Examination of River Sediment Microbial Communities Following the Gold King Mine Spill

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Background

- Sediment bacteria
  - Important for nutrients and metals cycling
  - Little is known about how high metals concentrations can affect these communities.

- High levels of metals contamination are well-documented in Cement Creek and to a lesser degree in the Animas River.
- The Gold King Mine spill and the extensive sampling campaigns afterwards may provide an opportunity to relationships between metals and sediment bacteria.

Research question: *How do these chronic and acute exposures affect sediment bacteria communities?*

Objectives

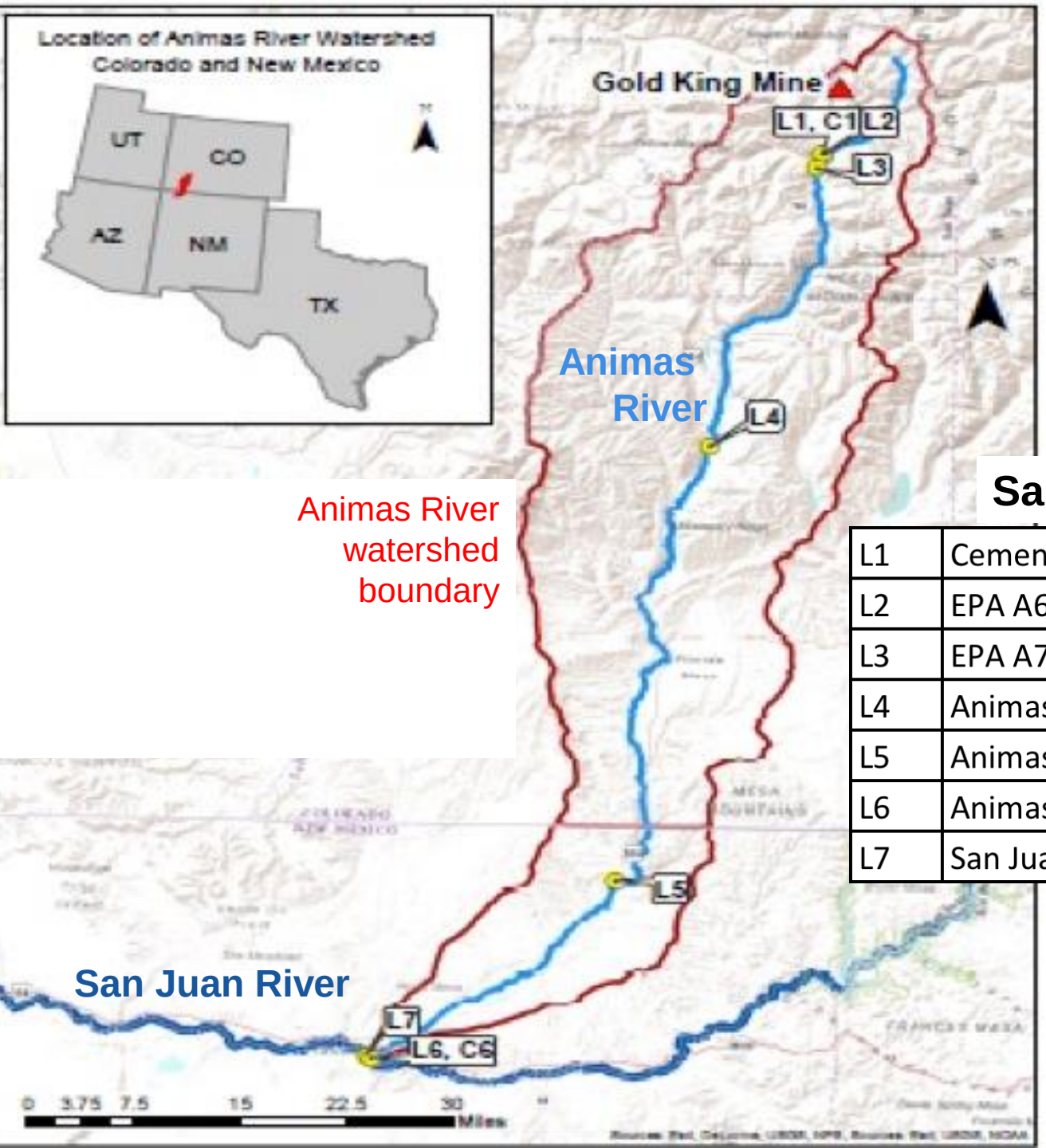
Determine **differences in microbial populations** in sediments with high and low metals concentrations, spanning from Cement Creek to the the San Juan River .

Gather **preliminary microbial community data** to assess future recovery/long-term changes at these sites after the GKM spill.

Approach

- On August 17th -18th, 2015 a research team from UNM collected sediment samples from seven sites along Cement Creek, Animas River, and San Juan River – coordinated with NM Tech team.

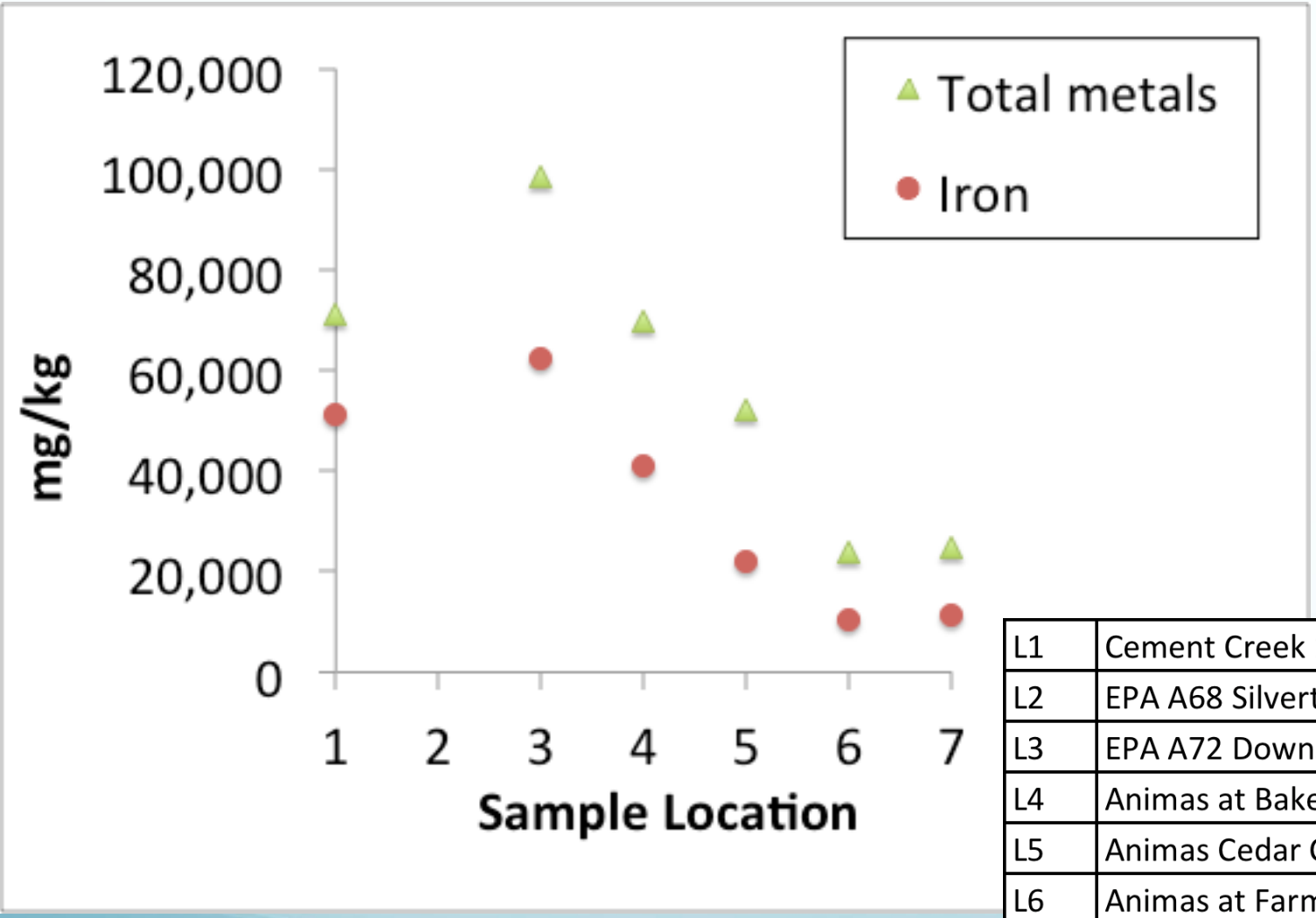
- DNA was extracted and 16s RNA gene sequences were analyzed by Illumina sequencing.



Sample Locations

L1	Cement Creek 14th St Bridge
L2	EPA A68 Silverton Animas upstream
L3	EPA A72 Downstream of Cement Creek
L4	Animas at Bakers Bridge
L5	Animas Cedar Creek
L6	Animas at Farmington
L7	San Juan River downstream

Variations in sediment metals content from upstream to downstream locations



Data by Cerrato group (UNM)

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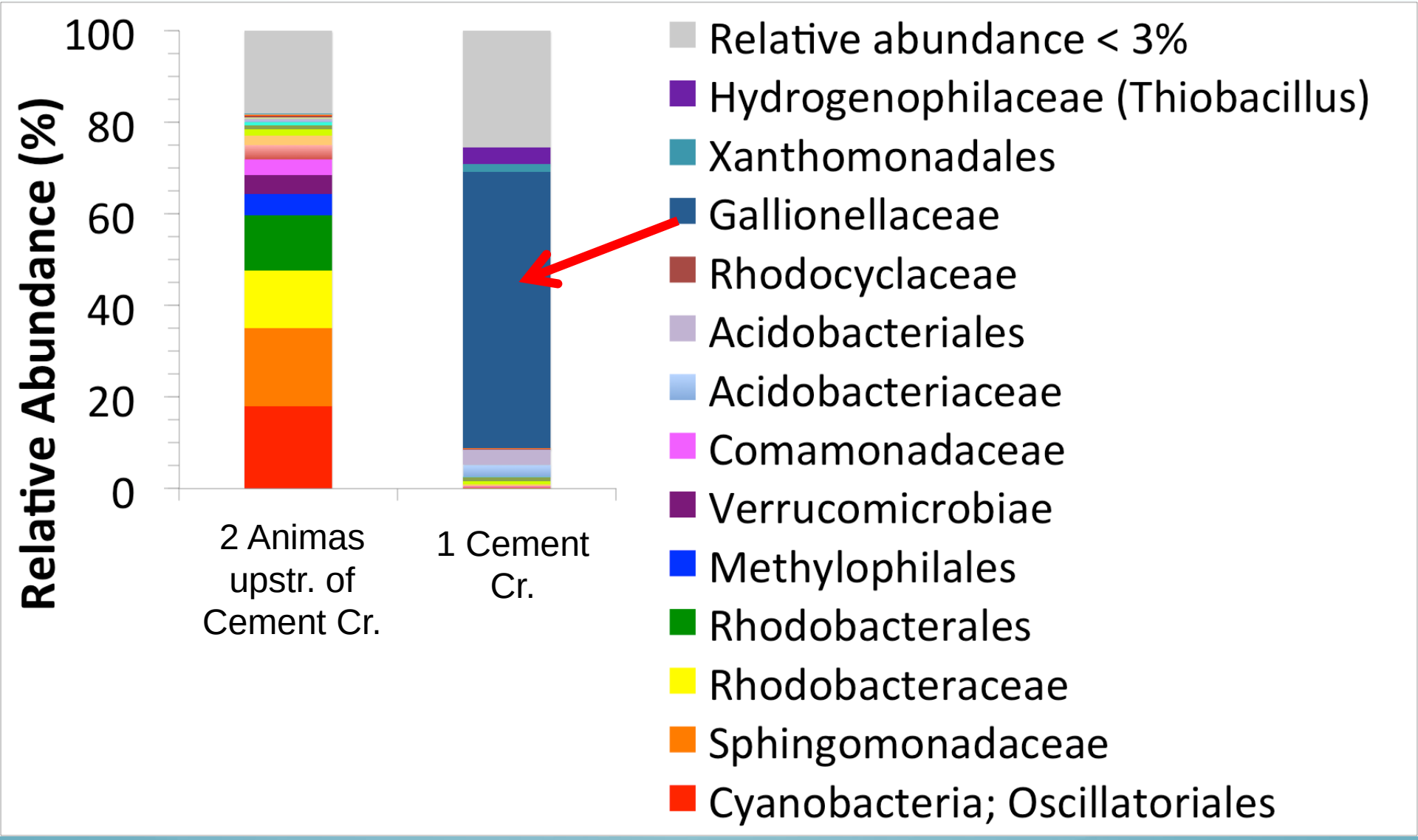
Animas upstream of Cement Creek (Sample 2)

Pristine location in Animas River upstream of Cement Creek confluence (EPA site A68, 8/18/15)

Cement Creek (Sample 1)

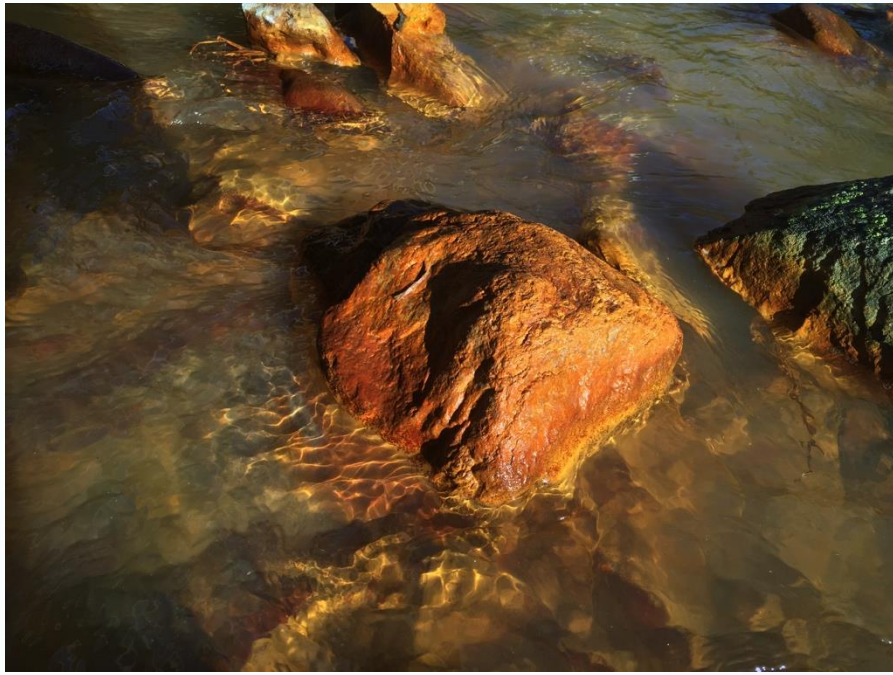
Cement Creek at Silverton 14th St Bridge (8/18/15)

Bacterial community compositions: Illumina Sequencing Results



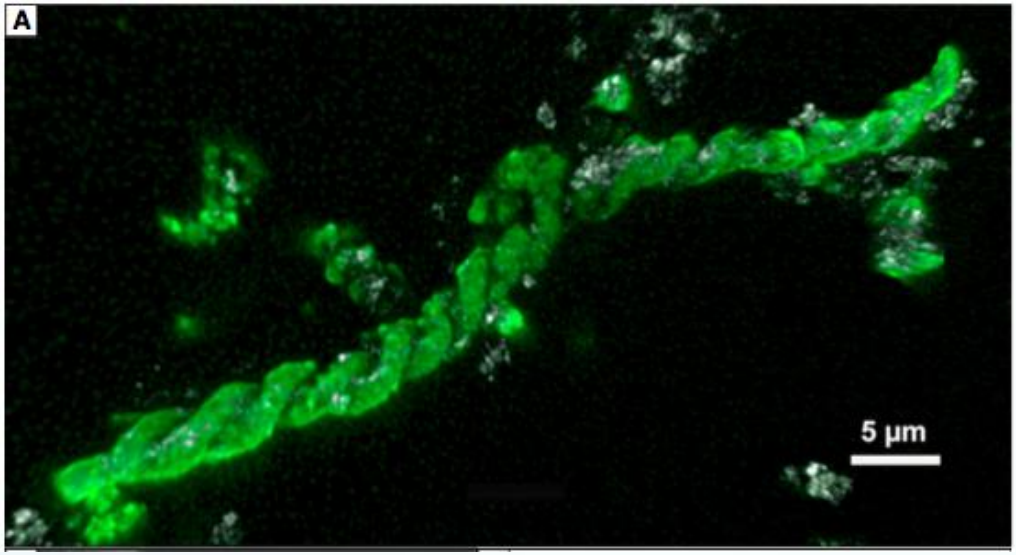
Bacteria Family *Gallionellaceae*

- Iron Is usually most abundant metallic element at acid mine drainage impacted sites
- *Gallionellaceae* are iron oxidizing bacteria (FeOB): can oxidize dissolved Fe(II) to precipitated Fe(III)
- Other heavy metals may co-precipitate or adsorb to Fe(III) precipitates.

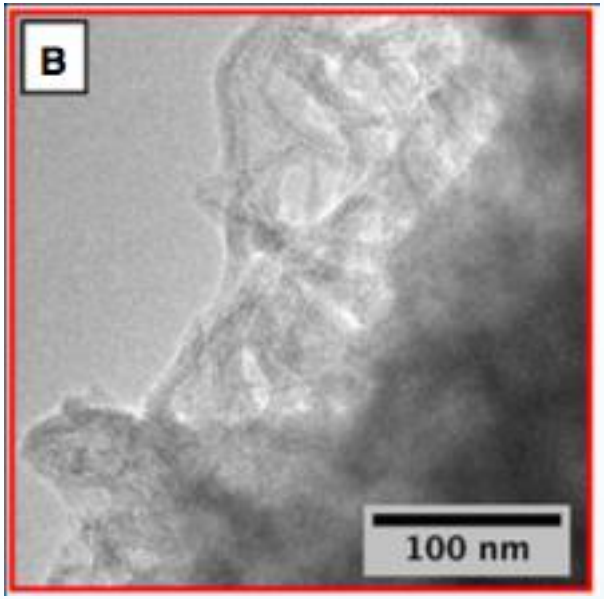


(Krepski et al 2012, Stumm et al. 1996, Fabisch et al. 2013))

Bacteria Family *Gallionellaceae*



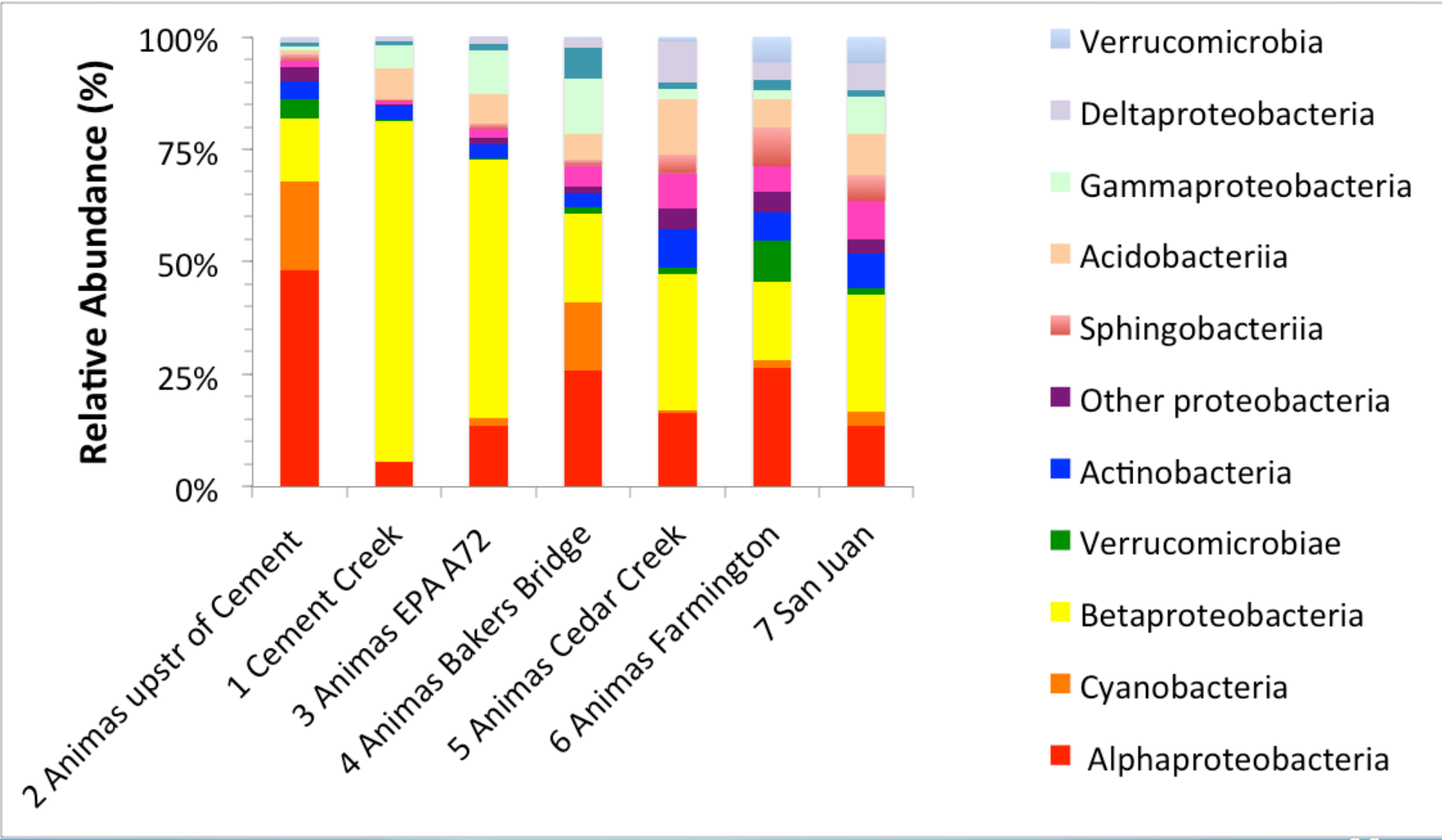
Confocal laser scanning microscopy of *Gallionella*-like twisted stalks.



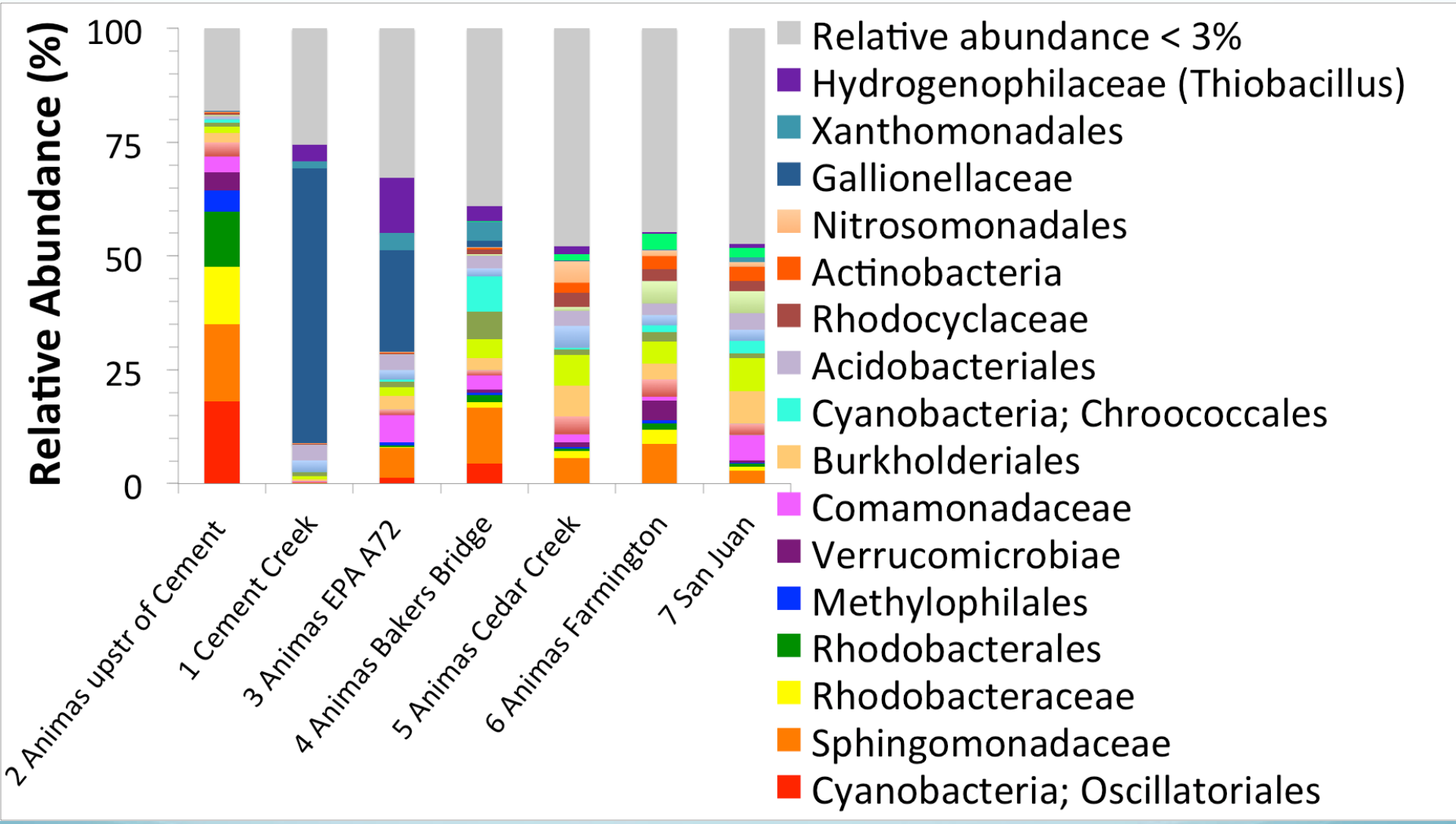
Medium range TEM image showing the iron oxide fibrils attached to stalks

Fabisch et al 2016, Dominance of 'Gallionella capsiferriformans' and heavy metal association with Gallionella-like stalks in metal-rich pH 6 mine water discharge, Geobiology, 14, 68–90

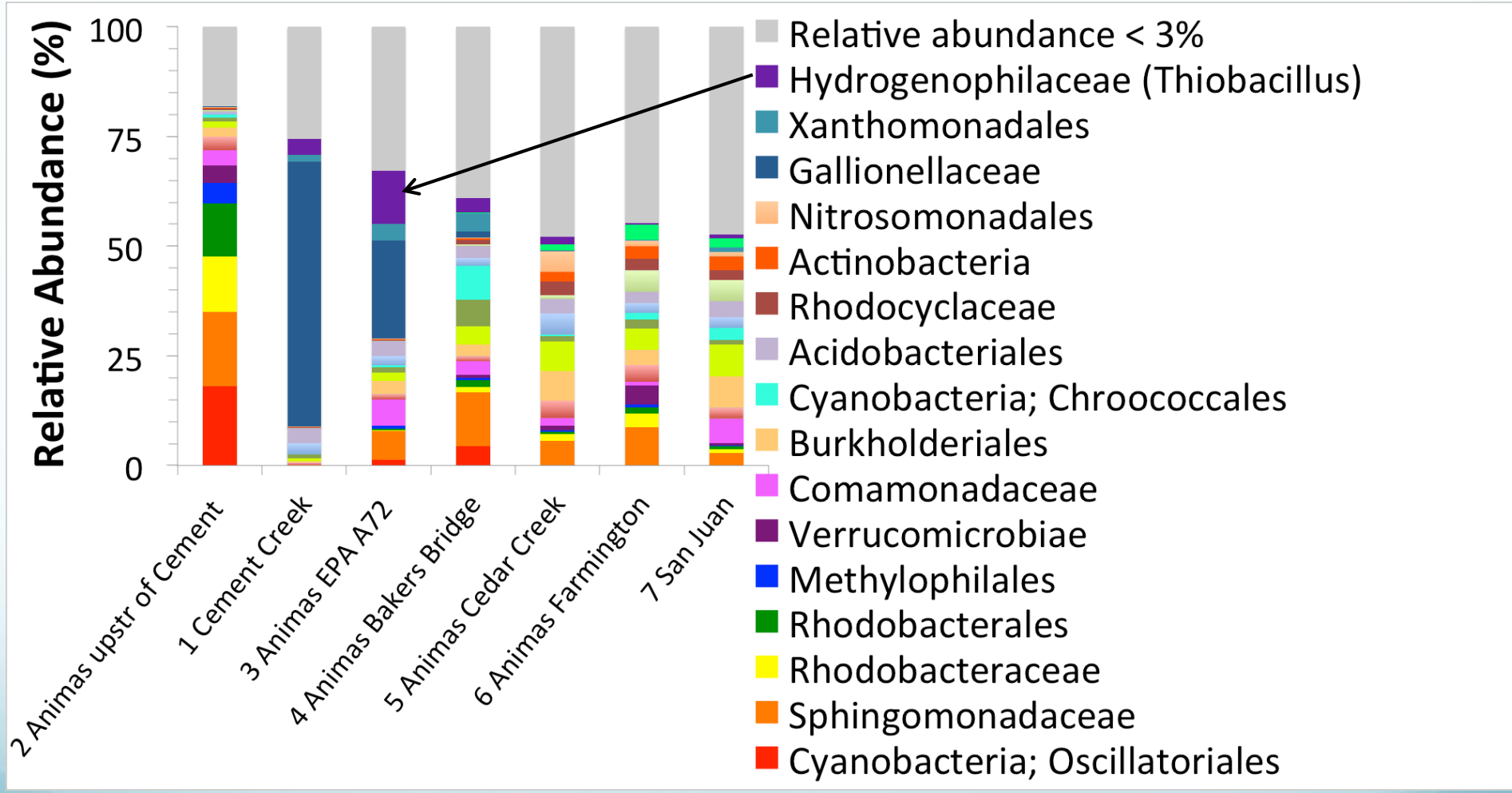
Illumina results across all samples - Class



Illumina results across all samples - Family

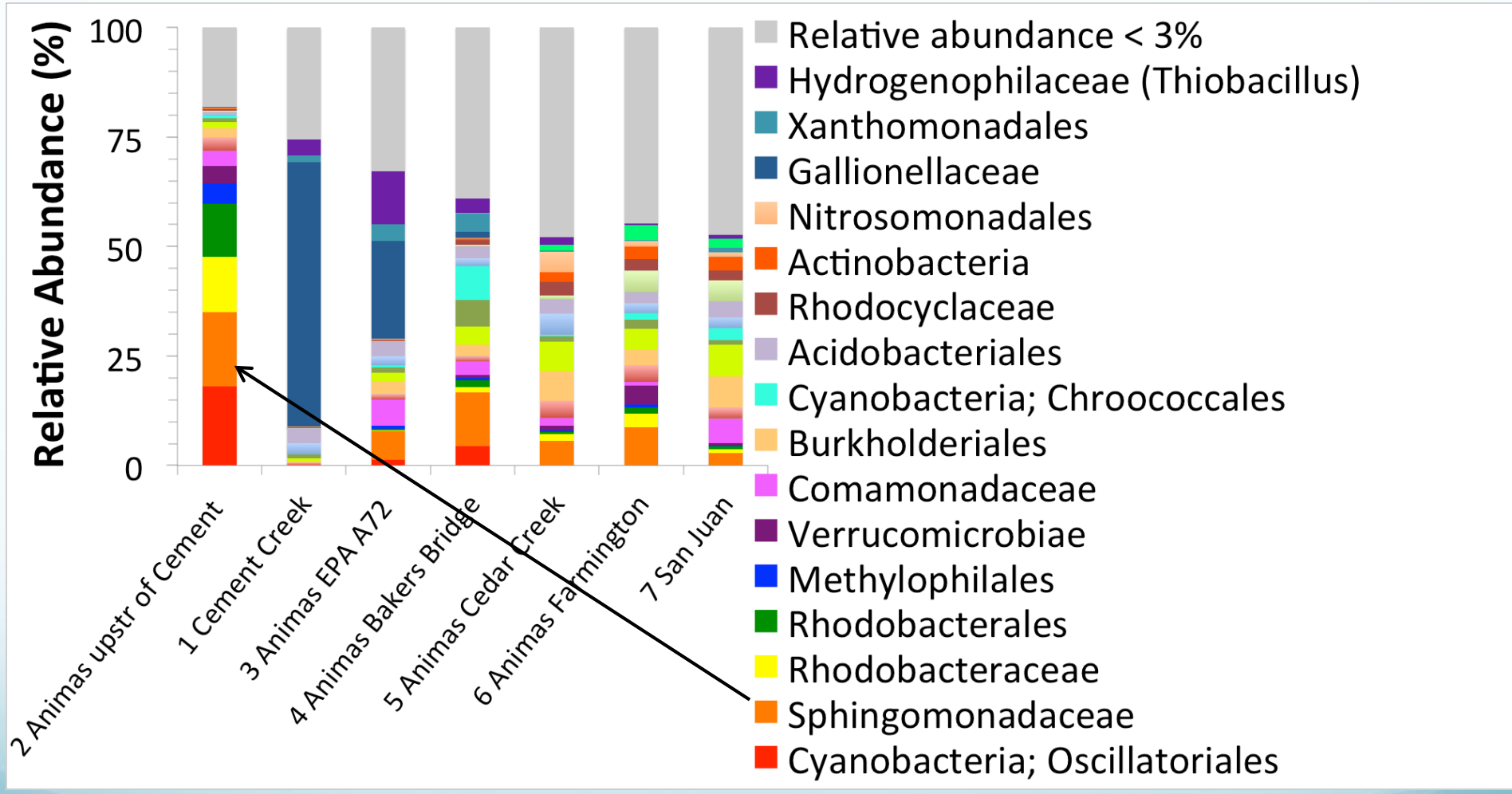


Illumina results across all samples - Family



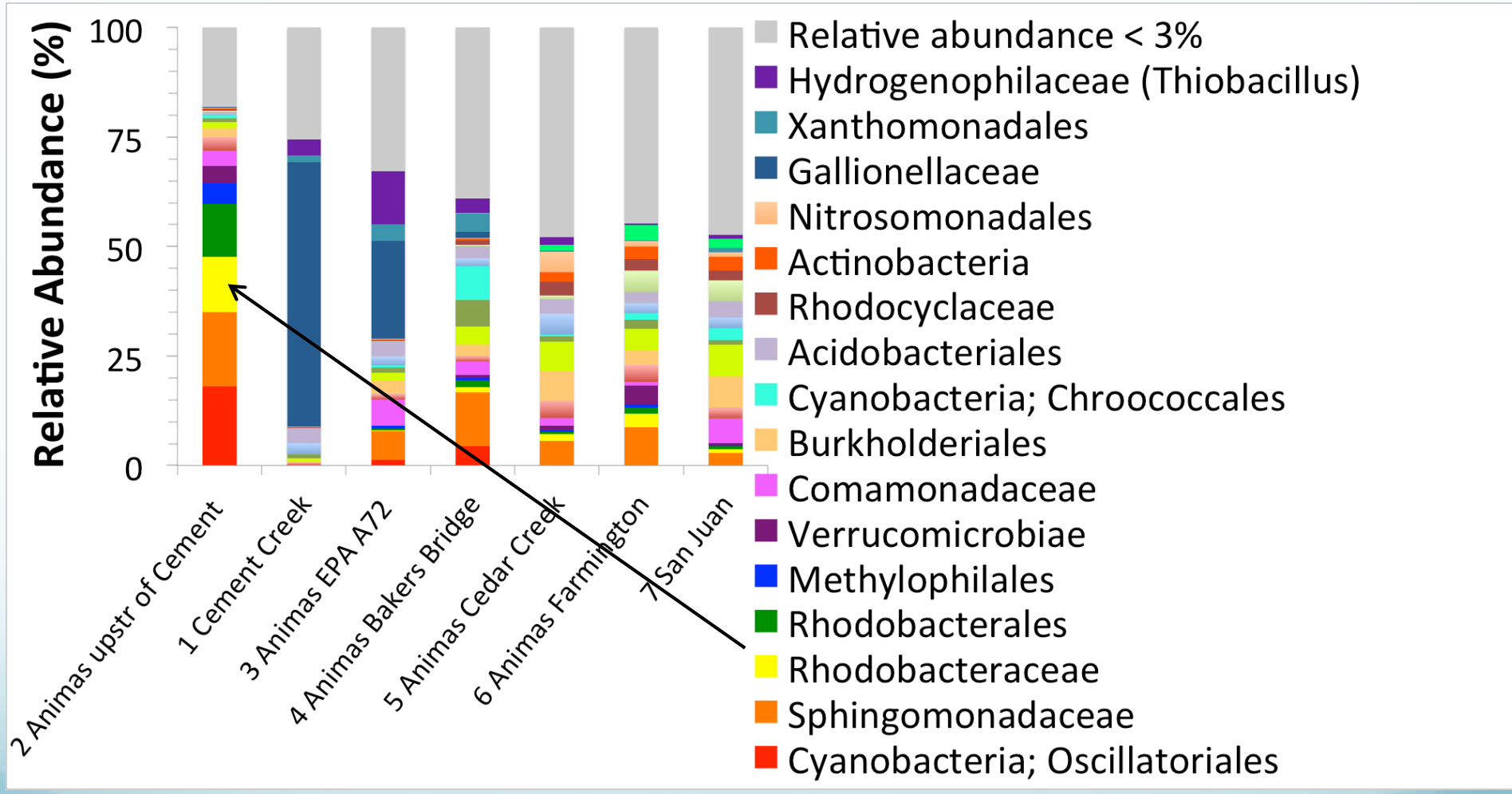
- Hydrogenophilaceae (Thiobacillus)
  - Prominent in Cement Creek and In Animas downstream of Confluence
  - Responsible for pyrite oxidation

Illumina results across all samples - Family



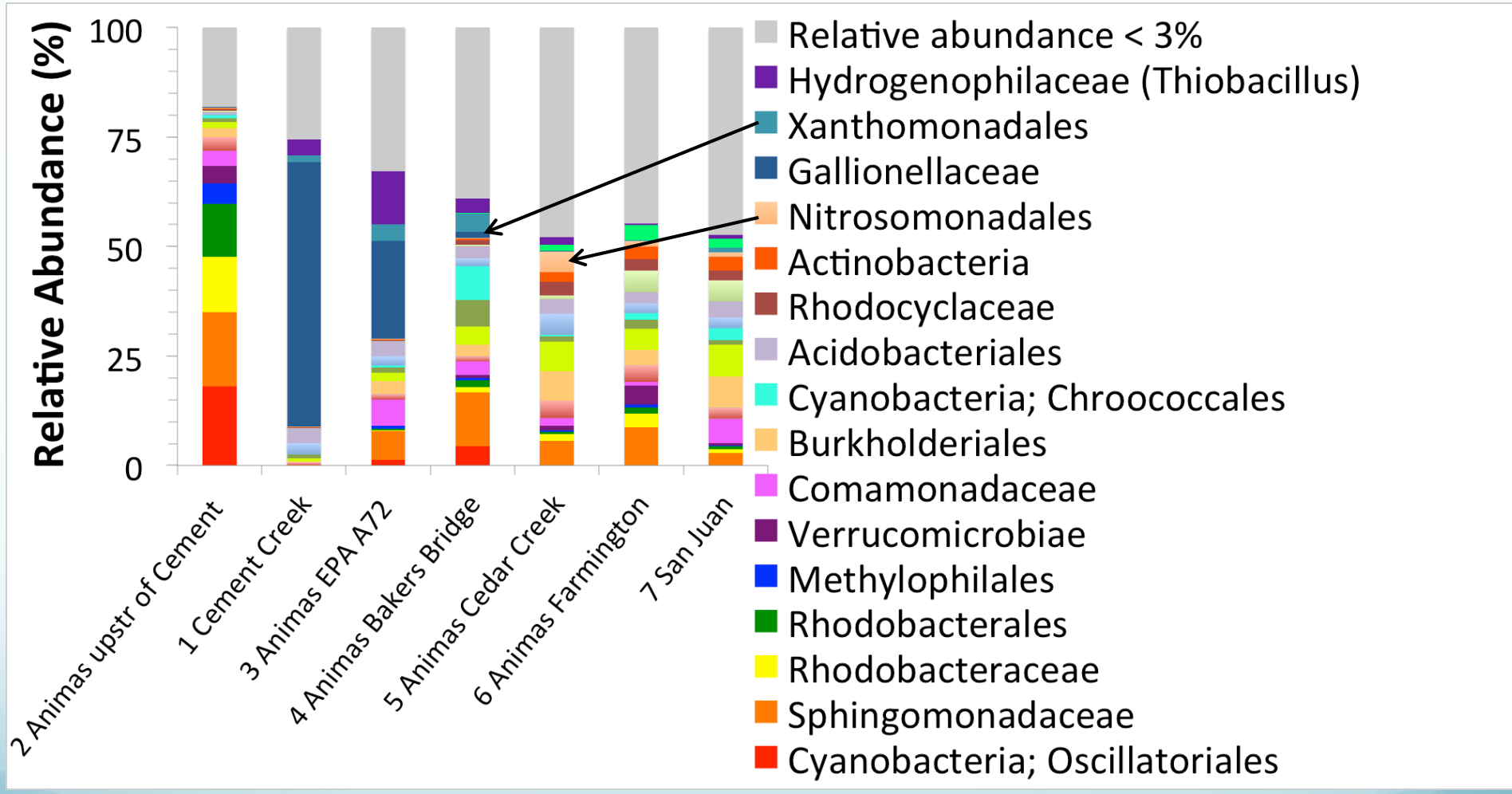
- Sphingomonadaceae – Prominent in polyaromatic hydrocarbon contaminated soil.
  - Prominent in Animas, but scarce in Cement Creek (Ibarrolaza et al 2011)

Illumina results across all samples - Family



- Rhodobacteraceae – Important for initial biofilm formation (Kviatkovski et al 2015)
  - Prominent in Animas, but scarce in Cement Creek

Illumina results across all samples - Family



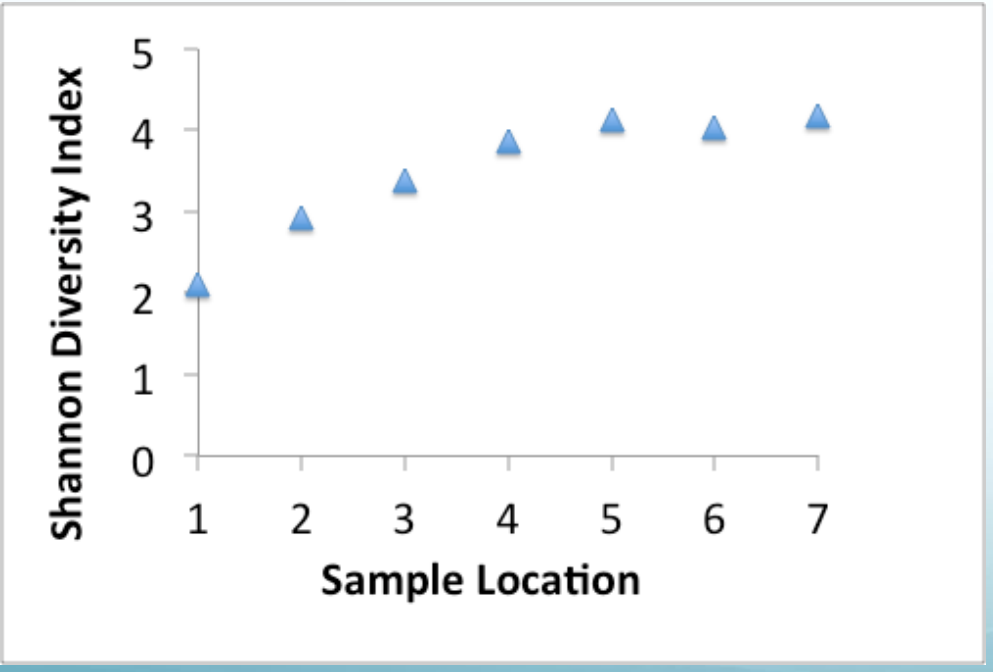
- Nitrosomonadacae, Xanthomonadacae – Known nitrifiers. Found in small abundance in all samples

Microbial diversity increased from upstream to downstream

Shannon Diversity Index

$$H' = -\sum_{i=1}^{R} p_i ln\, p_i$$

R = Richness
Pi = Proportion of Individuals



Conclusions

- There were large differences in bacterial populations in sediments with varying degrees of contamination
- Detection of key groups, such as iron oxidizers, supports the hypothesis that bacteria play important roles in fate and transport of metals in rivers and sediments.
- Low numbers of bacteria linked to nutrient cycling in upstream, contaminated sediments.

Future Research

- Additional measurements to see if microbial populations have shifted since the GKM spi
- Evaluation of seasonal/runoff effects
- Lab experiments to examine the impact of mine waste on nutrient cycling