



The DTSC Investigation of Perchlorate in Groundwater of the Eastern Chino Basin

May 2019

Michael Foster, PhD, PG

Acknowledgements and Disclaimer

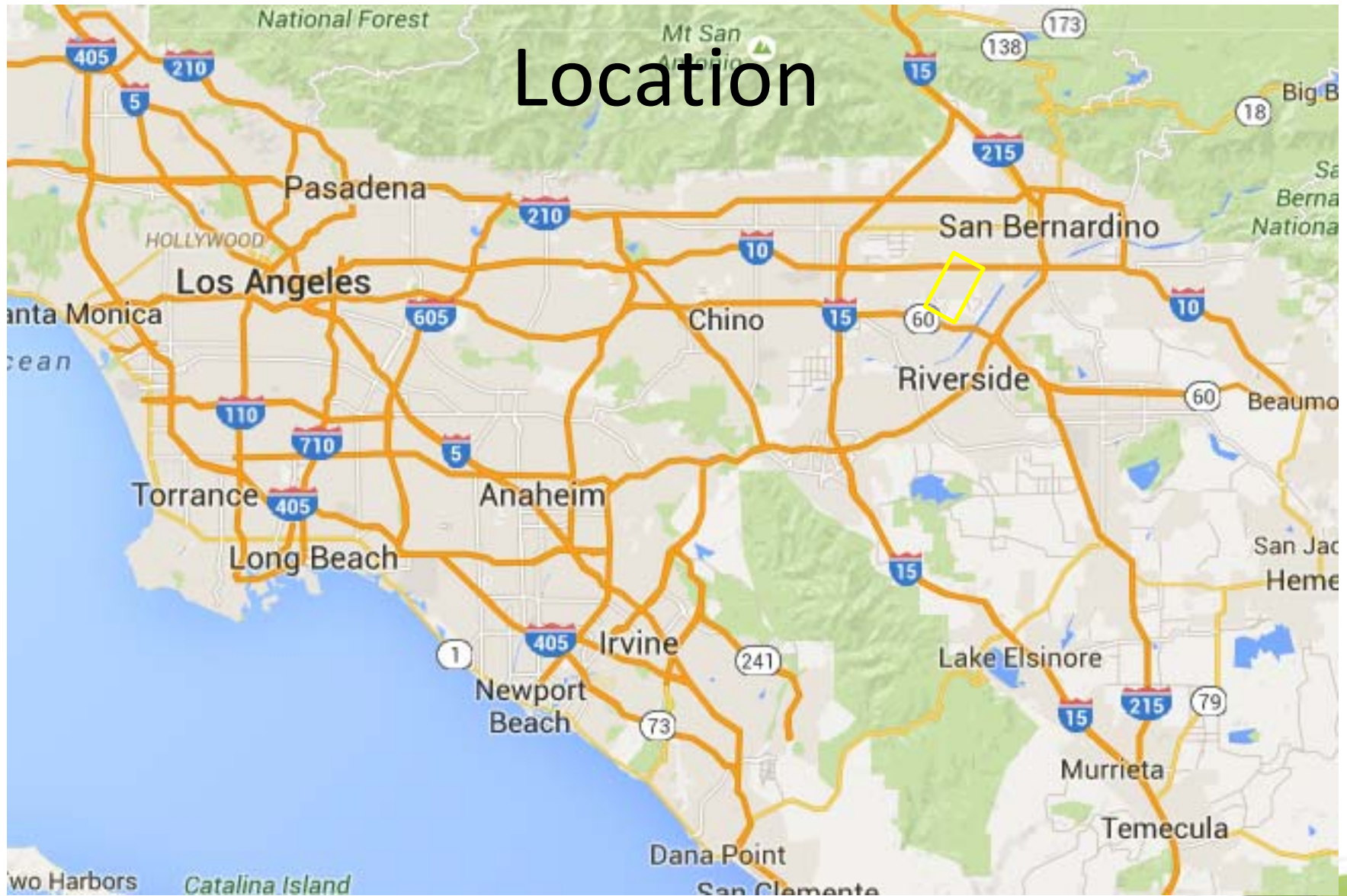
State of California Department of
Toxic Substances Control

- Legacy Landfill Unit

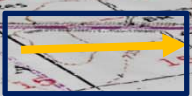
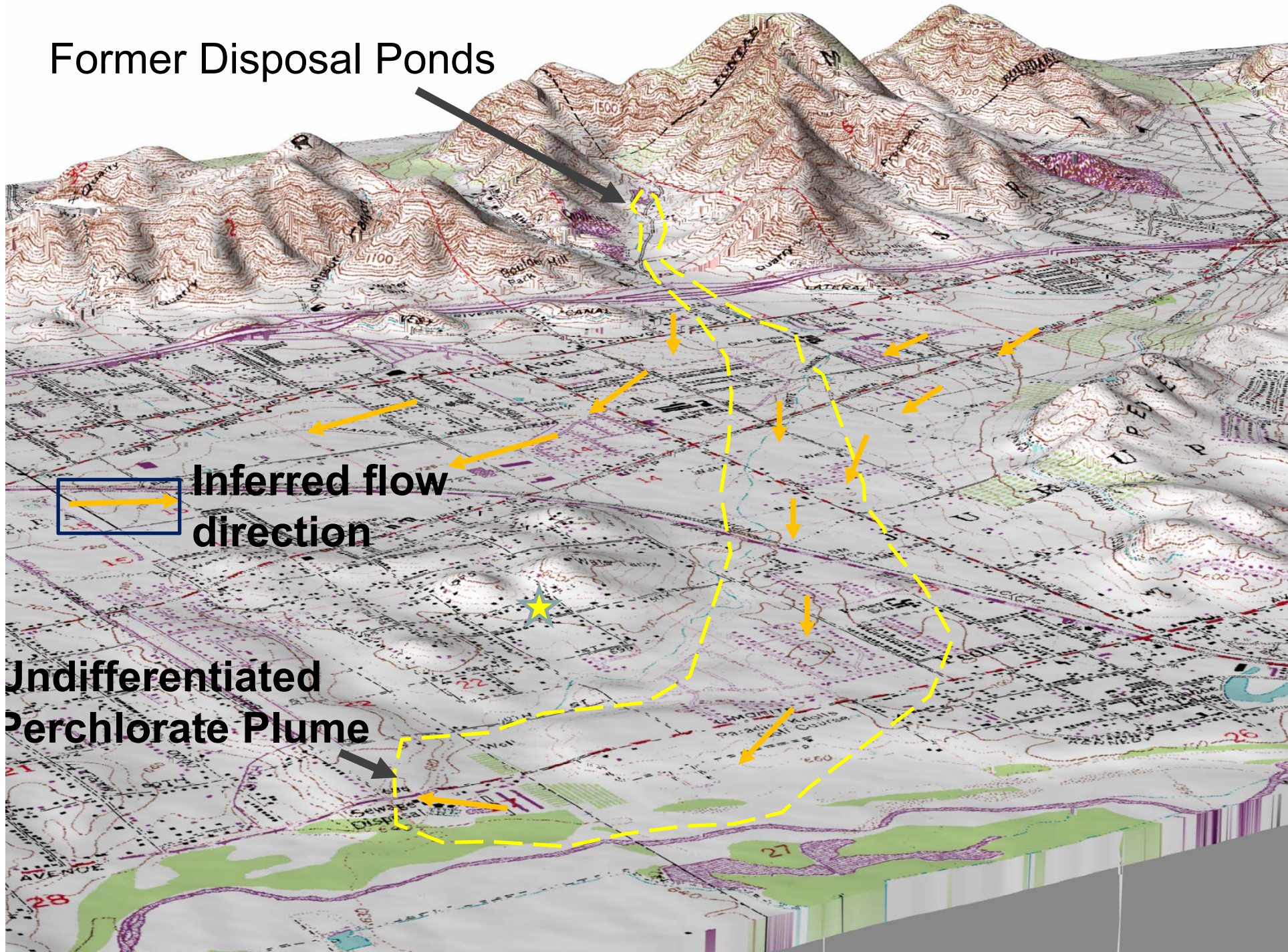
- Lindsay Ellingson, EIT



Location



Former Disposal Ponds



Inferred flow direction

Indifferentiated Perchlorate Plume



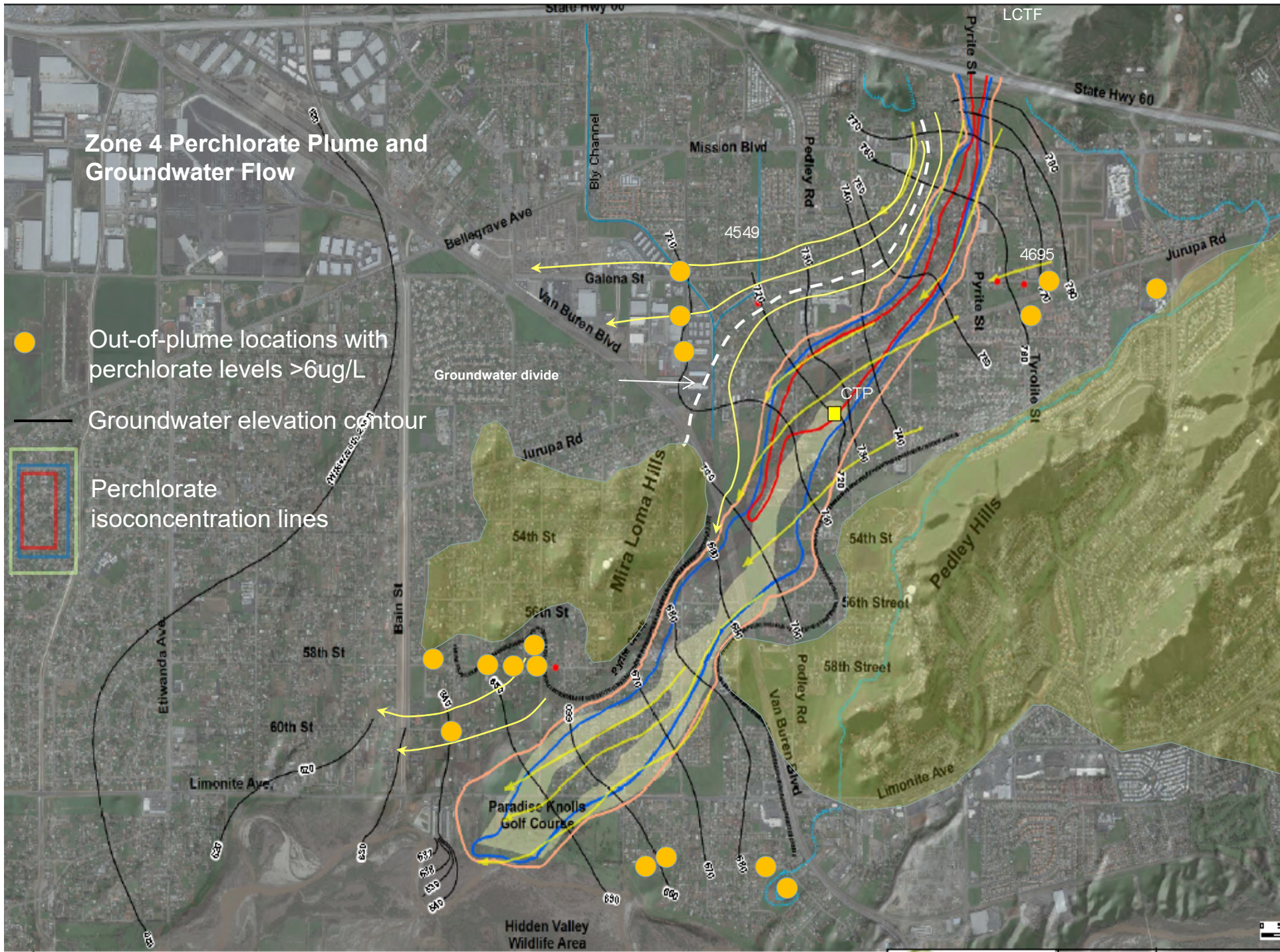


Stringfellow Superfund Site 1980

Perchlorate Primer

- ClO_4^-
- Used as a solid rocket propellant – also explosives, fireworks, flares and sodium hypochlorite in water treatment systems
- Highly soluble and stable in water (no retardation)
- CA MCL of 6 ug/L
- Interferes with thyroid function prevents the uptake of iodine
- Naturally occurring in evaporite deposits notably from Atacama desert (the source of Chilean nitrate fertilizers)
- Synthetic perchlorate is isotopically different based on stable isotopes of Cl and O in dissolved perchlorate

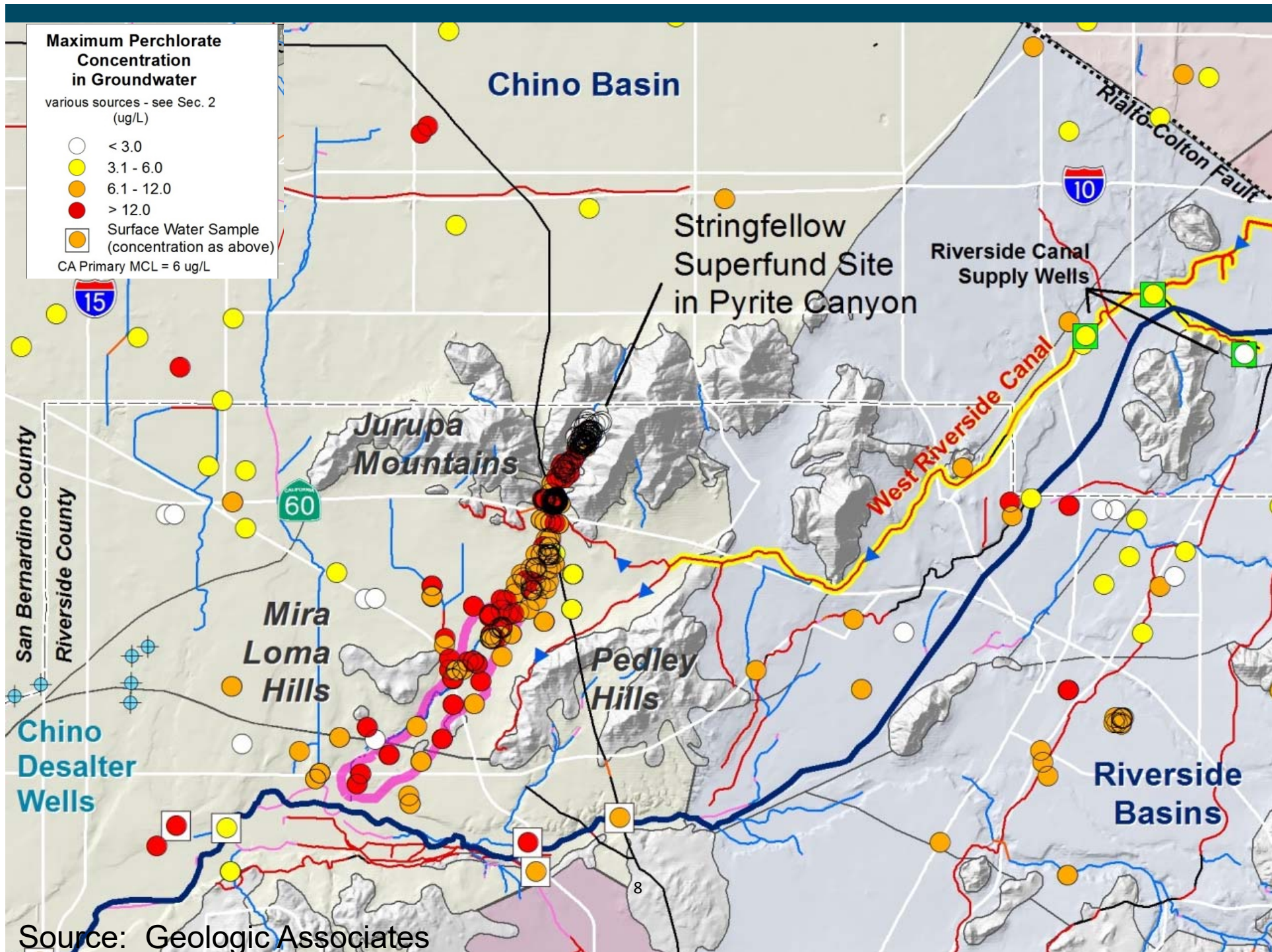




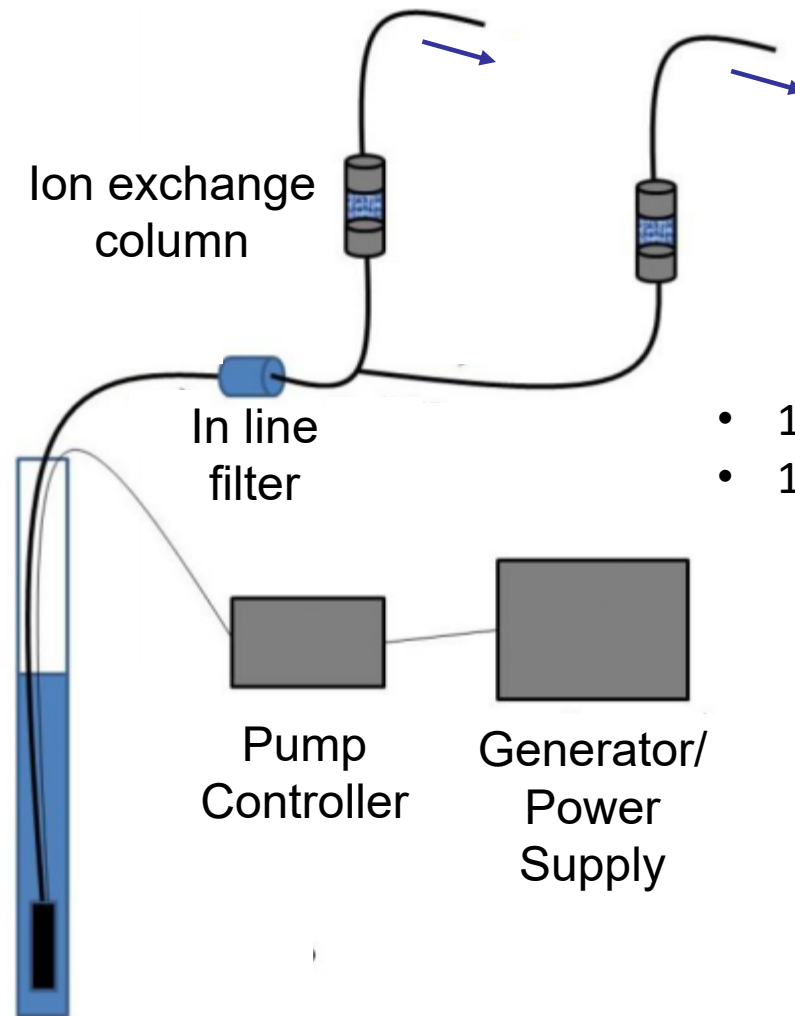
Zone 4 Perchlorate Plume and Groundwater Flow

- Out-of-plume locations with perchlorate levels >6ug/L
- Groundwater elevation contour
- Perchlorate isoconcentration lines





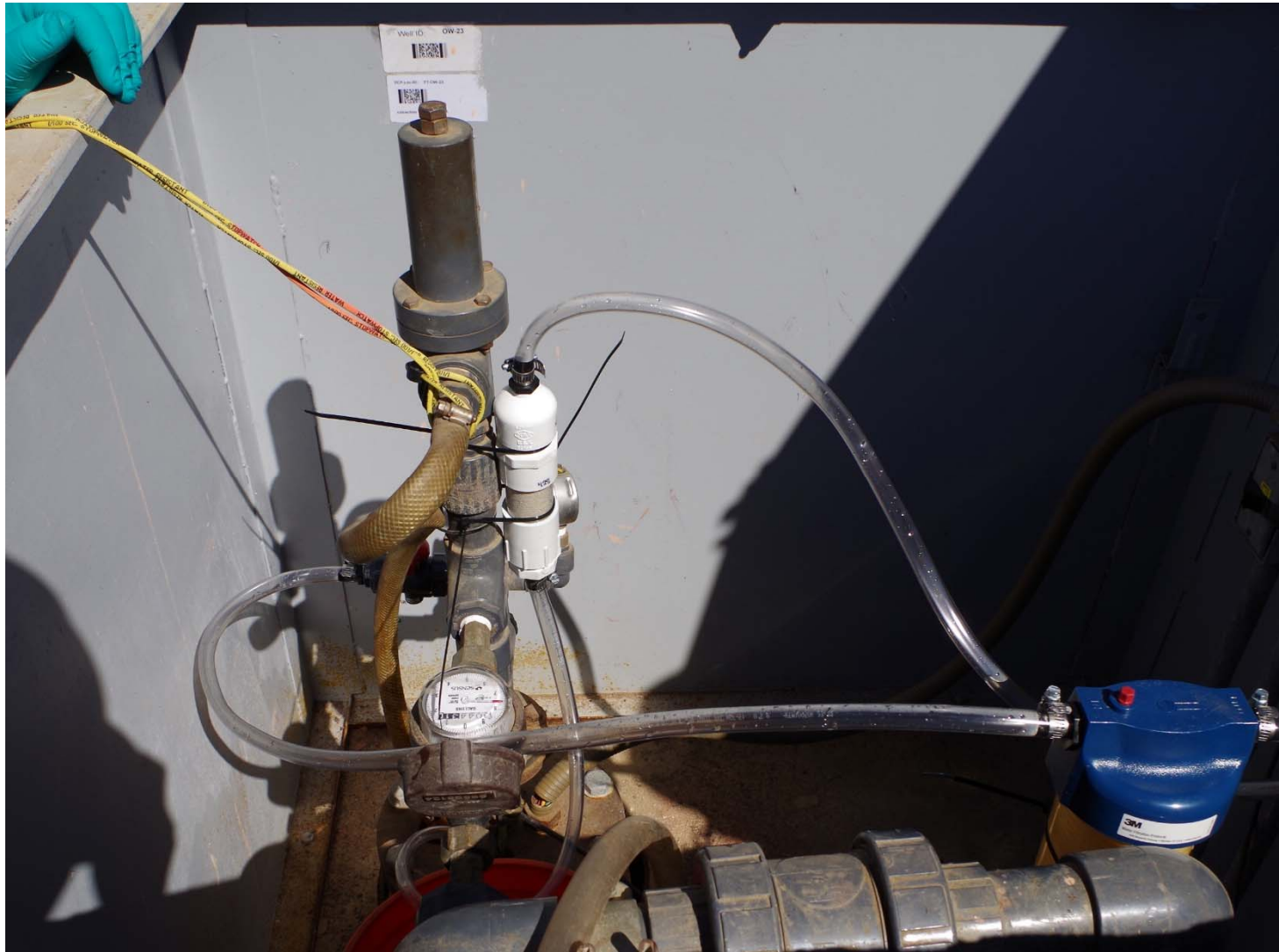
Sampling for Chlorine and Oxygen Isotopes in Perchlorate



- 100 mL sampling column
- 10 mg sample needed

Source: ESTCP 2013

Sampling for Chlorine Isotopes in Perchlorate



Chlorine Isotopes in Perchlorate

Isotopic Signature End Members

- Stable - ^{37}Cl , ^{35}Cl
- Radioactive - ^{36}Cl

- Synthetic
- Atacama – (present in Chilean based nitrate fertilizers)
- Southwestern US indigenous

$$\delta^{37}\text{Cl} = \left[\left(\frac{^{37}\text{Cl}}{^{35}\text{Cl}} \right)_{\text{sample}} / \left(\frac{^{37}\text{Cl}}{^{35}\text{Cl}} \right)_{\text{SMOC}} - 1 \right]$$

$$\delta^{18}\text{O} = \left[\left(\frac{^{18}\text{O}}{^{16}\text{O}} \right)_{\text{sample}} / \left(\frac{^{18}\text{O}}{^{16}\text{O}} \right)_{\text{SMOW}} - 1 \right]$$

$$\Delta^{17}\text{O} = \delta^{17}\text{O} - 0.52 * \delta^{18}\text{O}$$

Stable Isotopes of Chlorine and Oxygen in Perchlorate

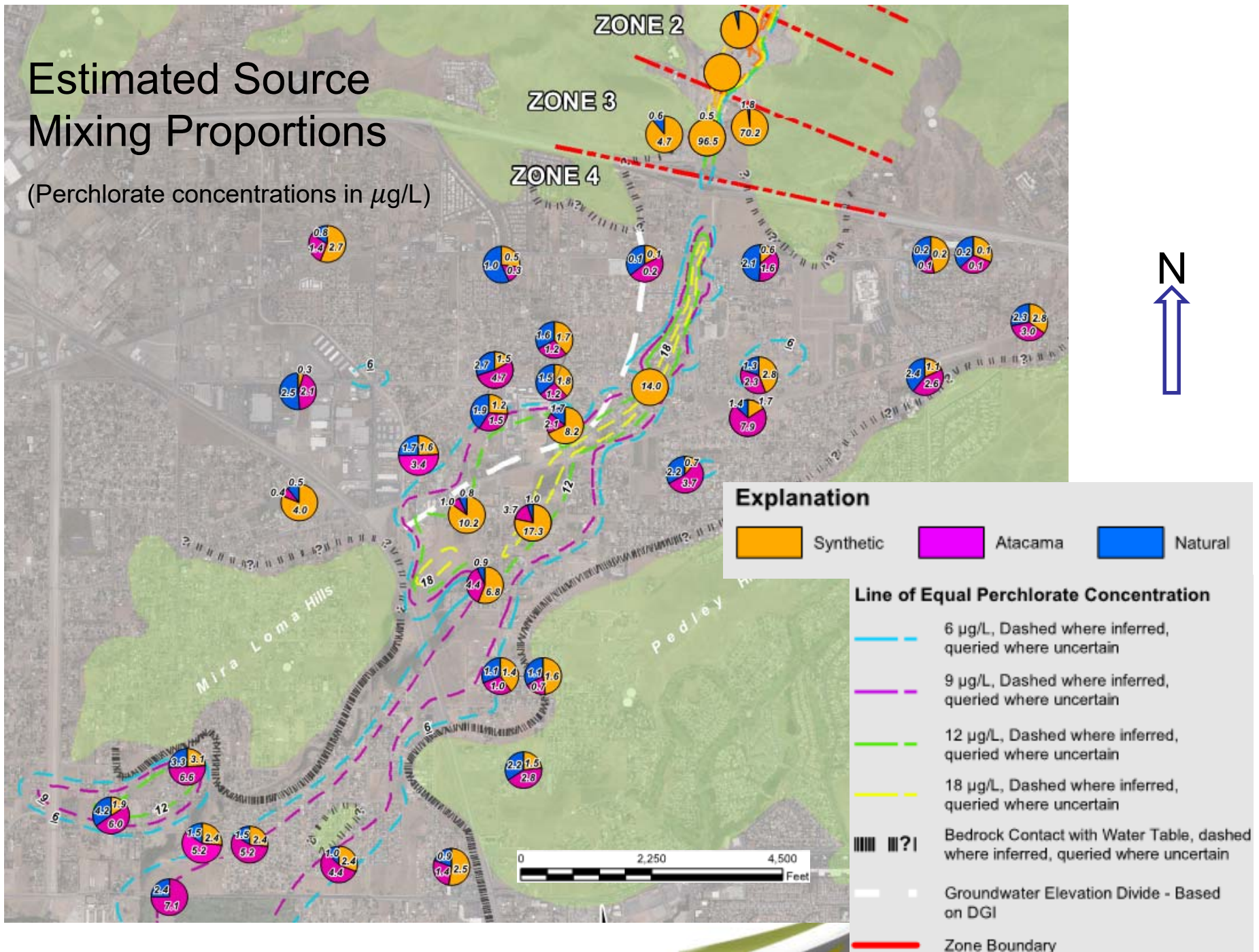
End Member/Isotope	$\delta^{37}\text{Cl}$ (per mil)	$\Delta^{17}\text{O}$ (per mil)	$\delta^{18}\text{O}$ (per mil)
Synthetic (S)	-3.1 to 1.6	0.0 ± 0.1	-24.8 to -12.5
Atacama (A)	-14.5 to -9.2	4 to 11	-24.8 to -2.2
Indigenous SW US (N)	-3.7 to 5.1	0.3 to 18.4	+2.9 to 25.5

Source: Sturchio et al 2012



Estimated Source Mixing Proportions

(Perchlorate concentrations in $\mu\text{g/L}$)



Explanation

- Synthetic
- Atacama
- Natural

Line of Equal Perchlorate Concentration

- 6 $\mu\text{g/L}$, Dashed where inferred, queried where uncertain
- 9 $\mu\text{g/L}$, Dashed where inferred, queried where uncertain
- 12 $\mu\text{g/L}$, Dashed where inferred, queried where uncertain
- 18 $\mu\text{g/L}$, Dashed where inferred, queried where uncertain
- Bedrock Contact with Water Table, dashed where inferred, queried where uncertain
- Groundwater Elevation Divide - Based on DGI
- Zone Boundary

Summary-Conclusions

- Perchlorate present in groundwater in the East Chino Basin has multiple sources both natural and anthropogenic
- Stable isotopes of chlorine in perchlorate were useful in separating out sources of perchlorate downgradient of the Stringfellow Superfund site.
- Next step is to plan a remedy where the MCL is the cleanup goal for perchlorate in a region with background levels of contamination.