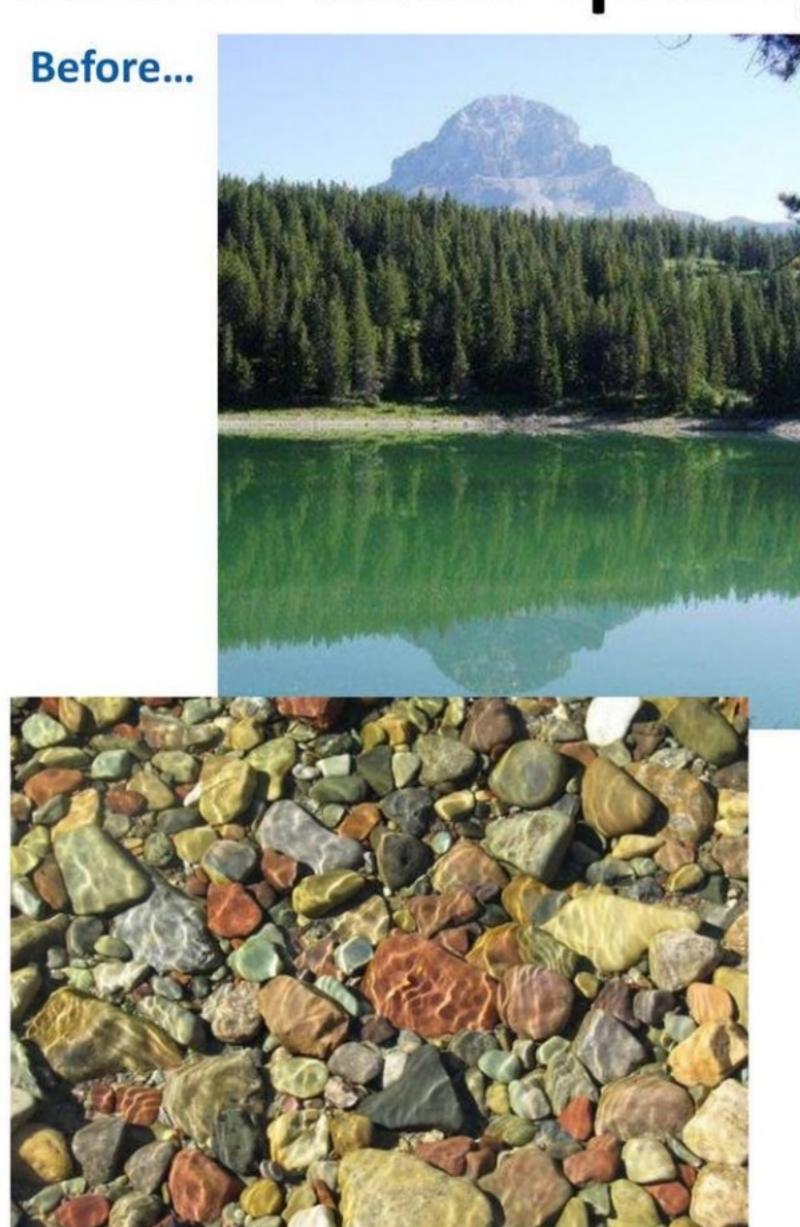






Source water quality deterioration can be expected after with



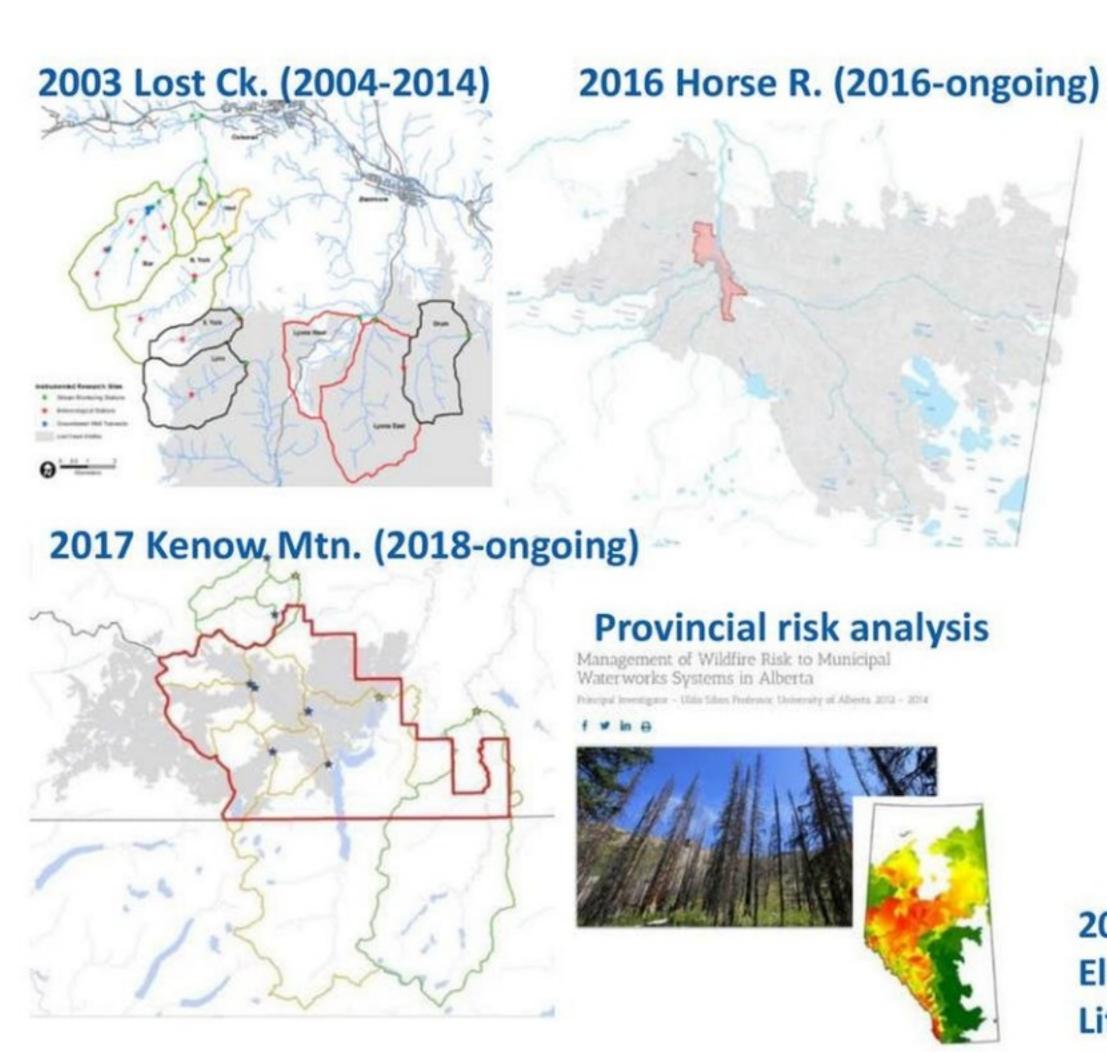




Southern Rockies Watershed Project













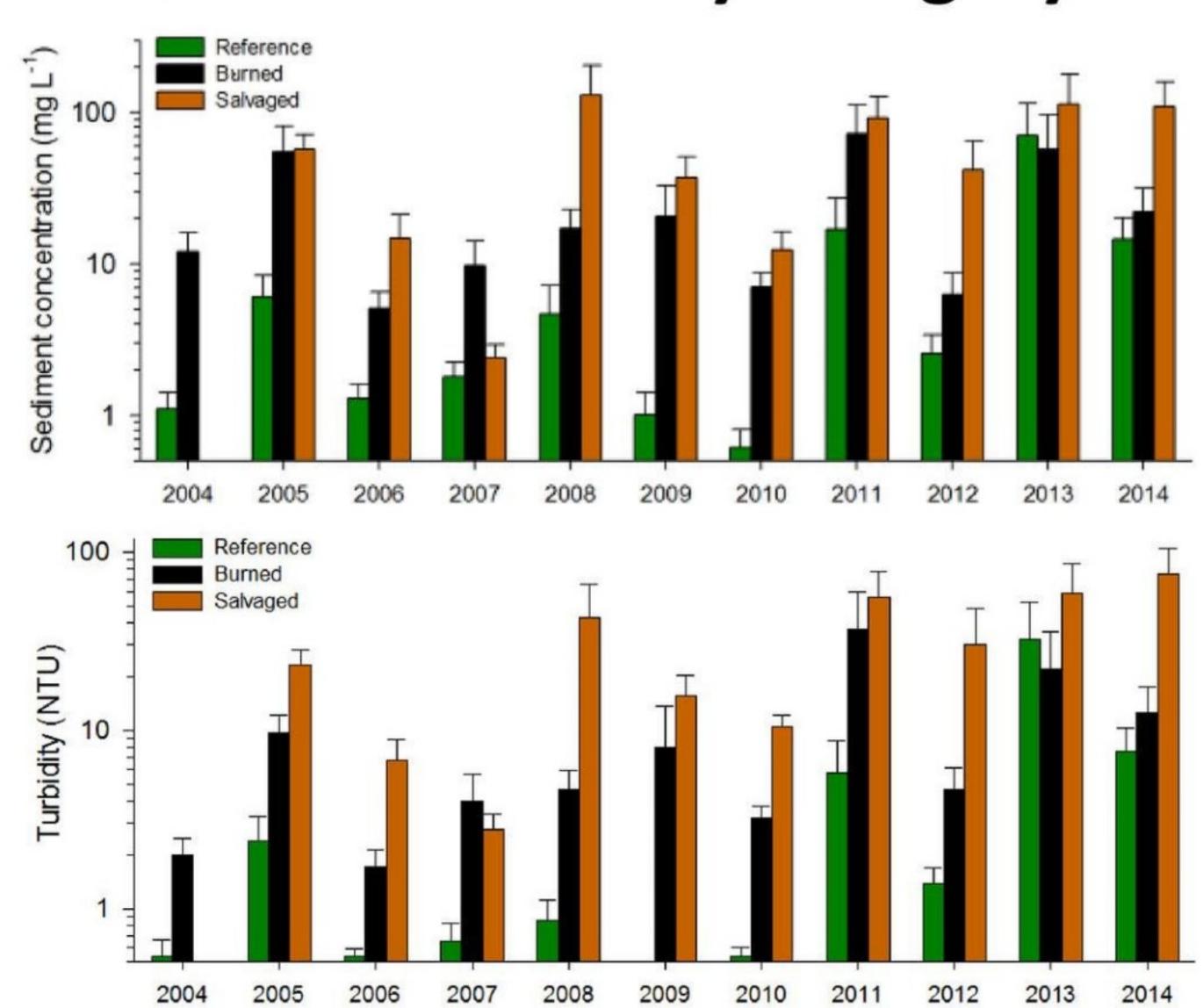


2017
Elephant Hill, Thuja Ck.
Little Fort Complex (B.C.)

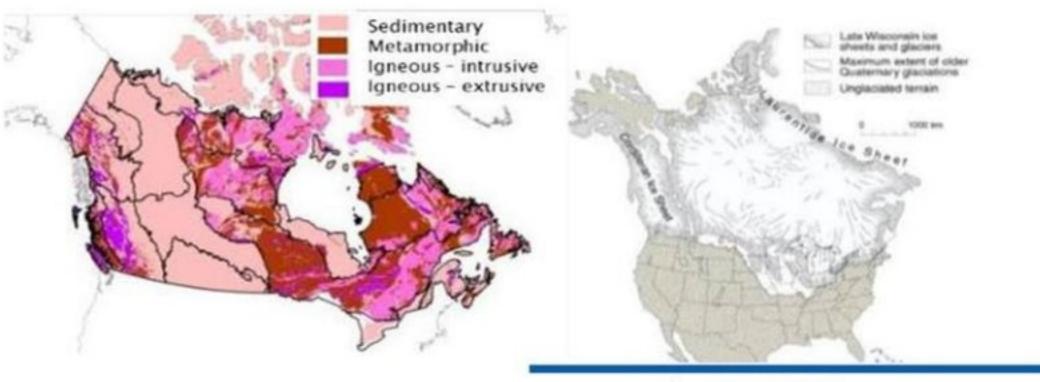


Sediment & turbidity: A legacy of wildfire impacts



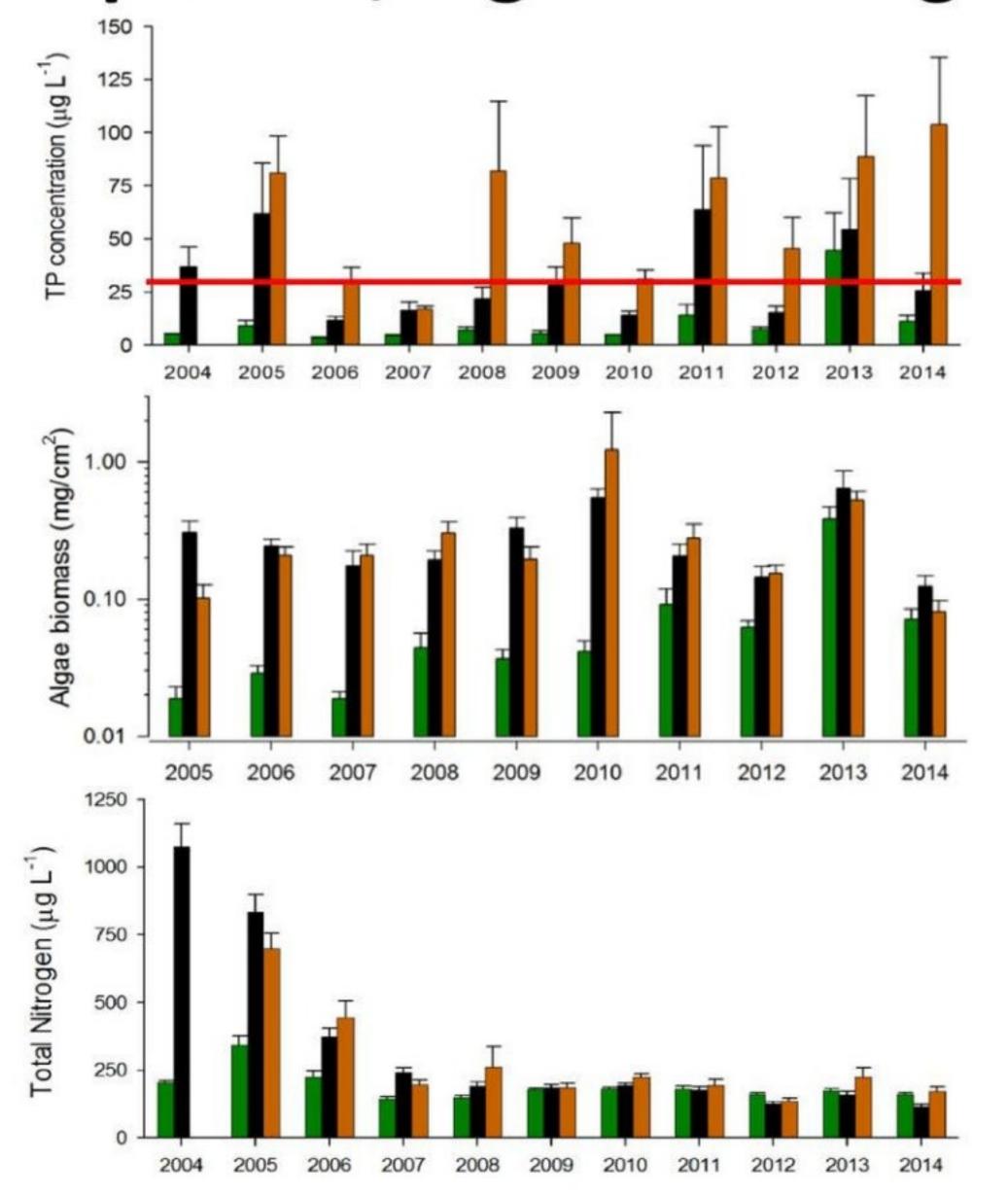








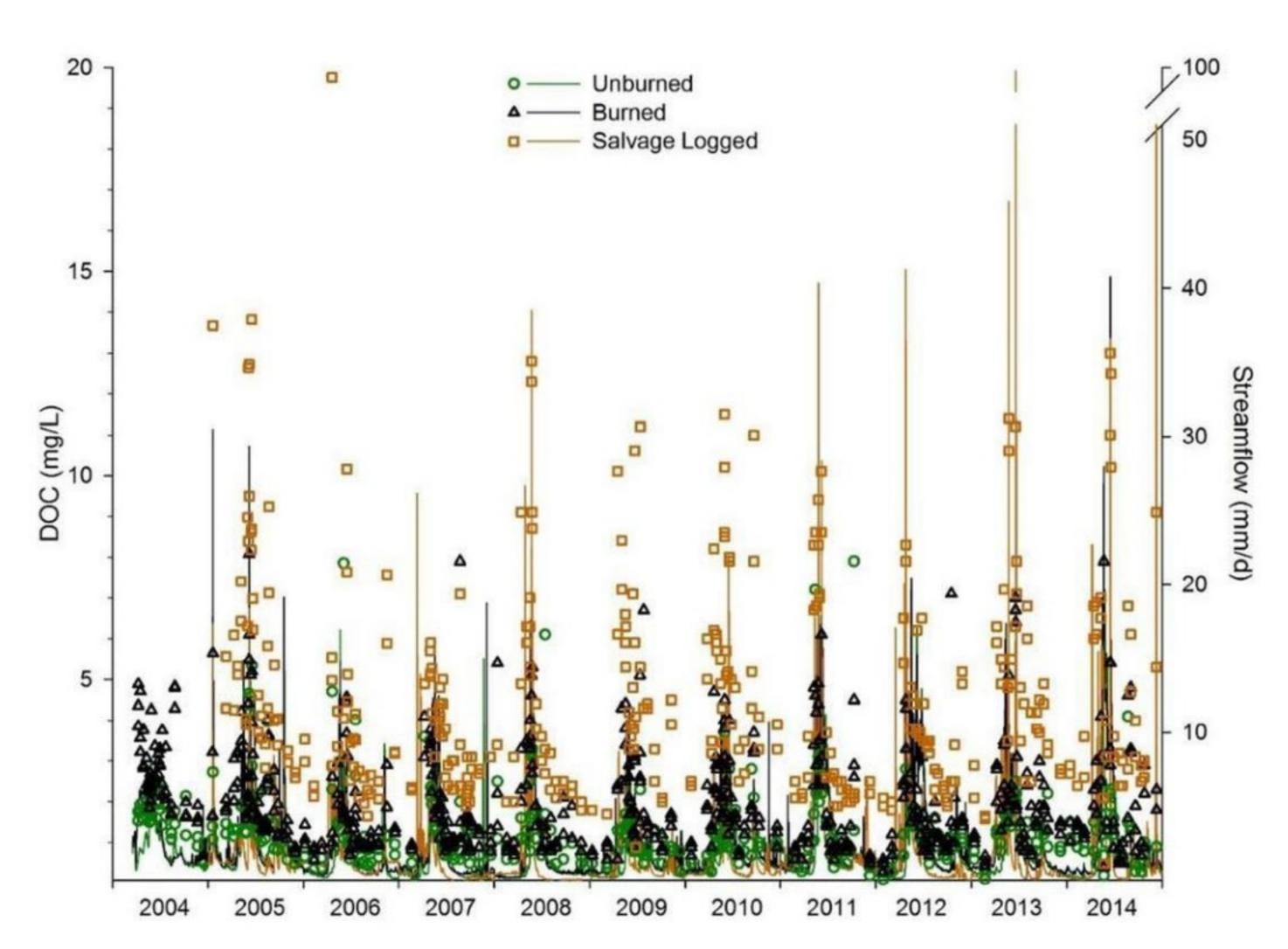
Phosphorus, algae & nitrogen: More legacy impacts of wil

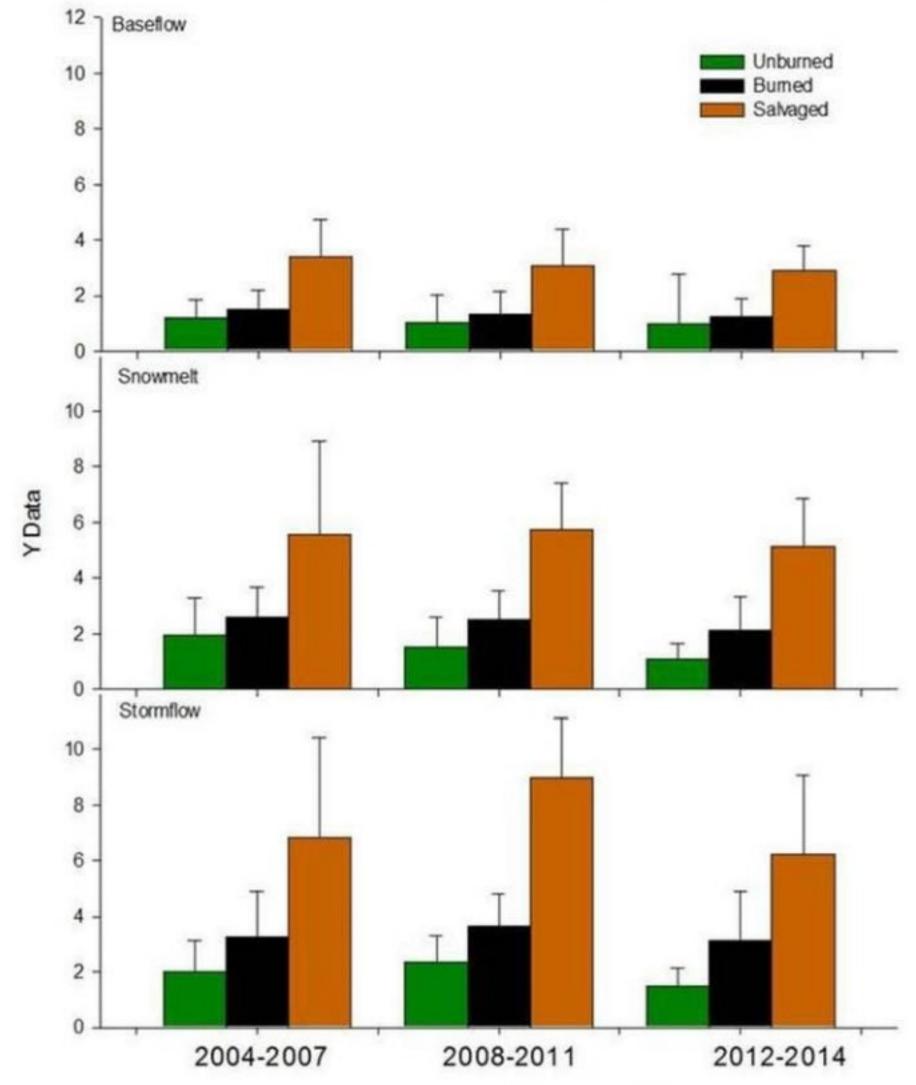




Dissolved organic carbon (DOC): Increased variability

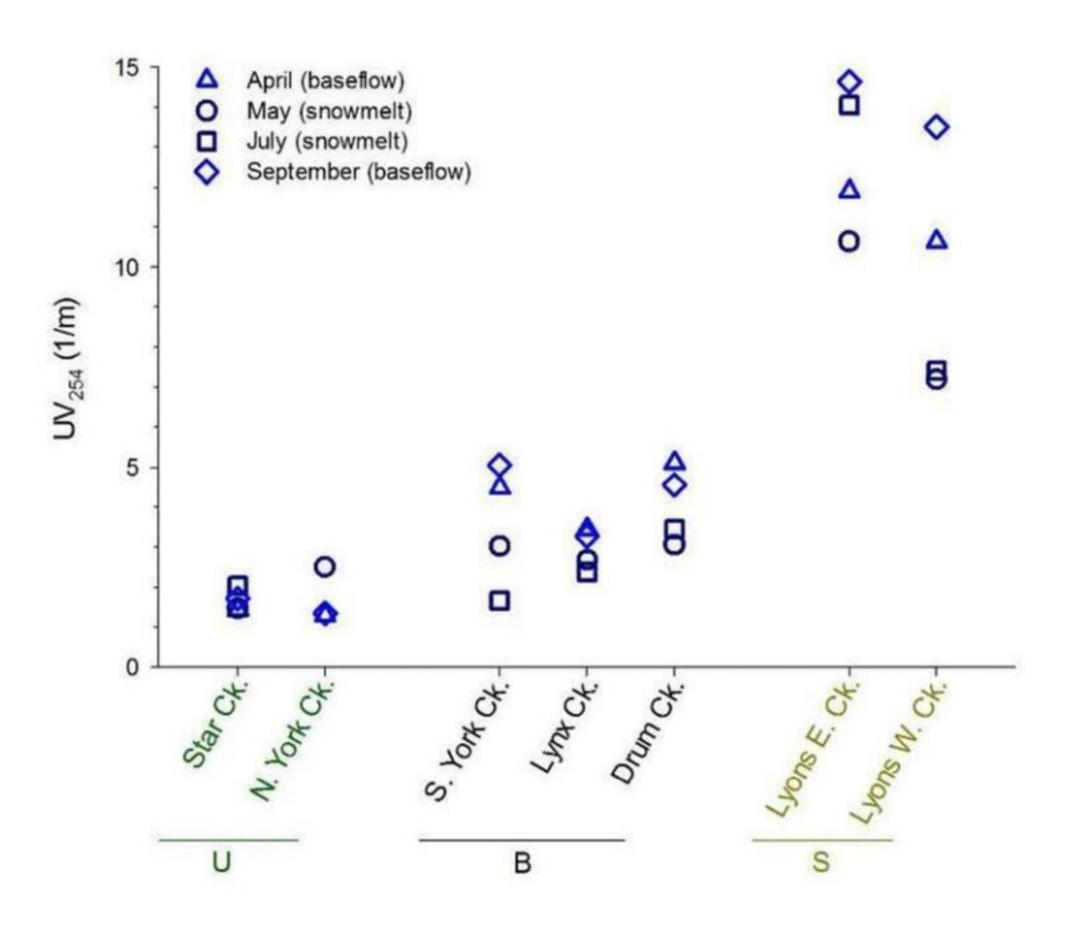


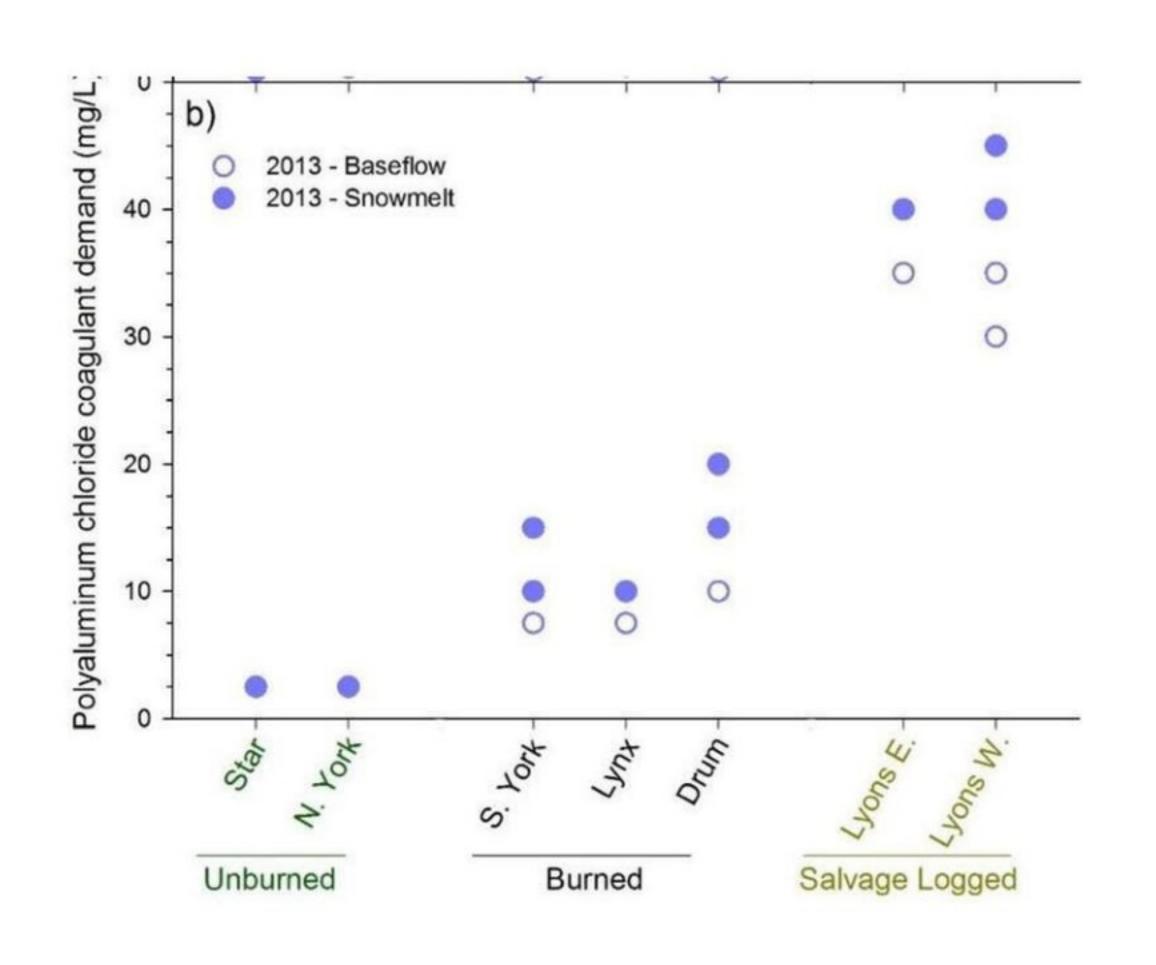






More aromatic DOC: Coagulant demand concerns and DB

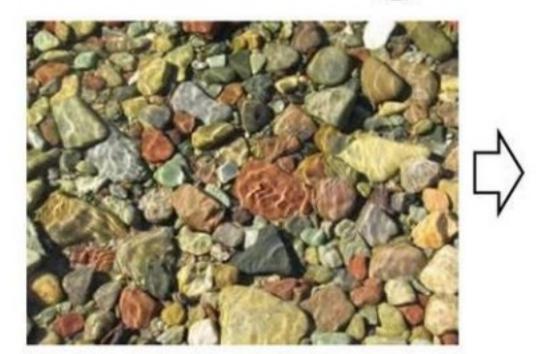






Dissolved organic carbon and increased coagulant dosing





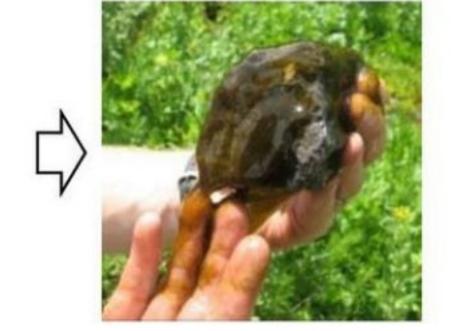
undisturbed riverbed



post-disturbance fine sediment



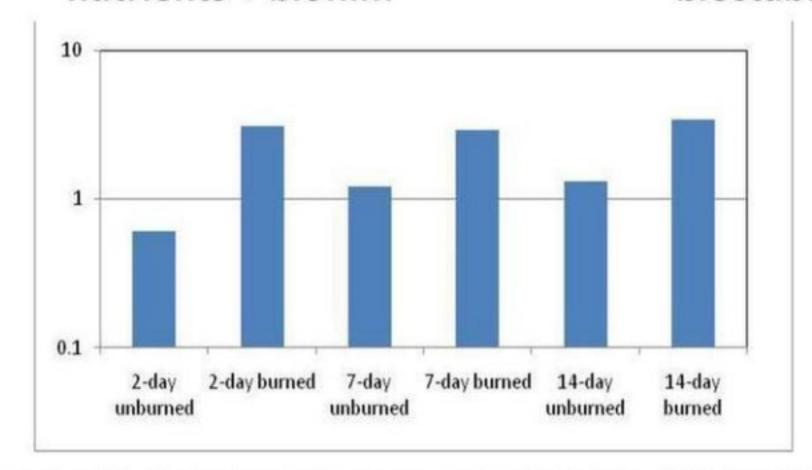
post-disturbance nutrients + biofilm



riverbed biostabilization

	Critical Shear		
	Consolidation	Stress for	Erosion
	Period	for Erosion (Tc)	Depth @ Tc
	[day]	[Pa]	[mm]
Castle River	2	0.105	0.013
UNBURNED	7	0.141	0.008
	14	0.165	0.014
Lynx Creek	2	0.120	0.336
BURNED	7	0.230	0.426
	14	0.310	1.540

Physical Sediment Characteristics



Total mid-chain branched saturated biofilm (%) by PLFA

- Disturbance may increase risk of taste & odor events.
- Disturbance results in more variable/rapidly changing downstream water quality.
- Better control over coagulation required!



Wildfire in Fort McMurray





Athabasca river basin...an already challenged system





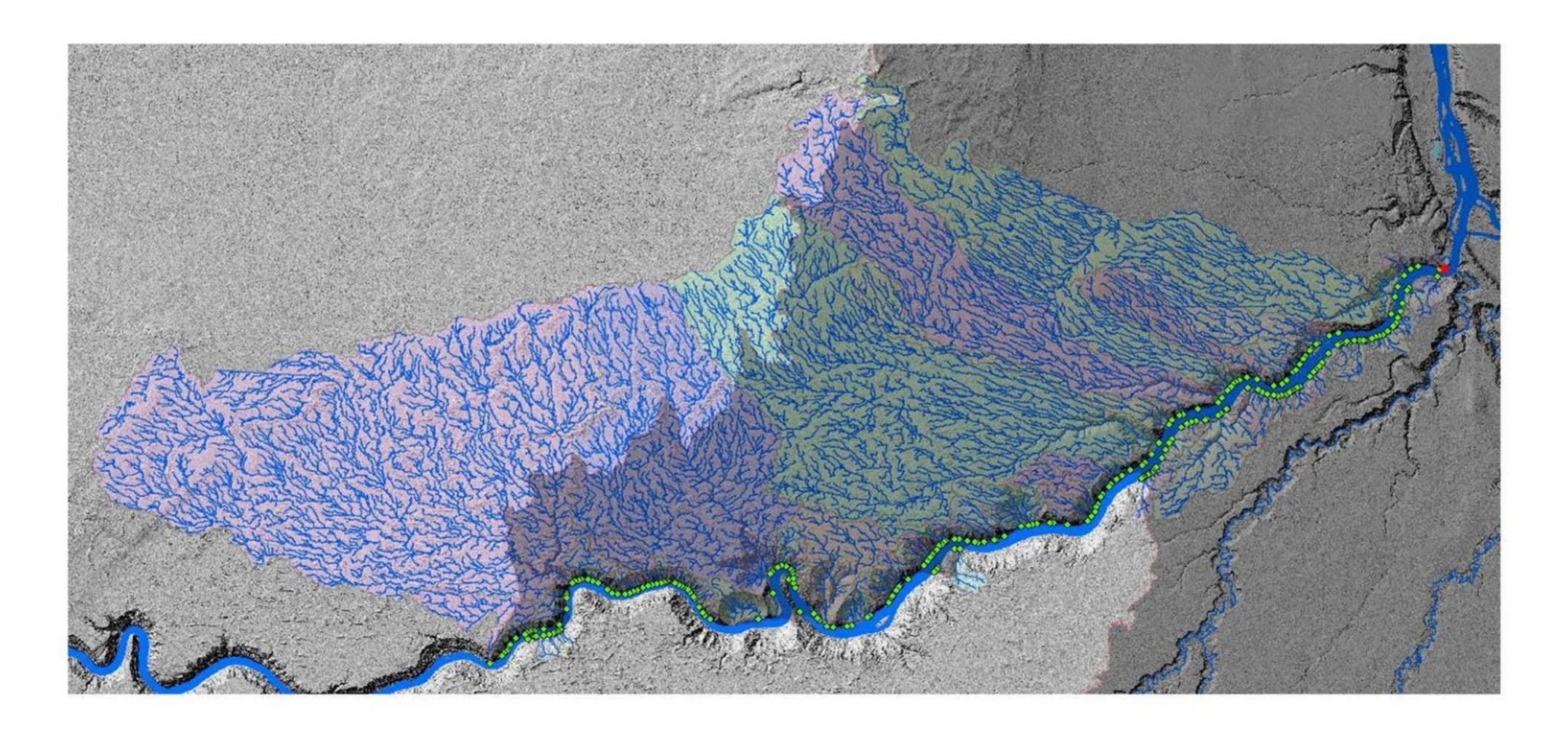
Impacts to drinking water treatment?





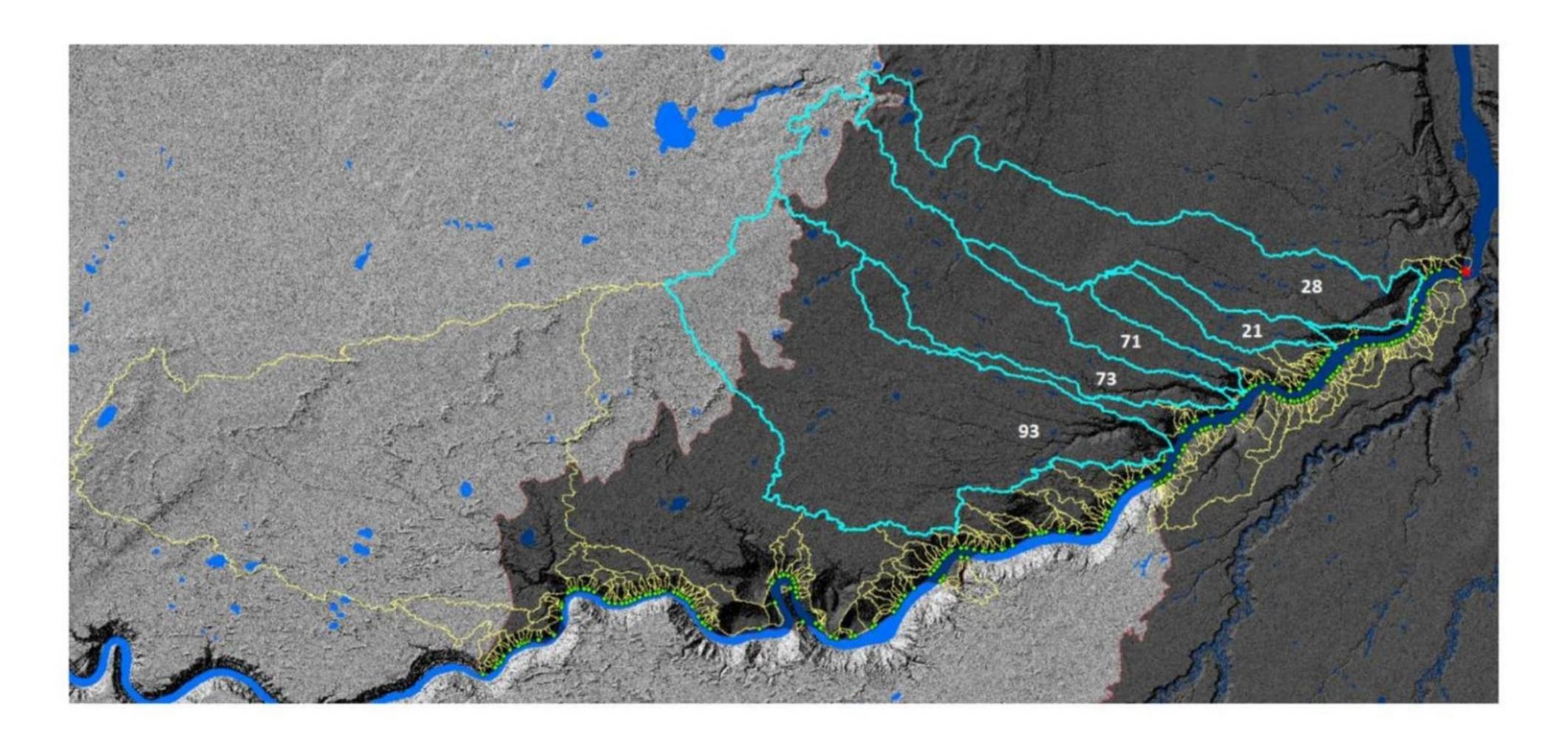
Contributors to source water quality in Fort McMurray





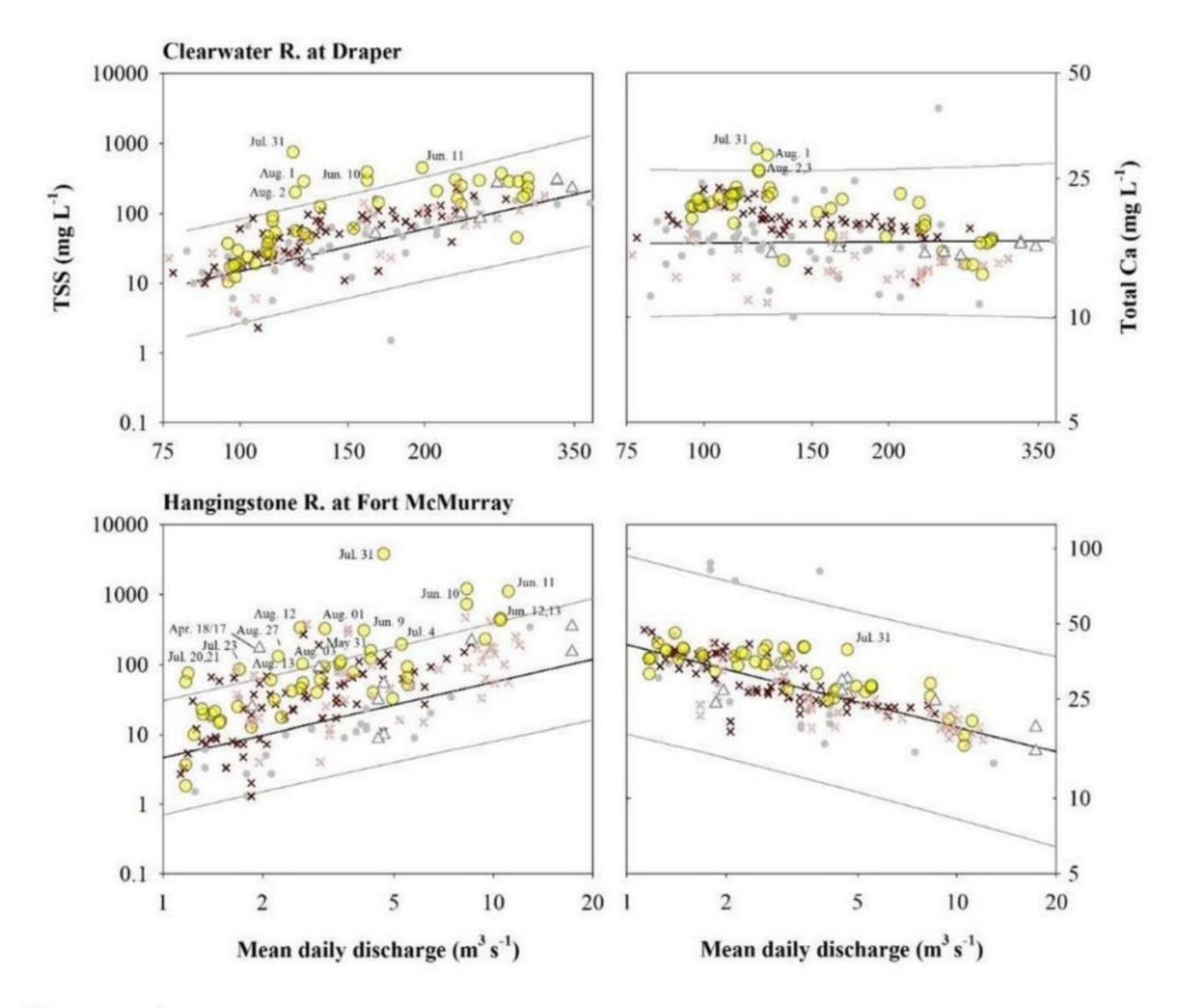
Contributors to source water quality in Fort McMurray





Contributors to source water quality in Fort McMurray







Importance of local hydrology in Fort McMurray





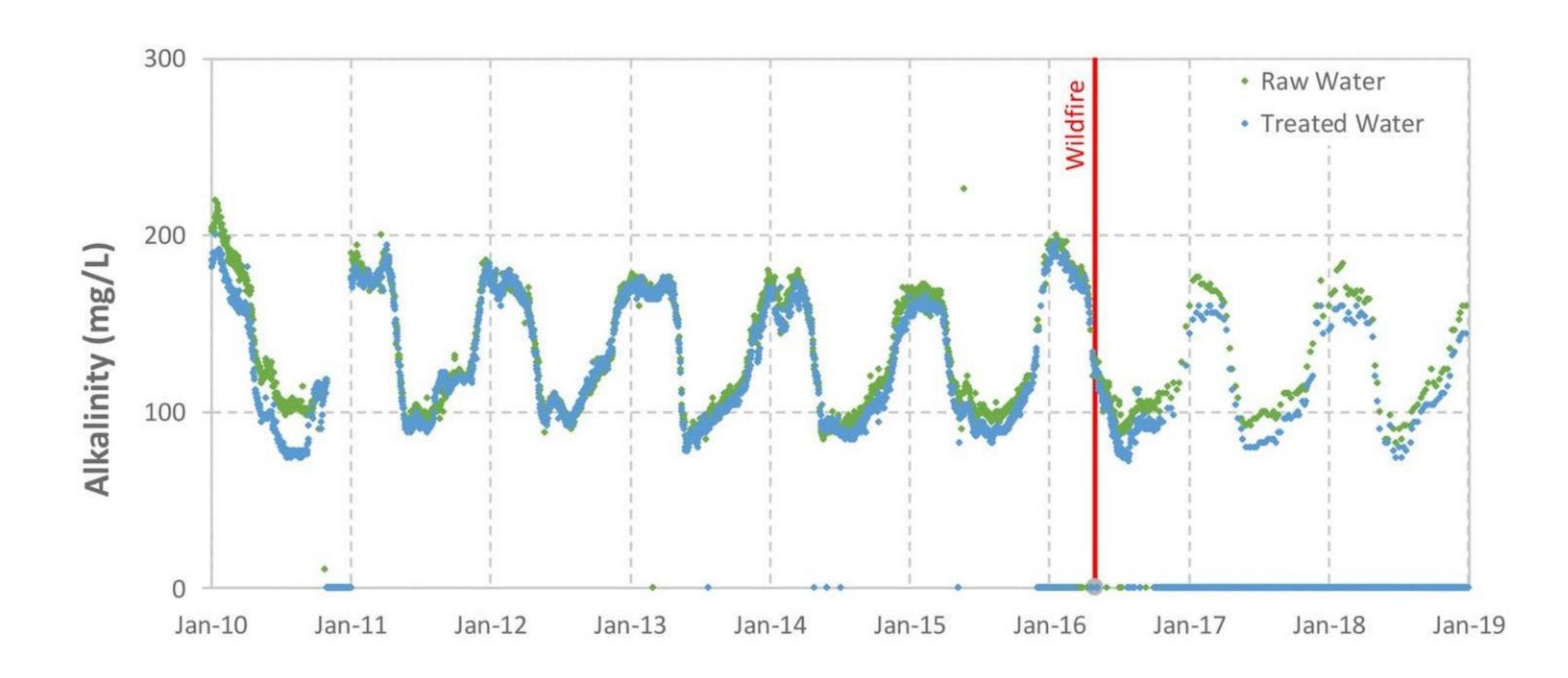
Fine sediment-associated phosphorus and algal blooms





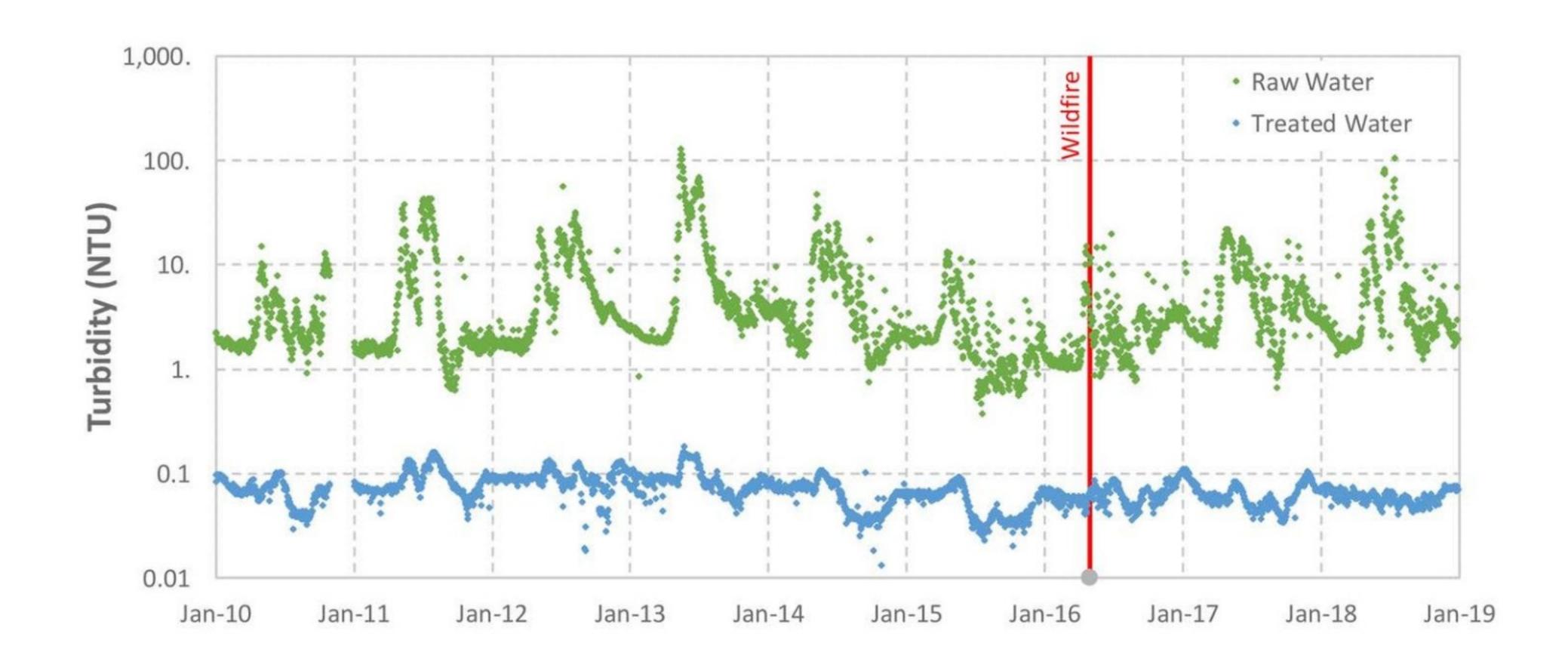
Alkalinity after wildfire in Fort McMurray





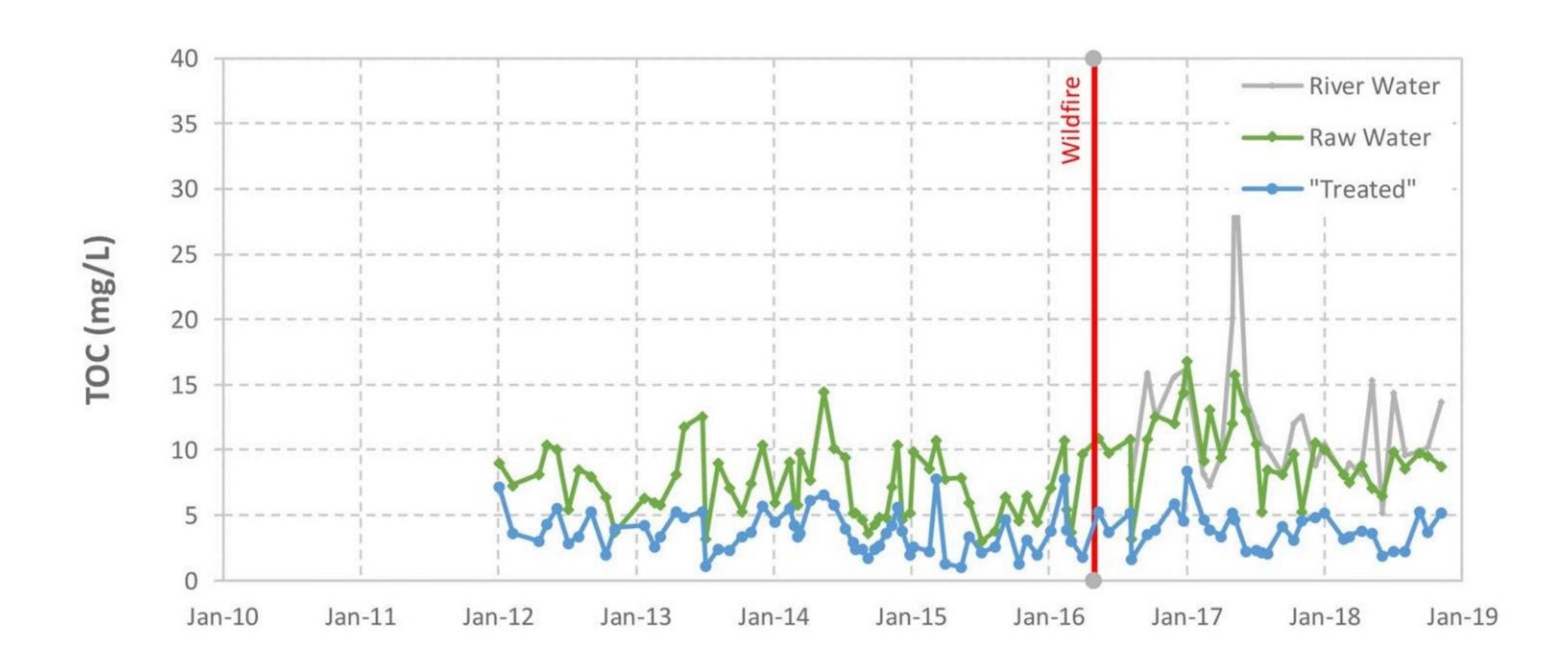
Turbidity after wildfire in Fort McMurray





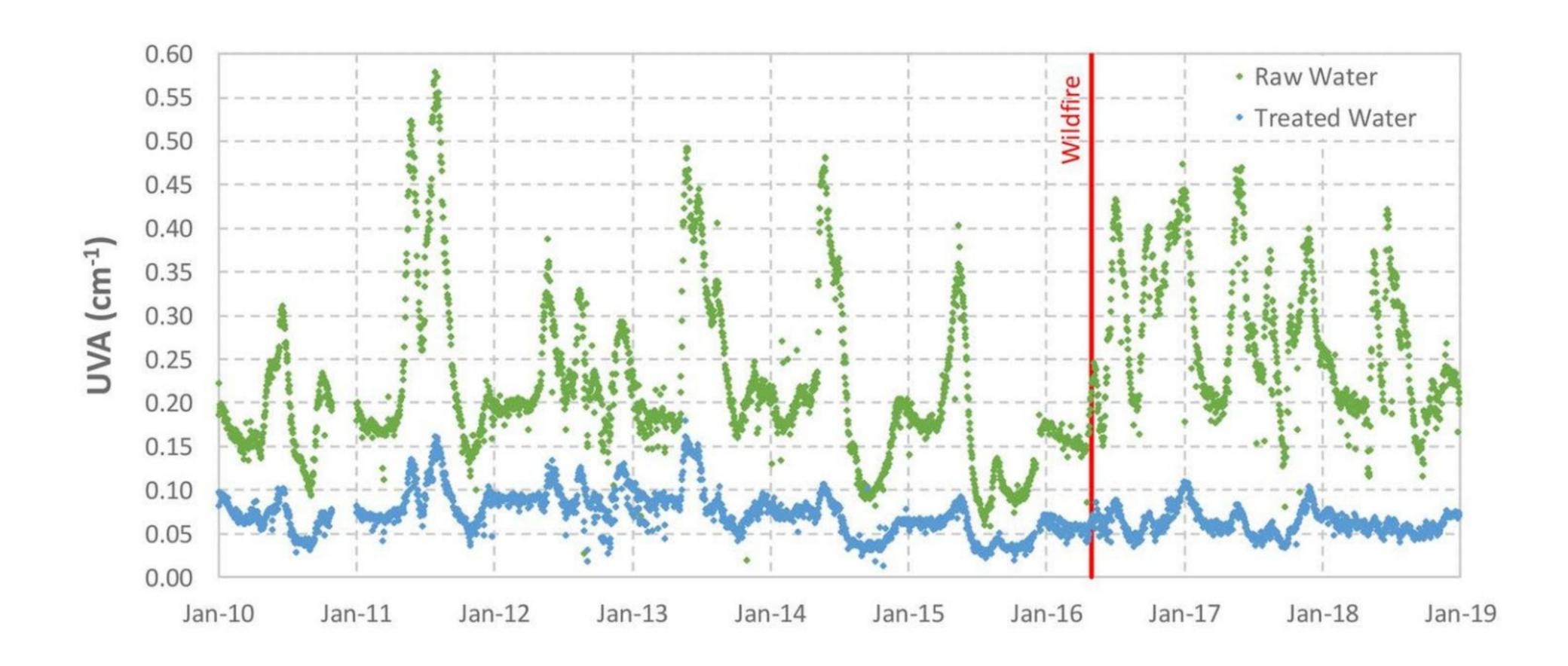
TOC after wildfire in Fort McMurray





Aromaticity of DOC after wildfire in Fort McMurray



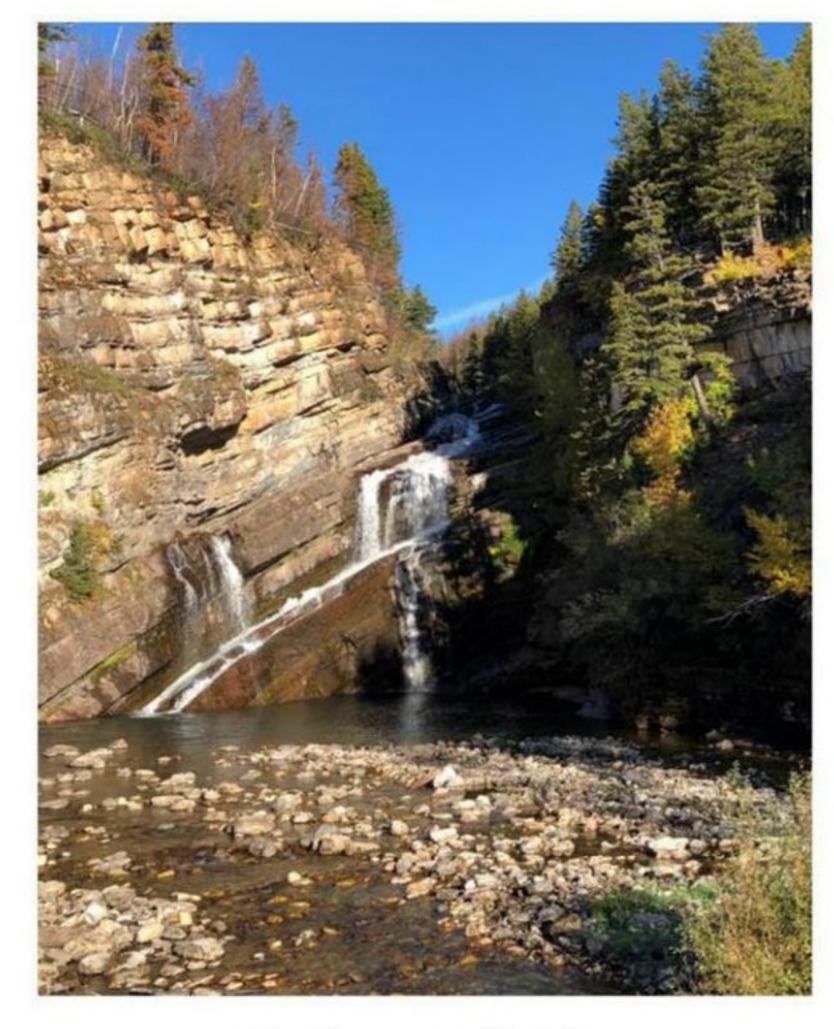


Coagulant dosing after wildfire in Fort McMurray

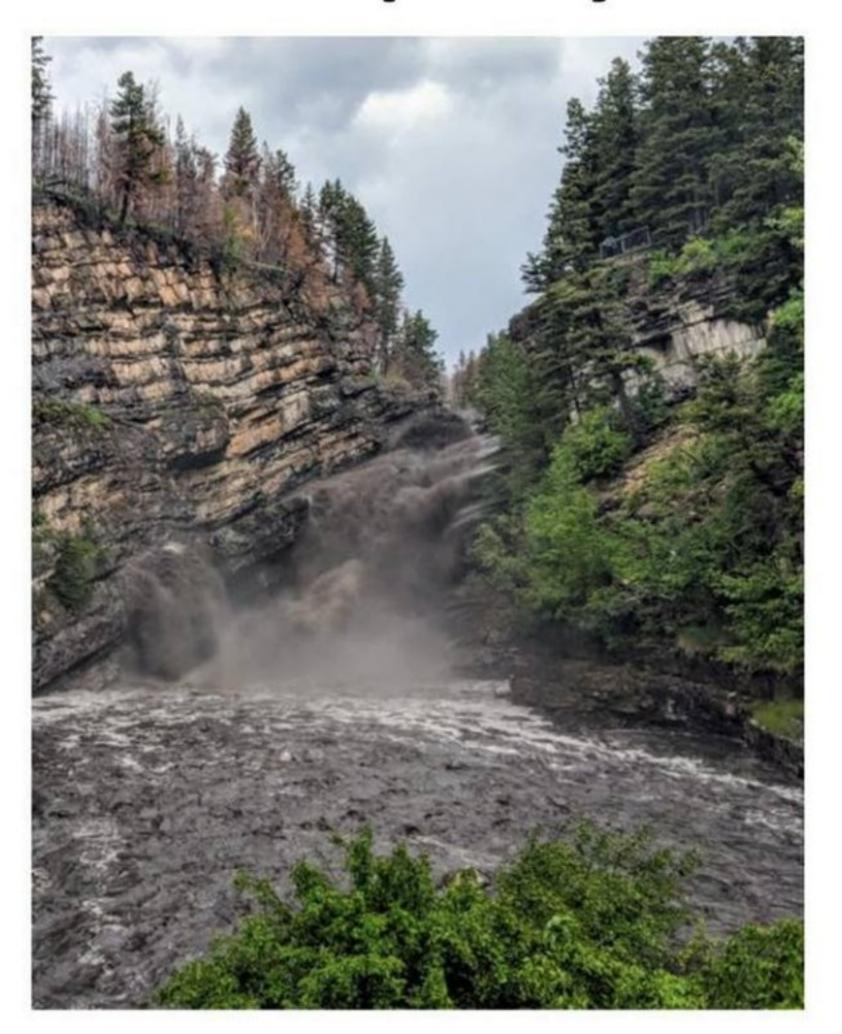




Potential episodic deterioration of water quality after wilder



Before wildfire



Episodic "black water" after wildfire

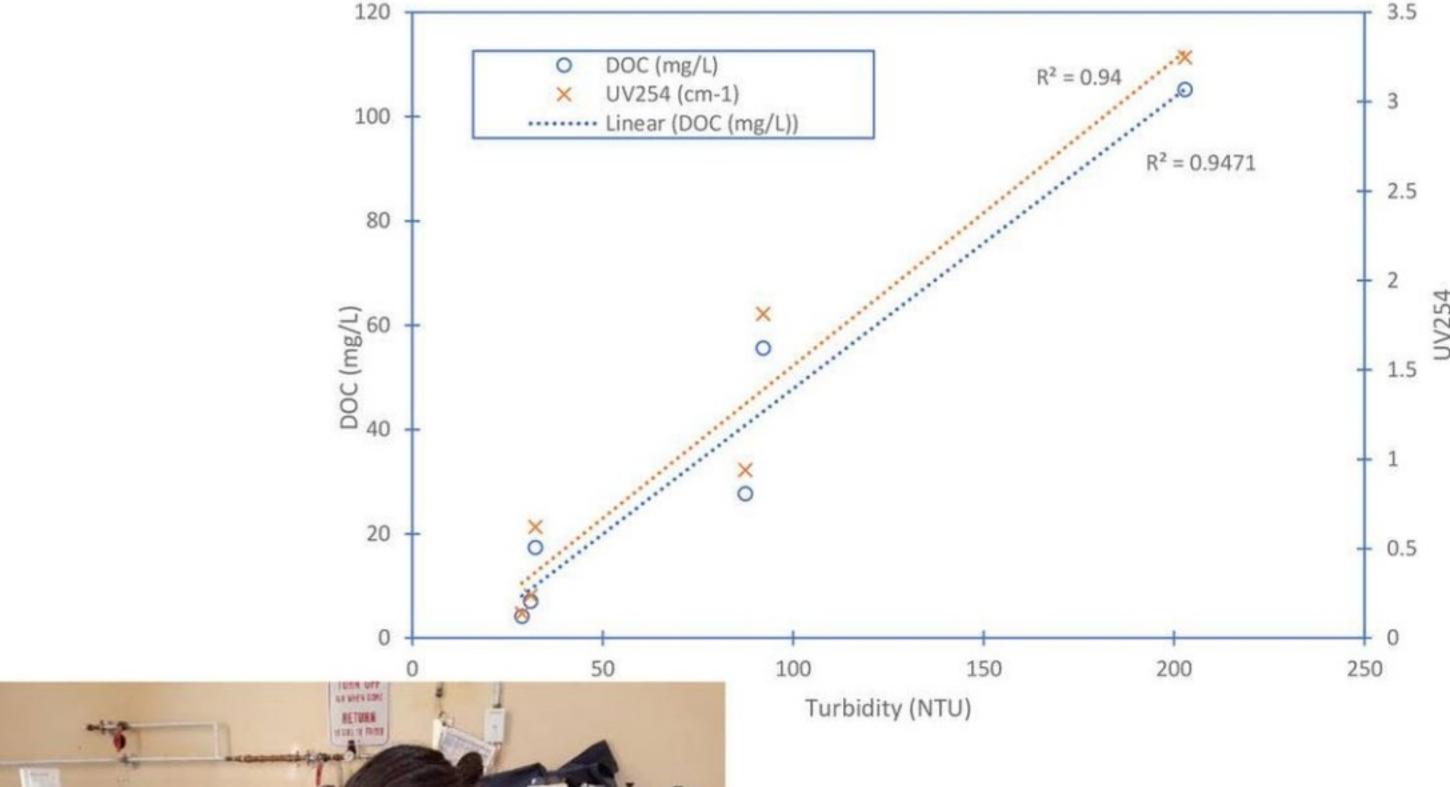


Re-creating deteriorated "black" water













Bench-scale conventional & ballasted sand flocculation (B

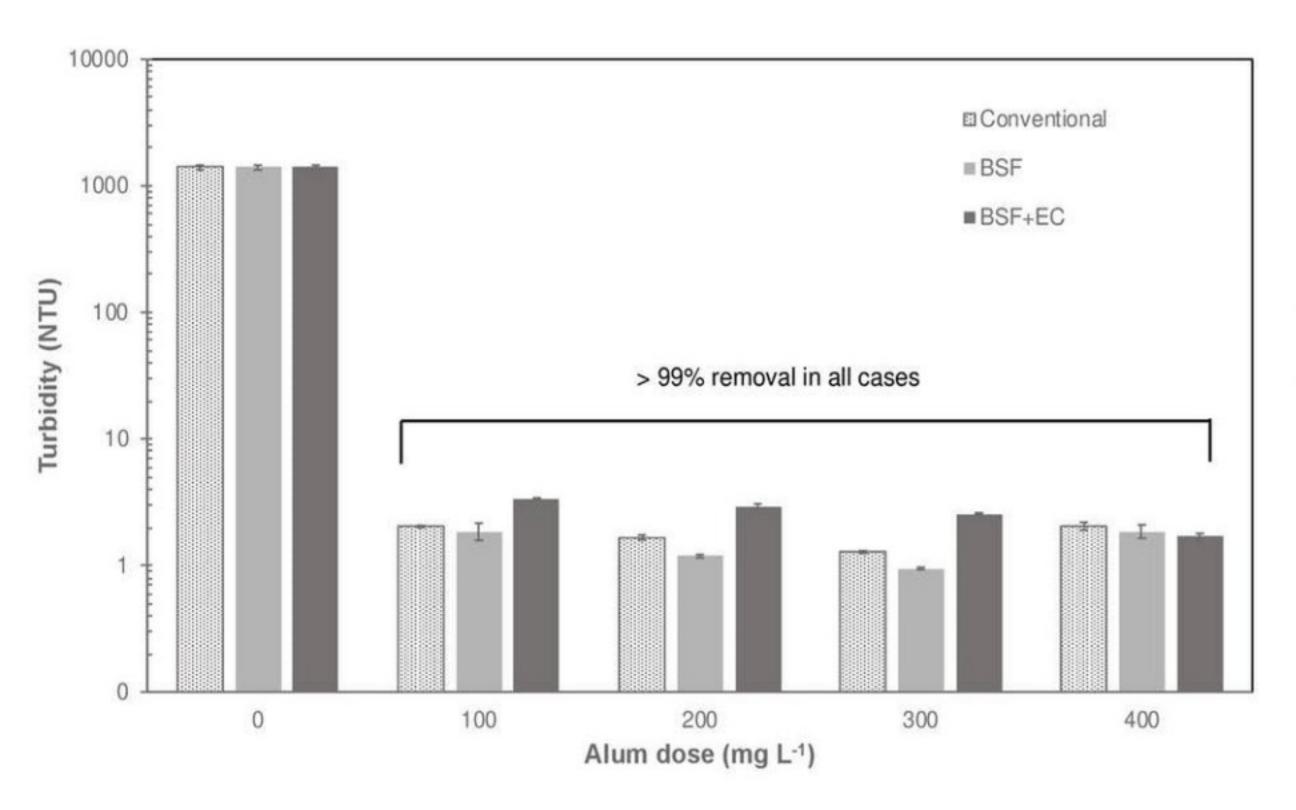


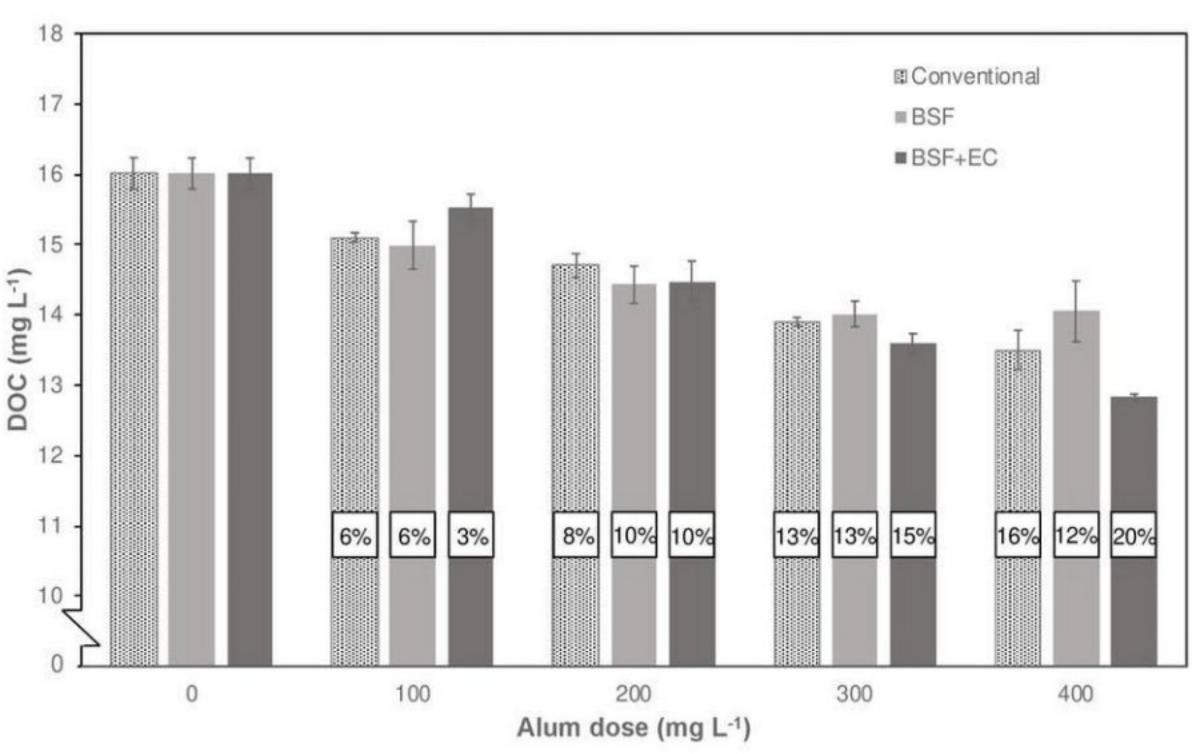


- Calgary's Elbow River source water utilized
- Over 30 different pre-treatment combinations examined little difference in performance



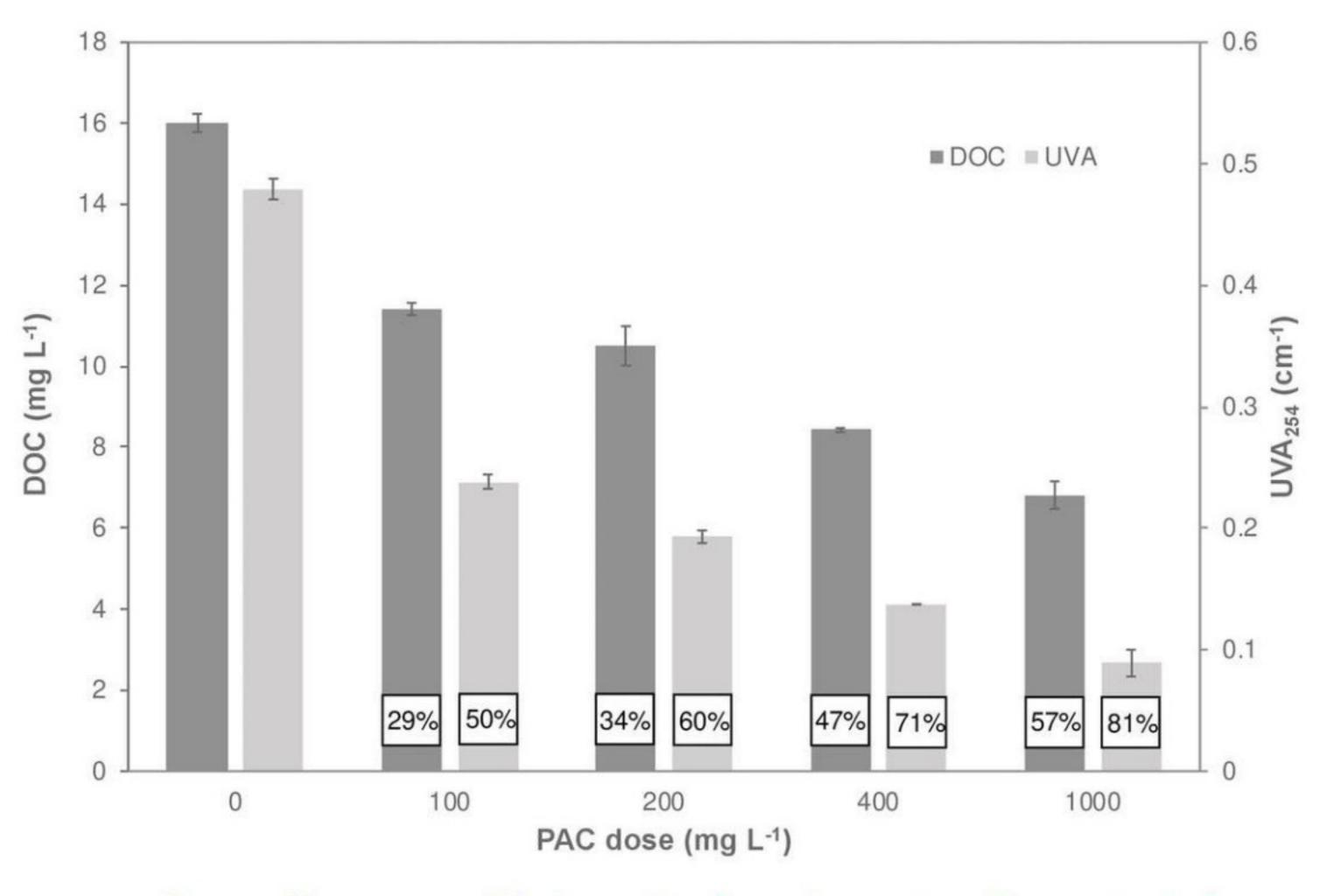
Bench-scale evaluation of treatment: Conventional, ballas disconsisted and flocculation (BSF), and BSF with enhanced coagulation





Bench-scale evaluation of BSF with PAC





Compliance with treated water requirements!

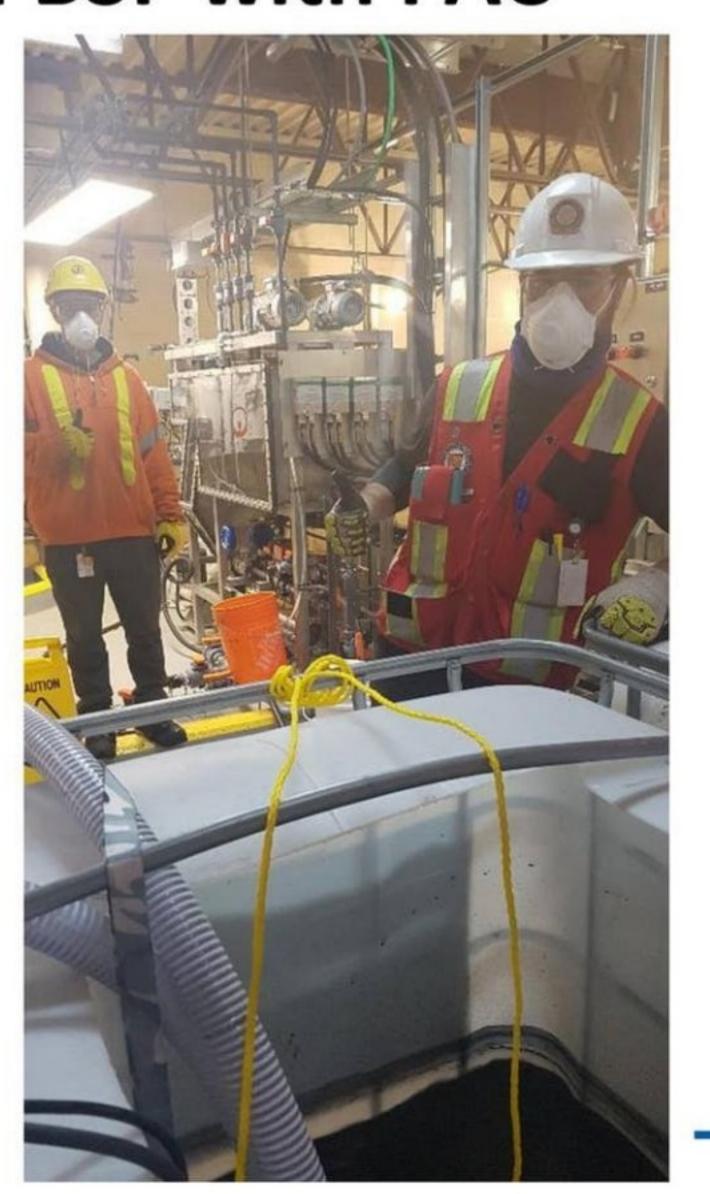


Pilot-scale evaluation of BSF and BSF with PAC









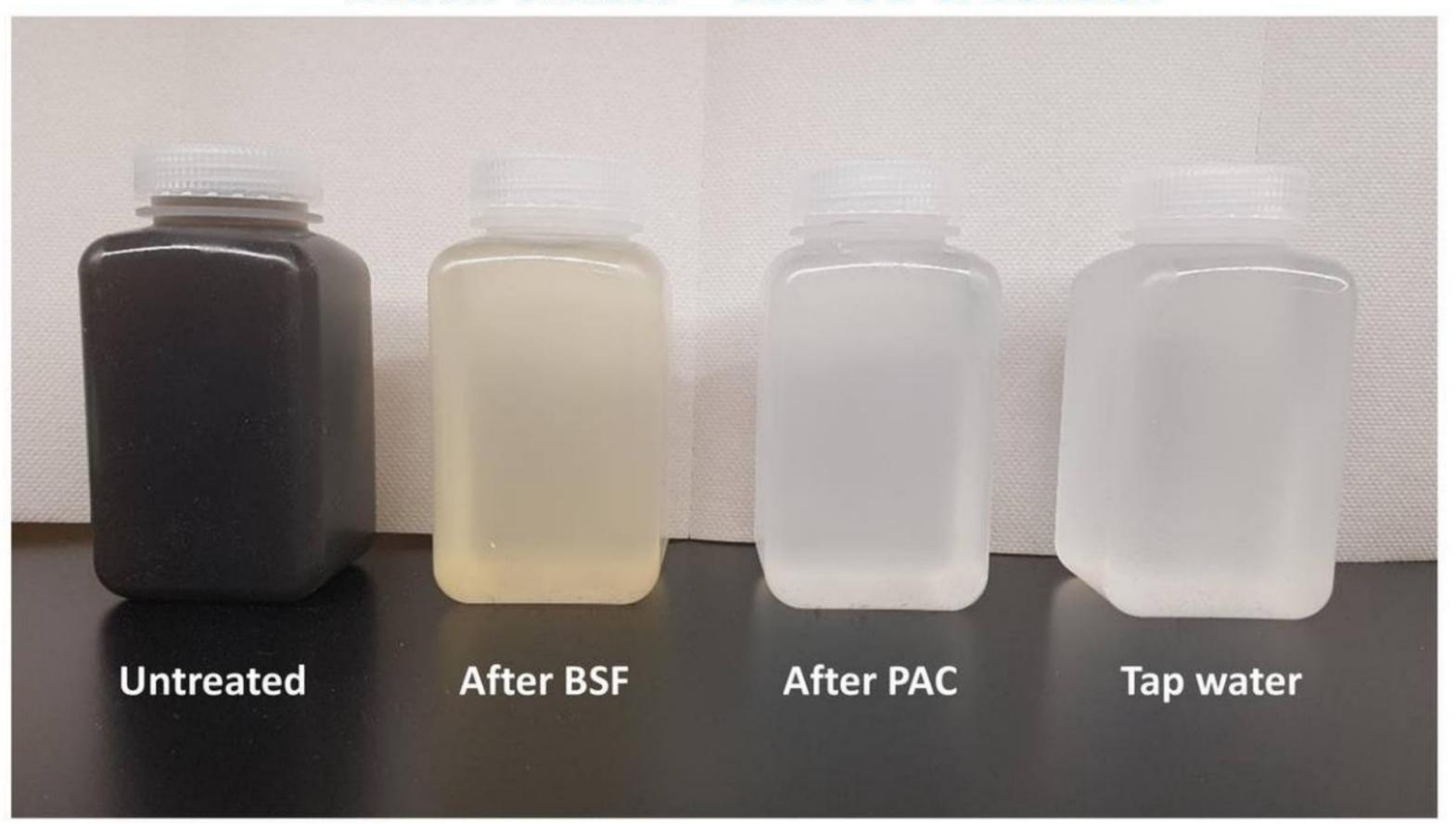


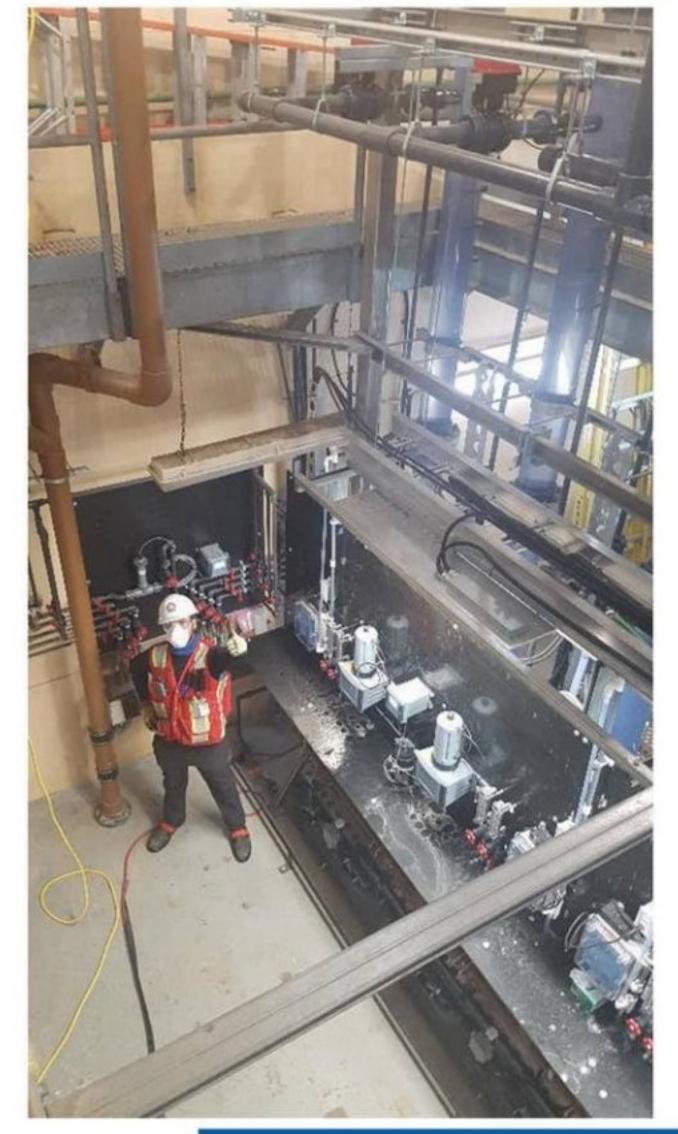
Extreme water requires extreme treatment: BSF with PAC LABORATIVES.











Key Messages



- Not all wildfires have the same effects on source water quality and treatability.
- Public health protection from waterborne disease from pathogens is the paramount objective of drinking water treatment.
- Wildfire can severely challenge chemical pre-treatment processes, thereby threatening adequacy of disinfection and ability to meet demand.
- Key wildfire-associated changes in source water quality that can most threaten drinking water treatment: DOC, turbidity/solids, and P.
- Wildfires can lead to severely deteriorated source water quality...
 BUT it does not manifest as a "step function"!
- Raw water storage reservoirs can mitigate, but also threaten raw water quality and treatability because of algal bloom risk.
- Fine-sediment management is a critical consideration.



Key Messages



- Wildfire impacts on water may not be evident immediately...may be long lasting.
- Treatment impacts of severe wildfire = costs... at a minimum!
- Preparedness: jar tests, coagulant availability & dosing capacity
- How quickly can your utility respond to rapid fluctuations in DOC? Resilient operations?
- Know the source, know the limitations of infrastructure!
- Investment in support infrastructure and operators leads to resilience.
- Severely deteriorated, post-fire "black water" can be treated....
 Extreme water quality requires extreme treatment...are we ready?
 It follows that less severely deteriorated source water can also be treated.
- Investment in the infrastructure warranted? It depends....





Partnerships

















































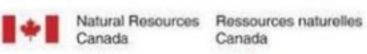








National Collaborating Centre for Environmental Health Centre de collaboration nationale



















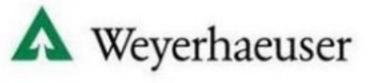




























Thank you

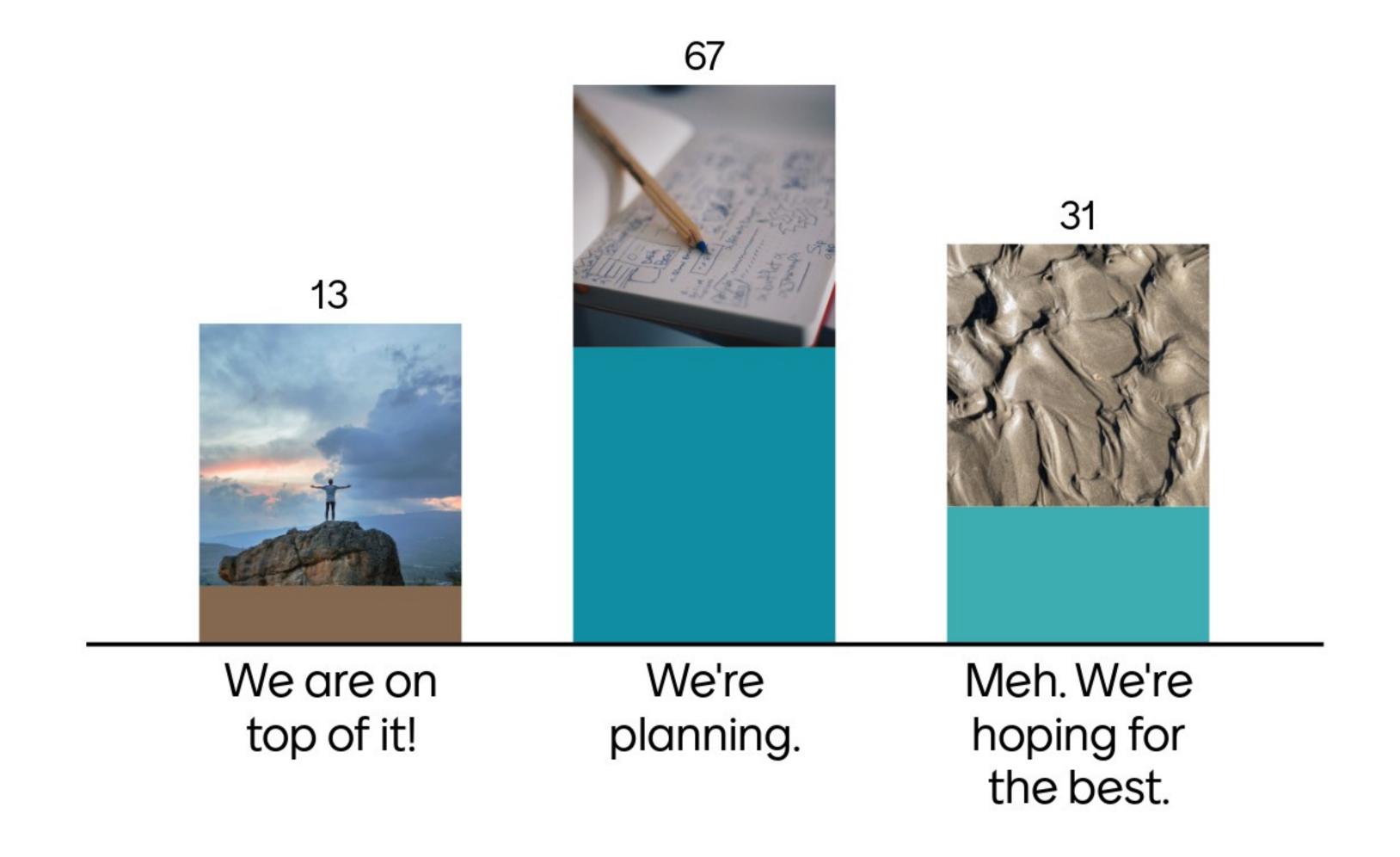
Monica B. Emelko

Canada Research Chair in Water Science, Technology & Policy

mbemelko@uwaterloo.ca

How well are you/your agency prepared for post-fire water impacts?

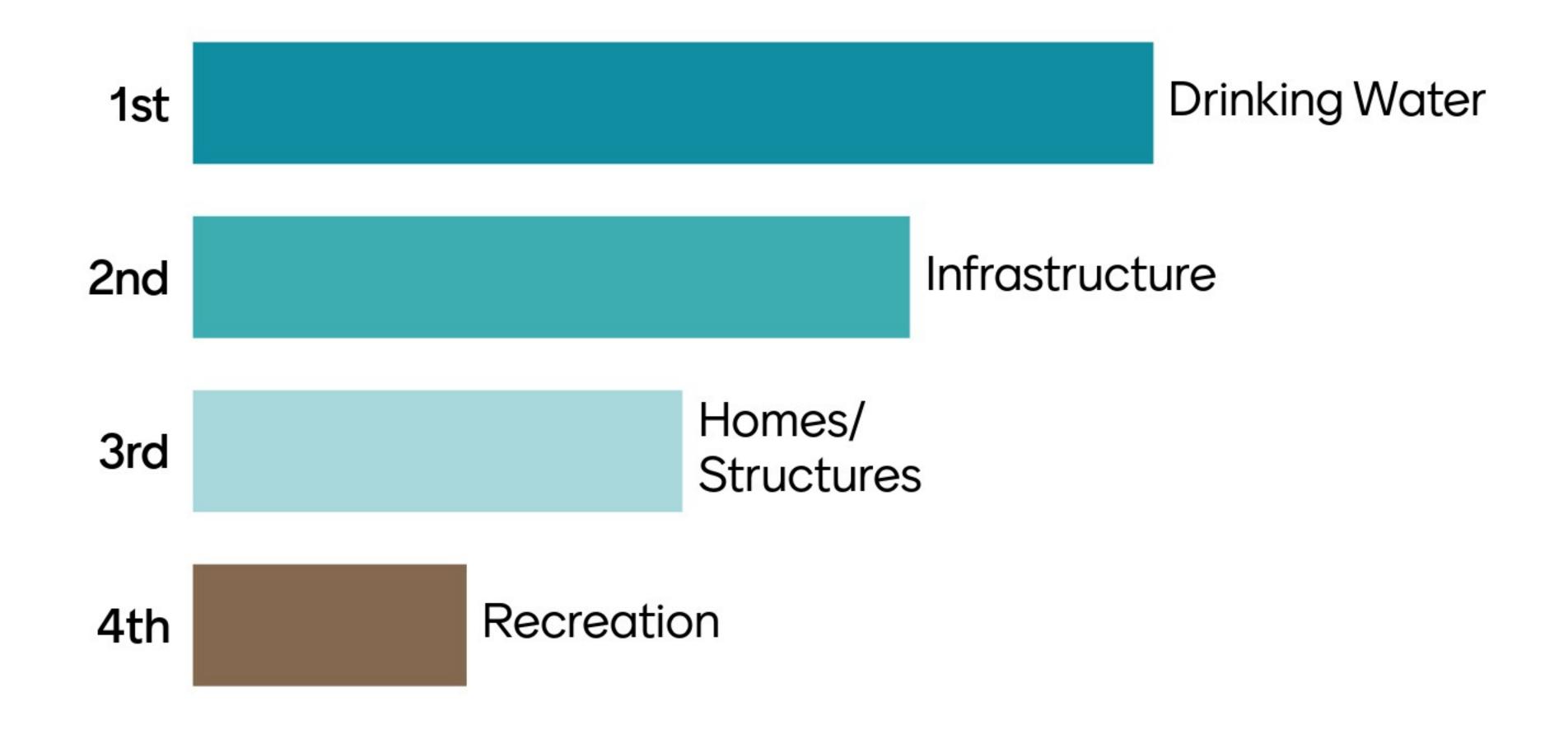






Prioritize values in recovery efforts.









Lasting Effects of Wildfires Considerations for Mitigation





CHUCK RHOADES & TIM FEGEL

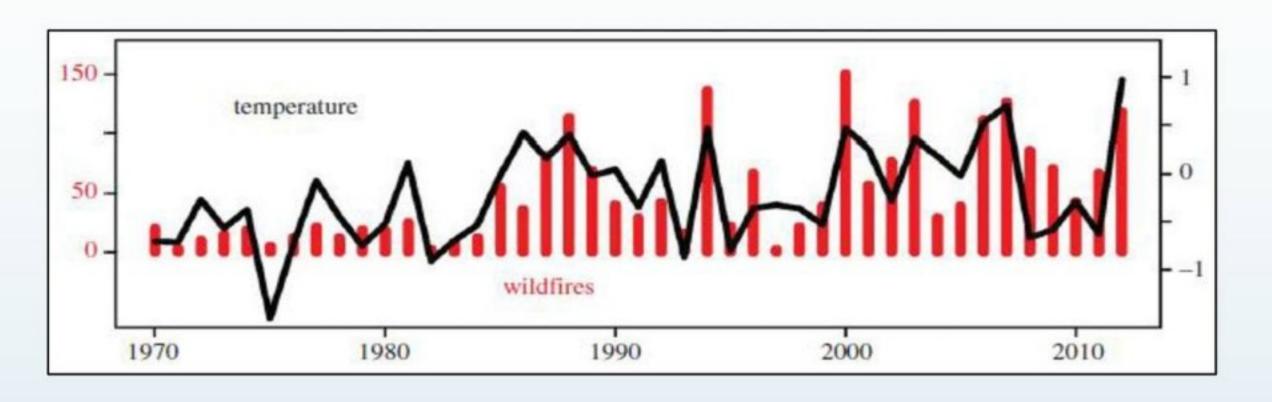
US Forest Service Rocky Mtn Research Station

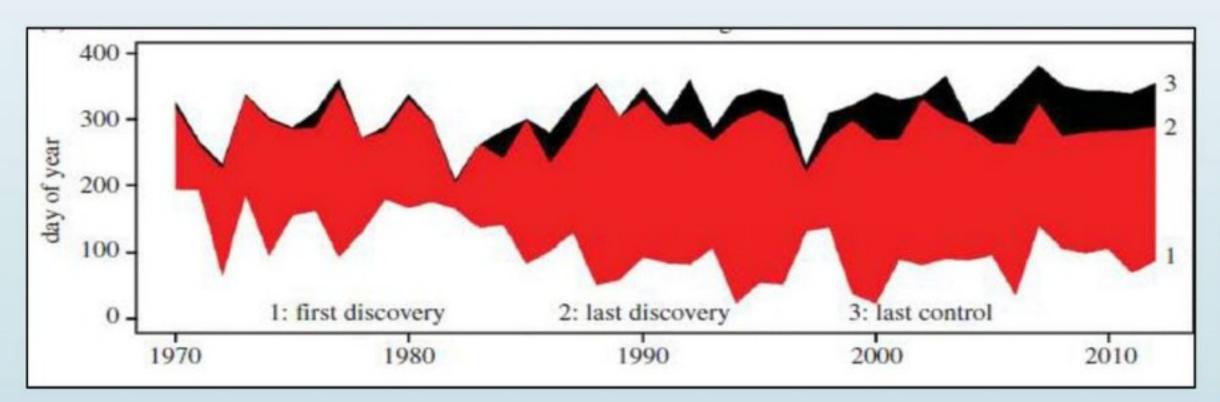
ALLISON RHEA, ALEX CHOW, TIM COVINO, FERNANDO ROSARIO-ORTIZ

Post Fire Water Quality Impacts & Mitigation

3 December 2020

Climatic Changes & Wildfire





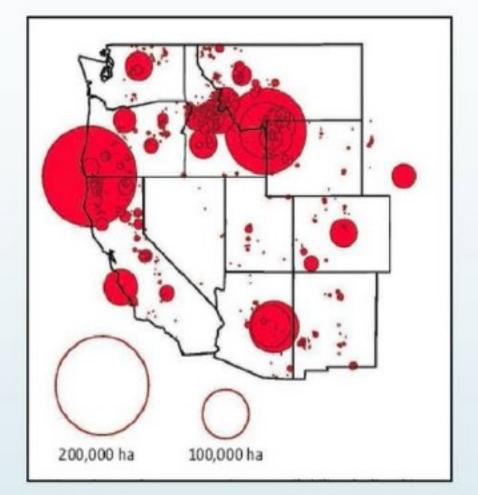






PHOTO CREDIT: NICHOLSON, K. The Denver Post, 2/20/17

COCC COALITIONS COLLABORATIVE

SHORT VS LONG TERM CHANGES

	Drivers			Watershed Responses		
	Climate	Veg, Fuel	Site, Topogr	Riparian, Upland	Streams	
Combustion (days)	Wildfire Behavior, Severity, Suppression			Veg lossSoil heat	Fish, invert die off, Fire Retardant	
Transport (months)	Ash and Sediment			• OM, soil loss	Ash/C PulseScour/Deposition	
Reorganization (years)	Ecosystem Dynamics		 Nutrient supply/demand C storage Habitat 	 Nutrient, C Export Stream biota Channel reconfig Hillslope/Hyporheic/ Stream links 		

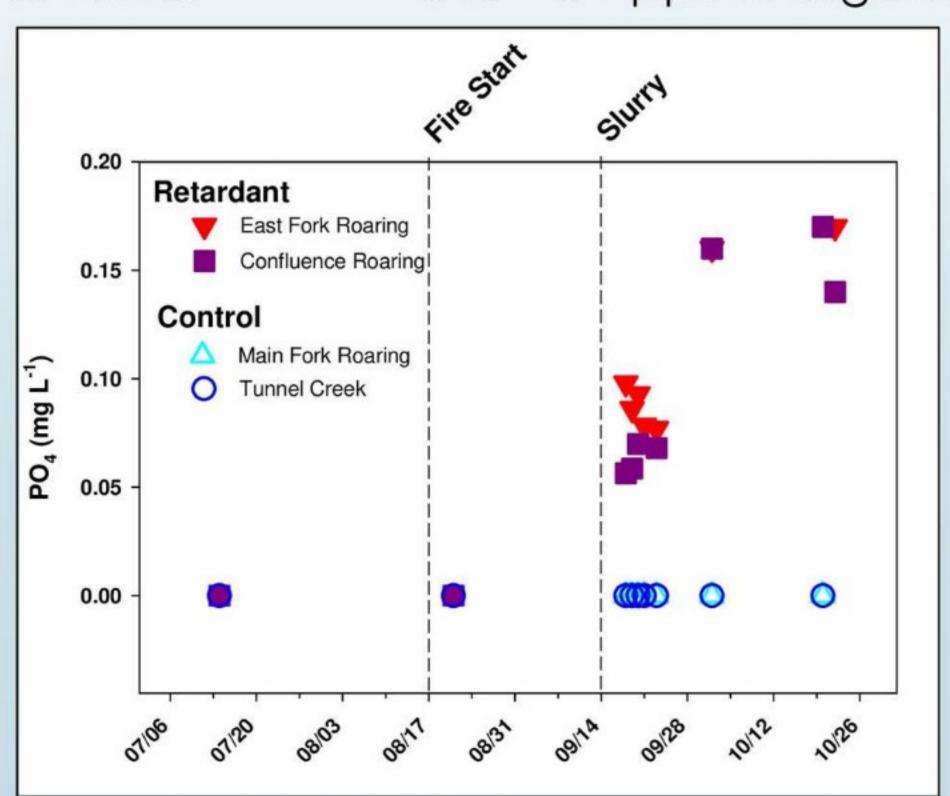
Fire Retardant Impacts

STREAM NUTRIENTS

Cameron Peak Fire: Slurry applied in riparian exclusion zone of Roaring Crk, other streams

PhosCheck Slurry > 1000 ppm inorganic P & N River Water

0 & < 0.1 ppm inorganic P & N





Roaring Creek

Main Stem 0.00 ppm PO4 East Fork 0.11 Confluence 0.09

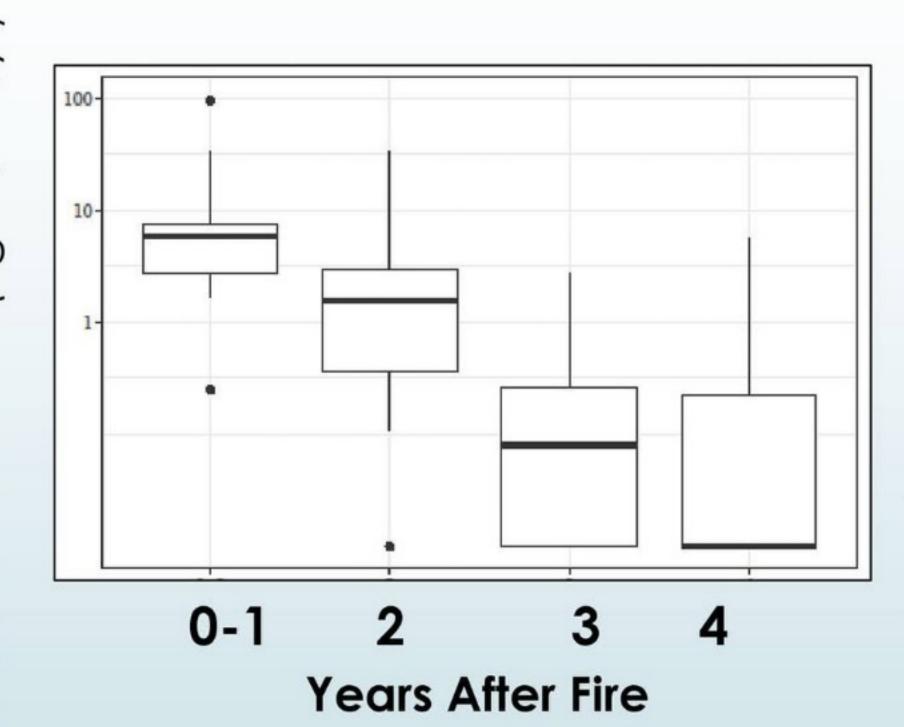
CLP River

Above 0.00 Below 0.04

Short Term Losses in Erosion



Sediment (kg N /ha/yr) N in Eroded





SEDIMENT, N AND C LOSSES INCREASE FOR SEVERAL YEARS AFTER FIRE, THEN RETURN TO LOW LEVELS.

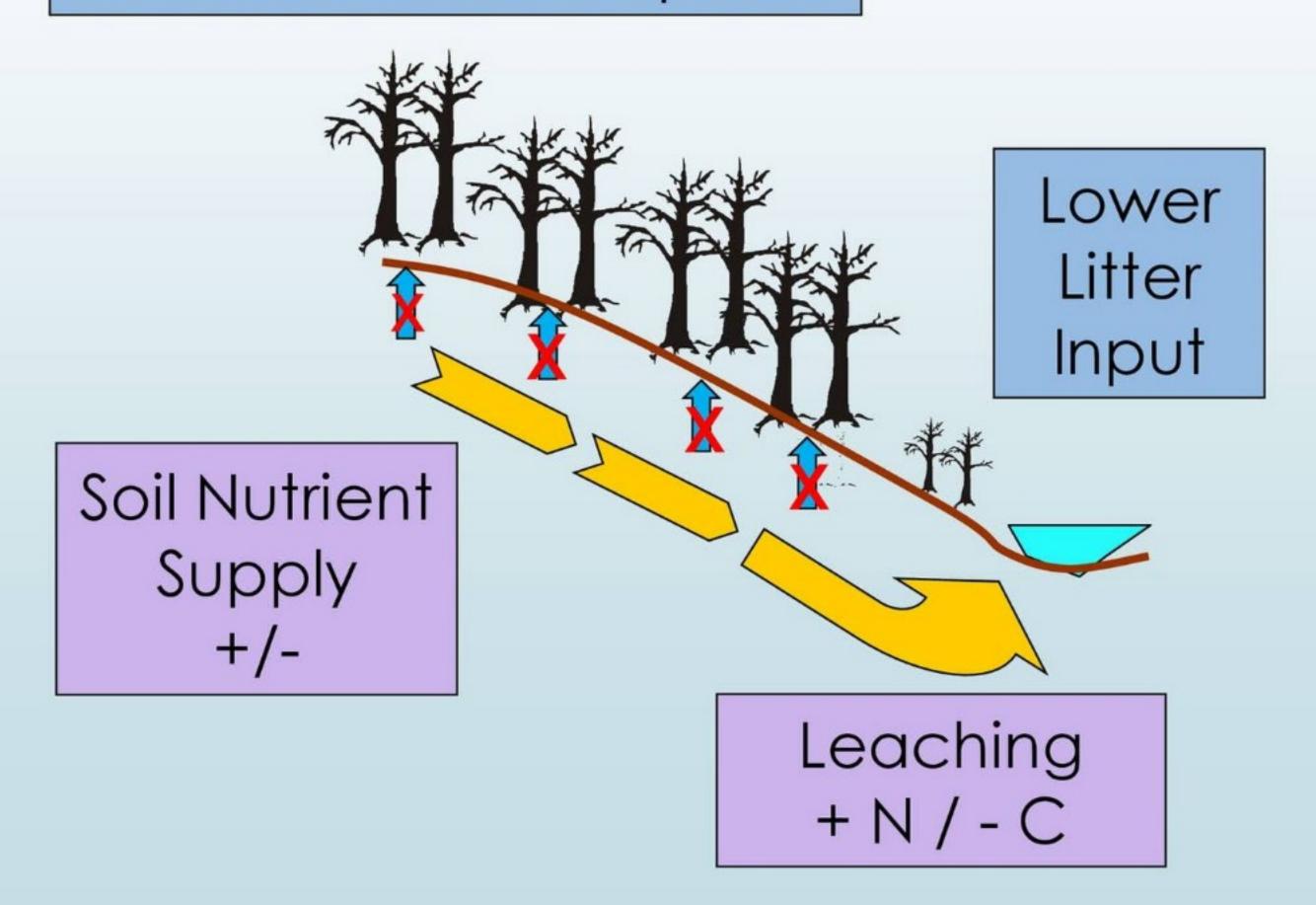
NUTRIENTS LOST IN EROSION ARE SMALL PART (< 10%) OF THE TOTAL LOST AFTER FIRE.



8 high severity fires, W. USA; PIERSON ET AL. 2019

Post-Fire Changes

Loss of Vegetation Reduces Nutrient Uptake



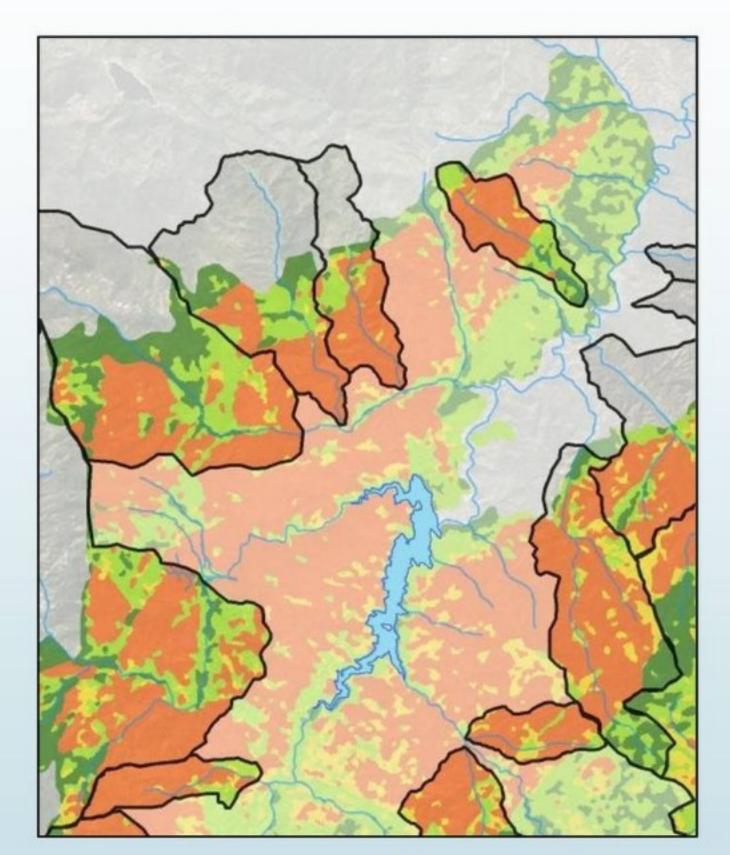






Watershed Responses

DEPEND ON BURN SEVERITY



Severity of 8 recent large CO wildfires

	High	Mod	Low
Mean	15	33	36
Maximum	35	46	67
Minimum	0	16	18

Low Severity

Vegetation remains 'green.' OM layers not fully consumed. Soil structure, roots unchanged

Moderate Severity

Most (50-80%) ground cover, OM consumed. Foliage may remain in tree canopies.

High Severity

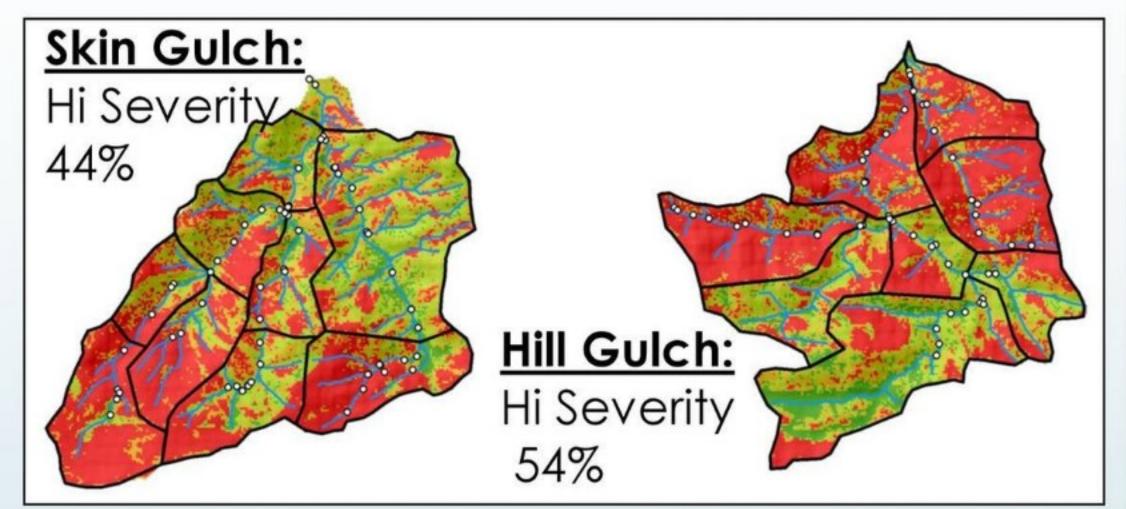
Consumption of nearly all pre-fire ground cover & surface organic matter.

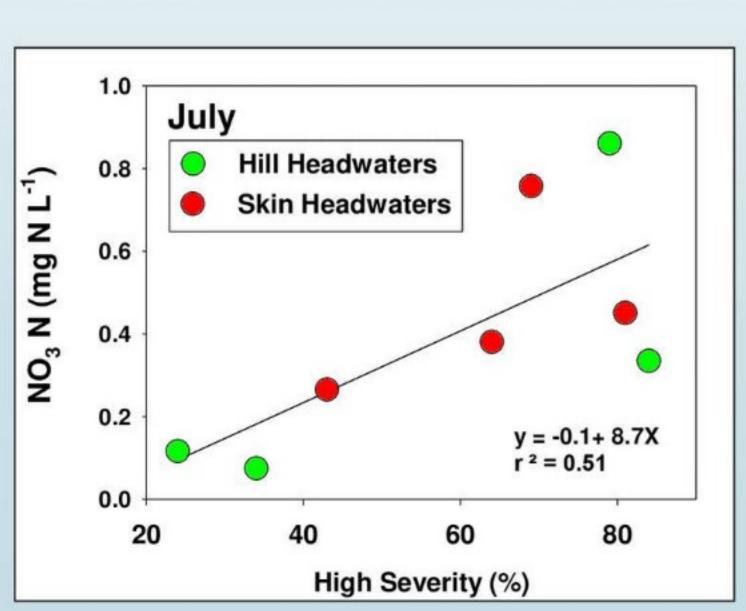


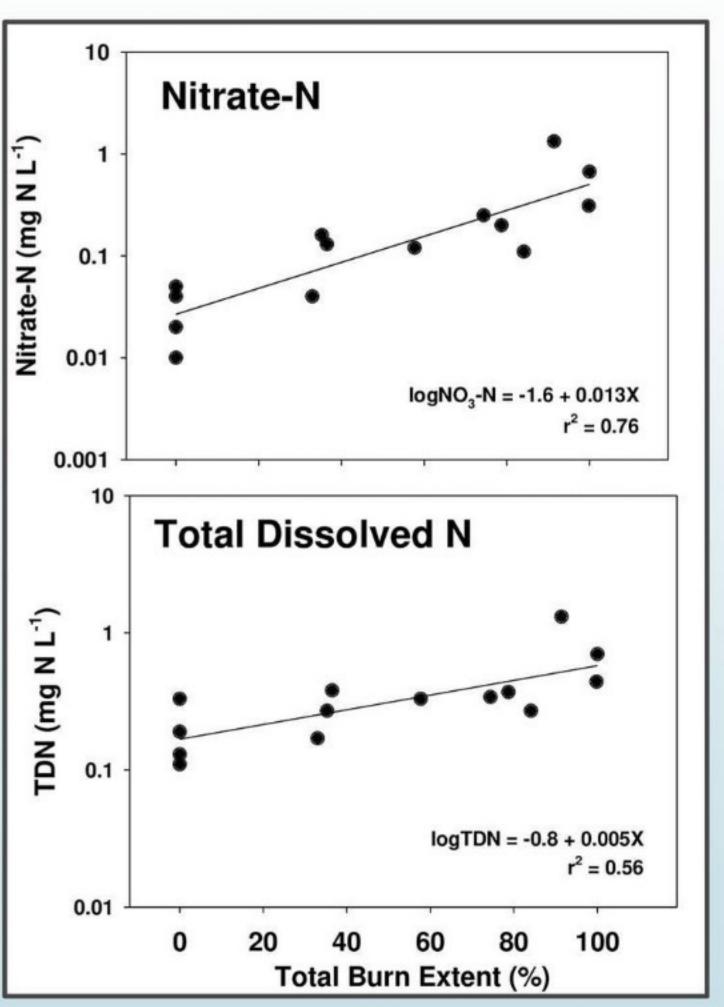


Severity Effect on Nitrate - N









 *5 Yrs post-fire NO_3 spans 2 orders of magnitude *5 Threshold * 50%

Long-Term Post-Fire Responses





Hayman Fire

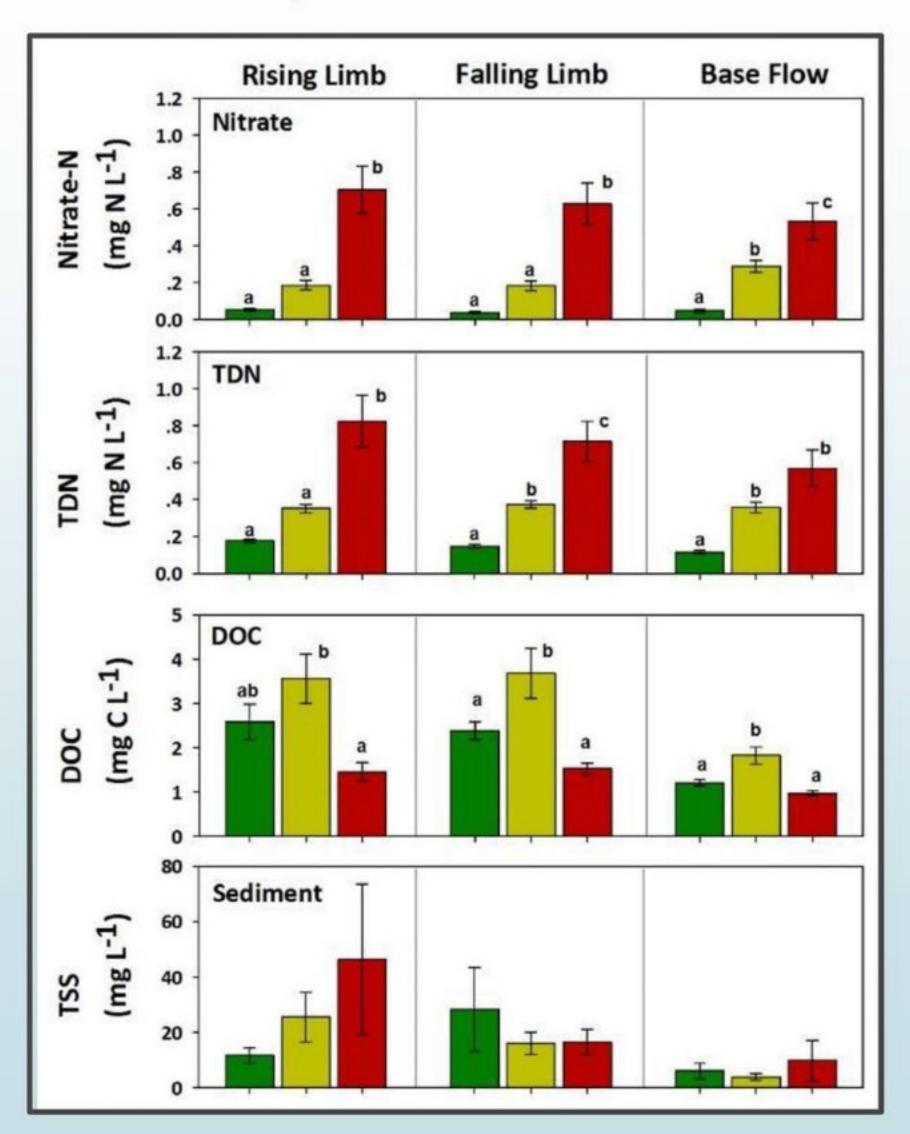
14-15 yr post-fire

Nitrate & TDN 5-10X above background in Extensive & elevated in Moderate

Lasting changes in nutrient retention (>95% pre- vs 48% post-fire)

DOC highest for moderate burns

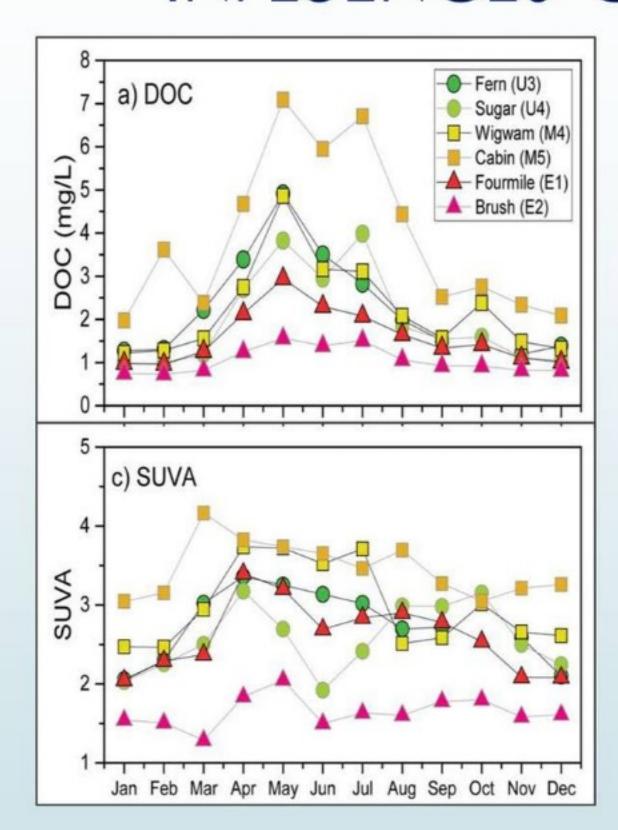
Sediment losses are minor



STREAM DISSOLVED CARBON

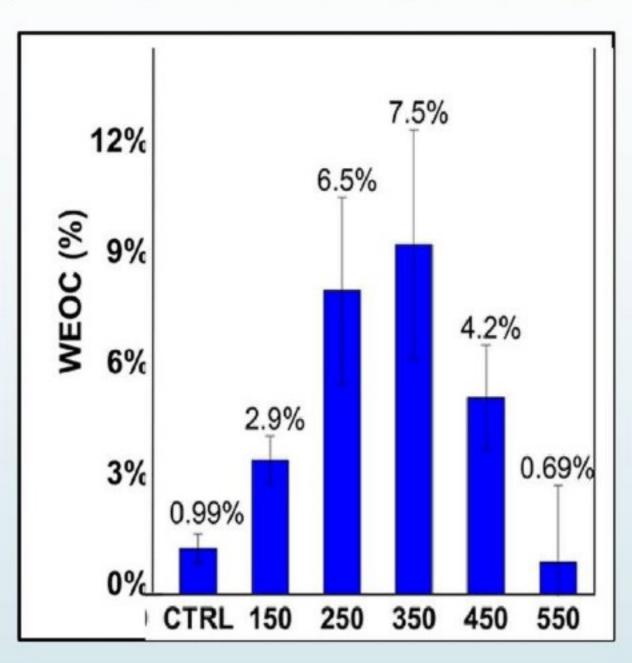
COCO COALITIONS & COLLABORATIVES, IN

INFLUENCES ON CHARACTER & TREATABILITY



Stream C Increase or Decrease Severe Fire:

Combustion then erosion losses, less complex C

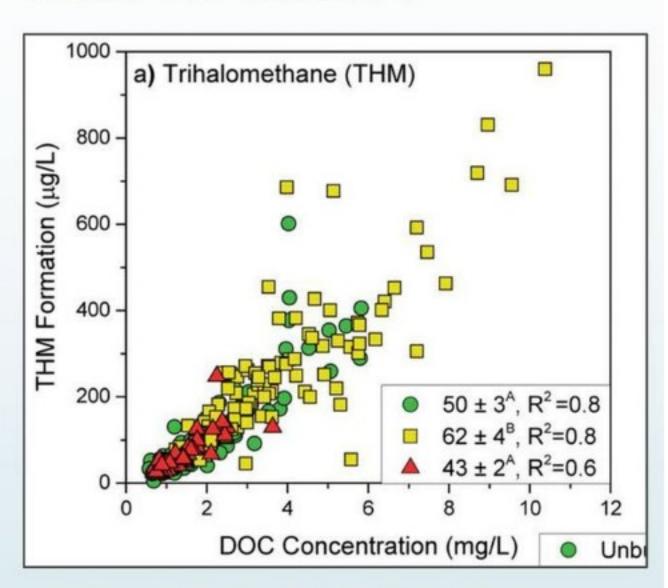


Highest DOC Release

from soils heated at mod temps

Moderate Fire & Unburned Streams

High Aromaticity
Older, complex C



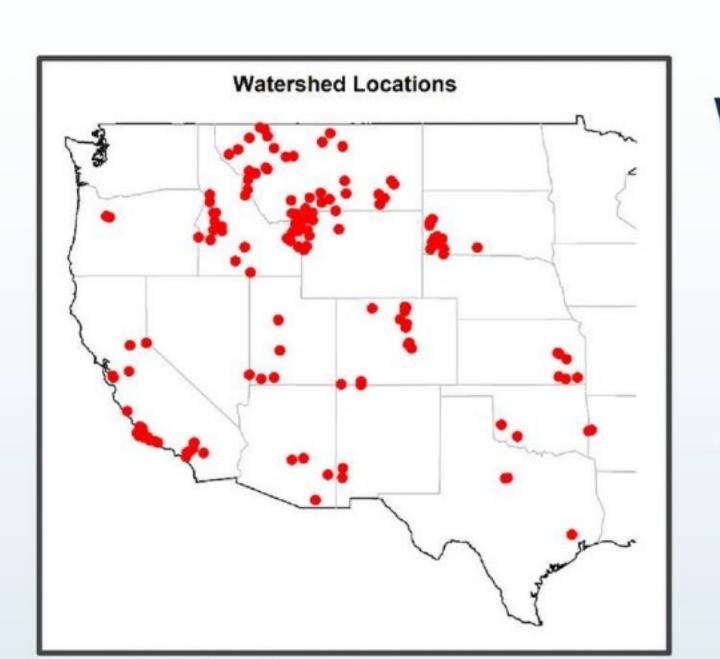
Harmful Disinfection Byproducts

Formation potential of THM, other DBPs increases with stream DOC

Highest in mod burns

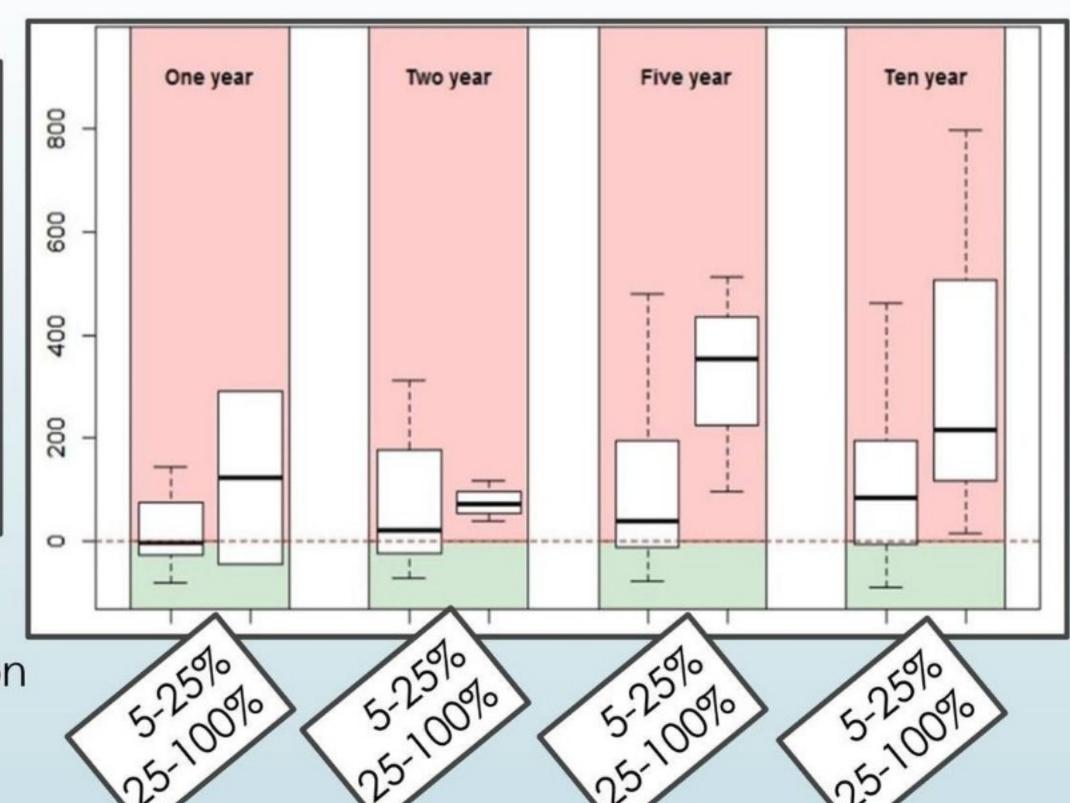
CHOW ET AL. 2019; HOHNER ET AL. 2019





Effects are Both Widespread & Lasting





Fire Extent

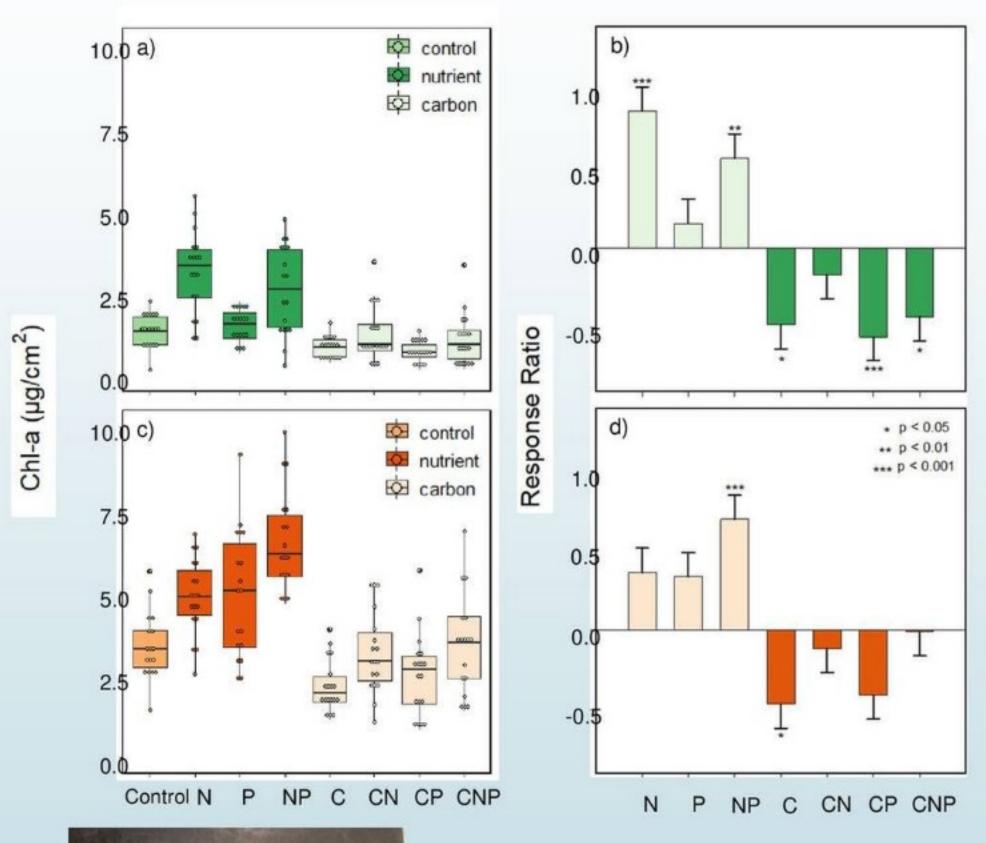
159 fires in Western US
Publically available Q, concentration
5 Post-fire vs 5 pre-fire years

Nitrate increased in 25% of fires OrthoP increased in 19% of fires

What Explains Lasting Fire Effects?



LOWER IN-STREAM PRODUCTION



Burned Streams are Productive
Higher Chl-a, autotroph, algae

Unburned streams are N limited (respond to N fertilizer)

Lower N response in burned streams Higher stream N lower N limitation

... so lower in-stream production does not explain elevated N export

Stream Metabolism, biofilm production from Hayman and High Park Fires;



416 Fire Hermosa Ck:

Rhea et al. in review

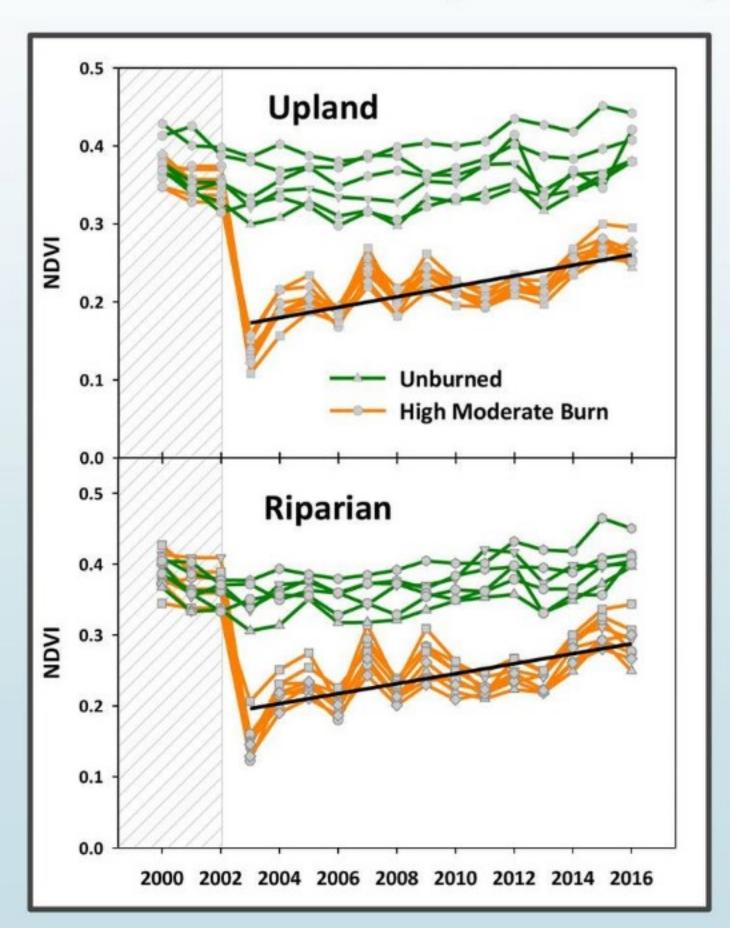
2-40 X higher algal biomass

3-5 X higher Chlorophyll-a:

What Explains Lasting Fire Effects?

VEGETATION RECOVERY

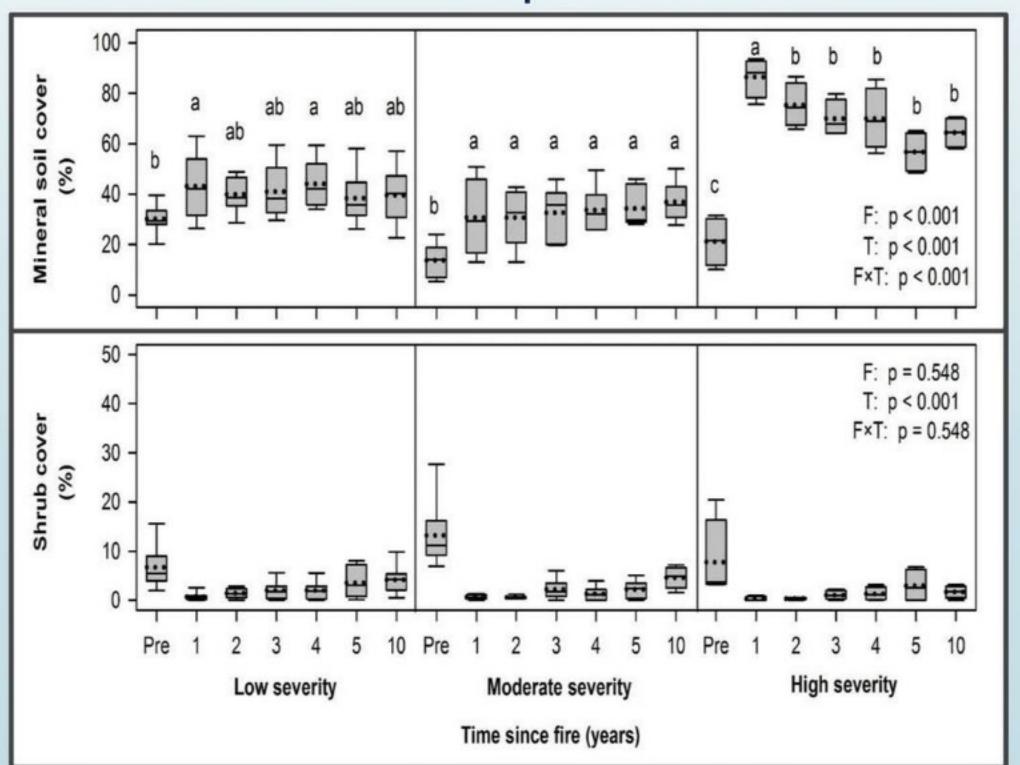
50% recovery @ 14 yrs



*May-June NDVI; 10 m DEM; Burned = Mod/Hi patches



Soil exposure > 2x pre-fire Plant response varies





RHOADES

2018;

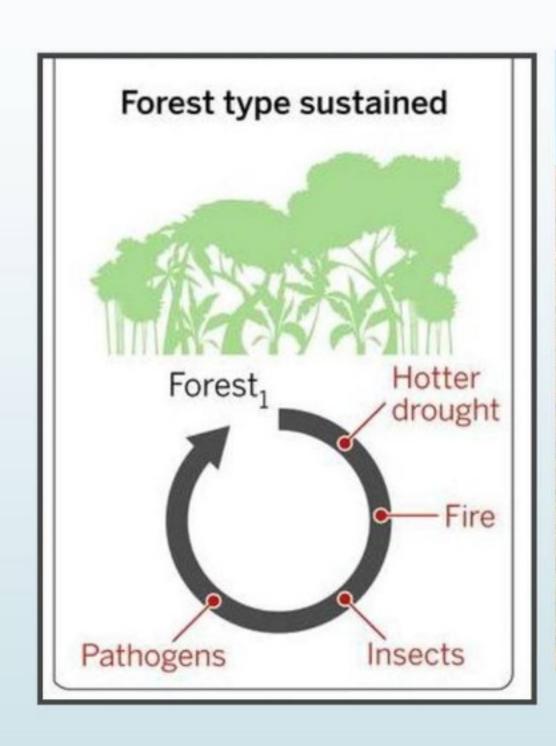
FORNWALT

Overlapping Disturbances

NOVEL RESPONSES & RECOVERY

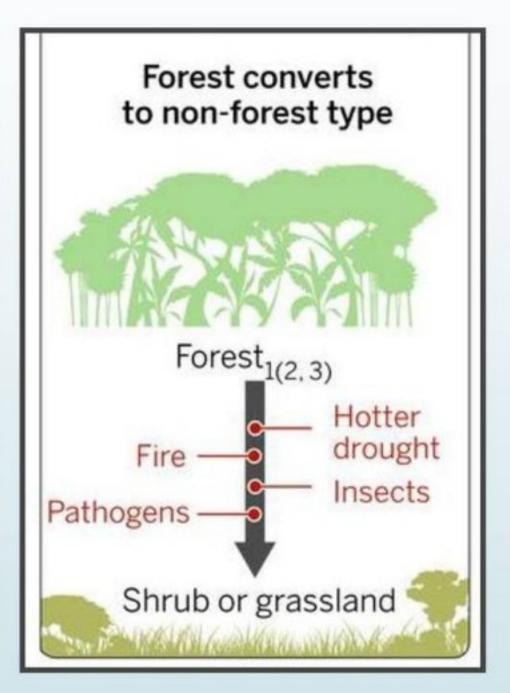








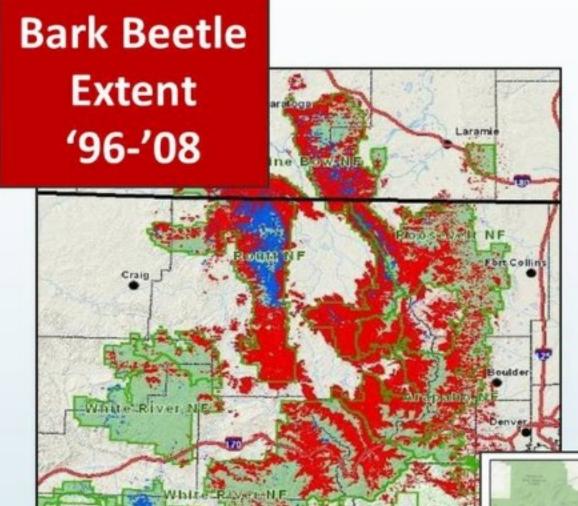




Additive Pressures – Severe, repeated or frequent wildfires directly or in combination with drought, insects or factors, push some forests beyond thresholds of sustainability.

Overlapping Disturbances





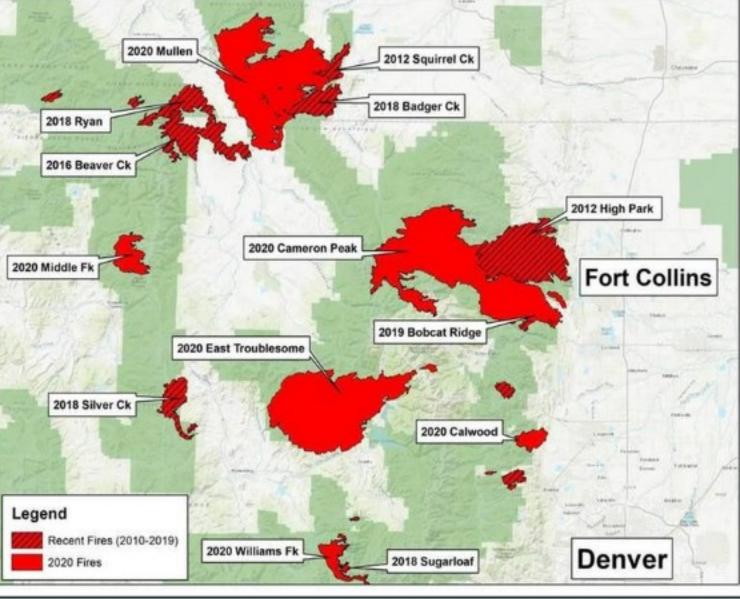
Beaver Crk Fire

Started 19 June 2016 60-80% in 'gray phase' 38,379 Acres 100-day-long event



Gray Phase Fires

Acres 2010-2019 150,000 2020 >600,000



Post-fire Recovery

Sparse tree regeneration after recent fires

Possible Factors

Low seed viability, drought, competition

Implications for water Stay tuned



Post-Fire Restoration Perspective



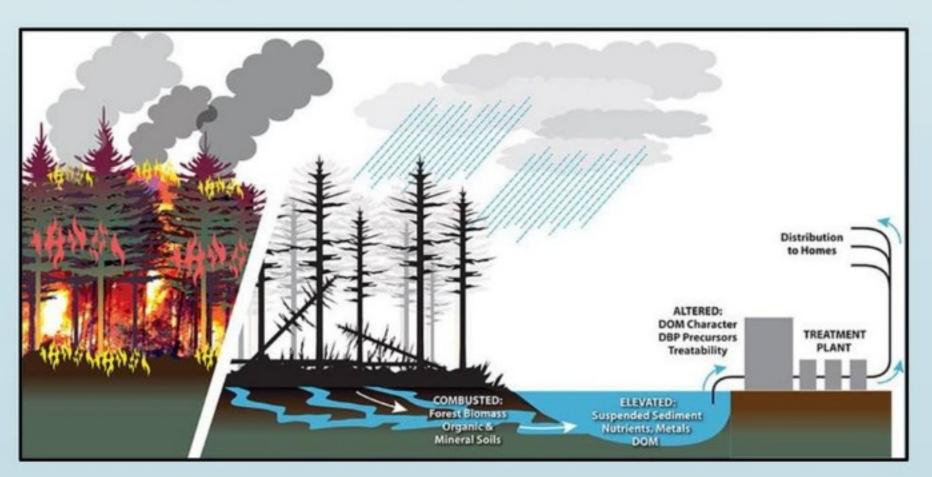


AQUATIC ECOSYSTEM HEALTH

NUTRIENT ENRICHMENT DEGRADES
AQUATIC HABITAT, WATER TREATMENT

UPLAND ECOSYSTEM CONDITION

VEGETATION PRODUCTIVITY
DISTURBANCE INDICATOR
RESTORATION TARGET



HOHNER ET AL. 2019

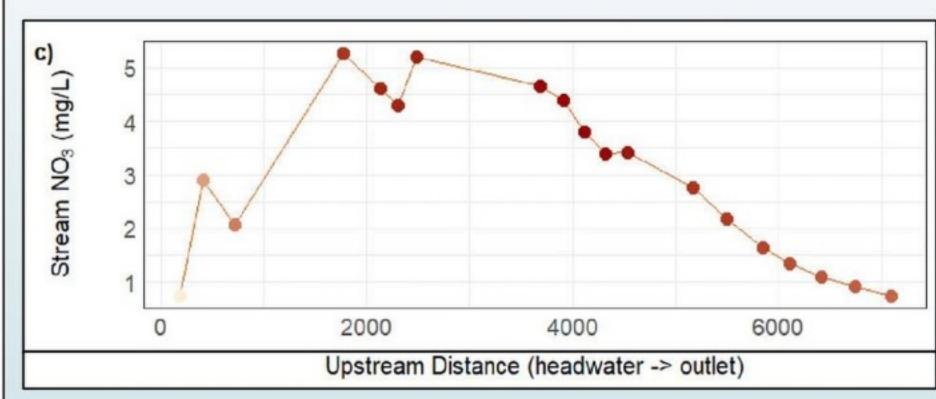
Post-Fire Restoration Perspective

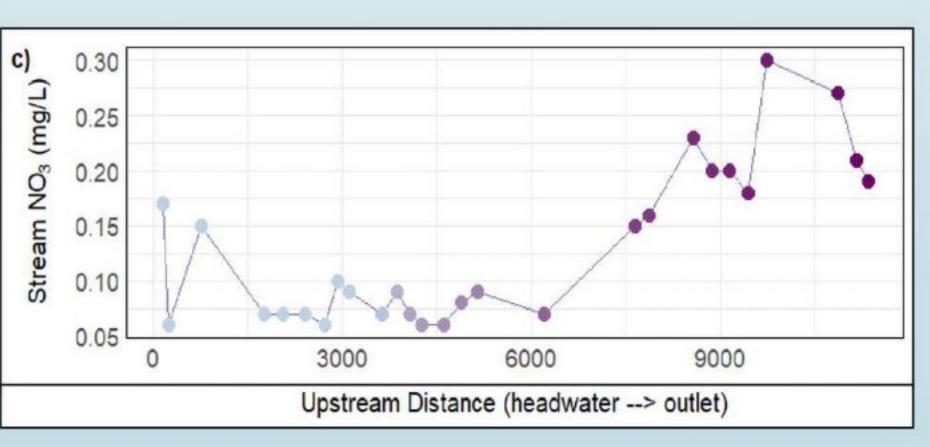


IDENTIFYING RESTORATION PRIORITY AREAS

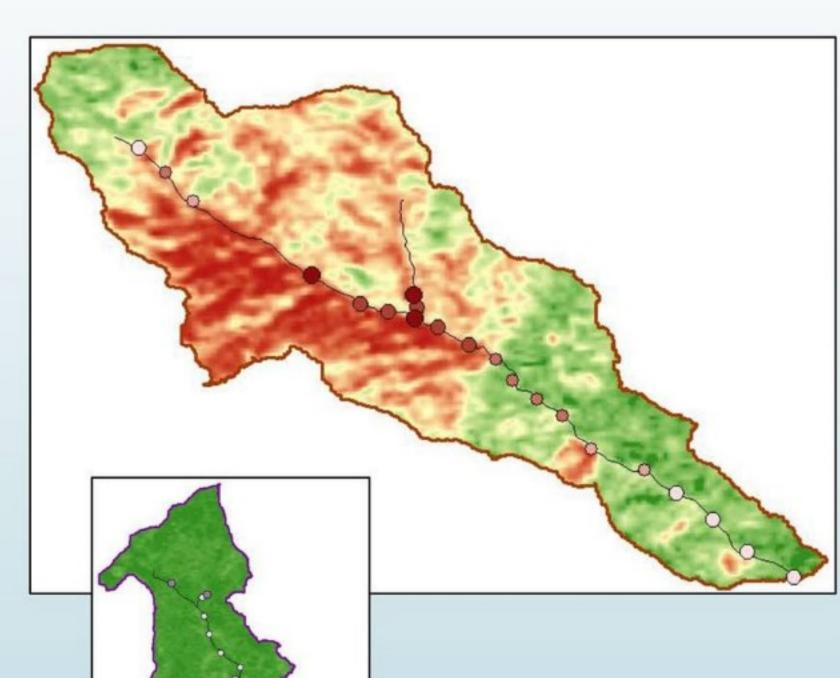
STREAM N HIGHEST WHERE HEADWATER BURNED

N DECLINED DOWN THROUGH UNBURNED FOREST, BUT REMAINED RELATIVELY HIGH





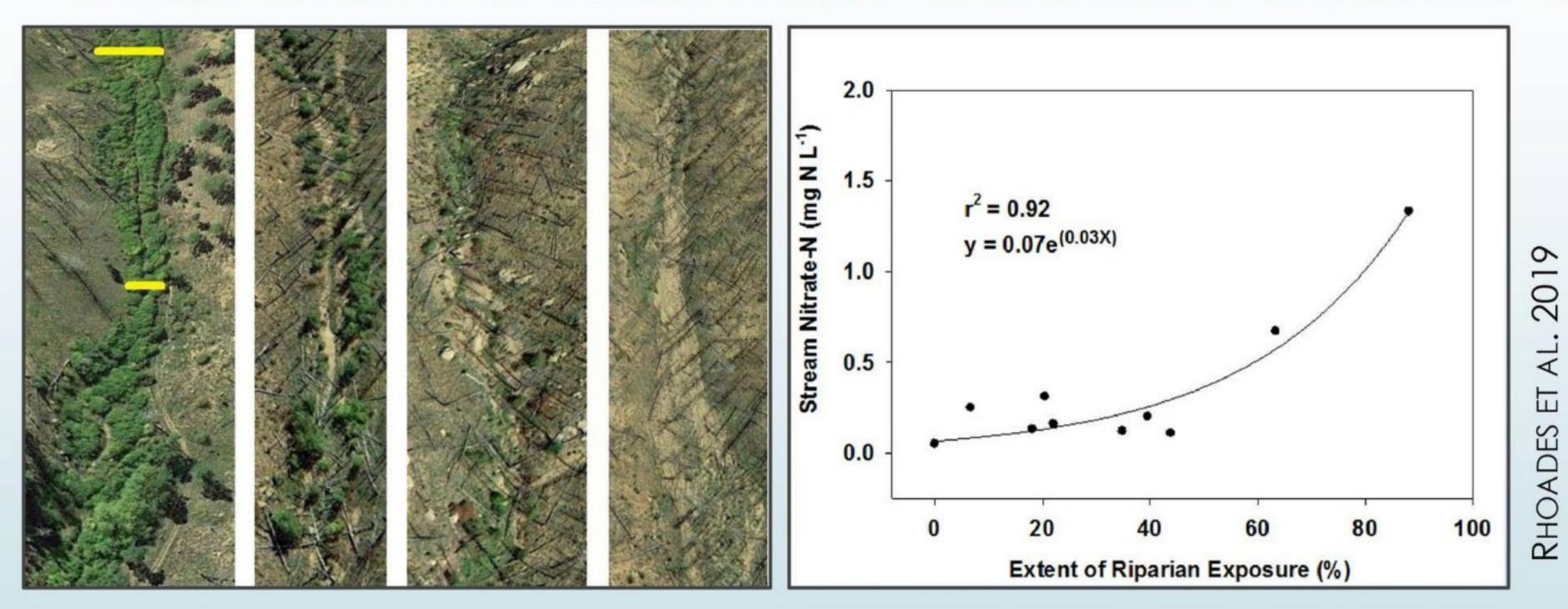
RHEA ET AL. IN PREP



Post-Fire Watershed Restoration



REESTABLISHING VEGETATION & NUTRIENT RETENTION



ELEVATED STREAM N WITH LOW RIPARIAN COVER

Nutrient retention much lower in extensively burned watersheds

Higher nutrient uptake, C inputs, decreased light and temperature with greater riparian cover

Likelihood of multiple positive effects with stream corridor revegetation

Short & Long of It...



WILDFIRE EFFECTS ON WATERSHEDS

Post-Fire Take Homes

- Dramatic, short-term effects on chemistry (ash), erosion (days, months)
- Long-term changes in nutrient, C export both significant & common (yrs)
 Signify shifts watershed nutrient retention (supply/demand)
- Sources of persistent change: Higher soil N supply, hillslope leaching, associated with low plant recovery and N demand (upland & riparian)
- In-stream productivity remains high, does not explain higher stream N, but indicates a relaxation in N limitation

Implications of Long-Term Effects for Restoration

- Watershed changes persist after post-fire rehabilitation ends
- Water quality hot spots can guide / refocus restoration priorities
- Long term data: opportunity to test if riparian and upland plantings increase nutrient retention and mitigate elevated stream N
- Many unknowns about overlapping wildfire with other disturbances

Evaluating & Balancing Options









Sound Management

What are the options & challenges to increasing the pace & scale of activities aimed at addressing current & future forest health concerns





THANKS! Contact: charles.c.rhoades@usda.gov



Colorado Water Conservation Board

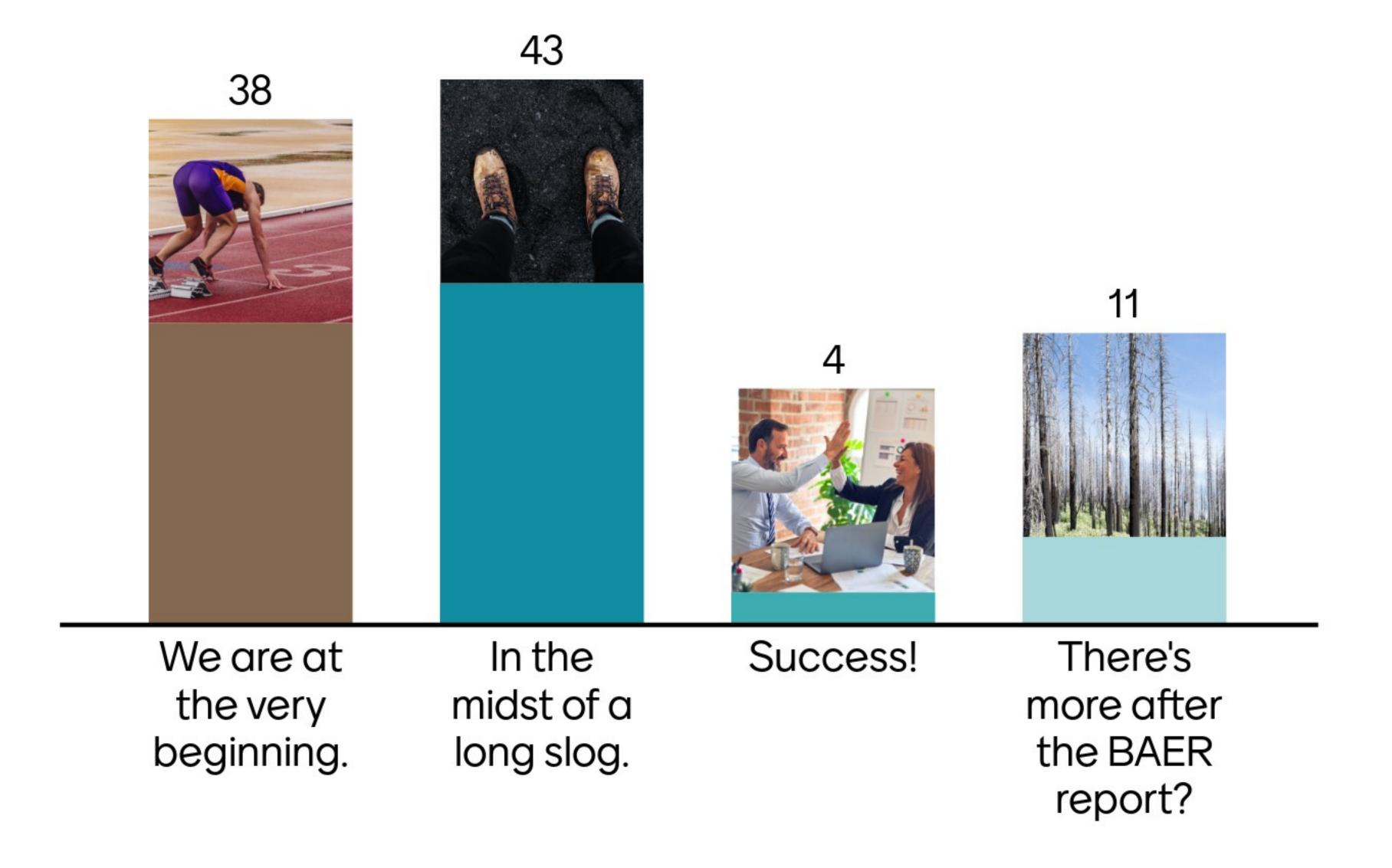
South West Basin Roundtable: 416 Fire research North Platte Basin Roundtable: MPB research





What is your experience in reversing long-term impacts from fire to the ecosystem?









Thank you!

Excellent Presentations. Thank you!

Thank you for all the great information.

With a comprehensive prescribed burning/fuel management program leading to a LONG term change, should water managers and costs be part of the planning and government funding?

Monica is there a particular size fraction of fine sediment that you find most challenging?

Monica: What sediment size is most important in terms of impacts to drinking water treatment?

Christina how was "mid range sediment management" defined?

Given the large costs of providing high quality water supply, should the industry seek consolidation so that large regional water authorities are better positioned to deal with wildfires and other issues?

For Monica - some of your graphs seem to indicate that salvage is more impactful than not salvaging? We face pressure to salvage in Western OR...maybe not the best move for water quality?





Chuck, the reduction in Nitrogen uptake after a severe burn made me think of the effects of the fire on mycorrhizal fungi. Has there been any work done that you know of looking at this and has anyone tried inoculating burned areas with local mycorrh

Can beavers save the day?

Chuck said studies have shown it will take decades or even a century to get forests back to where they were. He also mentioned climate change. Where does that leave us in the case of the Cameron Peak Fire, East Troublesome & Grizzly fires?

Is it true that a lot of our lodgepole pine forests in Colorado are not native, bur replanted previously timbered areas, and should that be part of our restoration considerations?

Christine what is the long term plan for management of the sediment traps?

When you talk about poor vegetation regrowth in lodgepole pine forest, Chuck, is it because of the burn's severity, or is it some other factor? There are optimistic reports of veg regrowth for East Troublesome, and I am unclear what it means.

There will be more sediment for a long time in the Spring Creek Fire region also.

Forest thinning is supposed to decrease the likelihood of severe fire. Are there examples of forest thinning having a positive effect on water quality parameters after the treated areas have been burned in a fire?

How do you handle in-stream water quality BMP treatments post fire in small first order streams as compared to larger rivers?





For total fire suppression costs versus presuppression activities, are ecoservices per acre monetized and valuated, such as stormwater dispersion, hydrological production, sedimentation, habitat degradation, refugia destruction, carbon storage?

Chuck-Have you seen, or would you expect to see, differences in the post-fire nutrient increases in different soil types?

Chuck, regardin the comment about DOC release from prescribed burning. We (NGO who work with USFS) spend a huge amount of time promoting rx burning as the best ecological tool, did you say that you've seen poor water quality from controlled burning?

Chuck: Very interested in the stream corridor planting as a potential part of the solution. Are you hoping to set up areas where you can study the impacts of riparian planting versus upland/overall planting?

Anybody monitoring pfas levels post fire?

Monica how do you treat for voc's in water treatment. Have you seen VOC after fire?

Does planting grasses in a high severity fire area delay the long term succession back to a forest (as opposed to planting nursery plugs)?

Monica, several of your slides showed post-fire salvage areas contributed the most sediment. I'm assuming that was wood/timber salvage. Did these areas also undergo recovery treatments like coverage with wood shreds?

So, Chuck, for post-wildfire mitigation efforts is your recommended focus on high severity burn zones, upland areas, down in the riparian drainage zones or some crossover between burn severity and specific drainages?





I am thinking that if nutrient uptake is arrested from a severe burn, will grasses take up too much nutrients to begin with and delay forest come back on its own and would require planting plugs. Monica, some of what you presented about the potential for treating fire-impacted water is reassuring. But what about small, local water provision systems like rural coops - what can they do?

Chuck. Will the regrown forest look different from before burn?

Chuck, all else is constant, how many more years of post beetle kill damage wildfires should we expect? How long would the damaged forests burn hypothetically? Christina - It seems like water districts and water users have an incentive to do fuels treatments/Rx fire to reduce future sediment loads to reservoirs. Have you heard about downstream water users paying to treat forests? Seems that clarifying the economic return on investment for active management of the natural infrastructure supplying the built water systems is critical. What tools are available for water utilities to make the case with their boards/rate payers?

What did Denver do with all the debris that came down?

Remove the culverts!

Chuck - Similar to beavers saving the day, can Stage 0 restoration save the day?





Easier to abandon a road in the forest, but what about county rds and state highways?

Will there inevitably be a 'fire industry' kind of like the water industry?

fungal network impacts on post fire landscapes? Anyone?

Thank you! Excellent set of presenters and Q&A.

Christina, is your forest to faucets program part of your operational budget, in other words part of Denver Water's rate structure, or are the costs externalized in another budget line item, i.e. CIP, etc.?

Excellent presentation. I especially appreciated Christina's presentation. Thank you for the invite.





Thank you!

- Visit AfterTheFlames.com for access to more post-fire resources
- Recordings of past webinars available!
- > Fluvial Hazard Zone Mapping, Recovery Techniques, Practical Resiliency in Urban Stream Corridors