

Post-fire Water Quality Impacts		
3-Dec-20		
	Questions	Response
Christina	Christina how was "mid range sediment management" defined?	There were 3 "categories" of sediment management: 1) immediate/short term 2) mid range and 3) long range. Mid range is loosely defined as projects such as the sediment basins took a little over a year to implement, and are not a long range solution because we consider long range efforts to lead to the stability of the forest and riparian ecosystems in the watershed for more permanent/long range watershed health. The sediment basins, while considered mid range, are actually "temporary" according to the USACE until there is permanent stabilization of the surrounding watersheds or permanent recovery.
Monica	Monica is there a particular size fraction of fine sediment that you find most challenging?	Well-operated drinking water treatment is designed to manage and effectively remove particles, even in the sub-micron size range--this is why coagulant dosing (and getting it right) is so important after any landscape disturbance. With respect to the longer-term risks attributable to sediment-associated contaminants such as phosphorus, they are typically associated with fine sediments that have an operational definition of less than 63 microns in size.
Christina	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?	Many utilities partner and consolidate to prepare and share lessons learned to be better positioned for wildfires and watershed issues. For example, Aurora Water gets 90% of their water from Denver Water's Strontia Springs Reservoir. We have an agreement in place where we share the responsibility of operations of the reservoir. Consolidation could help to have more flexibility in terms of water sources and operations. Smaller water utilities may lack the flexibility, which could be more challenging during and after a fire in their watershed.
	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?	Yes
Monica	Monica: What sediment size is most important in terms of impacts to drinking water treatment?	Well-operated drinking water treatment is designed to manage and effectively remove particles, even in the sub-micron size range--this is why coagulant dosing (and getting it right) is so important after any landscape disturbance. With respect to the longer-term risks attributable to sediment-associated contaminants such as phosphorus, they are typically associated with fine sediments that have an operational definition of less than 63 microns in size.
Monica	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?	The issue of salvage logging is complicated because while more disturbance (i.e., the combination of wildfire plus salvage logging) can have a greater impact on soil erodibility and water quality in receiving streams, salvage logging can also contribute to more rapid recovery. This is an important issue that we are continuing to study.

Chuck	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	There's been quite a bit of post-fire myco work. There are short term heating effects that reduce soil fungi and fires alters the composition of soil fungi. There's less certainty about the long-term implications of the burning on soil fungi and what the role of vegetation recovery vs the initial post-fire change are. Based on some of our burn pile work, it appears that ecto colonization may be lower for a number of years (~10?) post-fire. However there's enough EMF present to colonize and support obligate plants like lodgepole. Still much to learn and lots of on-going stuff. Look at work by Sydney Glassman at UC Riverside and watch for microbiome work by Amelia Nelson and Mike Wilkins at CSU.
Chuck	Is it true that a lot of our lodgepole pine forests in Colorado are not native, but replanted previously timbered areas, and should that be part of our restoration considerations?	No, they are native.
Chuck	There will be more sediment for a long time in the Spring Creek Fire region also.	Probably so, given the burn severity
Chuck	Can beavers save the day?	Good question, folks including us are studying this. The interest is whether beaver dams create hydrologic conditions that trap post-fire ash, sediment and particulate nutrients or that create conditions where dissolved nutrients can be taken up by aquatic biota, riparian vegetation or lost through denitrification.
Christina	What is the long term plan for management of these sediment traps? Eventually I would imagine they could become sources for the future, or could be in danger of failing.	The sediment traps are considered "temporary" according to the permitting agencies (USACE) until there is permanent stabilization of the surrounding watersheds or permanent recovery.
Christina	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?	We have seen specific examples of where forest treatments aided in suppression and slowing/stopping wildfires (example: \$1 B saved through forest treatments during the Buffalo Mtn fire). Researchers such as Fernando Rosario Ortiz and Chuck Rhoades have some great research about the effects of fire severity on water quality.
Chuck	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?	There's lots of uncertainty. Some of these areas will certainly recover just fine, but since recovery is naturally something on the order of decades to centuries, long recoveries are to be expected. There are concerns and uncertainty about whether the trees that were dead for 15 years prior to the fires will have sufficient viable seed in the canopy seedbank to regenerate after the fires.
Chuck	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.	It depends on what sort of vegetation is recovering. The early reports from E Troublesome for example are probably grasses and forbs that are sprouting back quickly after the dry foliage was burned off. This is great and indicates that the sites will regain important herbaceous vegetation cover that will slow erosion and start to stabilize the sites. This however, does not provide an idea of the longer-term response and potential trajectory back to pre-fire forest vegetation or something else. That sort of thing depends not only on burn severity, but the size of burn patches/distance from a seed source, seed availability, etc. Here's a great paper that helps frame this discussion for Ponderosa forests: Chambers, M.E., P.J. Fornwalt, S.L. Malone, and M.A. Battaglia. 2016. Patterns of conifer regeneration following high severity wildfire in ponderosa pine – dominated forests of the Colorado Front Range. <i>Forest Ecology and Management</i> 378:57-67.

Chuck	How do you handle in-stream water quality BMP treatments post fire in small first order streams as compared to larger rivers?	I assume you're talking about physical erosion control barriers and streambank stabilization. I have no useful experience with this and would refer you to Carol Ekarius or Leah Shipstead (Pike San Isabel NF) for their specific experience following the Hayman, Waldo and other fires.
Chuck	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?	No
Chuck	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?	Yes, we have great opportunities and sites for this sort of work and have been looking for support to set something up in areas that are still recovering from the Hayamn Fire. Our long-term data from these streams provides a great template of evaluating whether simple riparian plantings can mitigate water quality concerns. I'd be happy to discuss further, as would Cristina Burri at Denver Water and others at CFRI (Marin Chambers).
Chuck	Does planting grasses in a high severity fire area delay the long term succession back to a forest (as opposed to planting nursery plugs)?	Not sure, but I suspect this is site specific.
Chuck	Chuck-Have you seen, or would you expect to see, differences in the post-fire nutrient increases in different soil types?	Yes, one example is the difference between the post-fire P response that Monica's group observe in areas with high-P soils/lithology. We don't see that in CO on low-P soils/lithology. Another interesting response is the high post-fire N seen following fires in areas where chronic, high atmospheric deposition have loaded up with soils (i.e., LA Basin). Similar concerns regarding metal accumulation downwind of power plants.
Chuck	Anybody monitoring pfas levels post fire?	Lots of people are now talking about this, so probably.
Monica	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?	Yes, this was post-fire wood/timber salvage. These area did not undergo recovery treatments like wood shreds.
Chuck	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?	This is a great question. What I said is that we've seen some post-fire changes that are relevant to Rx burning. There's surprisingly little known about Rx burning effects on water quality. This is interesting considering that most folks who promote Rx burning are doing so for some sort of watershed protection objectives. There's a general idea that it will have limited influence on water quality - especially, if one compares small upland burns to large, high severity burns. Our limited, preliminary Rx fire data in the Elkhorn (ARP NF), suggest that small fires that burn riparian vegetation and stream corridors alter stream chemistry to a small extent. Our Hayman study indicates that moderate burning may have a greater effect on DOC than high severity burn. DOC is naturally exported from unburned watersheds, so this pattern is not necessarily a cause for concern. Coupled with our N data from these sites, the take away is that even moderate fires may tweak water quality for years. However, to be a useful tool to influence the very serious water quality concerns associated with large, severe wildfires, Rx fires may need to be larger, hotter and more frequent. There's a large decision space between what we don't want from catastrophic fires and what we can accept with Rx fires. We currently have little information to support that conversation.

Monica	Monica, How do you treat for VOCs in water treatment. Have you seen VOC conatamination happen after fires in water distribution systems	Most of the wildfires that we have studied have not impacted urbanized landscapes; therefore, VOC concerns would largely be limited to contaminants likes dioxins, furans, and PAHs. Interestingly, we have not seen high levels of these contaminants post-fire. Solid-associated organics can often be readily removed by conventional filtraiton plants (which include coagulation, flocculation, clarification [typically by sedimentation], and granular media filtration). More persitent organics can be removed by adsorption on activated carbon, typically applied either as powdered activated carbon during coagulation or when granular activated carbon is used as a filtration medium. Reliance on activated carbon significantly increases treatment costs because maintenance costs are high.
Chuck	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 have had no opportunity to evaluate this, but given the chance, I would like to test whether streamside and lower landscape plantings benefit water quality by reducing nutrient enrichment. I was speculate that this would require some years to establish sufficient vegetation cover and would involve changes in the microenvironment (light, temp), nutrient uptake and litter and wood inputs.
Chuck	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.	Grass competition can be a problem for tree regeration in some sites, but probably not in these dry mixed conifer forests.
Monica	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?	This is the big challenge because the cost of water treatment does not scale linearly with population! What can be done in small communities will largely depend on the treatment infrastructure that is already in place. Some of the biggest risks can be mitigated as long as treated water turbidity is reduced to treated water standards and adequate disinfection is applied (as required). Thus, it is critical to practice jar tests to ensure adequate coagulate dosing. In absence of conventional filtration infrastructure or package plants (e.g., skid-mounted with bag filters or such), source water quality characterization and offline water storage capacity should be evaluated so that water can be collected during periods of acceptable quality.
Chuck	Chuck. Will the regrown forest look different from before burn?	This would depend on the fire, specific location within a fire, etc. So probably yes and no.
Chuck	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?	This is an interesting and complicated question. Based on our studies of treefall, we expect the MPB killed lodgepole overstory will remain standing for some time to come across large parts of N Colorado and S Wyoming. Fallen snags will add to surface fuels and are not likely to decompose for many decades, so the legacy of the MPB outbreak on fuel profiles and potential fire behaviour could certainly persist for a century.
Christina	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?	Denver Water (DW) as a downstream water user has committed \$33 M toward forest health projects, and it is a smart business decision for utilities such as DW to invest in proactive forest management in priority watersheds because it is so costly to be reactive. Other utilities such as CO Springs, Aurora Water, Northern Water, and Cheyenne have invested in proactive forest and watershed health investments.

Christina	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?	American Water Works Association has some great resources and manuals with guidance for water utilities that want to invest in source water protection. Also, the USFS has a lot of great information to help water utilities make a business case to their boards/rate payers. A lot of the justification is lessons learned from the costs of being reactive.
Christina	What did Denver do with all the debris that came down?	We used a boom to collect the debris on the surface, and then had to dredge the debris that settled. The dredging was very costly, which is why it's so important to be proactive and try to prevent the debris from getting in the reservoir. We still deal with post fire debris to this day, and have to collect it from the surface and pile it and burn it, which we need air permits for.
	Remove the culverts!	
Chuck	Chuck - Similar to beavers saving the day, can Stage 0 restoration save the day?	See response on beavers - Good question, folks including us are studying this. The interest is whether beaver dams create hydrologic conditions that trap post-fire ash, sediment and particulate nutrients or that create conditions where dissolved nutrients can be taken up by aquatic biota, riparian vegetation or lost through denitrification.
	Easier to abandon a road in the forest, but what about county rds and state highways?	
	fungal network impacts on post fire landscapes? Anyone?	See Previous Response - There's been quite a bit of post-fire myco work. There are short term heating effects that reduce soil fungi and fires alters the composition of soil fungi. There's less certainty about the long-term implications of the burning on soil fungi and what the role of vegetation recovery vs the initial post-fire change are. Based on some of our burn pile work, it appears that ecto colonization may be lower for a number of years (~10?) post-fire. However there's enough EMF present to colonize and support obligate plants like lodgepole. Still much to learn and lots of on-going stuff. Look at work by Sydney Glassman at UC Riverside and watch for microbiome work by Amelia Nelson and Mike Wilkins at CSU.
Christina	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.?	It is part of our operational budget, and not a separate line item. Denver Water considers sustaining healthy watersheds as a part of our collection system operations.
	Will there inevitably be a 'fire industry' kind of like the water industry?	Probably
Christina	Could we get a pdf of the report showing the benefits of restoration to reducing sediment input to the reservoir?	See attached. - "Return on investment from fuel treatments to reduce severe wildfire and erosion in a watershed investment program in Colorado"
Christina	Great to hear about the institutionalization of management of the natural infrastructure that is the source of the water routed through the built infrastructure at Denver Water. How do we share and scale that concept at other water utilities across the West/Nation?	CoCo, USFS, NRCS, and American Water Works Association have all been using their national conferences and platforms to advance partnerships, such as Denver Water's. I think there could always be more outreach and advocacy on a national level though. There is a need to engage more of our federal legislators on the importance and success of proactive forest and watershed investments. I welcome any thoughts or ideas about this.
Chuck	Chuck, when you talk about poor vegetation regrowth in lodgepole pine forest, is it because of the severity of the burns where they happened or is it some other factor? We are hearing optimistic reports regarding the East Troublesome fire in terms of potential for regrowth. Does it mean that there might be regrowth of some vegetation but that it might not look like the prior forest that existed before the burn?	See Previous Responses

Christina	In municipal water portfolio management, diversification of supply is an expensive best practice, but this fire season has shown us that a diverse portfolio can still be greatly impacted by drought and associated wildfire. Have any of you started working with your peers in water resource engineering on revisions to best practices and priorities for supply resiliency?	Yes, and this is a great point about limitations of water sources and flexibility if there are fires in several watersheds. Because of this fire season, Denver Water is conducting internal focus group discussions to identify gaps in communications and operations when there is a fire, to try to plan ahead of a fire season like we saw this year. We are calling this project the Wildfire Readiness & Recovery Framework. Fort Collins and Northern Water have really good plans for wildfire preparedness as well, that have been a good example for Denver Water to follow. Water quality monitoring is always a good idea to understand a baseline and then track trends when wildfire events occur.
From Steve Hardegen - FEMA		
	FEMA is currently working with the Colorado Office of Emergency Management is currently conducting Preliminary Disaster Assessments in Colorado from this years events: Boulder, Larimer, Grand, and Garfield Counties. Contact your county or local emergency managment office to submit potential costs. Costs are required to justify a submission for a full Presdential Declaration. Every dollar counts.	
	FEMA also has a new program; Post Wildfire Hazard Mitigation Assistance for FMAG declarations, (Fire Managment Assistance Grants) each FMAG is capped at \$600K. Again contact your local emergency manager for more information.	