

# Increasing Preparedness in the San Diego River Watershed for Potential Contamination Events

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# Outline

- Background and motivation for the study
- Project objectives
- Results for each objective
- Conclusions
- Outputs





# Microbial pollution of the San Diego River



- Human-associated fecal contaminants have been detected in the San Diego River during storm events
- Increased incidents of gastrointestinal illness and infections in surfers after rain events



# Storms and infrastructure

Sewer infrastructure becomes inundated; sanitary sewers overflow



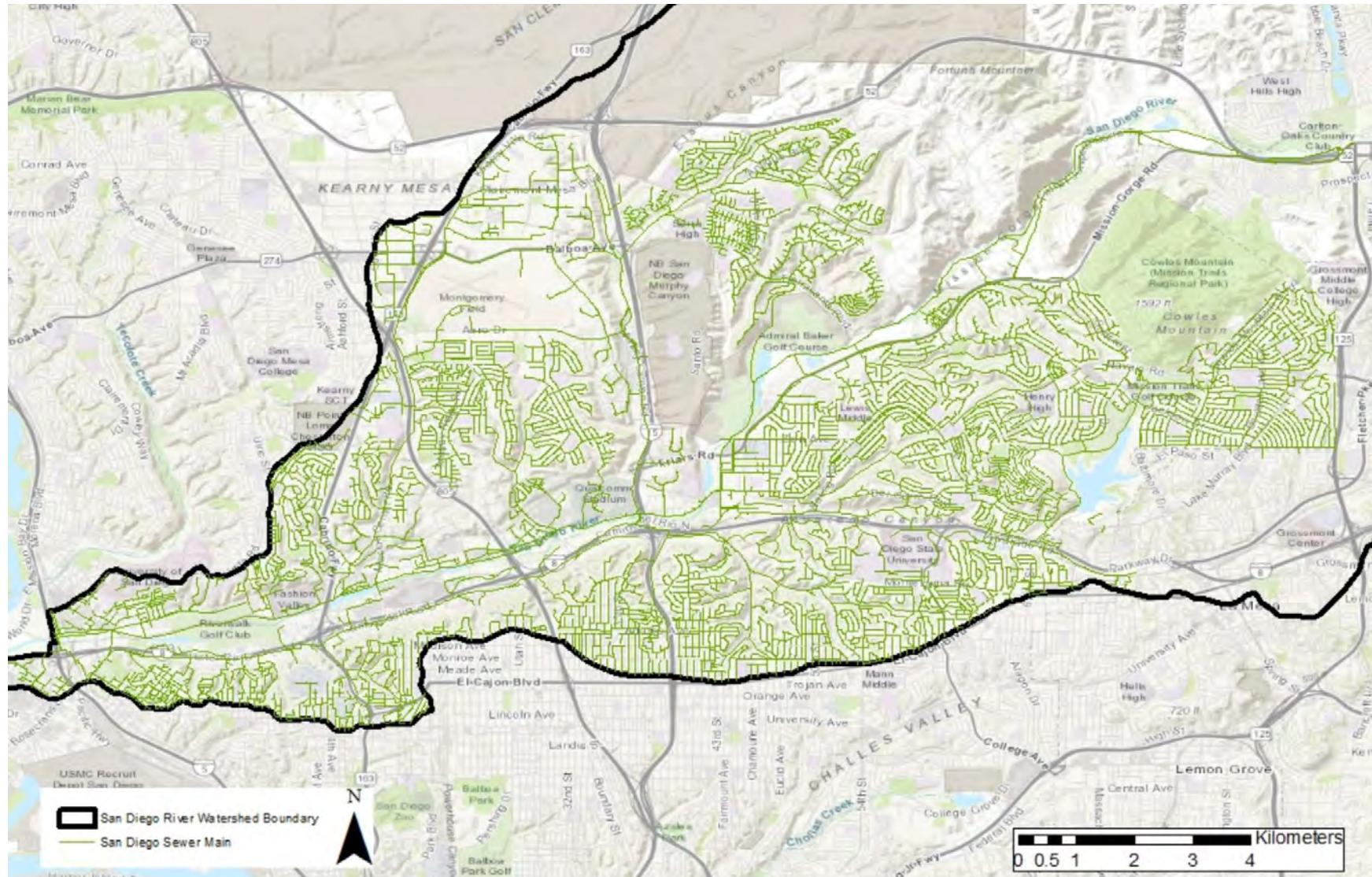
Photo credit: Eric Frost, SDSU



Photo credit: Eric Frost, SDSU



# Sewer infrastructure





# Sanitation associated with encampments

San Diegans experiencing unsheltered homelessness often **lack access to** basic **water, sanitation, and hygiene services**, and sometimes practice **open defecation**.



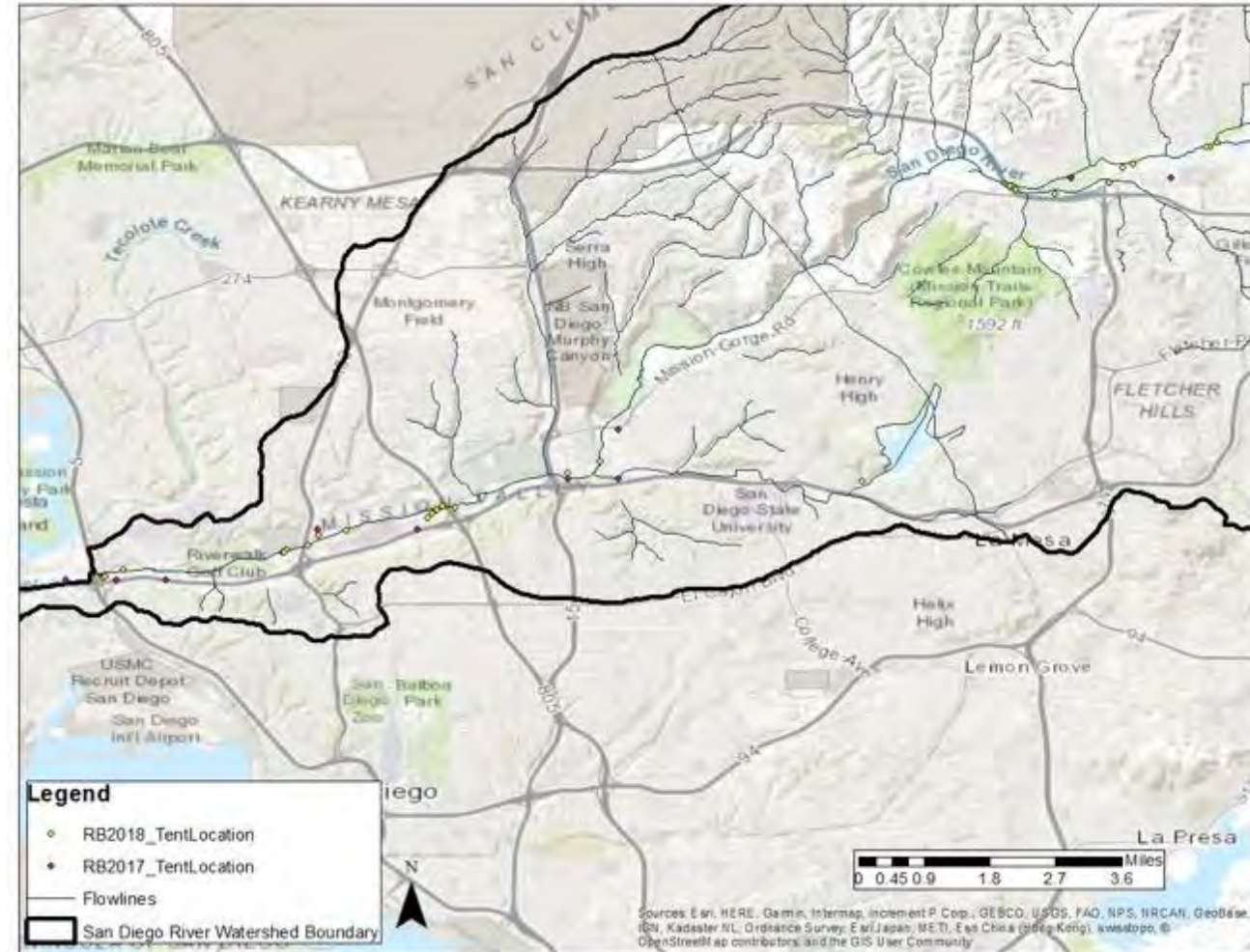
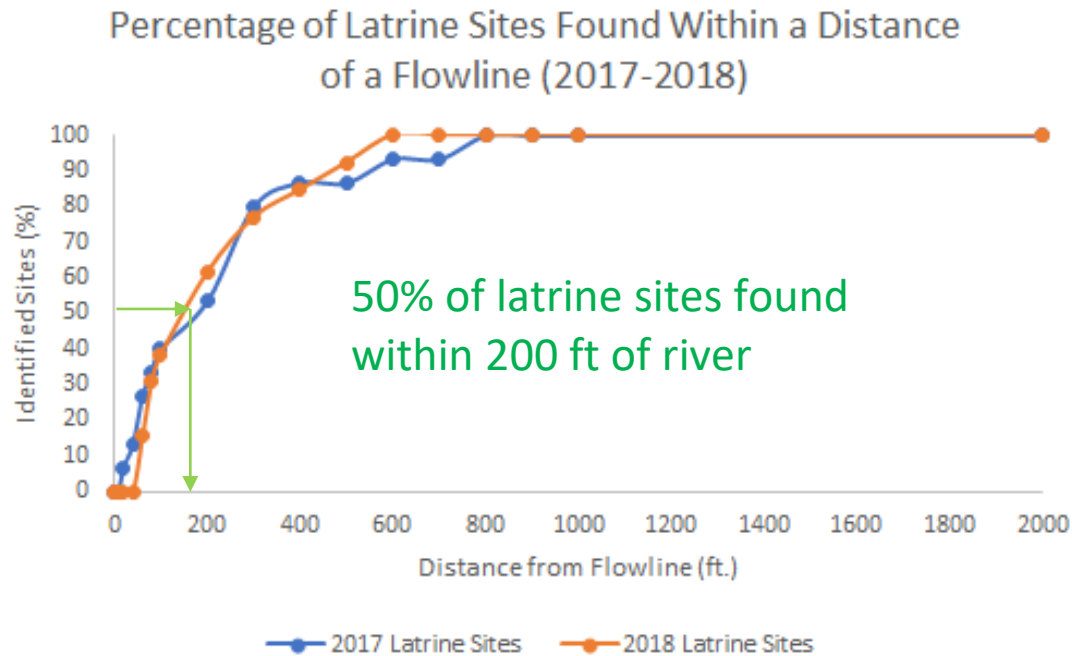
<https://www.realchangenews.org/2017/11/15/one-man-s-quest-provide-sanitation-homeless-people-just-drop-bucket>



[https://en.wikipedia.org/wiki/Flying\\_toilet](https://en.wikipedia.org/wiki/Flying_toilet)

# Encampments: distance from river

- 2017 had 31 encampments, >39 tents, 15 “latrines”
- 2018 had 26 encampments, ~16 tents, 13 “latrines”



# Interviews with people experiencing homelessness: Reported sanitation and hygiene practices

	River/canyon dwelling individuals (n=56)	Non-river dwelling individuals (n=28)	Full sample (n=84)
Use soap when able to wash hands	45 (80.4%)	21 (75%)	66 (78.6%)
Defecate in port-a-potty or public restroom	28 (50%)	14 (50%)	42 (50%)
Defecate at business establishment (e.g., gas station or coffee shop)	32 (57.1%)	20 (71.4%)	52 (61.9%)
Self or group practices open defecation	41 (73.2%)	11 (39.3%)	52 (62%)
Use river water for drinking	1 (1.8%)	0	1 (1.2%)
Use river water for non-drinking purposes	11 (19.6%)	2 (7.1%)	13 (15.5%)



# Project Objectives

- Evaluate pollutant inputs **from homeless encampments** during **dry weather** conditions.
- Evaluate pollutants during and after **encampment cleanups**.
- Quantify the **leaching of pollutants** from wastewater-contaminated and feces-contaminated soils.
- Quantify changes in pollutant concentration and loadings **during storm events**.







# Microbial markers

- *E. coli*
- Enterococci
- PhiX174
- HF183
- Pepper Mild Mottle Virus
- **Hepatitis A Virus**
- **Norovirus**
- *Campylobacter coli*
- *Campylobacter jejuni*



# Chemical markers

**Caffeine:**  
biodegradable

**Sucralose:**  
persistent



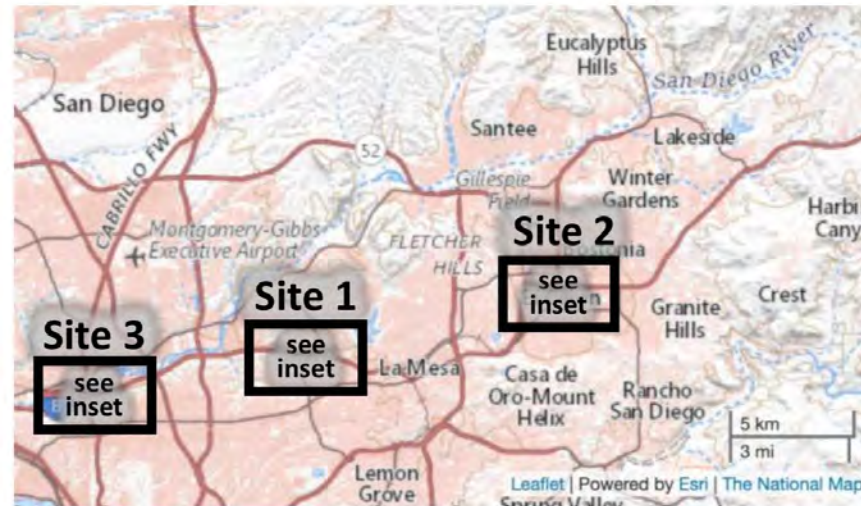
# Objective 1

*Measure pollution from  
homeless encampments  
during dry weather  
conditions*

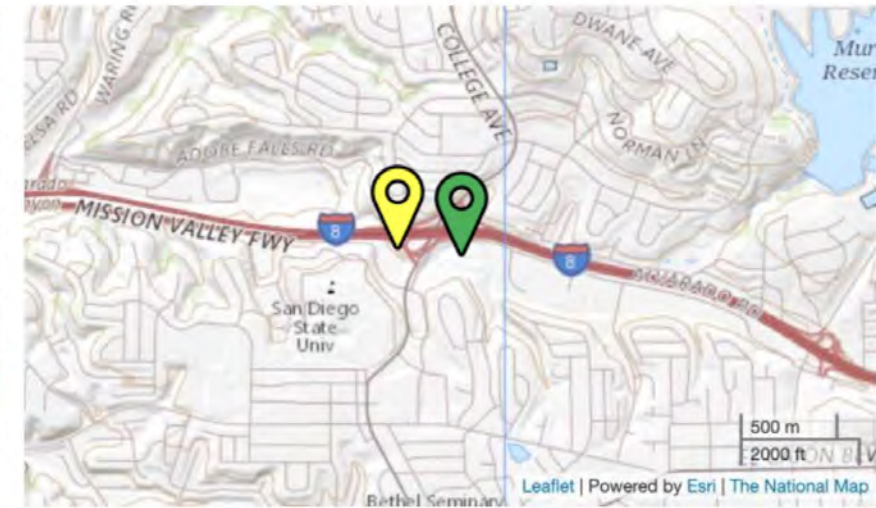




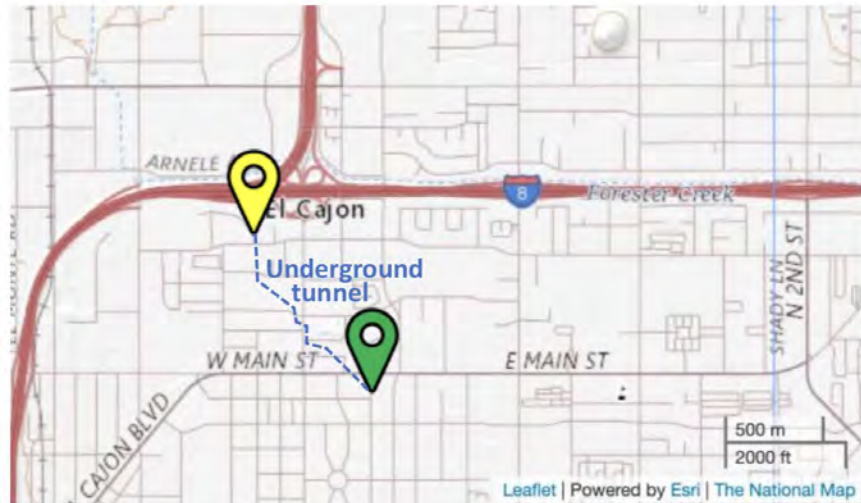
## Overall Map of Sampling Sites



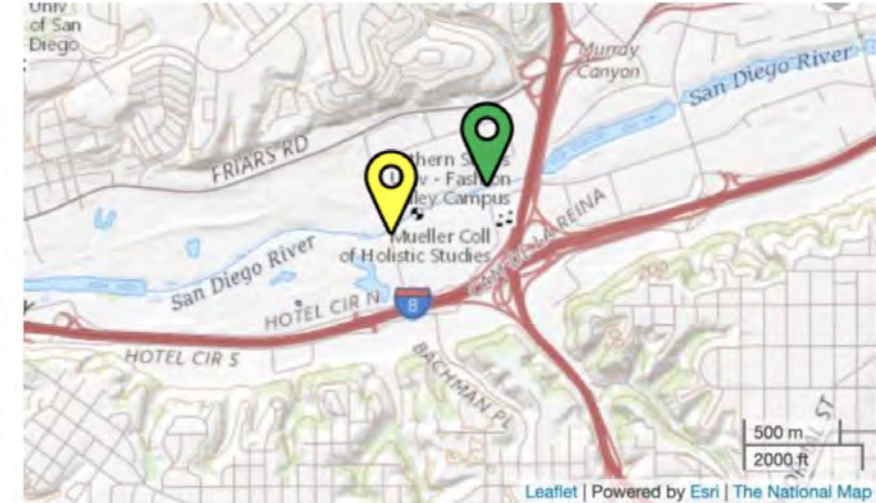
## Inset for Site 1: Alvarado Creek



## Inset for Site 2: Forester Channel



## Inset for Site 3: Fashion Valley



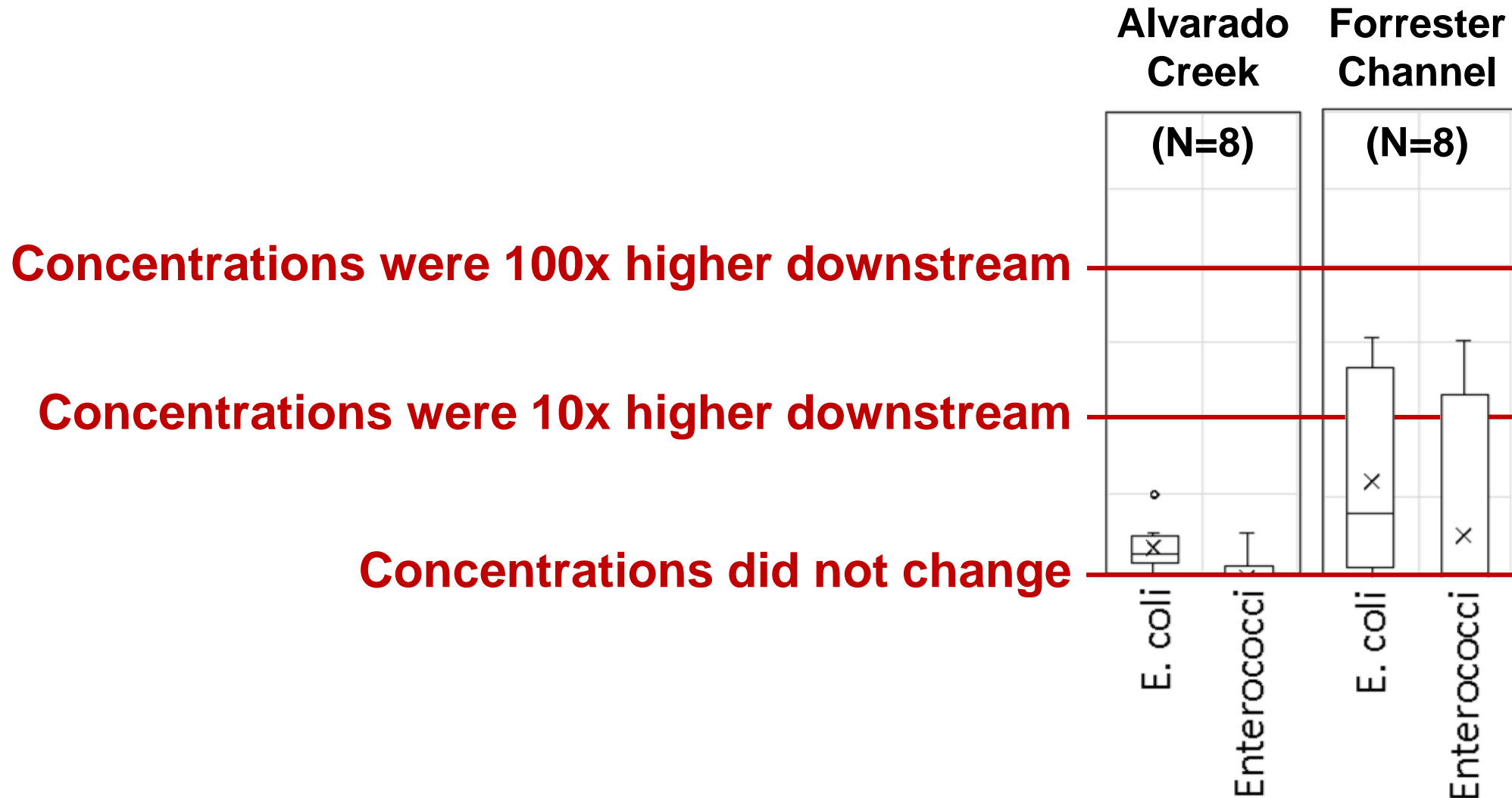
Upstream  
sample location



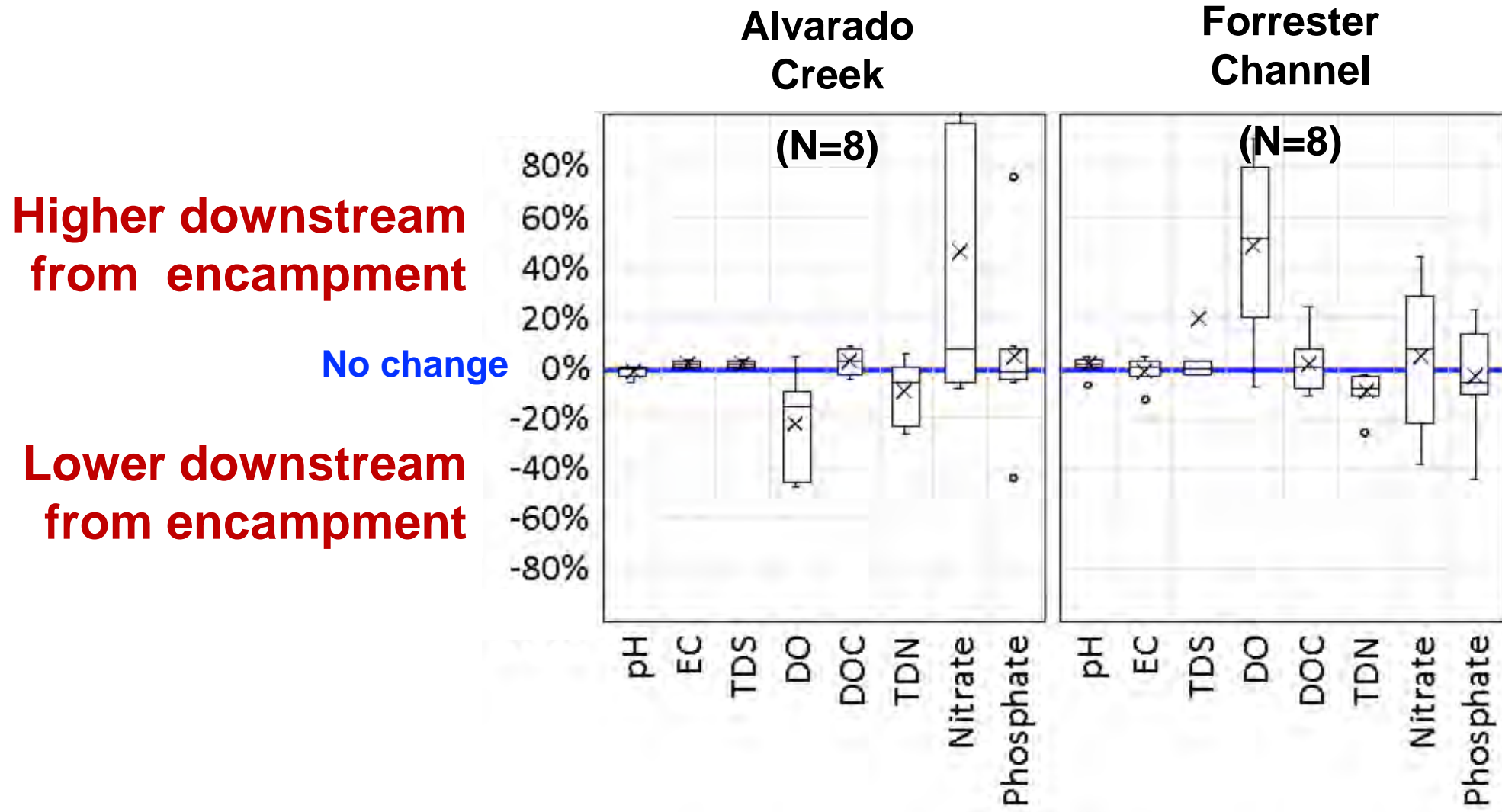
Downstream  
sample location



# Bacterial Fecal Indicators



# General Water Quality Indicators





*We analyzed upstream and downstream samples for bacterial fecal indicators, HF183, caffeine, sucralose, and a variety of other general water quality indicators.*

**“Encampments did not have a significant influence on the microbial pollution of surface waters during dry weather.”**





# Objective 2/3

*Evaluate pollution in water and soils during and after riverbank cleanup activities*

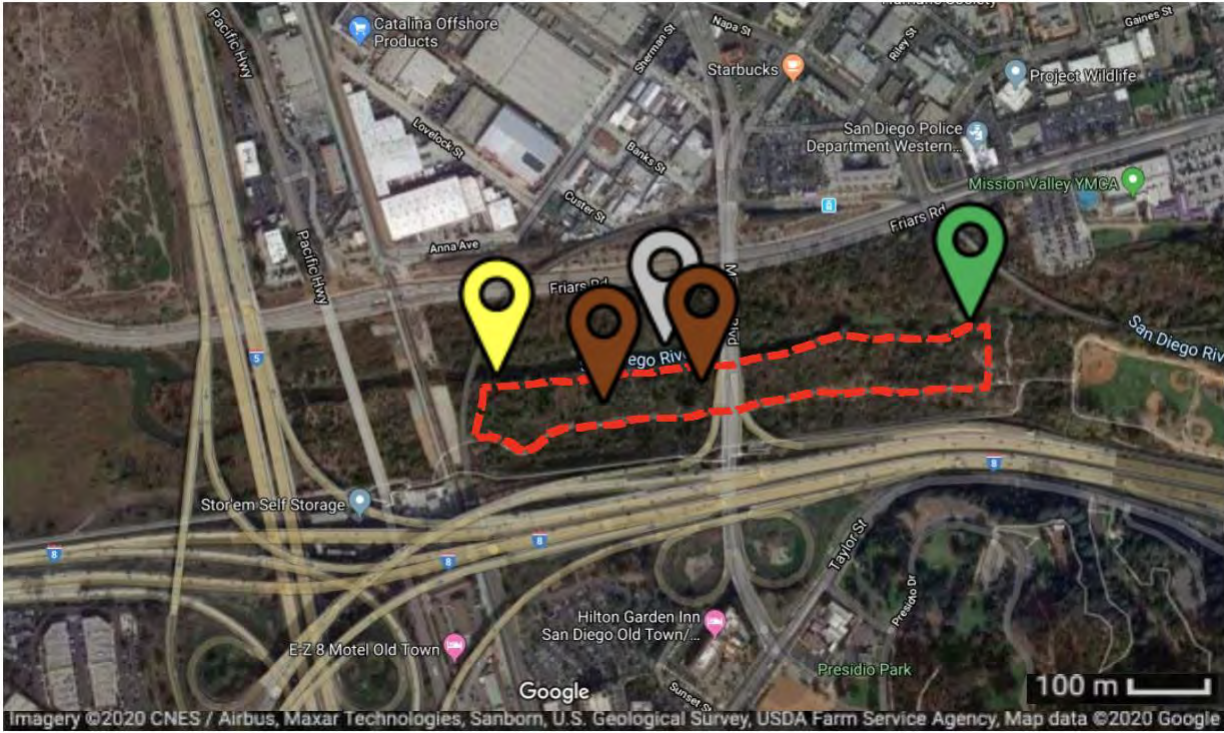








# Overall Map: Location of the Cleanup Site



# Inset: Sampling Locations at Cleanup Site



-  Location of soil and fecal samples
-  Downstream water sample location
-  Adjacent water sample location
-  Upstream water sample location



Approximate delineation of the area being cleaned by volunteers from the San Diego River Park Foundation









*We analyzed soil and water samples  
at a former homeless encampment  
near areas with open defecation  
during and after a cleanup event*

**“Encampments did result in  
microbial contamination of soils  
at sites with open defecation,  
even after site cleanup.”**



# Objective 4

*Evaluate the leaching of  
pollutants from  
contaminated soils*



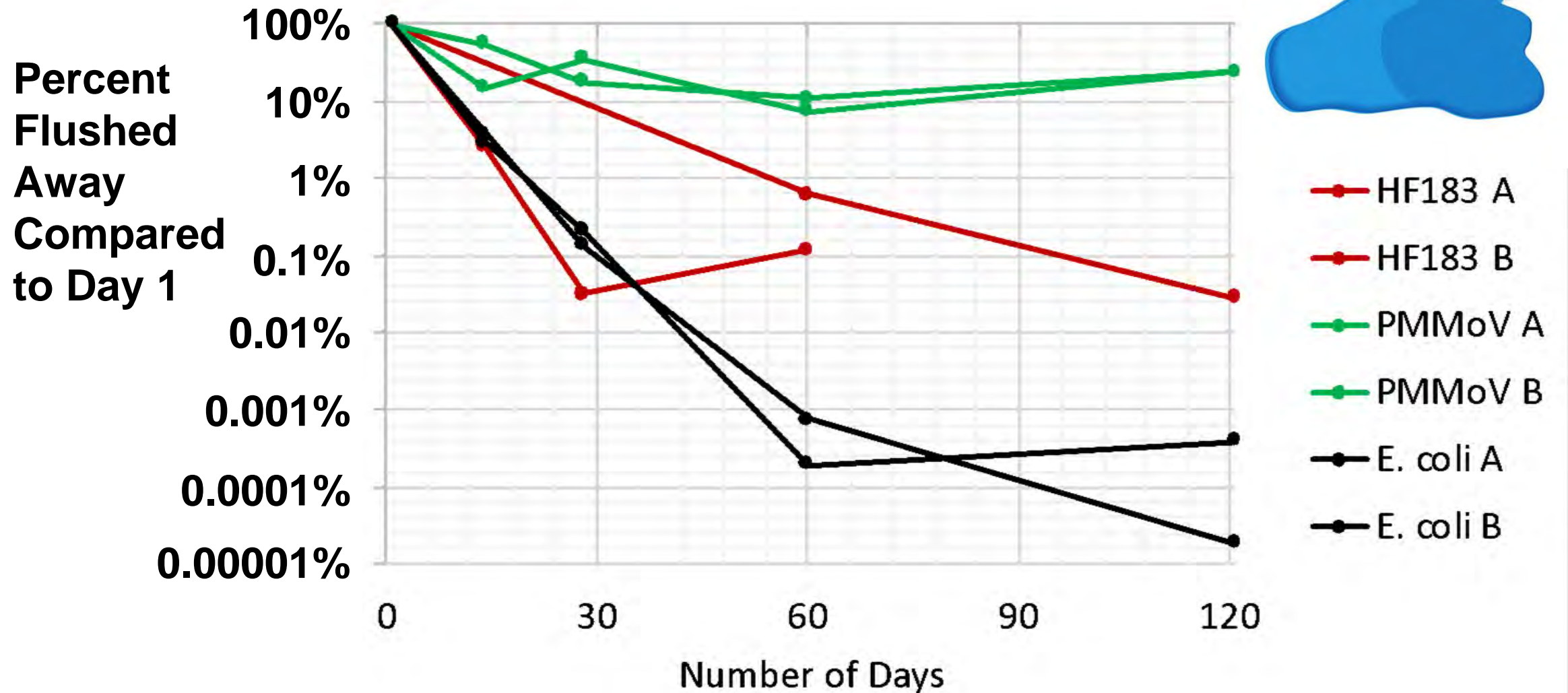


*We simulated sewer exfiltration  
by spiking clean soil with wastewater,  
and tested the persistence of microbial  
pollutants when flushed with rainwater*

**“Wastewater-spiked soils  
continued to be a source of  
*E. coli*, HF183, and PMMoV  
even after 4 months.”**



# Persistence of viruses/bacteria flushed away from soil after simulated sewer exfiltration

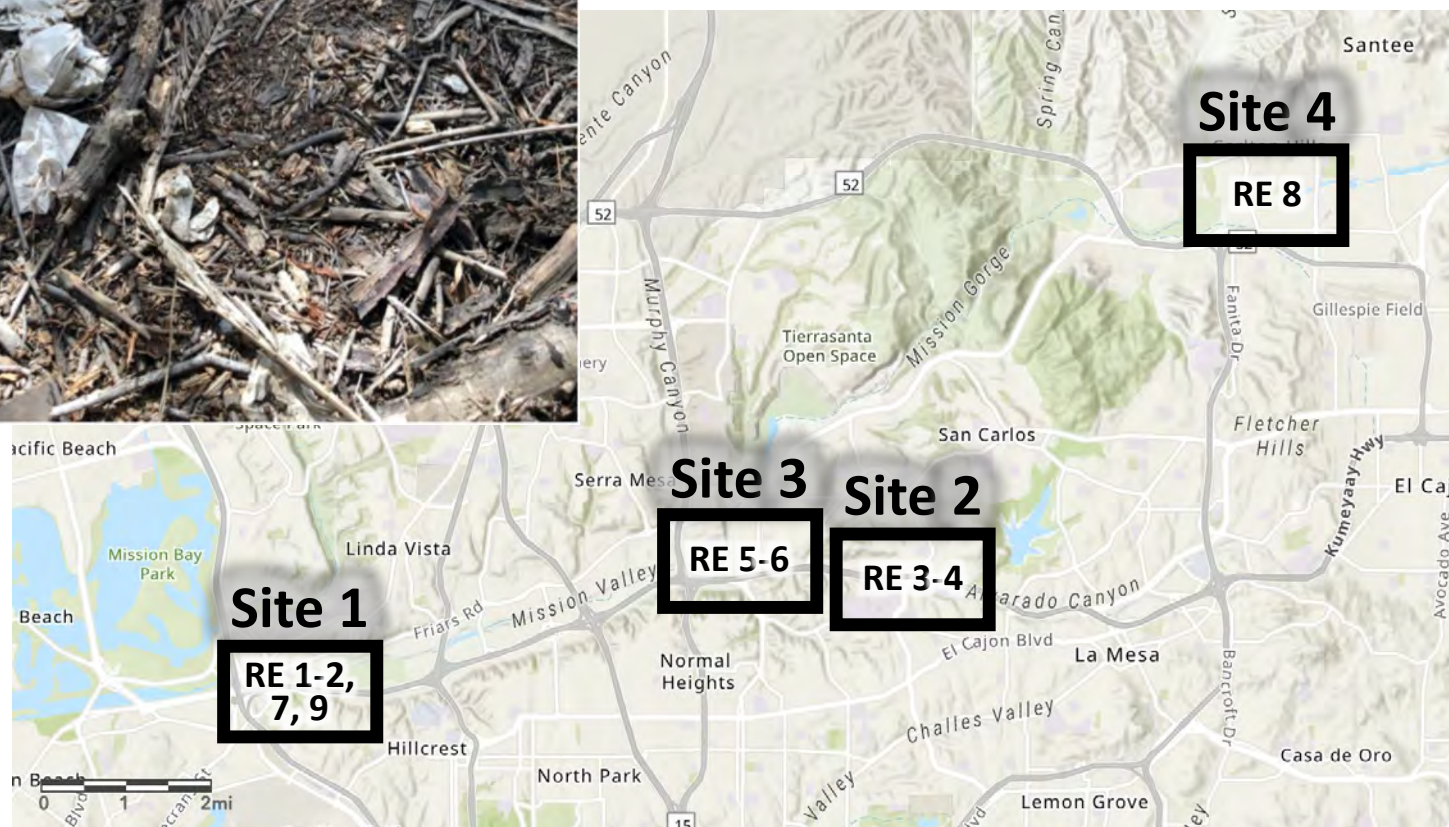




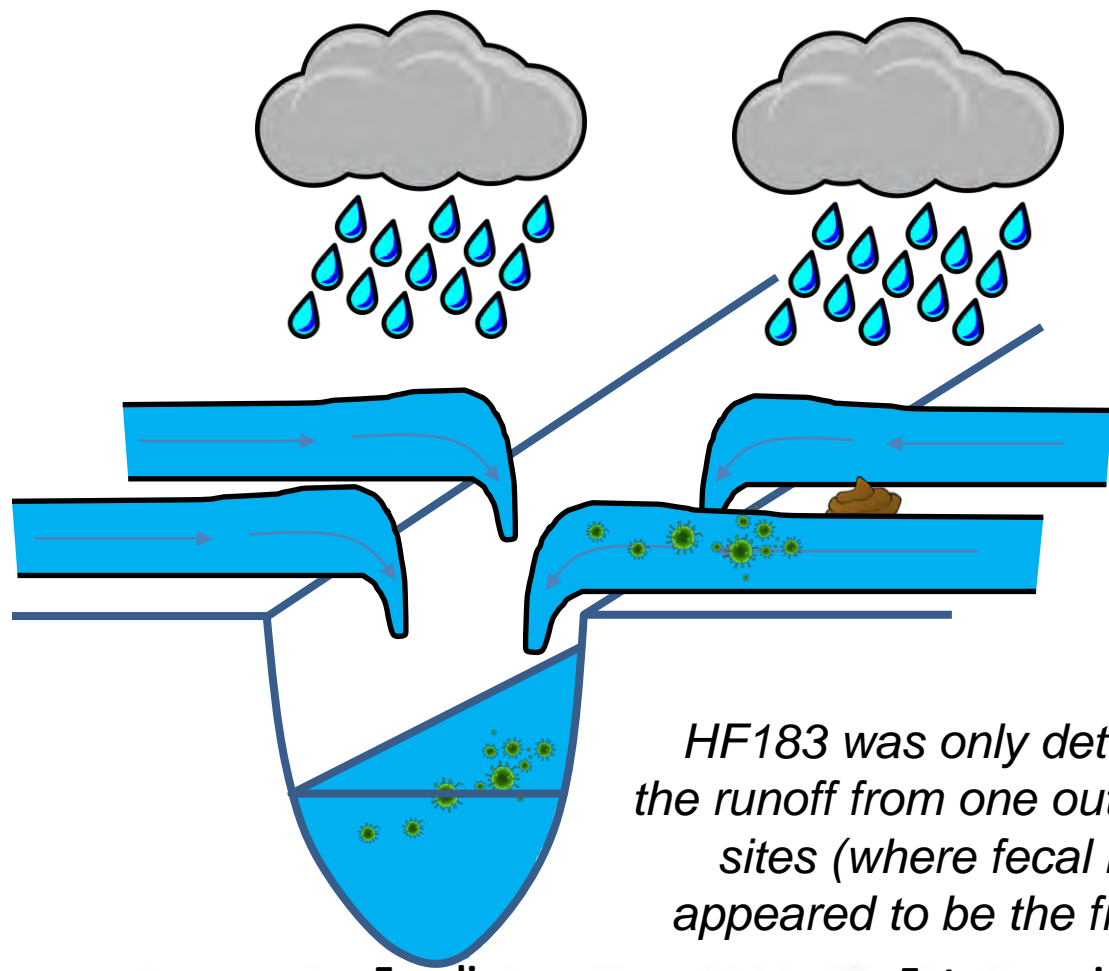
**Experimental  
Set-Up**



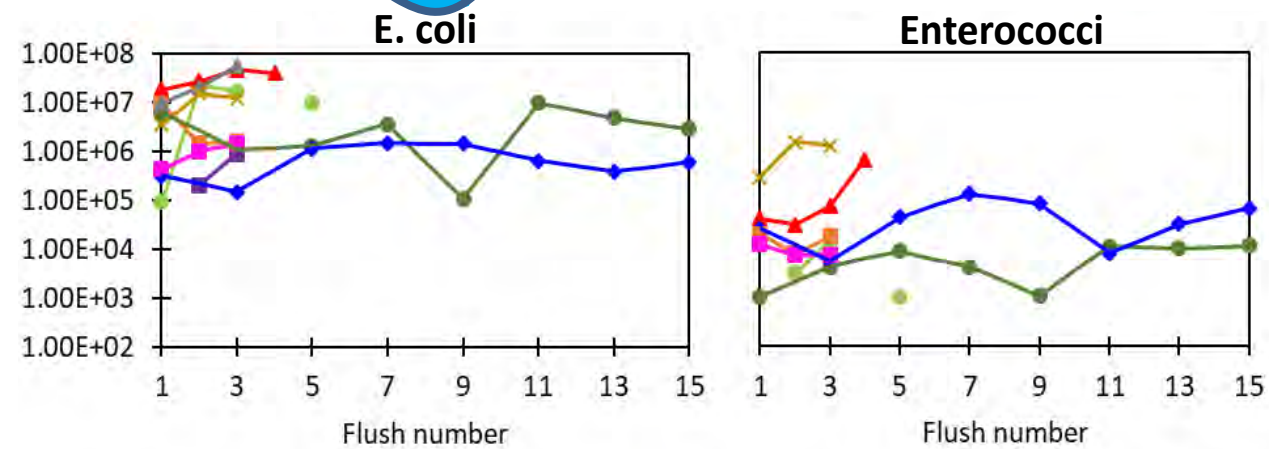
**Napkins and  
Toilet Paper**







*HF183 was only detected in the runoff from one out of nine sites (where fecal material appeared to be the freshest)*





*Areas of soil with evidence of open defecation were flushed with synthetic rainwater, and the runoff was analyzed*

**“Caffeine and HF183 have high concentrations in untreated wastewater but are almost undetectable in stormwater runoff from soil with open defecation”**





# Objective 5

***Quantify changes in  
pollutant  
concentrations and  
loadings during storm  
events***

Photo credit: Eric Frost, SDSU





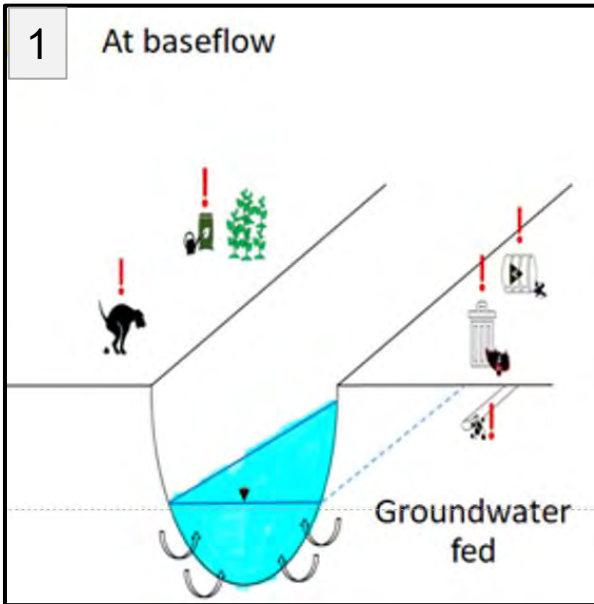


*We measured concentrations of chemical and microbial pollutants in the San Diego River and two tributaries during storm events at 1 to 3 hr increments*

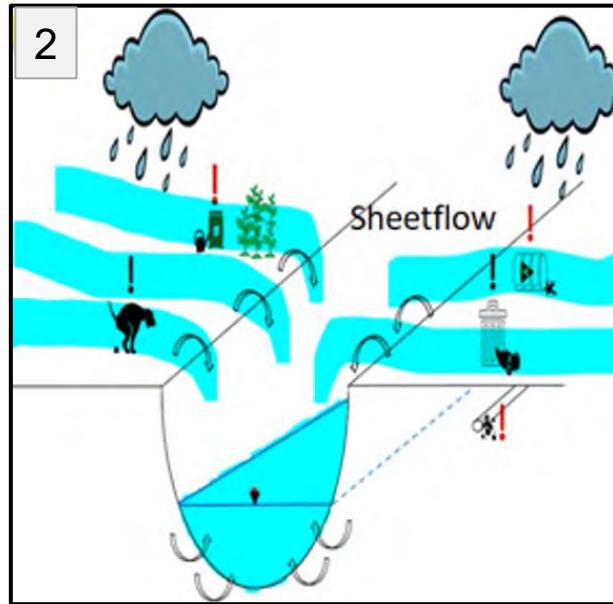
**Chemical and bacterial markers reveal that untreated wastewater is a major source of San Diego River pollution.**

# Storm Hydrology

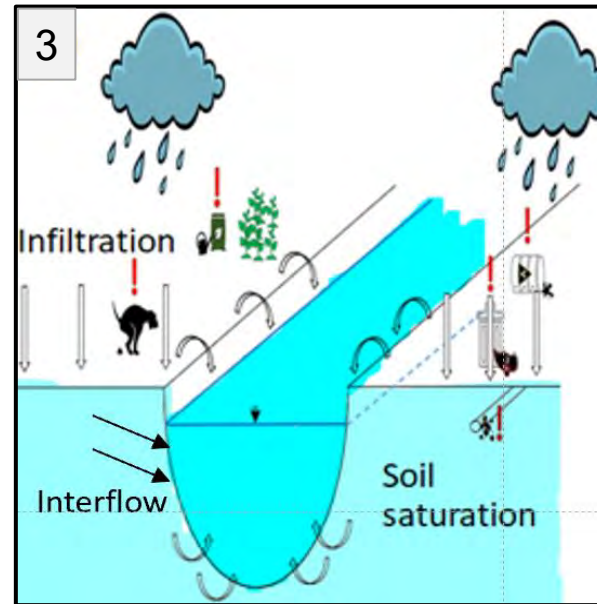
1 At baseflow



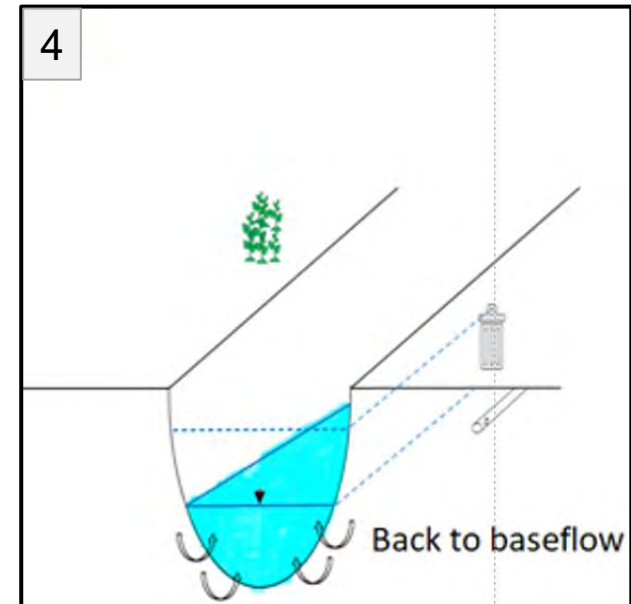
2



3

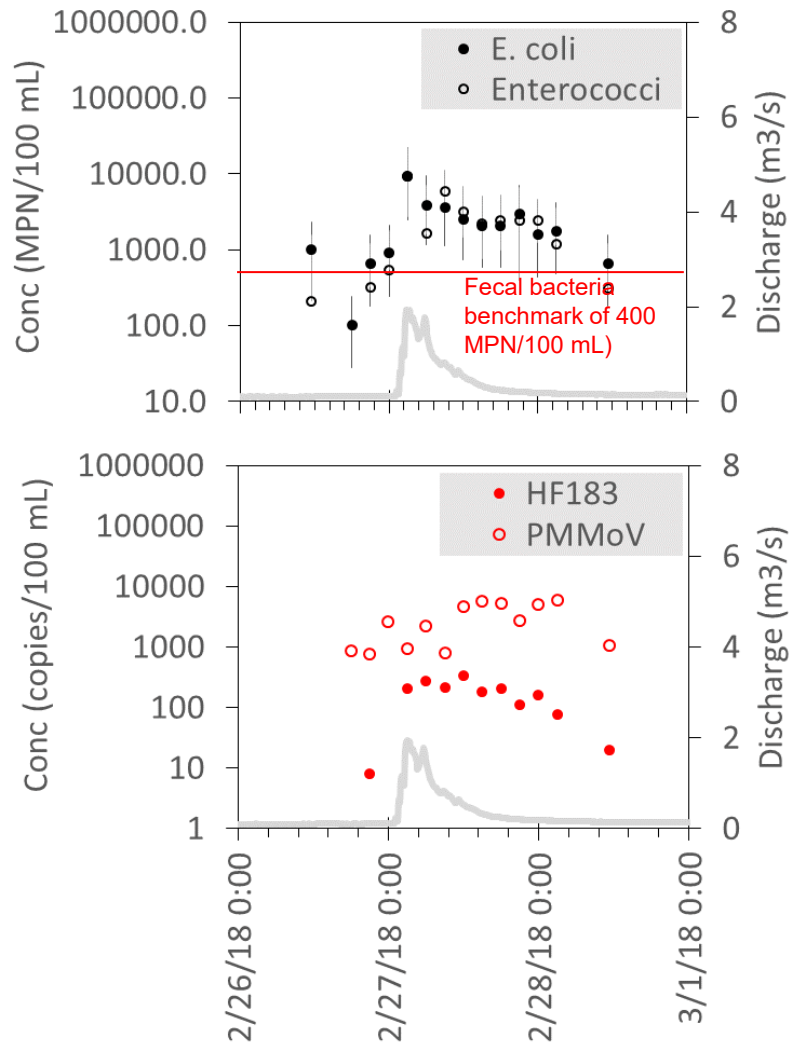


4





# Microbial markers during storms



- Fecal indicator bacteria (*E. coli* and enterococci) exceeded benchmarks
- Human fecal markers were detected in **all** storms.
- **Hepatitis A was NOT detected** but other human pathogens were detected in **some** storms.
- 

## Untreated wastewater

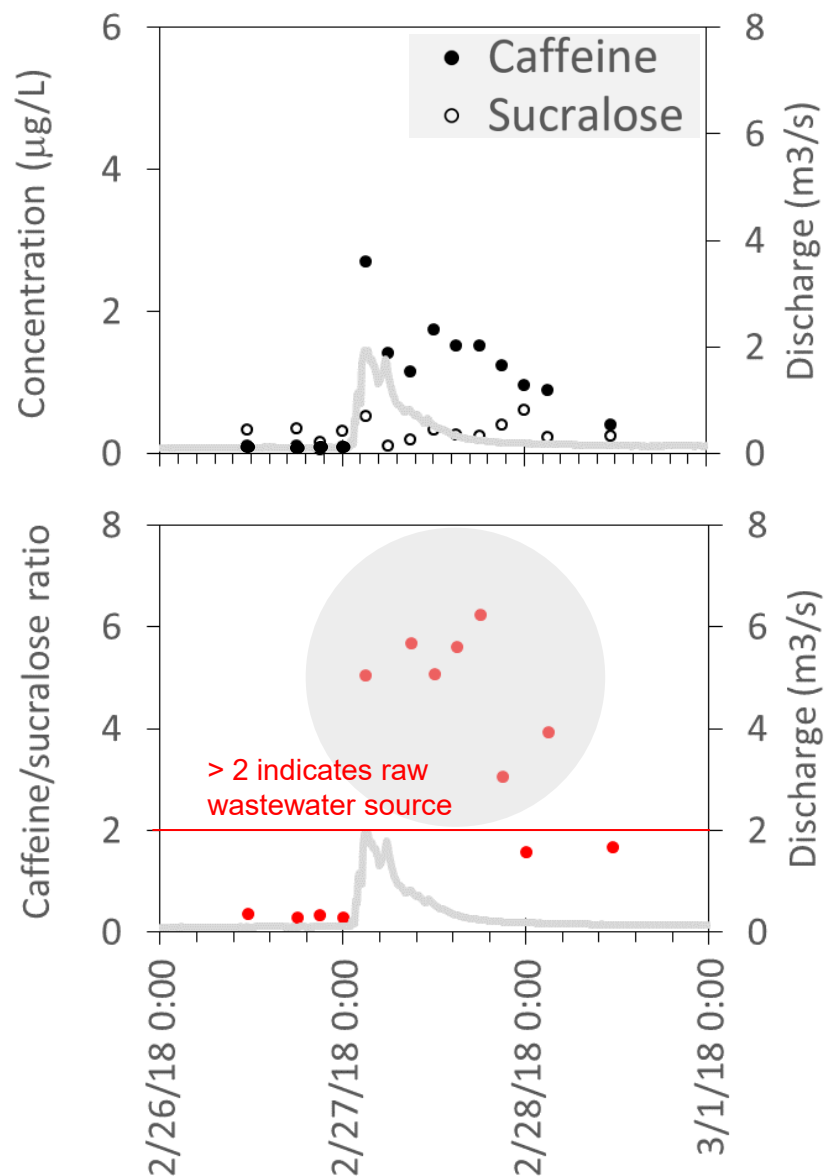


## Open defecation





# Chemical markers during storms



During and after peak flow:

- Caffeine concentrations increased and exceeded 1 – 5 µg/L; sucralose remained low, at 0.2 to 1.0 µg/L
- Caffeine/sucralose ratio had raw sewage signature

## Untreated wastewater



## Open defecation





# Conclusions

- There was **no** strong evidence that homeless encampments are causing increases in the concentration of pollutants **in water** during dry weather conditions.
- **Soils** at homeless encampment cleanup sites did have fecal contamination during and after cleanup.
- **Despite no evidence of inputs into water during dry conditions, individuals living near the river should have adequate sanitation.**

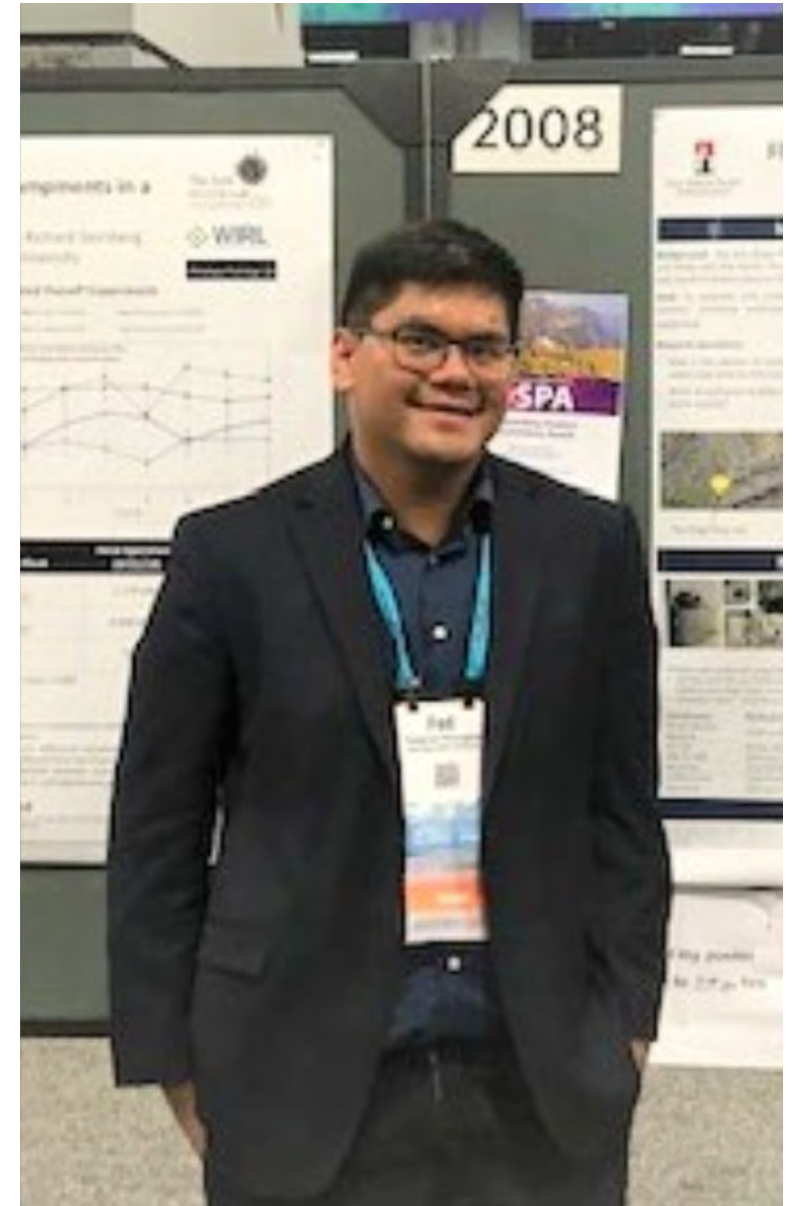


# Conclusions

- Wastewater spills in soils are sources of bacteria and viruses even in flushed soils and after as long as 4 months.
- Evidence from chemical and bacterial markers suggests that untreated wastewater is the **main source** of microbial contamination during storm events.
- Efforts to repair damaged/aged sewers are needed.

# Outputs

- MS Theses
  - Pinongcos - *Anthropogenic sources of contamination in the San Diego River during storm events*
  - Calderon - *An evaluation of microbial source tracking markers for human-associated fecal contamination to a river from non-point sources*
  - Garcia - *An evaluation of microbial pollutants in a watershed with homeless encampments: dry weather conditions*
- Presentations
  - Quarterly updates to SDRC and Water Board
  - Conference presentations (2018 AGU, 2019 SDSU Student Research Symposium, 2019 NMC Denver, 2019 AEESP, 2019 ACS)
- Technical Reports
- Executive Summary
- Final report – at end of project (May 2020)





# Acknowledgements

## **Funding and support from:**

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