

# Post-Fire Groundwater Quality Monitoring

California Dept. of Water Resources  
Northern Region Office  
Water Quality Section



Evan MacKinnon,  
Scott McReynolds

Camp Fire Water Resources Monitoring and Research Symposium

June 4, 2019

California State University, Chico Farm

# **Summary**

**California Dept. of Water Resources (DWR)**

**DWR's Water Routine Quality Programs  
(surface & groundwater)**

**Camp Fire Recovery Assistance**

**Preliminary Data**



# California Department of Water Resources (DWR)

## DWR Mission:

*To sustainably manage the **water** resources of California, in cooperation with other agencies, to benefit the state's people and **protect, restore, and enhance the natural and human environments.***

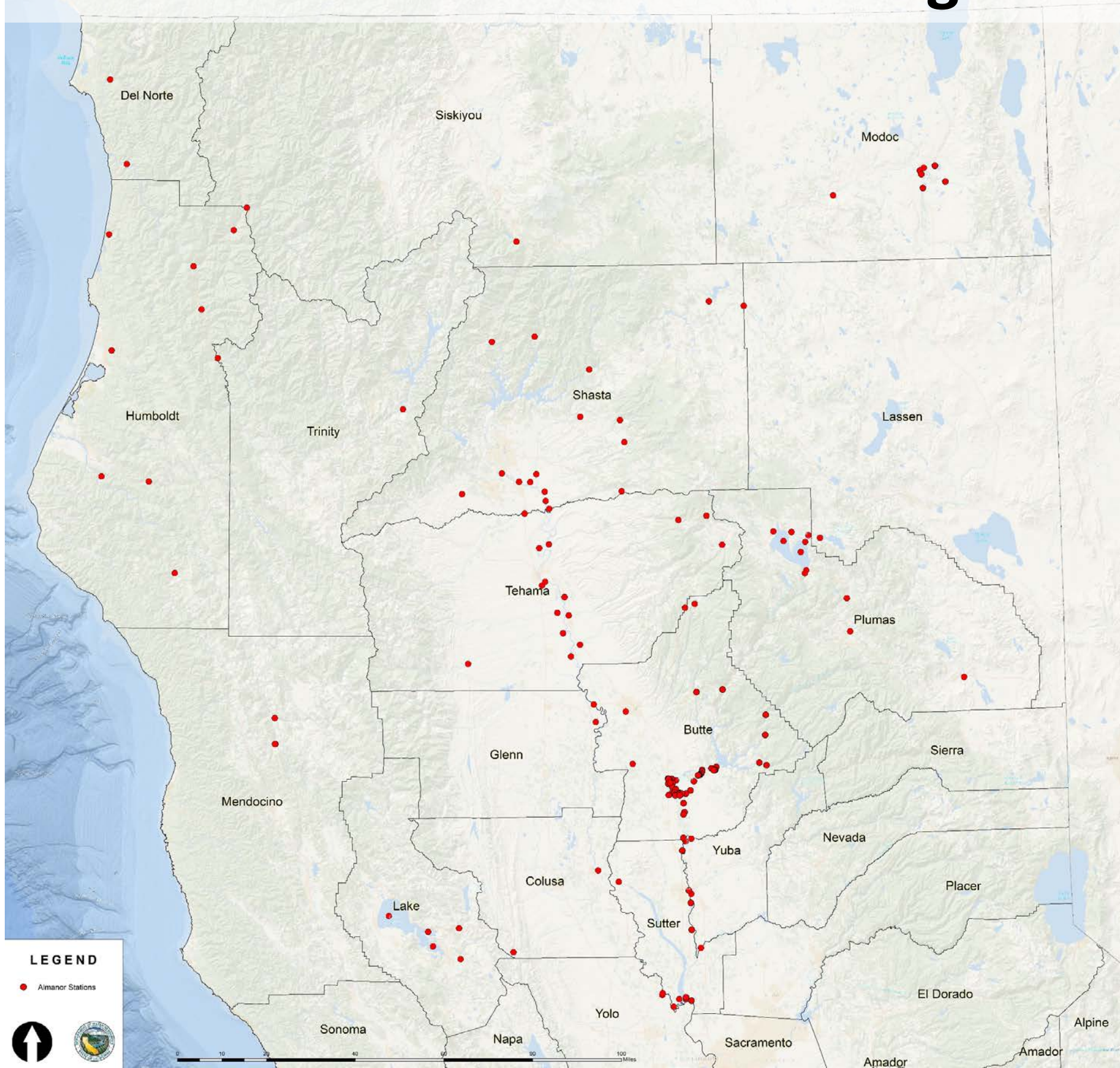
## What does DWR do?

- Manage and maintain water infrastructure (e.g. State Water Project)
- Power generation
- Respond to emergencies (e.g. flood, drought, catastrophic events)
- Ensure public safety and inform the public on water issues
- Use science to plan for the future (climate change impact mitigation)
- Perform large-scale ecological restoration and recreation projects

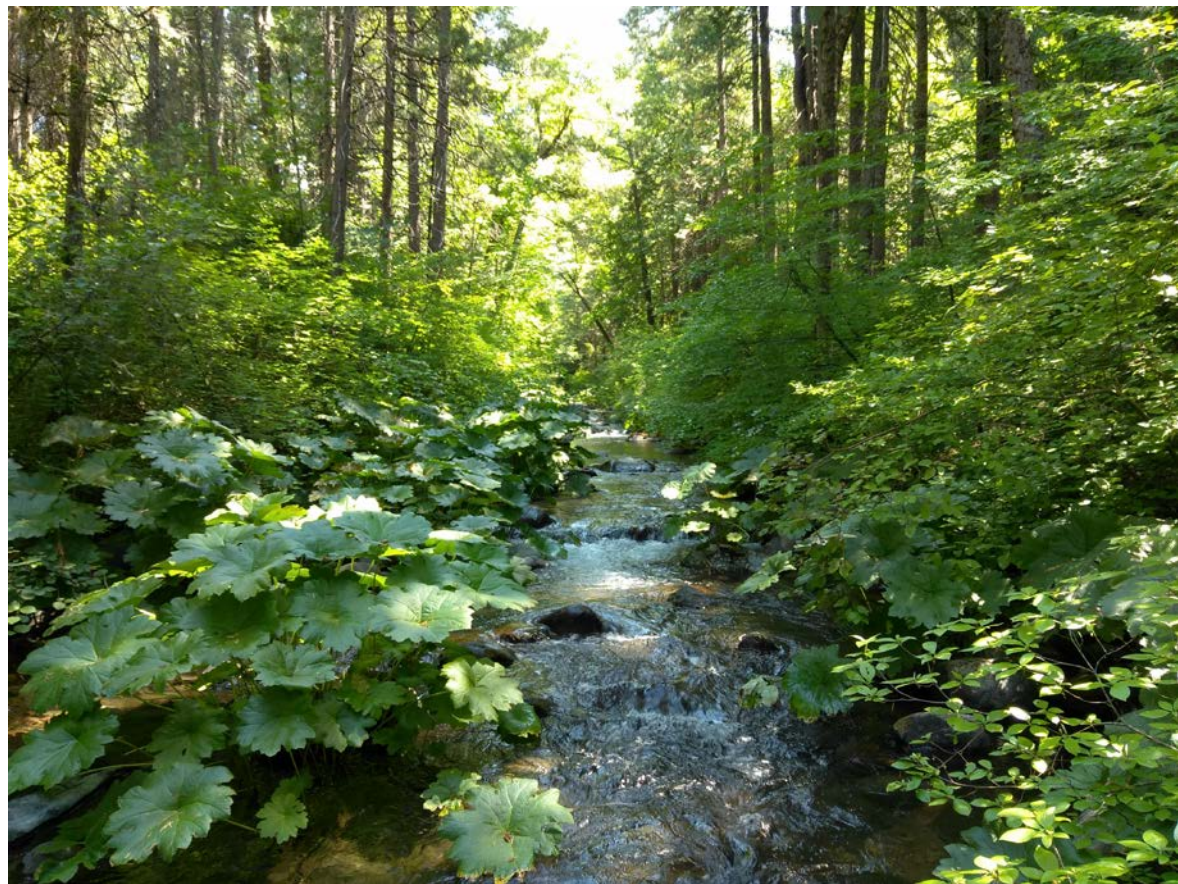
## Northern Region Office (NRO) – Water Quality Section

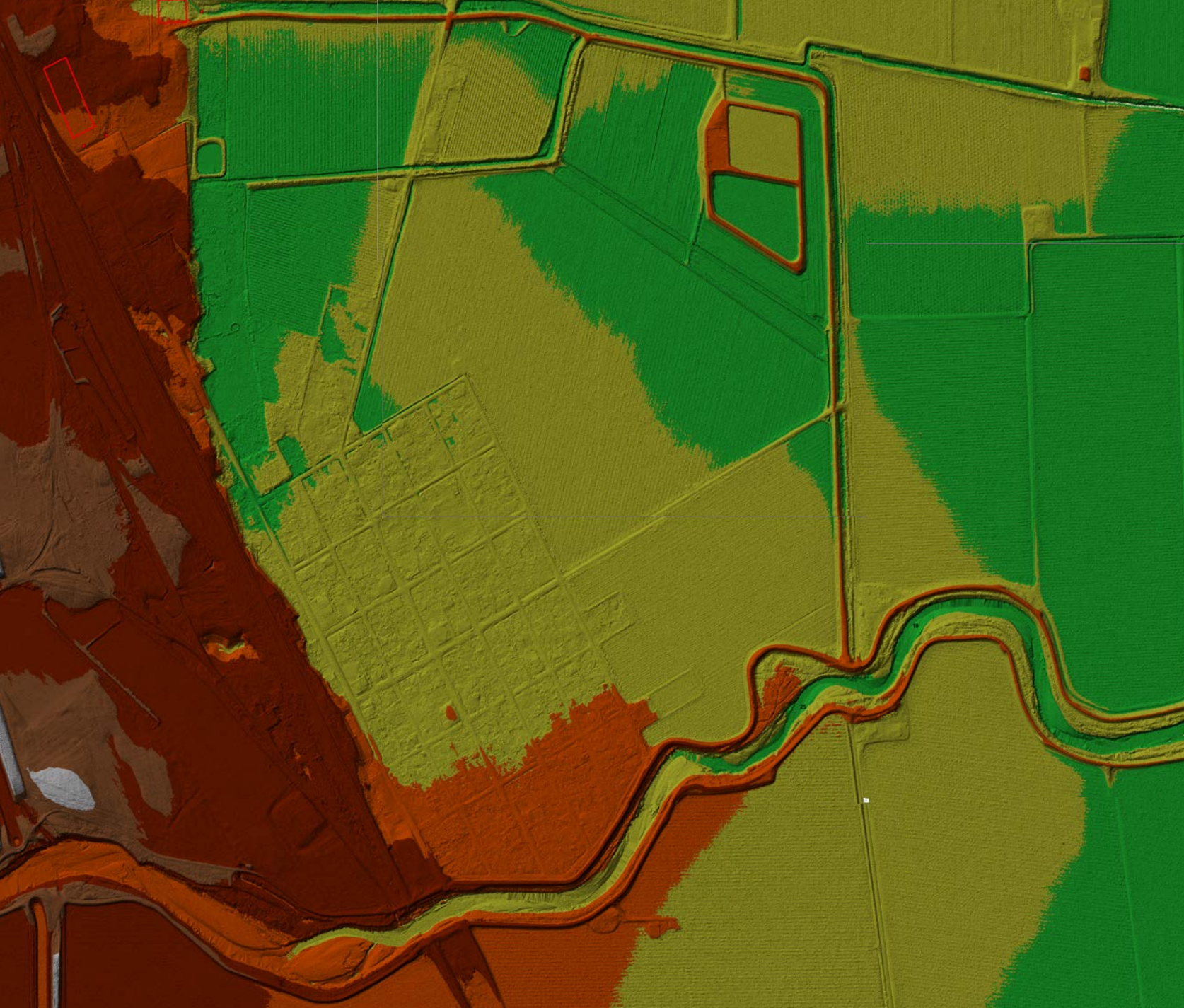
- Surface water and groundwater monitoring
- Natural resources monitoring (terrestrial and aquatic biology)

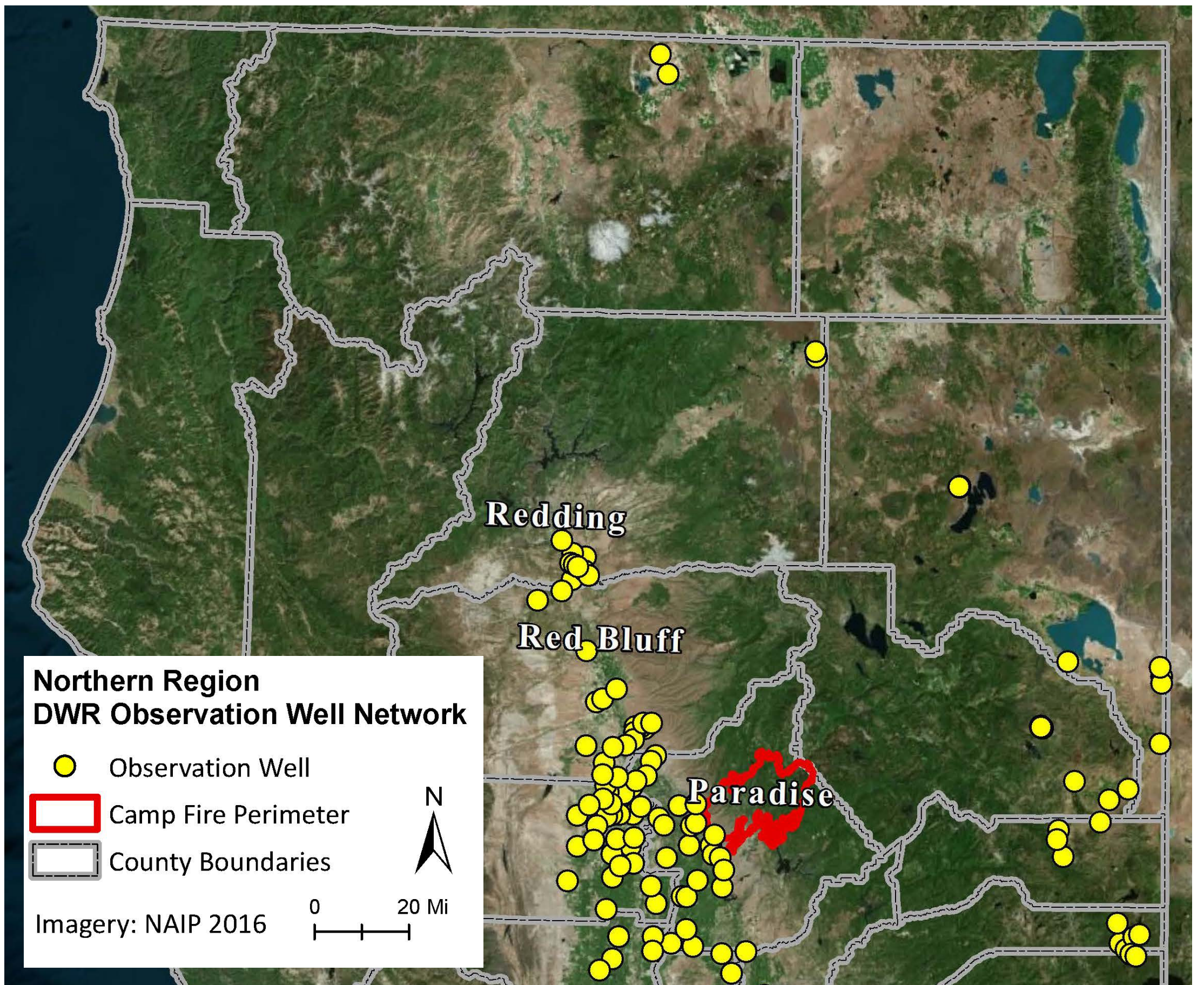
# DWR NRO Surface Water Monitoring Network





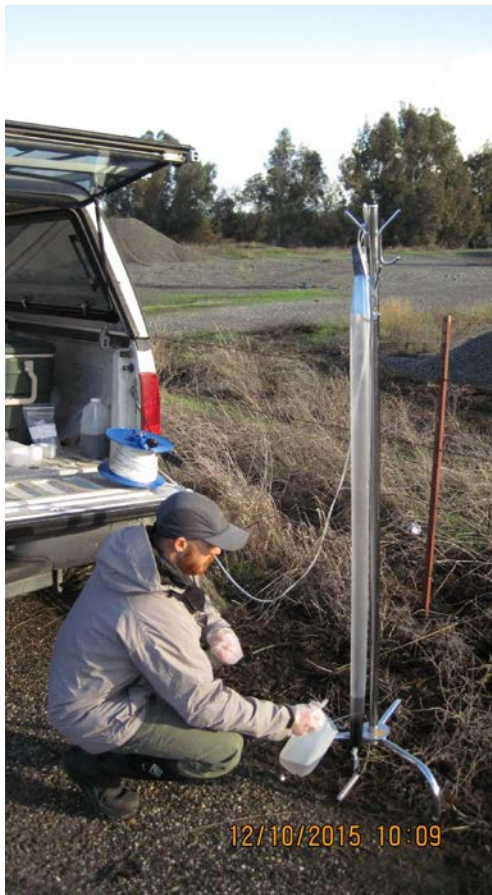












Home

- » Water Data Library Home
- » Groundwater Level Data
- » Water Quality Data
- » Continuous Data
- » Surface water, groundwater and water quality
- » Historical Publications
- » Well Standards (Bull. 74)
- » NHD Stewardship
- » Contact Information

**DWR CLIENTS ONLY**

- » Admin Login
- » Climate Data (Beta 1.1)
- » Climate Data (Access Prototype)
- » WCR Number

## Water Data Library

Use the map below to locate monitoring stations. You can find an area of interest if you zoom and pan the map. Use the search gox below to find features on the map such as the name of a city, park, landmark, lake, water feature, or zip code within California. Additional searches by data type are possible by clicking the links on the left. For help on these and other ways to find your data [click here](#).

### WDL STATION MAP

**Location Search**

To find monitoring stations for a specific area, enter the placename or zip code into the text box below

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**Site Type**

Select the desired site type using the checkboxes

Groundwater Level

Water Quality

[Include Historic Data](#)

Continuous Data

■ = Multiple Stations at one Location

● = Cluster, showing number of stations

**Cursor Coordinates (WGS84)**

Lat: 39.8017, Long: -121.8062

0 3 6mi

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## Camp Fire:

- Over 150,000 Acres
- Nearly 14,000 Residences
- Over 500 Commercial buildings
- Over 4,000 Other structures

# Water Quality Sampling Plan

## Surface water sampling

Scott McReynolds (DWR), Michael Parker (Water Board)

→ Target surface water quality parameters adopted from Carr Fire

## Groundwater sampling

Multi-agency meetings:

**Dr. Michelle Newcomer**

Lawrence Berkeley National Laboratory

**Michael Parker**

Central Valley Regional Water Quality Control Board

**Christina Buck**

Butte County Water and Resource Conservation

**Alisha Wenzel**

Central Valley Regional Water Quality Control Board

→ List of groundwater quality parameters

→ Approach to groundwater sampling

# What are possible impacts to water?



# What are possible impacts to water?



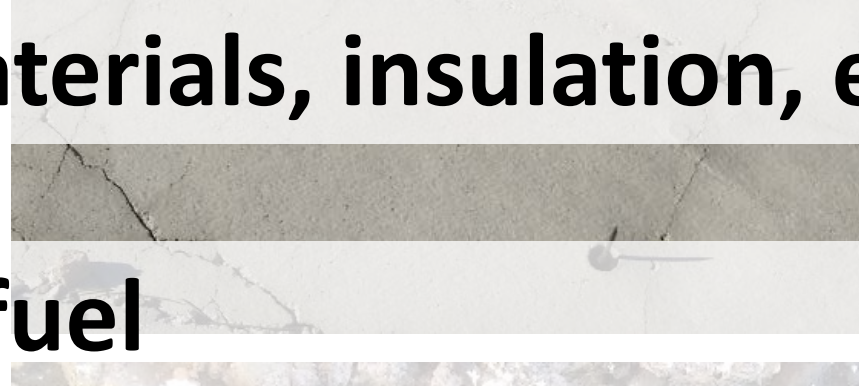
Building materials, insulation, electrical systems



# What are possible impacts to water?



**Building materials, insulation, electrical systems**



**Vehicles & fuel**

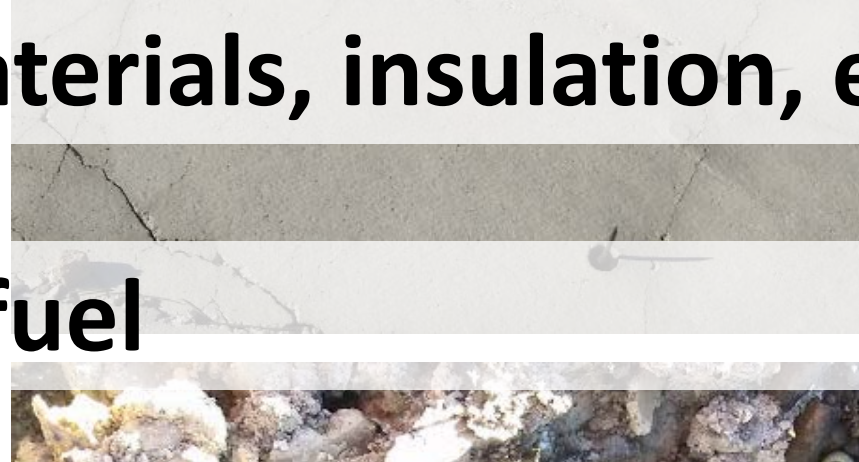




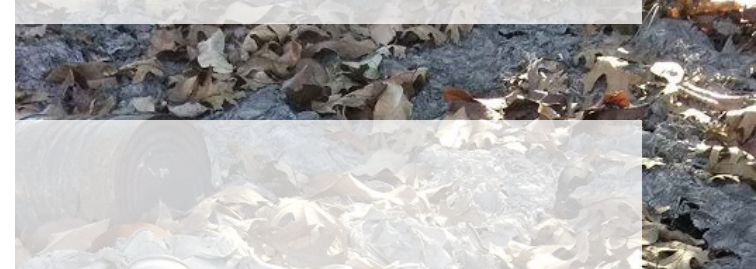
# What are possible impacts to water?



**Building materials, insulation, electrical systems**



**Vehicles & fuel**



**Plastics, chemicals, paints, etc.**



# Lab Analysis

Constituent	Method	Units
<b>Minerals</b>		
Total suspended solids	2540D	mg/L
Total dissolved solids	2540C	mg/L
Alkalinity	2320B	mg/L
Total and dissolved hardness	2340B	mg/L
Total and dissolved calcium	200.7 (D)	mg/L
Total and dissolved magnesium	200.7 (D)	mg/L
Dissolved sodium	200.7 (D)	mg/L
Dissolved potassium	200.7 (D)	mg/L
Dissolved sulfate	300.0	mg/L
Dissolved chloride	300.0	mg/L
Dissolved boron	200.7 (D)	mg/L
Dissolved carbonate, bicarbonate, and hydroxide	4500-CO2D	mg/L
Dissolved magnesium	200.7	mg/L
Specific Conductance	2510-B	µS/cm
pH (acidity)	2320B	pH units
<b>Nutrients</b>		
Total ammonia as nitrogen	350.1	mg/L
Total Kjeldahl nitrogen	351.2	mg/L
Total organic nitrogen	351.2	mg/L
Total and dissolved ammonia	350.1	mg/L
Dissolved nitrate	300.0	mg/L
Dissolved nitrate + nitrite	4500-NO3-F	mg/L
Dissolved orthophosphate	365.1	mg/L
Total phosphorus	365.4	mg/L
Total and dissolved organic carbon	415.1 (T) (D) Ox	mg/L
<b>Trace elements and metals</b>		
Total and dissolved copper	1638	µg/L
Total and dissolved aluminum	1638	µg/L
Total and dissolved cadmium	1638	µg/L
Total and dissolved chromium	1638	µg/L
Total and dissolved arsenic	1638	µg/L
Total and dissolved iron	1638	µg/L
Total and dissolved lead	1638	µg/L
Total and dissolved manganese	1638	µg/L
Total and dissolved nickel	1638	µg/L
Total and dissolved selenium	1638	µg/L
Total and dissolved silver	1638	µg/L
Total and dissolved zinc	1638	µg/L

Constituent	Method	Units
<b>Mercury</b>	245.1 - Mercury (CVAA)	mg/L
<b>Bacteria</b>		
E. coli	SM 9223B	MPN/100ml
Fecal coliform	SM 9221B/E	MPN/100ml
<b>Volatile Organic Compounds</b>		
Benzene	8260B - Volatile Organic Compounds (GC/MS)	µg/L
Polycyclic aromatic hydrocarbons (PAHs)	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Acenaphthene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Acenaphthylene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Anthracene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Benzo[a]anthracene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Benzo[a]pyrene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Benzo[b]fluoranthene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Benzo[g,h,i]perylene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Benzo[k]fluoranthene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Chrysene ND	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Dibenz(a,h)anthracene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Fluoranthene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Fluorene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Indeno[1,2,3-cd]pyrene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Naphthalene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Phenanthrene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
-Pyrene	8270C SIM - Semivolatile Organic Compounds (GC/MS SIM)	µg/L
<b>Gasoline Range Organics</b>	<b>8015B - Gasoline Range Organics (GC)</b>	µg/L
<b>Diesel Range Organics</b>	<b>8015B - Diesel Range Organics (DRO) (GC)</b>	mg/L
<b>Polychlorinated Biphenyls</b>	<b>8082 - Polychlorinated Biphenyls (PCBs) (GC)</b>	µg/L
-Aroclor 1016	8082 - Polychlorinated Biphenyls (PCBs) (GC)	µg/L
-Aroclor 1221	8082 - Polychlorinated Biphenyls (PCBs) (GC)	µg/L
-Aroclor 1232	8082 - Polychlorinated Biphenyls (PCBs) (GC)	µg/L
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-Aroclor 1260	8082 - Polychlorinated Biphenyls (PCBs) (GC)	µg/L



**Can these chemicals get into groundwater?**

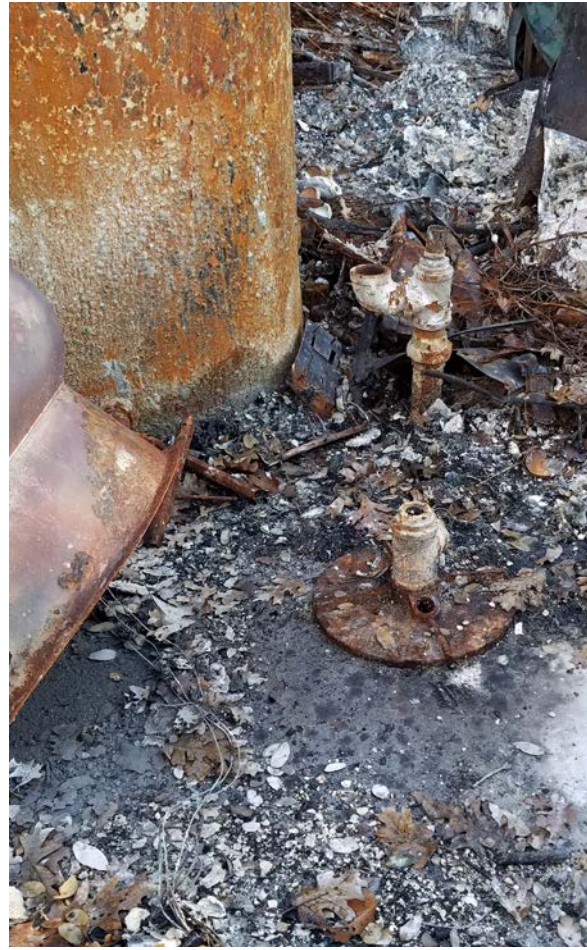
# Can these chemicals get into groundwater?



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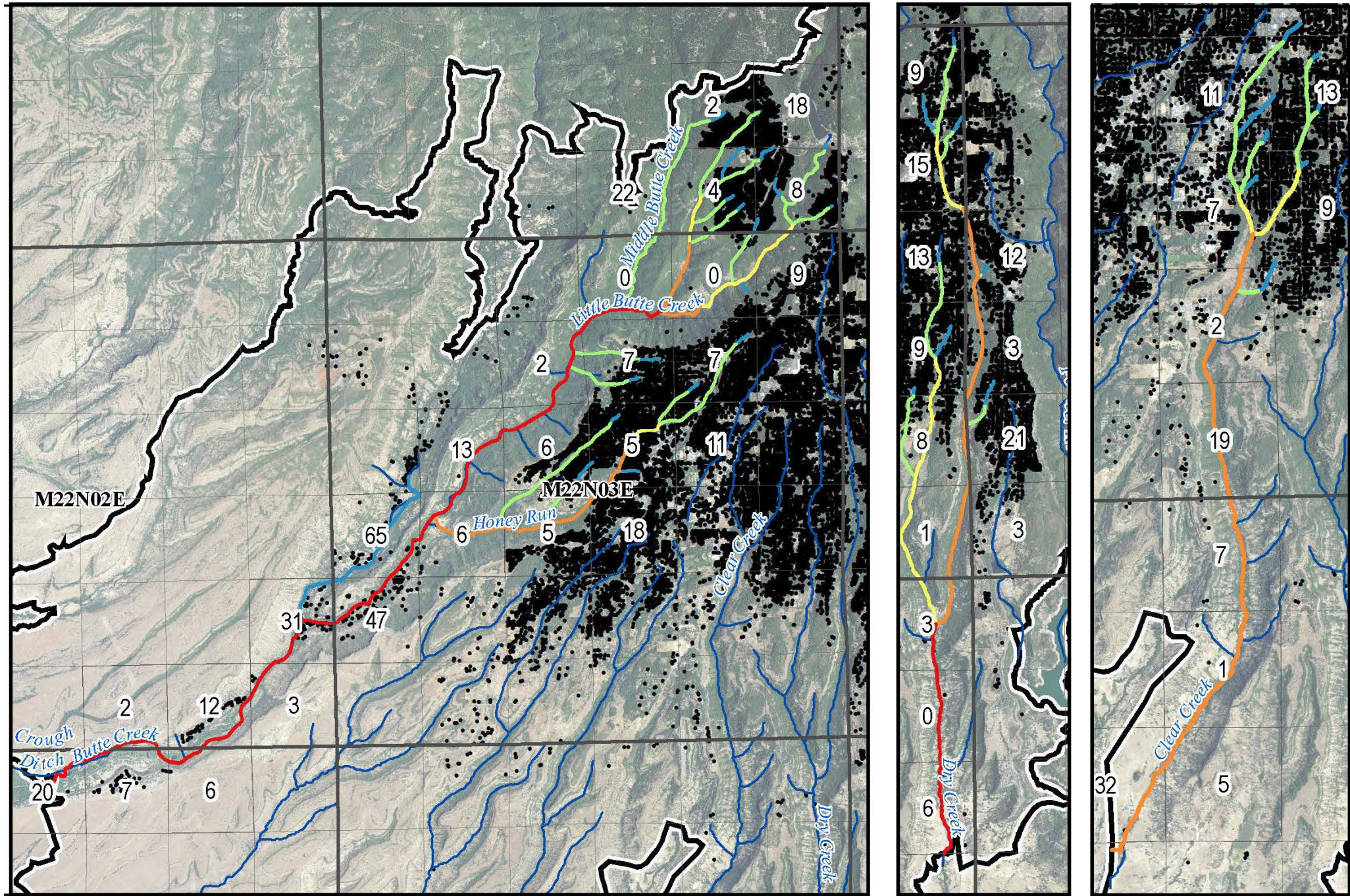


# Can these chemicals get into groundwater?



# Groundwater Sampling

# Groundwater Sampling



**Groundwater Supply Wells  
Adjacent to Accumulated  
Flow of Damaged Structures  
in the Camp Fire Perimeter**

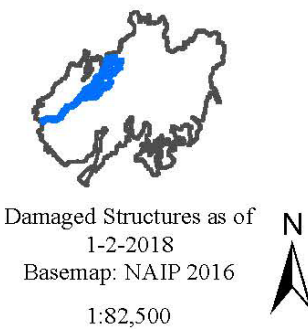
**PLSS Section**  
 # of Wells in Section  
**Damaged Structures**

**Flow from Damaged Structures**

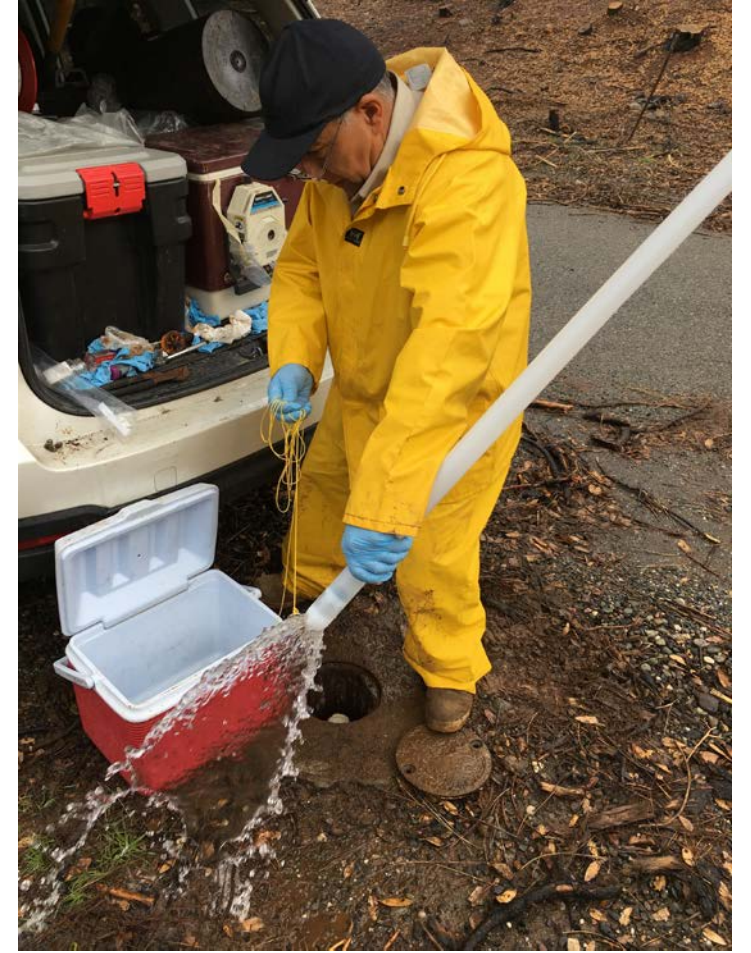
- 51 to 100 Structures
- 101 to 500 Structures
- 501 to 1000 Structures
- 1001 to 2000 Structures
- 2001 to 5000 Structures

**NHD Streams and Rivers**

- 
- Camp Fire Perimeter**
- NHD Waterbodies**
- PLSS Township Sections**



# Groundwater Sampling



Water Quality Parameter	Paradise Ridge (n=5)	Butte Creek Canyon (n=3)
<b>Well Depth (feet)</b>	18	74
<b>Bacteria</b>		
Fecal Coliforms (MPN/100ml)	NA	ND
E. coli (MPN/100ml)	NA	ND
<b>Nutrients</b>		
Dissolved Ammonia mg/L as N	ND	0.07 ± 0.07
Ammonia (as N) (mg/l)	ND	ND
Total Kjeldahl Nitrogen (mg/l)	ND	ND
Dissolved Nitrate + Nitrite mg/L as N	1.34 ± 0.49	0.61 ± 0.61
Dissolved Nitrate mg/L	6.79 ± 2.79	2.74 ± 2.74
Dissolved Organic Carbon mg/L as C	0.18 ± 0.18	0.63 ± 0.13
Dissolved Ortho-phosphate mg/L as P	ND	0.04 ± 0.02
<b>Minerals</b>		
Dissolved Calcium mg/L	5.20 ± 1.52	27.60 ± 4.30
Dissolved Chloride mg/L	4.26 ± 1.52	9.82 ± 3.71
Dissolved Magnesium mg/L	3.32 ± 0.93	18.90 ± 2.80
Dissolved Potassium mg/L	0.47 ± 0.21	ND
Dissolved Potassium mg/L	0.23 ± 0.14	1.95 ± 0.04
Dissolved Sodium mg/L	3.16 ± 0.95	8.61 ± 1.07
Dissolved Sulfate mg/L	3.44 ± 2.17	9.63 ± 4.33
pH pH Units	5.22 ± 1.31	7.90 ± 0.00
Specific Conductance $\mu\text{S}/\text{cm}@25^\circ\text{C}$	73.00 ± 20.77	328.33 ± 43.10
Total Alkalinity mg/L as CaCO3	20.20 ± 5.27	149.33 ± 13.93
Total Dissolved Solids mg/L	50.00 ± 14.30	198.00 ± 23.18
Total Suspended Solids mg/L EPA 160.2 [1]*	ND	8.00 ± 8.00
Total Organic Carbon mg/L as C	1.40 ± 1.17	0.70 ± 0.10
Total Phosphorus mg/L as P	0.13 ± 0.09	0.14 ± 0.09
Dissolved Hardness mg/L as CaCO3	26.60 ± 7.49	146.67 ± 22.30
<b>Trace Elements and Metals</b>		
Dissolved Aluminum $\mu\text{g}/\text{L}$	5.91 ± 2.23	0.38 ± 0.13
Dissolved Arsenic $\mu\text{g}/\text{L}$	0.03 ± 0.03	4.69 ± 3.13
Dissolved Boron mg/L	ND	ND
Dissolved Cadmium $\mu\text{g}/\text{L}$	ND	ND
Dissolved Chromium $\mu\text{g}/\text{L}$	1.28 ± 0.37	1.36 ± 0.43
Dissolved Copper $\mu\text{g}/\text{L}$	0.50 ± 0.17	1.04 ± 0.47
Dissolved Iron $\mu\text{g}/\text{L}$	3.96 ± 0.71	17.25 ± 16.03
Dissolved Lead $\mu\text{g}/\text{L}$	ND	0.03 ± 0.03
Dissolved Manganese $\mu\text{g}/\text{L}$	8.16 ± 2.27	549.07 ± 440.36
Dissolved Nickel $\mu\text{g}/\text{L}$	0.80 ± 0.24	0.53 ± 0.15
Mercury (mg/l)	ND	ND
Dissolved Selenium $\mu\text{g}/\text{L}$	ND	0.60 ± 0.16
Dissolved Silver $\mu\text{g}/\text{L}$	ND	ND
Dissolved Zinc $\mu\text{g}/\text{L}$	6.40 ± 2.94	1.96 ± 0.93
Total Aluminum $\mu\text{g}/\text{L}$	513.56 ± 235.32	1.33 ± 0.31
Total Arsenic $\mu\text{g}/\text{L}$	0.10 ± 0.06	12.35 ± 10.51
Total Cadmium $\mu\text{g}/\text{L}$	ND	ND
Total Chromium $\mu\text{g}/\text{L}$	3.19 ± 1.43	ND
Total Copper $\mu\text{g}/\text{L}$	2.23 ± 1.00	3.81 ± 2.84
Total Iron $\mu\text{g}/\text{L}$	447.00 ± 243.39	1860.86 ± 1731.14
Total Lead $\mu\text{g}/\text{L}$	0.19 ± 0.06	0.16 ± 0.11
Total Manganese $\mu\text{g}/\text{L}$	21.24 ± 7.81	557.73 ± 447.12
Total Nickel $\mu\text{g}/\text{L}$	2.02 ± 1.23	0.93 ± 0.24
Total Selenium $\mu\text{g}/\text{L}$	ND	0.64 ± 0.15
Total Silver $\mu\text{g}/\text{L}$	ND	ND
Total Zinc $\mu\text{g}/\text{L}$	8.34 ± 3.14	2.24 ± 0.94

Water Quality Parameter	Paradise Ridge (n=5)	Butte Creek Canyon (n=3)
<b>Well Depth (feet)</b>	18	74
<b>Volatile Organic Compounds</b>		
Benzene ( $\mu\text{g}/\text{l}$ )	ND	ND
Acenaphthene ( $\mu\text{g}/\text{l}$ )	ND	ND
Acenaphthylene ( $\mu\text{g}/\text{l}$ )	ND	ND
Anthracene ( $\mu\text{g}/\text{l}$ )	ND	ND
Benzo[a]anthracene ( $\mu\text{g}/\text{l}$ )	ND	ND
Benzo[a]pyrene ( $\mu\text{g}/\text{l}$ )	ND	ND
Benzo[b]fluoranthene ( $\mu\text{g}/\text{l}$ )	ND	ND
Benzo[g,h,i]perylene ( $\mu\text{g}/\text{l}$ )	ND	ND
Benzo[k]fluoranthene ( $\mu\text{g}/\text{l}$ )	ND	ND
Chrysene ND ( $\mu\text{g}/\text{l}$ )	ND	ND
Dibenz(a,h)anthracene ( $\mu\text{g}/\text{l}$ )	ND	ND
Fluoranthene ( $\mu\text{g}/\text{l}$ )	ND	ND
Fluorene ( $\mu\text{g}/\text{l}$ )	ND	ND
Indeno[1,2,3-cd]pyrene ( $\mu\text{g}/\text{l}$ )	ND	ND
Naphthalene ( $\mu\text{g}/\text{l}$ )	ND	ND
Phenanthrene ( $\mu\text{g}/\text{l}$ )	ND	ND
Pyrene ( $\mu\text{g}/\text{l}$ )	ND	ND
<b>Gasoline Range Organics</b>		
GRO (C4-C12) ( $\mu\text{g}/\text{l}$ )	ND	ND
<b>Polychlorinated Biphenyls</b>		
Aroclor 1016 ( $\mu\text{g}/\text{l}$ )	ND	ND
Aroclor 1221 ( $\mu\text{g}/\text{l}$ )	ND	ND
Aroclor 1232 ( $\mu\text{g}/\text{l}$ )	ND	ND
Aroclor 1242 ( $\mu\text{g}/\text{l}$ )	ND	ND
Aroclor 1248 ( $\mu\text{g}/\text{l}$ )	ND	ND
Aroclor 1254 ( $\mu\text{g}/\text{l}$ )	ND	ND
Aroclor 1260 ( $\mu\text{g}/\text{l}$ )	ND	ND

# Results so far...

Water Quality Parameter	Paradise Ridge (n=5)	Butte Creek Canyon (n=3)
<b>Well Depth (feet)</b>	18	74
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Dissolved Calcium mg/L	5.20 ± 1.52	27.60 ± 4.30
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Dissolved Magnesium mg/L	3.32 ± 0.93	18.90 ± 2.80
Dissolved Potassium mg/L	0.47 ± 0.21	ND
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Non-Detects

Results so far...

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Dissolved Potassium mg/L	0.47 ± 0.21	ND
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Dissolved Sodium mg/L	3.16 ± 0.95	8.61 ± 1.07
Dissolved Sulfate mg/L	3.44 ± 2.17	9.63 ± 4.33
pH pH Units	5.22 ± 1.31	7.90 ± 0.00
Specific Conductance µS/cm@25°C	73.00 ± 20.77	328.33 ± 43.10
Total Alkalinity mg/L as CaCO3	20.20 ± 5.27	149.33 ± 13.93
Total Dissolved Solids mg/L	50.00 ± 14.30	198.00 ± 23.18
Total Suspended Solids mg/L EPA 160.1*]	ND	8.00 ± 8.00
Total Organic Carbon mg/L as C	1.40 ± 1.17	0.70 ± 0.10
Total Phosphorus mg/L as P	0.13 ± 0.09	0.14 ± 0.09
Dissolved Hardness mg/L as CaCO3	26.60 ± 7.49	146.67 ± 22.30
<b>Trace Elements and Metals</b>		
Dissolved Aluminum µg/L	5.91 ± 2.23	0.38 ± 0.13
Dissolved Arsenic µg/L	0.03 ± 0.03	4.69 ± 3.13
Dissolved Boron mg/L	ND	ND
Dissolved Cadmium µg/L	ND	ND
Dissolved Chromium µg/L	1.28 ± 0.37	1.36 ± 0.43
Dissolved Copper µg/L	0.50 ± 0.17	1.04 ± 0.47
Dissolved Iron µg/L	3.96 ± 0.71	17.25 ± 16.03
Dissolved Lead µg/L	ND	0.03 ± 0.03
Dissolved Manganese µg/L	8.16 ± 2.27	549.07 ± 440.36
Dissolved Nickel µg/L	0.80 ± 0.24	0.53 ± 0.15
Mercury (mg/l)	ND	ND
Dissolved Selenium µg/L	ND	0.60 ± 0.16
Dissolved Silver µg/L	ND	ND
Dissolved Zinc µg/L	6.40 ± 2.94	1.96 ± 1.03
Total Aluminum µg/L	513.56 ± 235.32	1.33 ± 0.31
Total Arsenic µg/L	0.10 ± 0.06	12.35 ± 10.51
Total Cadmium µg/L	ND	ND
Total Chromium µg/L	3.19 ± 1.43	ND
Total Copper µg/L	2.23 ± 1.00	3.81 ± 2.84
Total Iron µg/L	447.00 ± 243.39	1860.86 ± 1731.14
Total Lead µg/L	0.19 ± 0.06	0.16 ± 0.11
Total Manganese µg/L	21.24 ± 7.81	557.73 ± 447.22
Total Nickel µg/L	2.02 ± 1.23	0.53 ± 0.24
Total Selenium µg/L	ND	0.64 ± 0.15
Total Silver µg/L	ND	ND
Total Zinc µg/L	8.34 ± 3.14	2.24 ± 0.94

Al, Fe, Mn

Water Quality Parameter	Paradise Ridge (n=5)	Butte Creek Canyon (n=3)
<b>Well Depth (feet)</b>	18	74
<b>Volatile Organic Compounds</b>		
Benzene (µg/l)	ND	ND
Acenaphthene (µg/l)	ND	ND
Acenaphthylene (µg/l)	ND	ND
Anthracene (µg/l)	ND	ND
Benzo[a]anthracene (µg/l)	ND	ND
Benzo[a]pyrene (µg/l)	ND	ND
Benzo[b]fluoranthene (µg/l)	ND	ND
Benzo[g,h,i]perylene (µg/l)	ND	ND
Benzo[k]fluoranthene (µg/l)	ND	ND
Chrysene ND (µg/l)	ND	ND
Dibenz(a,h)anthracene (µg/l)	ND	ND
Fluoranthene (µg/l)	ND	ND
Fluorene (µg/l)	ND	ND
Indeno[1,2,3-cd]pyrene (µg/l)	ND	ND
Naphthalene (µg/l)	ND	ND
Phenanthrene (µg/l)	ND	ND
Pyrene (µg/l)	ND	ND
<b>Gasoline Range Organics</b>		
GRO (C4-C12) (µg/l)	ND	ND
<b>Polychlorinated Biphenyls</b>		
Aroclor 1016 (µg/l)	ND	ND
Aroclor 1221 (µg/l)	ND	ND
Aroclor 1232 (µg/l)	ND	ND
Aroclor 1242 (µg/l)	ND	ND
Aroclor 1248 (µg/l)	ND	ND
Aroclor 1254 (µg/l)	ND	ND
Aroclor 1260 (µg/l)	ND	ND

Non-Detects

Results so far...

# Moving Forward...

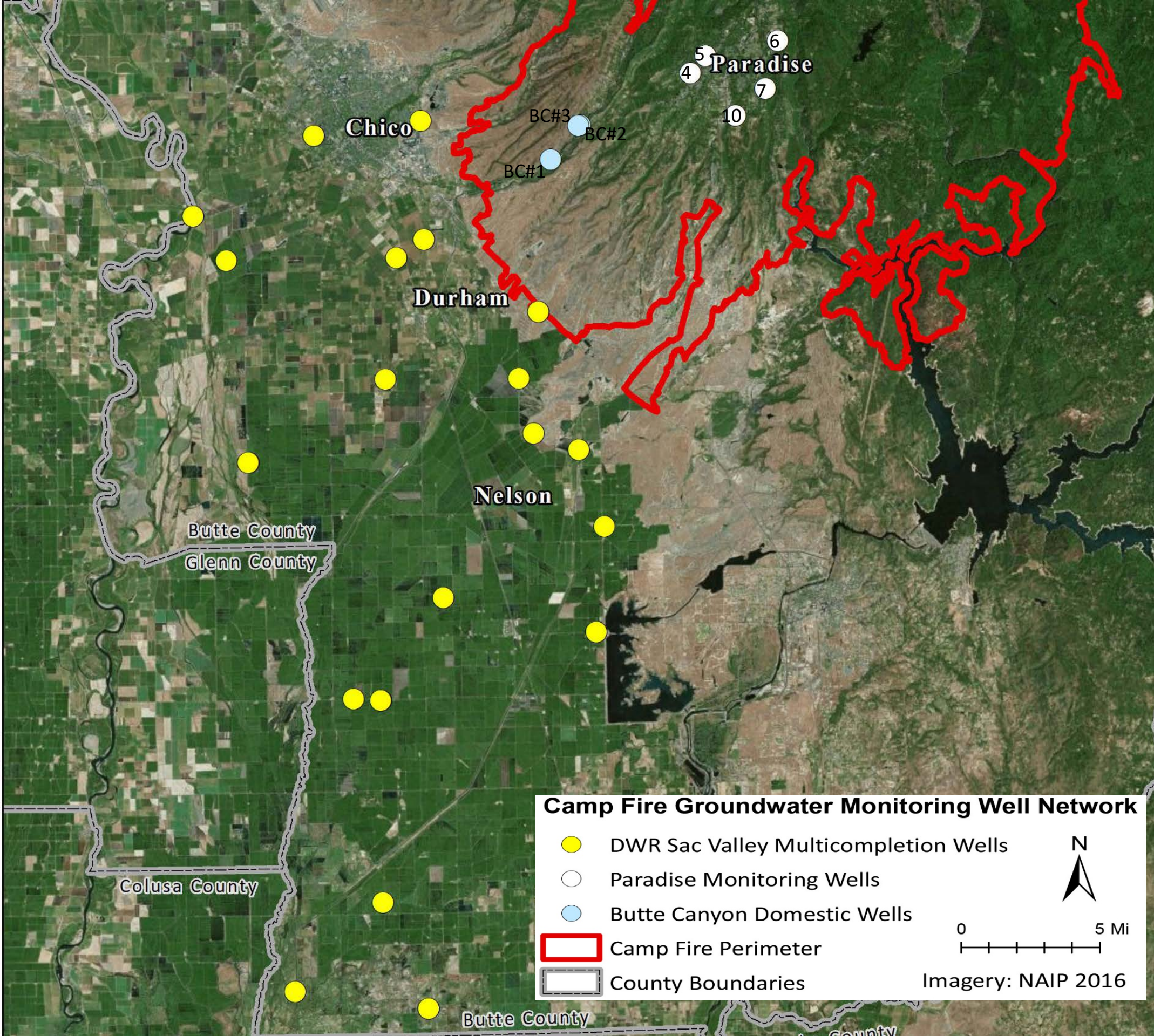




**Moving Forward...**

**Sample downgradient (Sacramento Valley)?**





**Camp Fire Groundwater Monitoring Well Network**

-  DWR Sac Valley Multicompletion Wells
  -  Paradise Monitoring Wells
  -  Butte Canyon Domestic Wells
  -  Camp Fire Perimeter
  -  County Boundaries
- 0 5 Mi
- Imagery: NAIP 2016

# Moving Forward...

**Sample downgradient (Sacramento Valley)?**

**Did we miss detecting an initial contaminant flush?**

**Are pollutants accumulating in Sacramento Valley?**



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**Pre- and post-fire comparisons**

**Use historical data from monitoring wells**



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**Use historical data from monitoring wells**

**Groundwater modeling?**

**Where are contaminants going?**



# Moving Forward...

**Sample downgradient (Sacramento Valley)?**

**Did we miss detecting an initial contaminant flush?**

**Are pollutants accumulating in Sacramento Valley?**

**Pre- and post-fire comparisons**

**Use historical data from monitoring wells**

**Groundwater modeling?**

**Where are contaminants going?**

**Long-term monitoring of Valley wells**

**How long? How persistent? Temporal trends?**



Thank  
You

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