TAMING THE WILD – UNDERSTANDING RISKS AND RESPONSES TO WATER SUPPLIES FROM WILDFIRES

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OUTLINE OF TALK

- Overview of wildfire activity and risks in the Pacific Northwest
- Wildfire effects to drinking water utilities
- Case Study: City of Brookings Municipal Watershed Post-Fire Assessment
  - Hydro-geomorphology assessment
  - Water quality assessment
- Relevancy to the water supply industry
- Conclusions

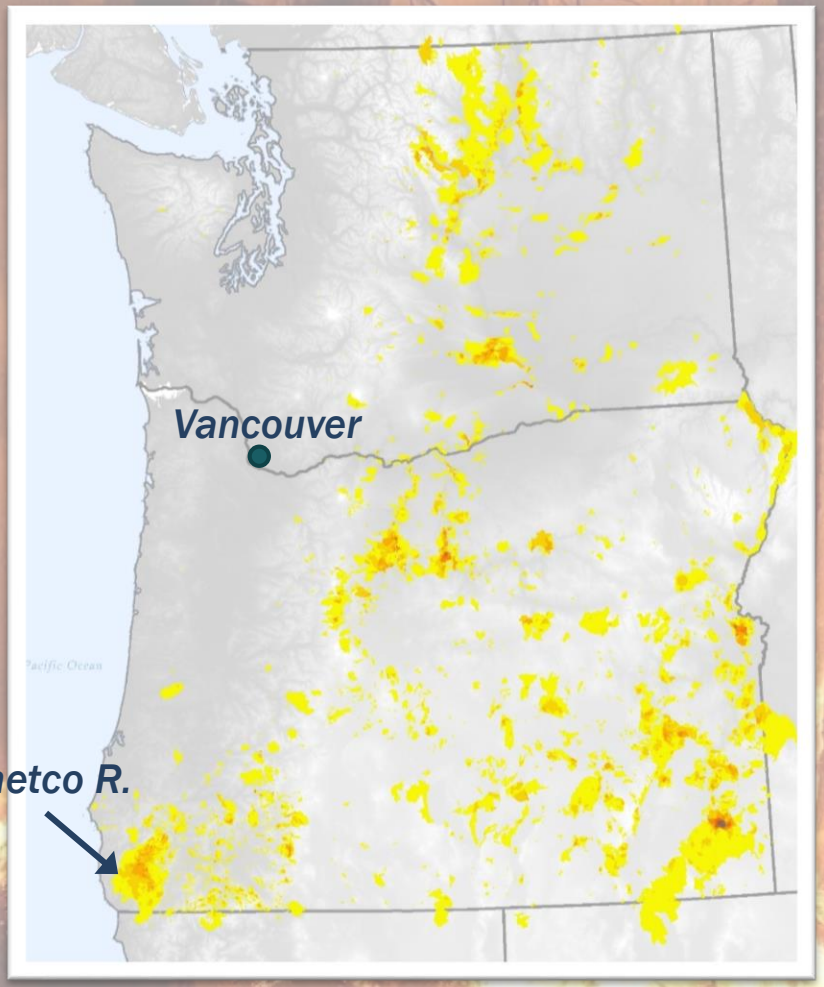
Photo of City of Brookings, OR
(courtesy of City of Brookings)

OVERVIEW OF WILDFIRE ACTIVITY AND RISKS IN THE NORTHWEST

- Wildfire activity is increasing throughout the West and is thought to be due to land uses and climate change: <u>denser forests with warmer and drier summers</u>
  (Abatzoglou and Williams, 2016, PNAS)
  - Climate projected to warm ~5°F by 2050s and summer water balance deficit to increase
    (Littell et al., 2016, Global Change Biology)
  - Fire return frequency increasing (Sheehan et al., 2015, Ecol. Mod.)
  - Fire season duration increasing steadily over the past four decades: 23 days in 1970s to 116 days in 2000s
    (Westerling, 2016, Phil. Trans. R. Soc. B)
  - Fire severity may decrease, however, assuming an equilibrium between climate and vegetation
    (Parks et al., 2016, Environ. Res. Letters)

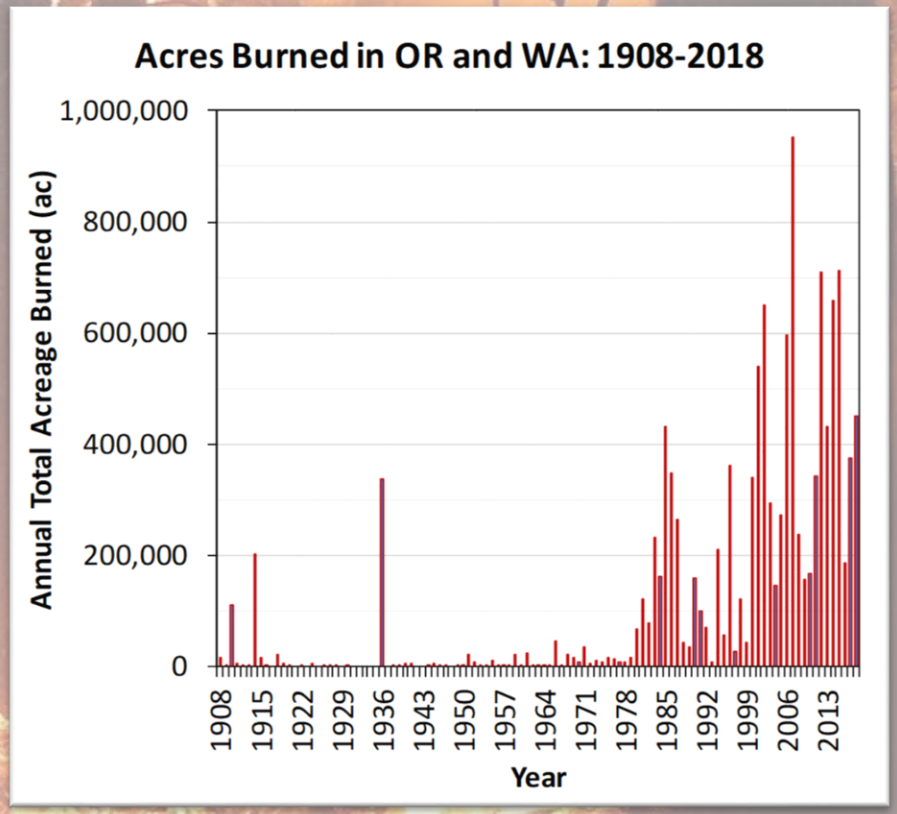
Photo of Chetco Bar Fire (courtesy of USFS)

Spatial frequency of recorded burn events in OR and WA: 1908–2017



Source data: BLM, 2017
GIS analysis: Stillwater, 2018

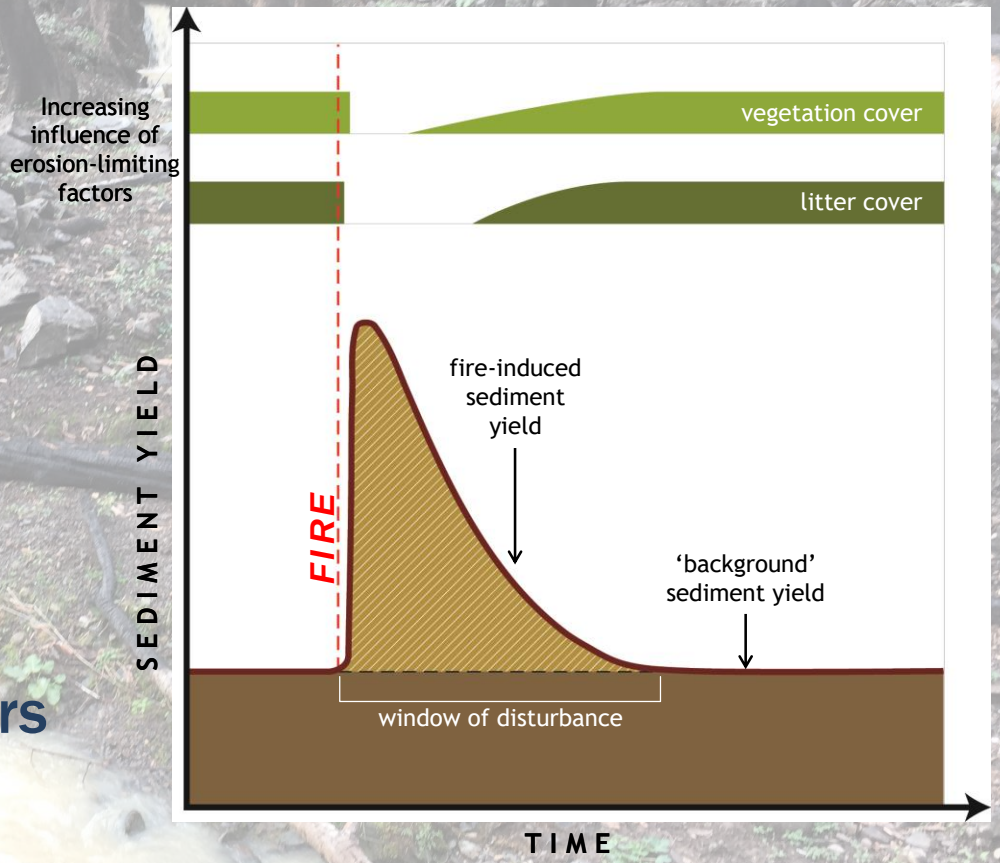
Annual total acres burned in OR and WA: 1908–2018



Source data: BLM, 2018
Analysis: Stillwater, 2019

- Wildfires can lead to accelerated rates of runoff and erosion
  - Exposed, burned soils during storms are more susceptible to mass wasting and sediment-laden runoff—the Fire-Flood-Erosion sequence (Neary et al., 2005, USDA)
  - "Window of disturbance" occurs for months to years until natural system recovers (Prosser and Williams, 1998, Hyd. Proc.)

Conceptualization of sediment yield and associated vegetation and litter recovery during the fire-induced "window of disturbance"



Adapted from Shakesby and Doerr, 2006, Earth Sci. Rev.

Photo of burned area of Chetco watershed (Stillwater Sciences)


Worst-case scenario:
Heavy Rains after a Severe Wildfire
Photo of Montecito Debris flows following Thomas Fire in Santa Barbara County, CA, Jan 2018
(photo courtesy of Scripps Institute)

WILDFIRE EFFECTS TO DRINKING WATER SUPPLY

Wildfires may impair water quality by increasing loading of constituents (Cannon et al., 2010, GSA Bull.; Furniss et al., 2010, USDA; Smith et al., 2011, J. of Hyd.; Burton et al., 2016, PLOS)

- Suspended/dissolved sediment → Facility/filtration impacts
- Nutrients (P, N) → Algal blooms
- Dissolved organic carbon → Coagulation impacts
- Metals (Fe, Mn, As, Cr, Al) → Treatment impacts

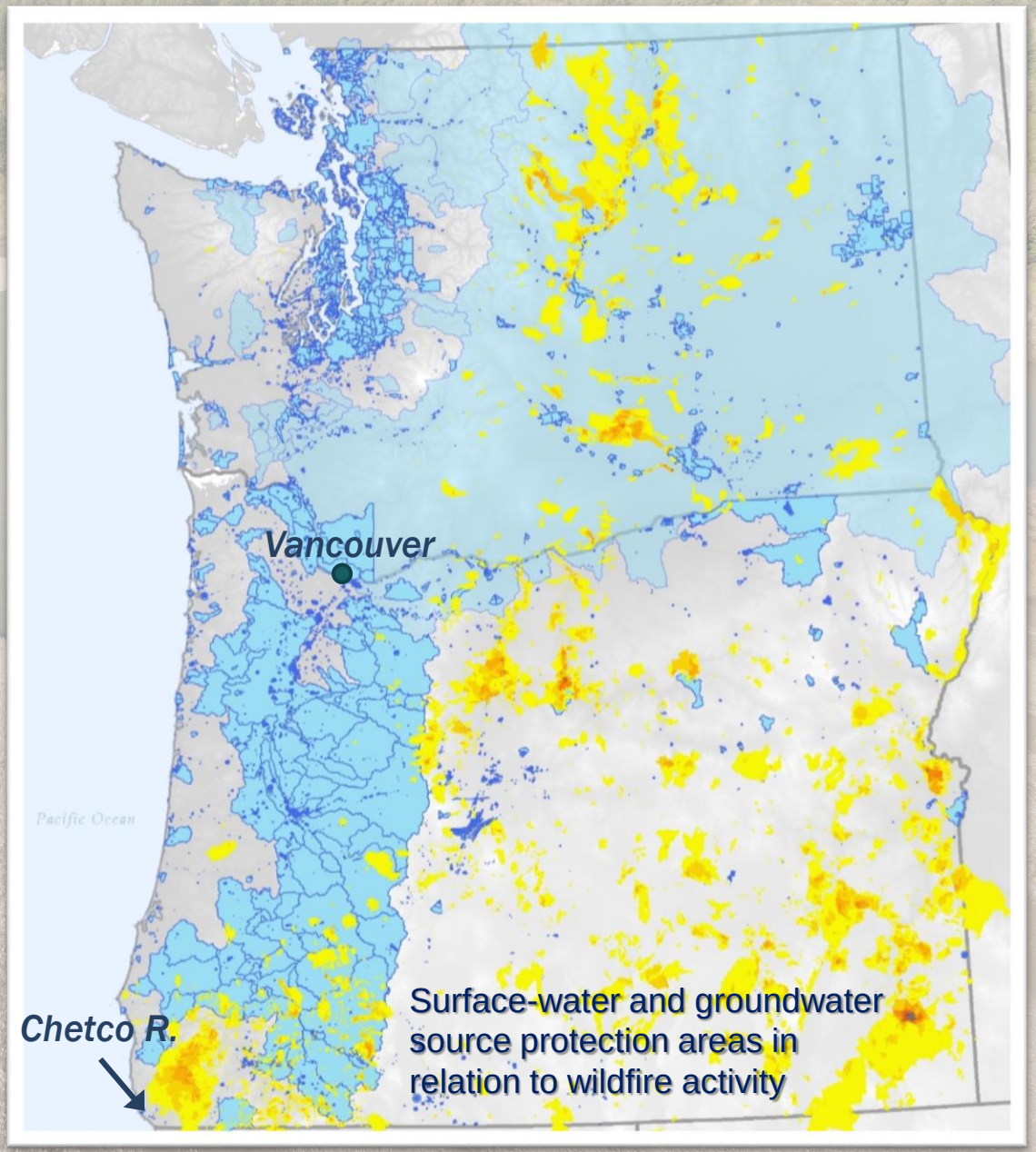
Photo of burned area of Chetco watershed (Stillwater Sciences)

WILDFIRE EFFECTS TO DRINKING WATER SUPPLY

- Two-thirds of freshwater resources in the U.S. originate on forested land
  (National Research Council)

- Three-quarters of OR and WA residents receive drinking water from 2,700 (OR) and 17,000 (WA) water systems
  (ODEQ, WDOH)

- Are facilities prepared for increases in wildfire activity?
  - Early warning systems?
  - Ability to shutdown intake?
  - Alternate sources?



CASE STUDY:
CITY OF BROOKINGS MUNICIPAL WATERSHED POST-FIRE ASSESSMENT

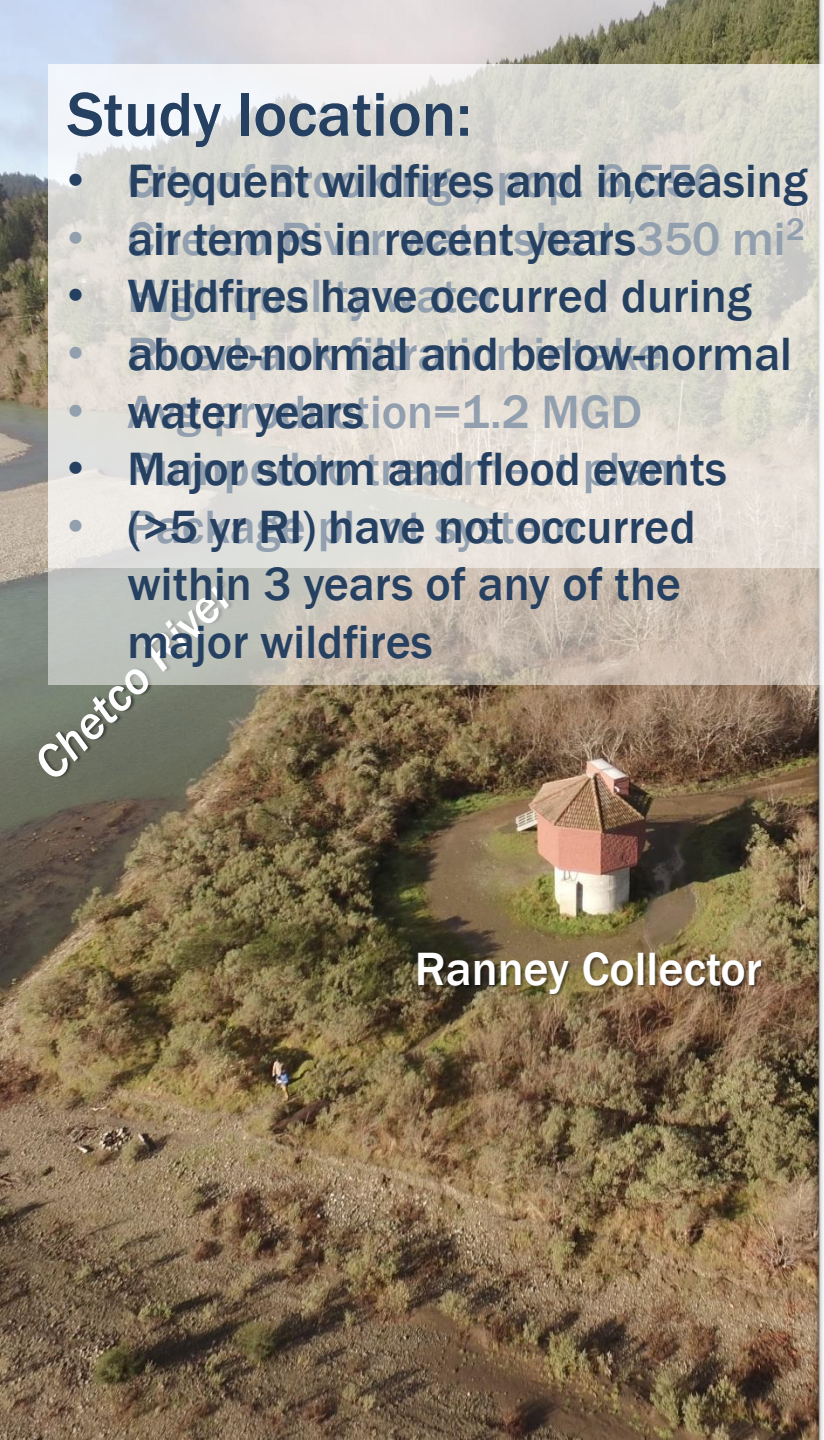
- Address potential effects on City's water system following the major Chetco Bar Fire in 2017
  - Has water quality changed?
  - Have geomorphic changes occurred that could undermine the water-intake structure?
  - Do the post-fire changes pose a risk to the City's water supply?

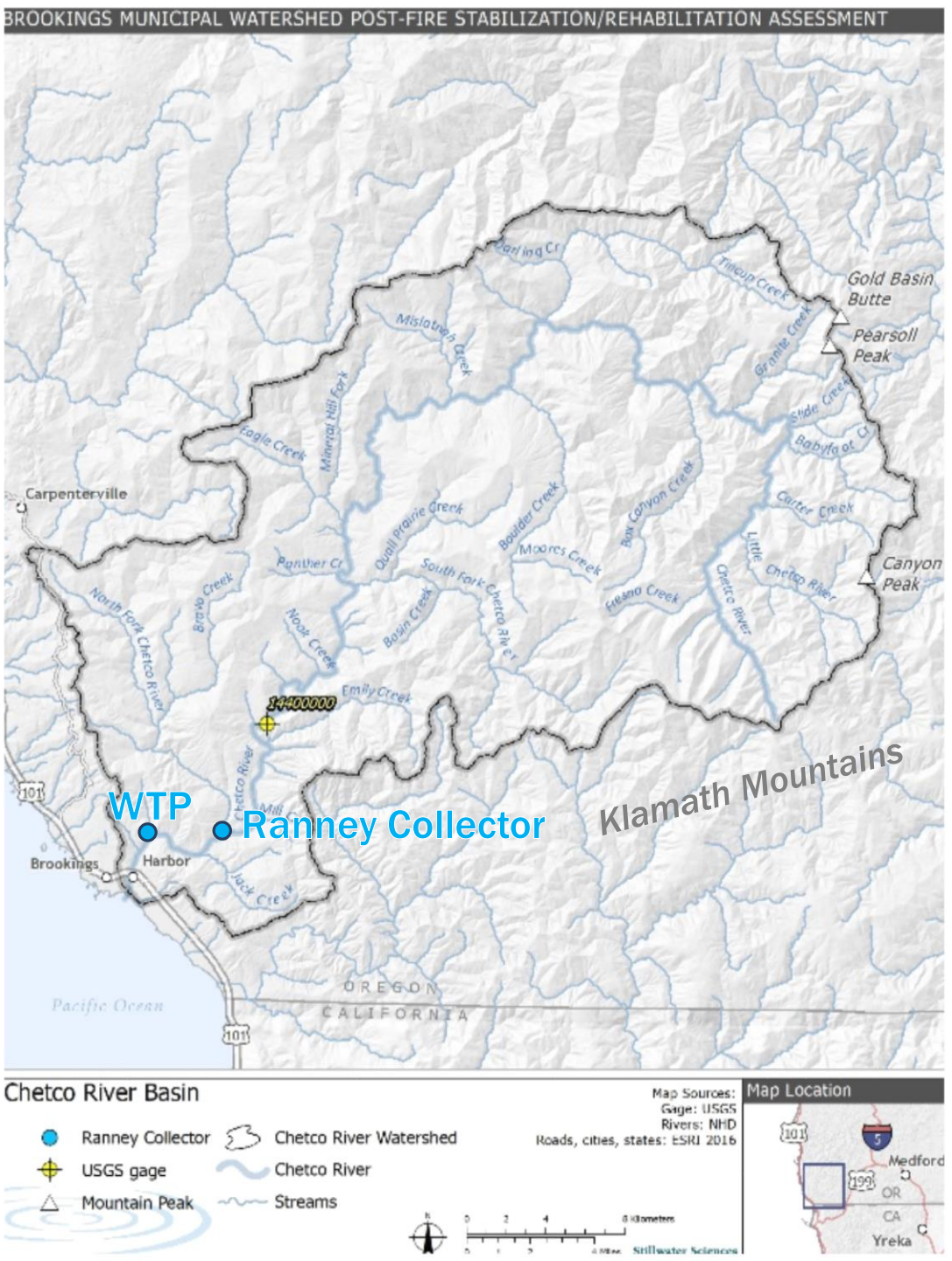
- Hydrology-Geomorphology and Water Quality Assessments
  - Assess water quality in the City's source water and potential treatment issues
  - Assess flow and channel conditions and potential scour and/or aggradation impacts to the infiltration gallery
  - Develop a "Wildfire Source Water Protection Sampling and Analysis Plan"

Photo courtesy of Del Norte Triplicate News

Study location:

- Frequent wildfires and increasing air temps in recent years
- Wildfires have occurred during above-normal and below-normal water years
- Major storm and flood events (>5 yr RI) have not occurred within 3 years of any of the major wildfires

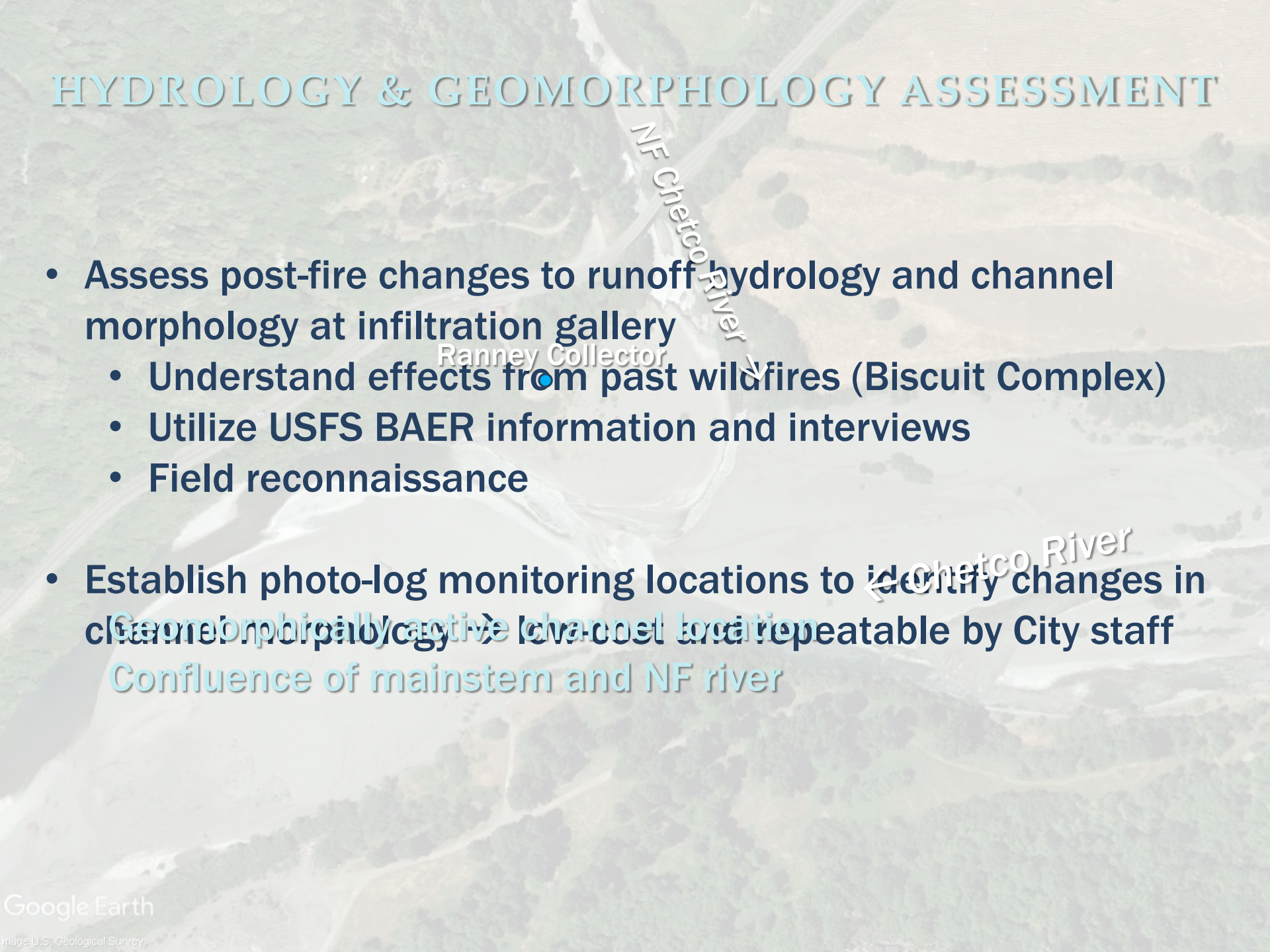




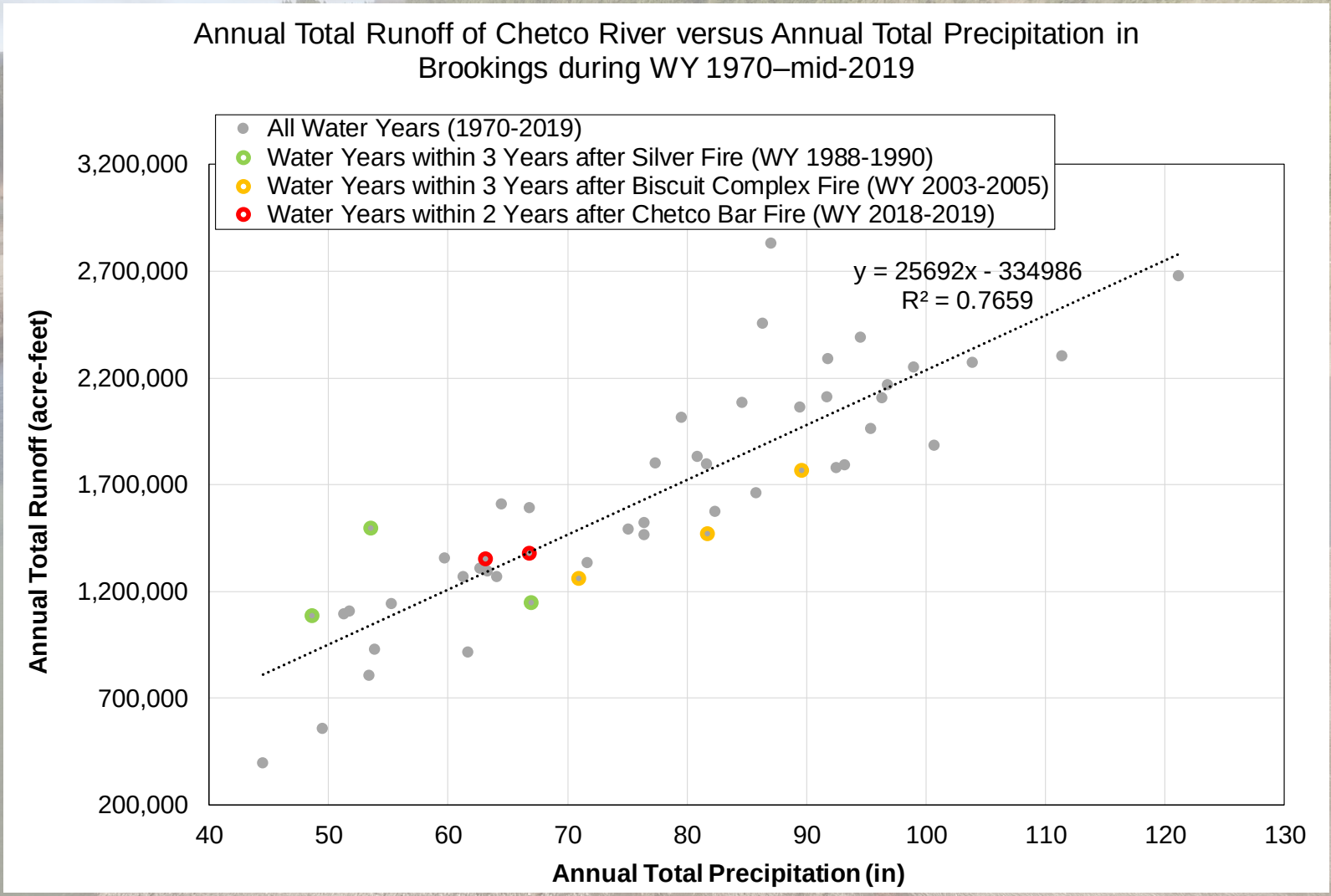
HYDROLOGY & GEOMORPHOLOGY ASSESSMENT

- Assess post-fire changes to runoff hydrology and channel morphology at infiltration gallery
  - Understand effects from past wildfires (Biscuit Complex)
  - Utilize USFS BAER information and interviews
  - Field reconnaissance

- Establish photo-log monitoring locations to identify changes in channel morphology -> low-cost and repeatable by City staff

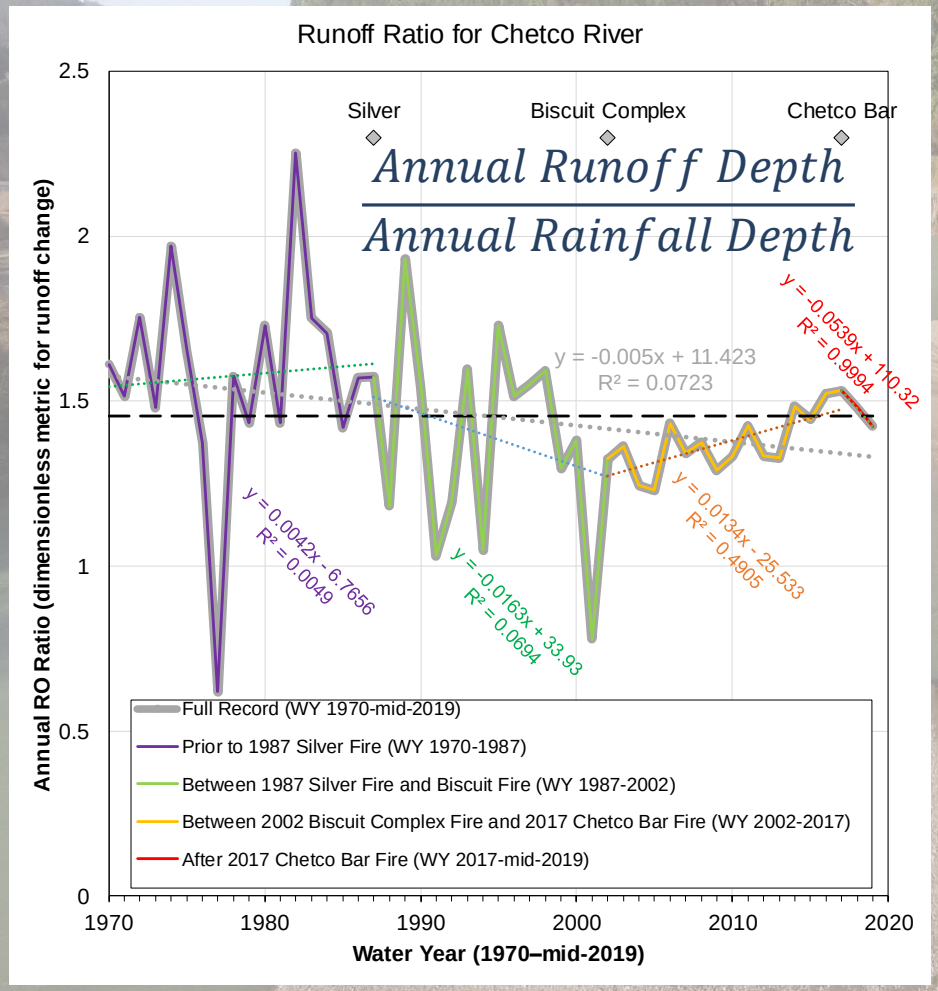


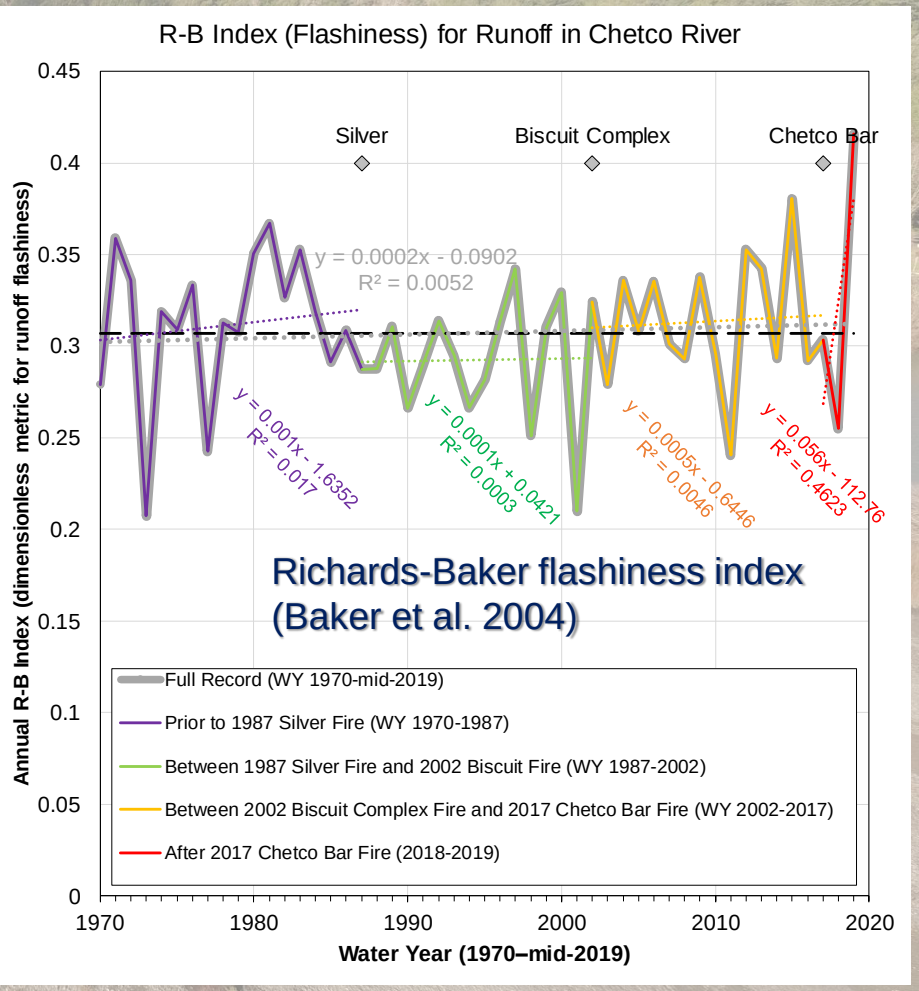
CHANGES IN RUNOFF VS. RAINFALL?



- No clustering of post-fire data in the 50-year record
- Rainfall-runoff relationship, at the USGS gage, exhibited no unusual pattern during those fire-recovery years

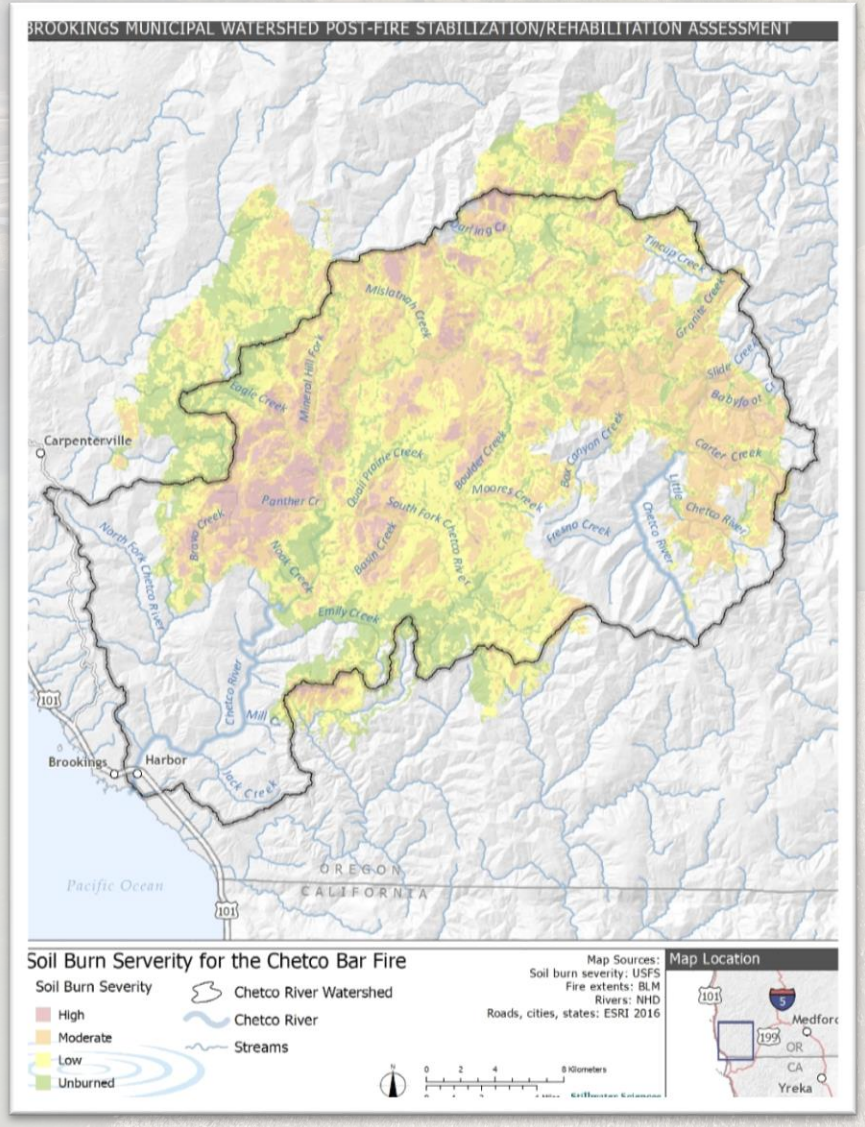
CHANGES IN RUNOFF FLASHINESS?





- No consistent increase (or decrease) following fire events
- Thus, none of the events led to a measurable change in runoff or flashiness as observed at the USGS gage

USFS BURNED AREA EMERGENCY RESPONSE (BAER) FORECASTS

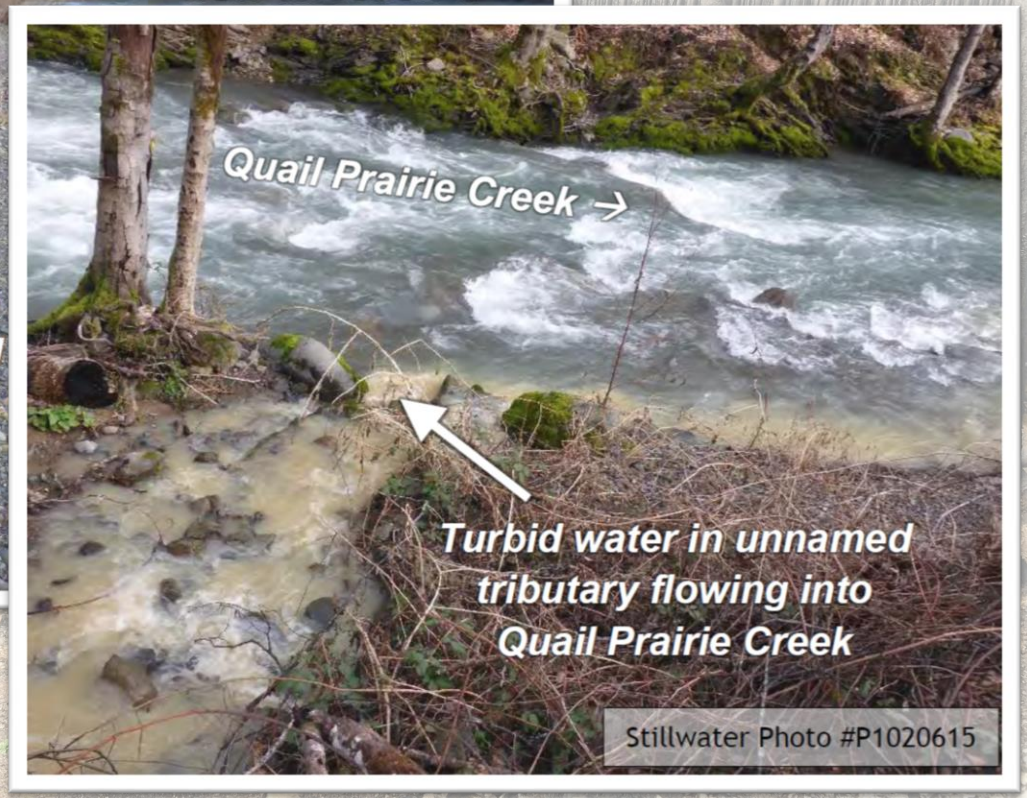


- Post-fire sediment-delivery rates for the 2-yr and 5-yr storm events were estimated to be a factor of <u>10–100 greater</u> than pre-fire rates from the burned areas (USFS 2017, Chetco Bar Fire BAER Report)

- Similar forecasts were made following the Silver and Biscuit fires, but were not realized due to mild storm activity following those events

- The importance of the sediment-delivery rates is in their predicted relative sediment-delivery potential from each of the watershed's major tributaries

HYDRO-GEOMORPHOLOGY FIELDWORK



- Conducted soon after largest storm of year

ng-term photo-
ints

WATER QUALITY ASSESSMENT

- Assessment Goal: <u>Understand water quality impacts as a result of Chetco Fire.</u>
  - Delineate Chetco River from North Fork Chetco River
  - **Overarching Goal**: Determine potential near-/long-term impacts of Chetco Bar Fire.

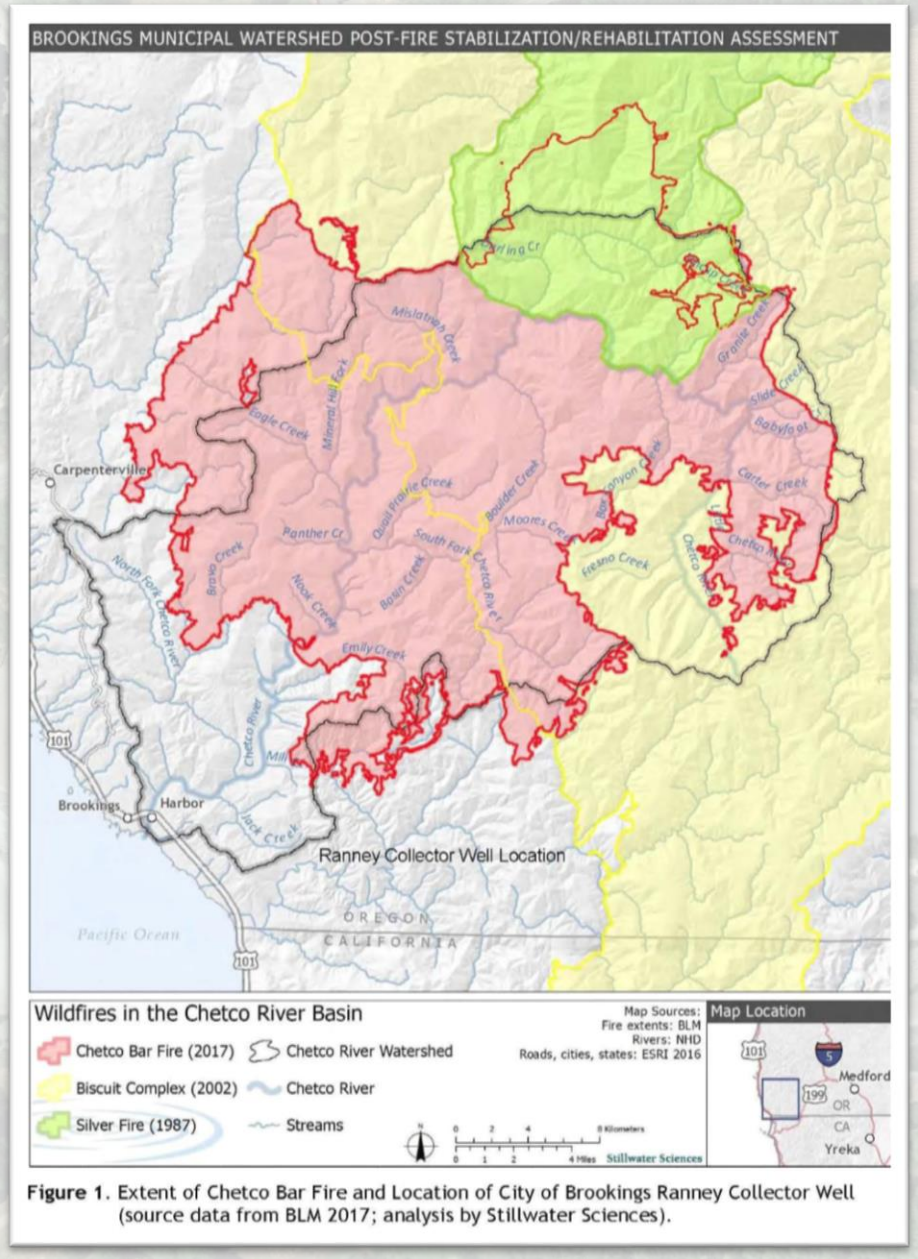


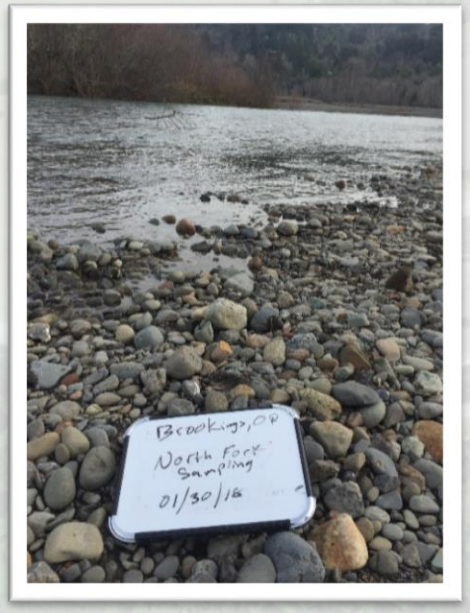
Figure 1. Extent of Chetco Bar Fire and Location of City of Brookings Ranney Collector Well (source data from BLM 2017; analysis by Stillwater Sciences).

FIELD METHODS

- Two post-fire sampling events conducted.
  - January 30, 2018 (relatively dry conditions)
  - March 23, 2018 (relatively wet conditions)
- Parameters
  - General
  - Major Anions/Cations
  - Nutrients
  - Metals
  - Microbial

General Conditions During Sampling Events		
Condition	Event 1 (Dry) January 30, 2018	Event 2 (Wet) March 23, 2018
Mean temperature* (°F)	41 to 54 °F	41 to 46 °F
Total measured precipitation for the day*	0.24 inch	1.13 inches
Peak flow measured at Chetco River (measured from gauge: 14400000)	5,460 cfs	9,420 cfs

Notes:
* Weather conditions based on data from Weather Underground (KBOK location near Brookings, Oregon).
°F = degrees Fahrenheit
cfs = cubic feet per second



FIELD METHODS

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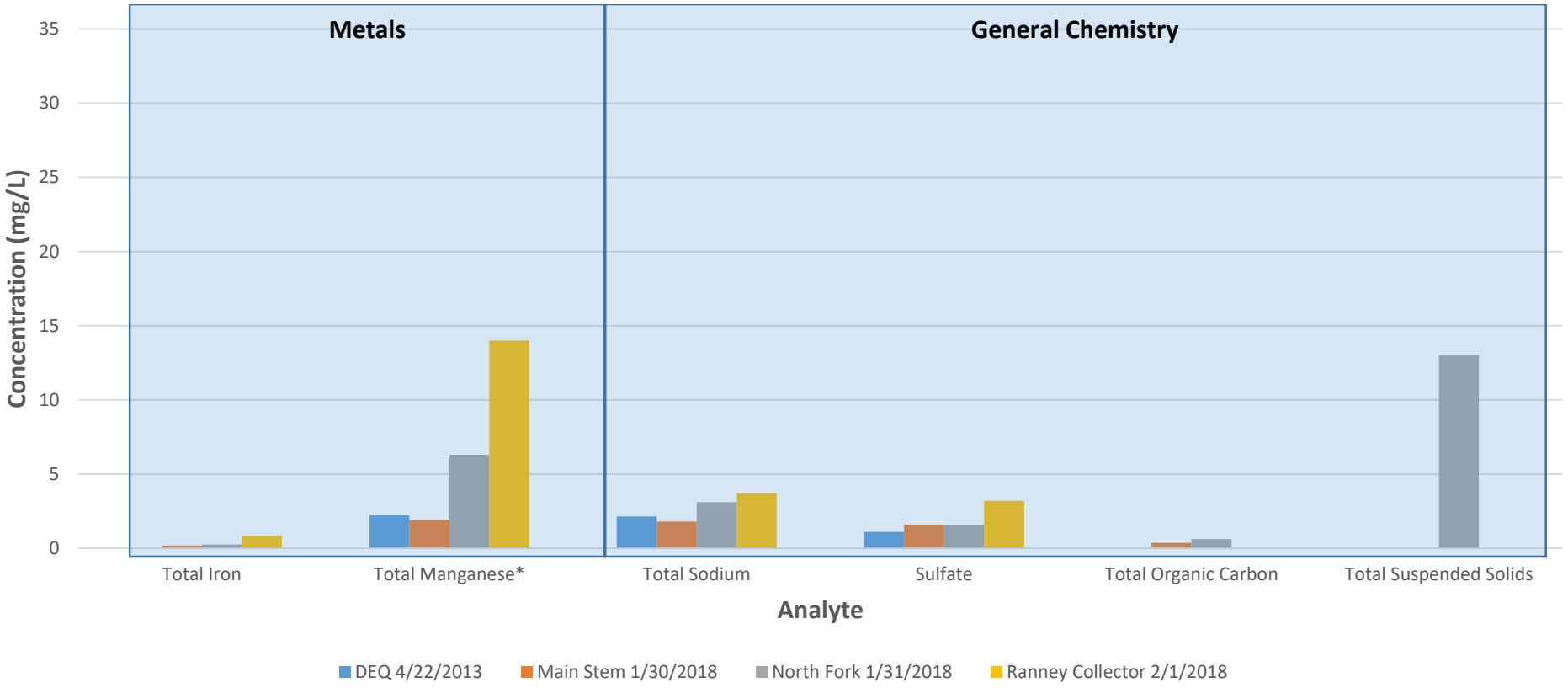
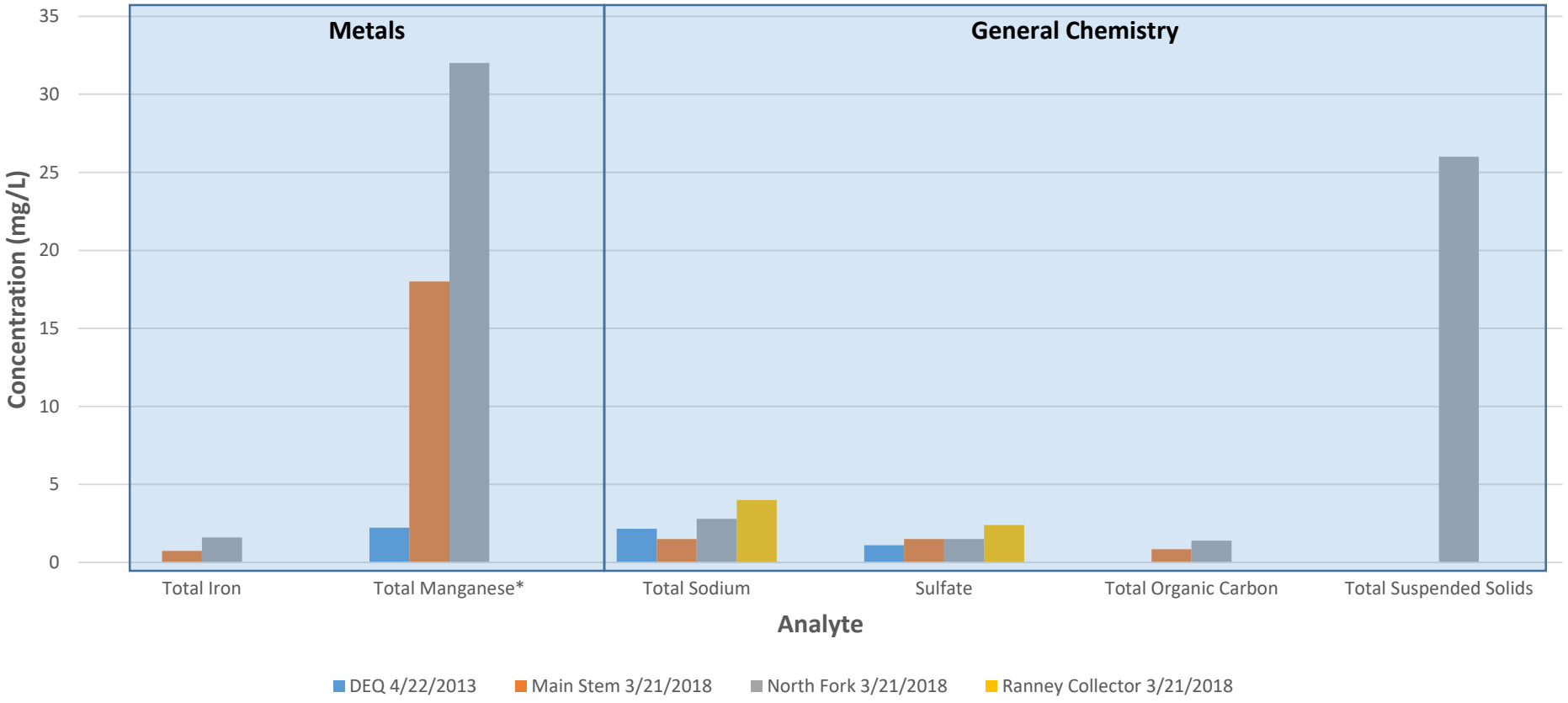
RESULTS – PRE-RAIN EVENT



RESULTS – AFTER RAIN EVENT



WATER QUALITY ASSESSMENT

- Initial Findings
  - Results indicate no significant water quality impacts.
    - Impacts specific to dissolved organic carbon, iron, and aluminum.
    - Undetected in Ranney well collector.

- However, difficult to make definitive conclusions from initial sampling events.

- Recent water quality data appear to be similar to historical sampling event results.

- Monitoring Plan developed for City as a result of case study

CONCLUSIONS

- Findings:
  - Generally, wildfires can impact water quality and treatment operations
  - Chetco watershed's physical characteristics have buffered effects to water quality from wildfire… so far.
  - Potential for post-fire impacts to the Ranney Collector from scour of the river channel appears low… so far.
  - The increase in wildfire activity could potentially overwhelm the watershed's resilience to wildfire impacts in the future.
  - Results indicate no significant water quality impacts to date.
  - Most parameters appear unaffected in surface water samples.
- Products:
  - "Wildfire Source Water Protection Sampling and Analysis Plan"
- Recommendations:
  - Continue low-cost monitoring of geomorphic and water quality changes → early warning detection
  - Collaboration and information sharing with federal, state, tribal, city, and private groups
  - Explore additional water supplies

Acknowledgements

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