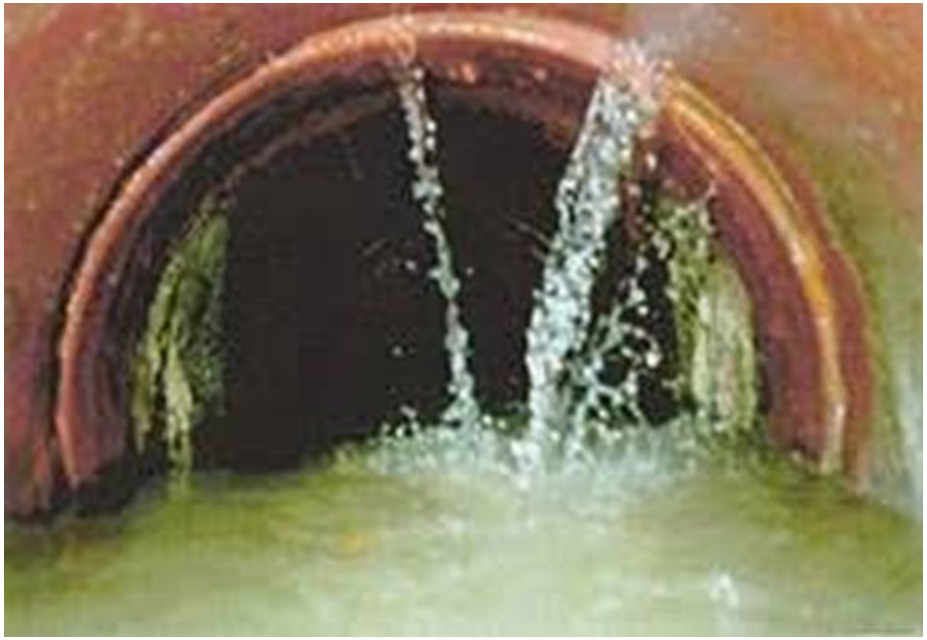
Sewer Exfiltration Theories

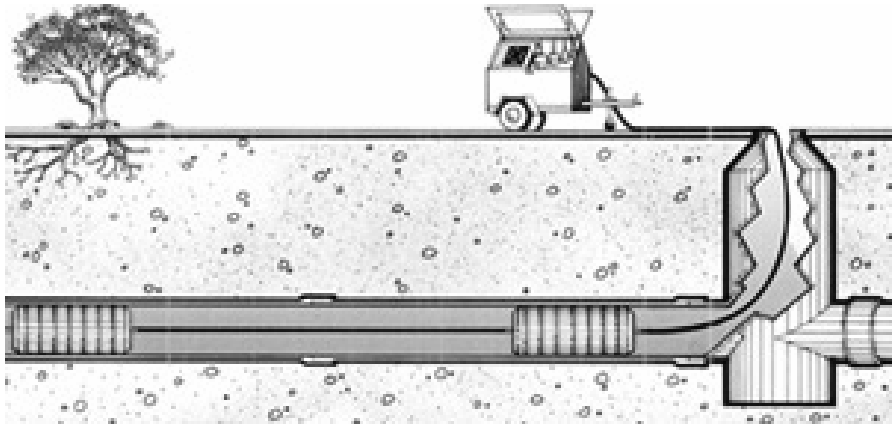


Presented by:
Steve Jepsen
sjepsen@cleanwatersocal.org

BACWA Collection Systems Committee
February 13, 2025

Are Sewers a Watershed Bacteria Source? **Unlikely.**

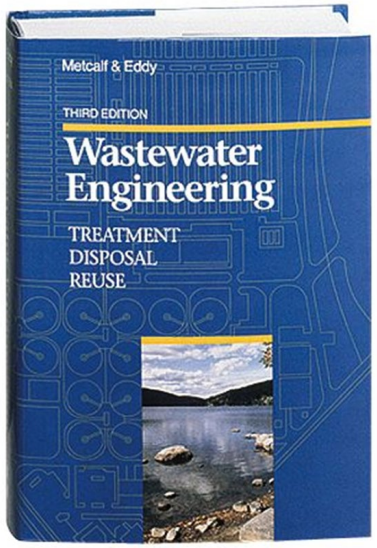
UC Irvine, OCSD, Brown and Caldwell Study 2005 –
Quantifying Sub-surface discharges from Individual Sewer Defects



Metcalf & Eddy Water Treatment Book has a chapter dedicated to how natural treatment systems, in the soil, effectively treat bacteria and viruses

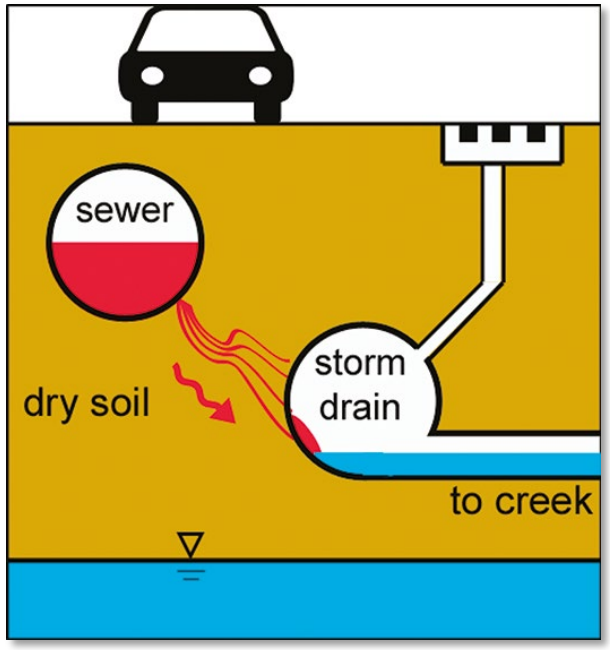
TABLE 14-7
Treatment performance of onsite system components and intermittent or recircu

Parameter	Raw waste (1)	Septic tank effluent (2)	1.0 ft below bottom of leachfield trench (3)	3.0 ft below bottom of leachfield trench (4)
BOD_5, mg/L	210–530	140–200	0	0
SS, mg/L	237–600	50–90	0	0
Nitrogen, mg/L				
Total	35–80	25–60	—	—
NH_4^+	7–40	20–60	20[b]	—
NO_3^-	<1	<1	40[b]	40[b]
Total phosphorus, mg/L	10–27	10–30	10[b]	1[b]
Fecal coliforms, MPN/100 mL	10^6–10^{10}	10^3–10^6	^{20}–10^2	0
Viruses, PFU/mL[c]	Unknown	10^5–10^7	^{20}–10^3	0



Are Sewers a Possible Bacteria Source? **Can be.**

* City of Santa Barbara Studies
  - Bacteria found in storm drains
  - Dogs used to identify sources
  - Human specific HF 183 tests positive
  - Sewers shown to be a source
  - Dye tests confirm sewer exfiltration into storm drain occurring



(Sercu et al. 2011, ES&T)

The San Diego River Investigative Order – SDR IO

The ten agencies in the watershed shall:

* Identify and quantify relative contributions of suspected sources of human fecal material in wet weather discharges to the San Diego River

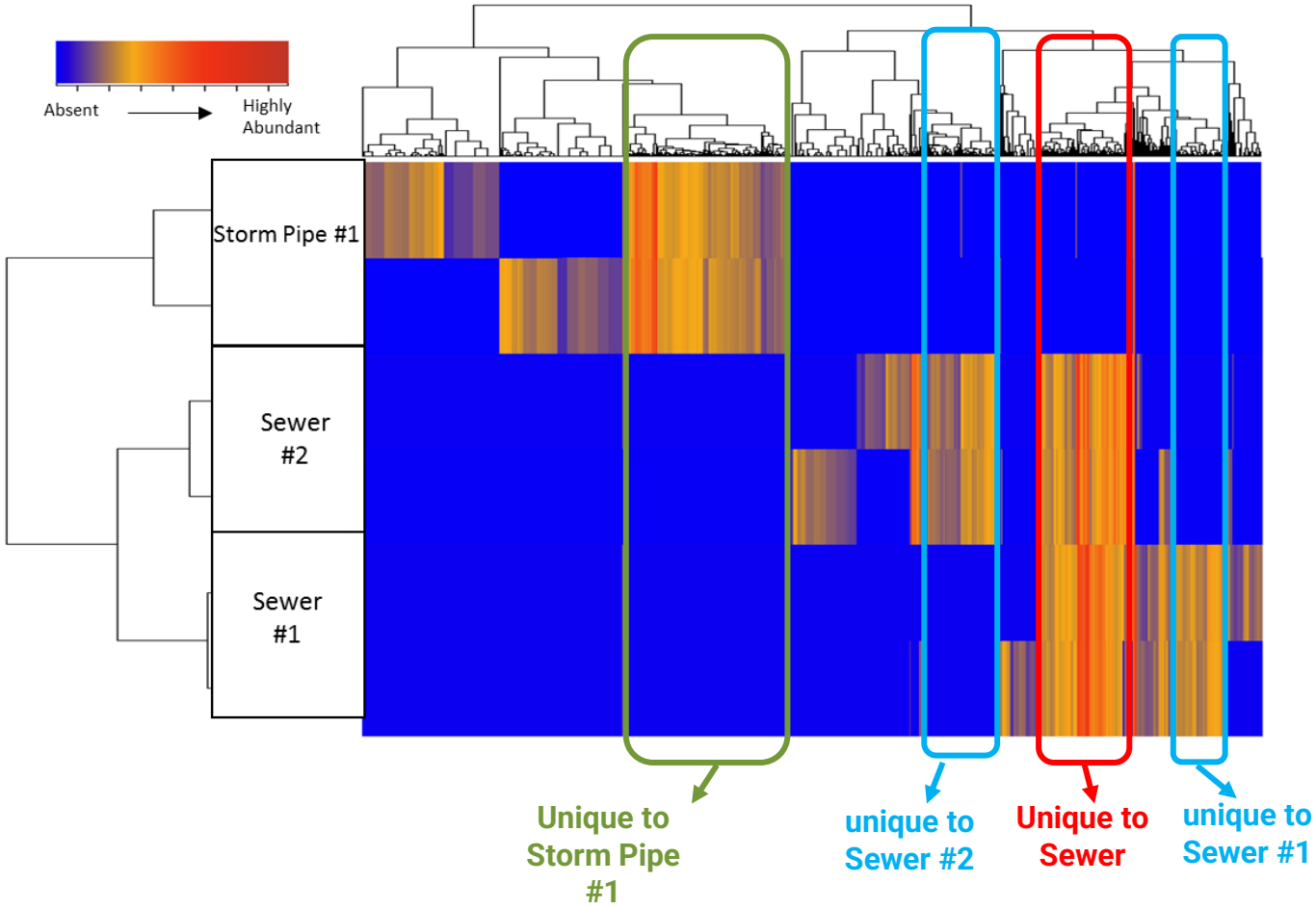
* Determine the transport pathways of such discharges

* Determine how this information will be used by each Discharger to assess the effectiveness of current management measures in preventing discharges of human fecal matter into the San Diego River

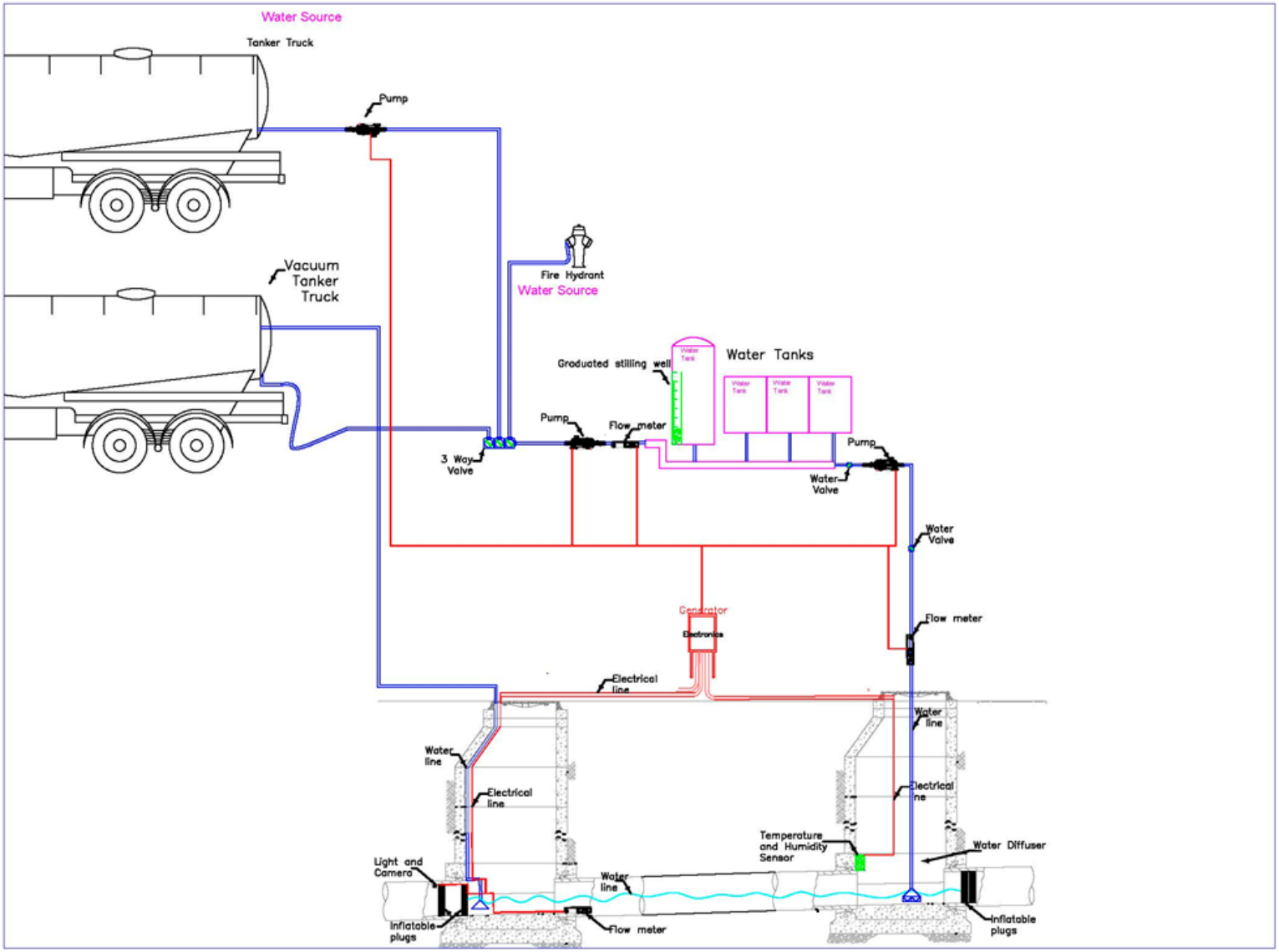
SDR IO - SCCWRP Work Plan

1. **Steering Committee and Technical Advisory Committee**
2. **GIS Foundation**
3. Human Fecal Contamination from **Exfiltration of Publicly Owned Collection Systems**
    - **Microbial Community Profiling**
4. Human Fecal Contamination from **Exfiltration of Private Laterals**
5. Human Fecal Contamination from **Homeless Encampments**
6. Human Fecal Contamination from **Septic Systems**
7. Human Fecal Contamination from **Dry Weather Illicit Connections/Illicit Discharge**
8. **Frequency and Magnitude of Sanitary Sewer Overflows**
9. **Reporting and Data Management**

Microbial Community Profiling



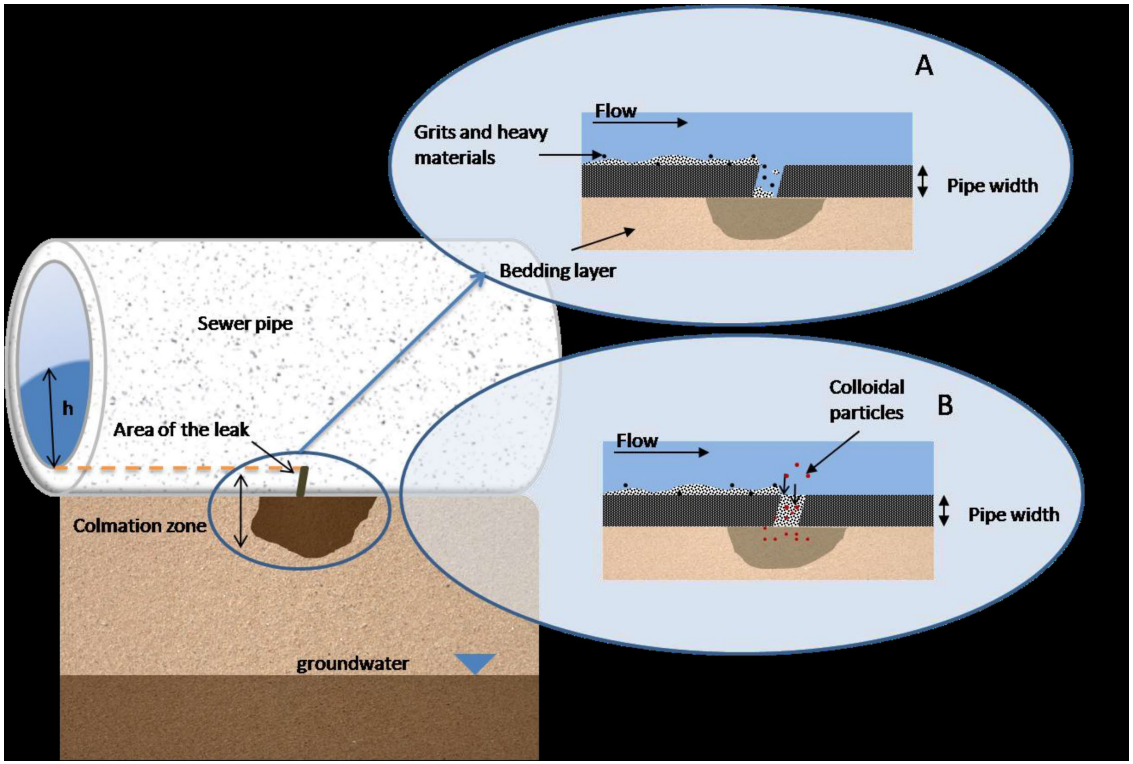
Exfiltration Measurement Device



Issues with SCCWRP Study

1. Test uses highly chlorinated potable water
2. Test does not account for test system losses
3. Even CIPP was found to “leak”
4. Loss calculations do not account for diurnal flow patterns
5. Physics, Soil Fate and Transport, Collection System Construction/Condition/Operation largely ignored
6. Unknown transport to MS4/watershed
7. And more…

Colmation Layer

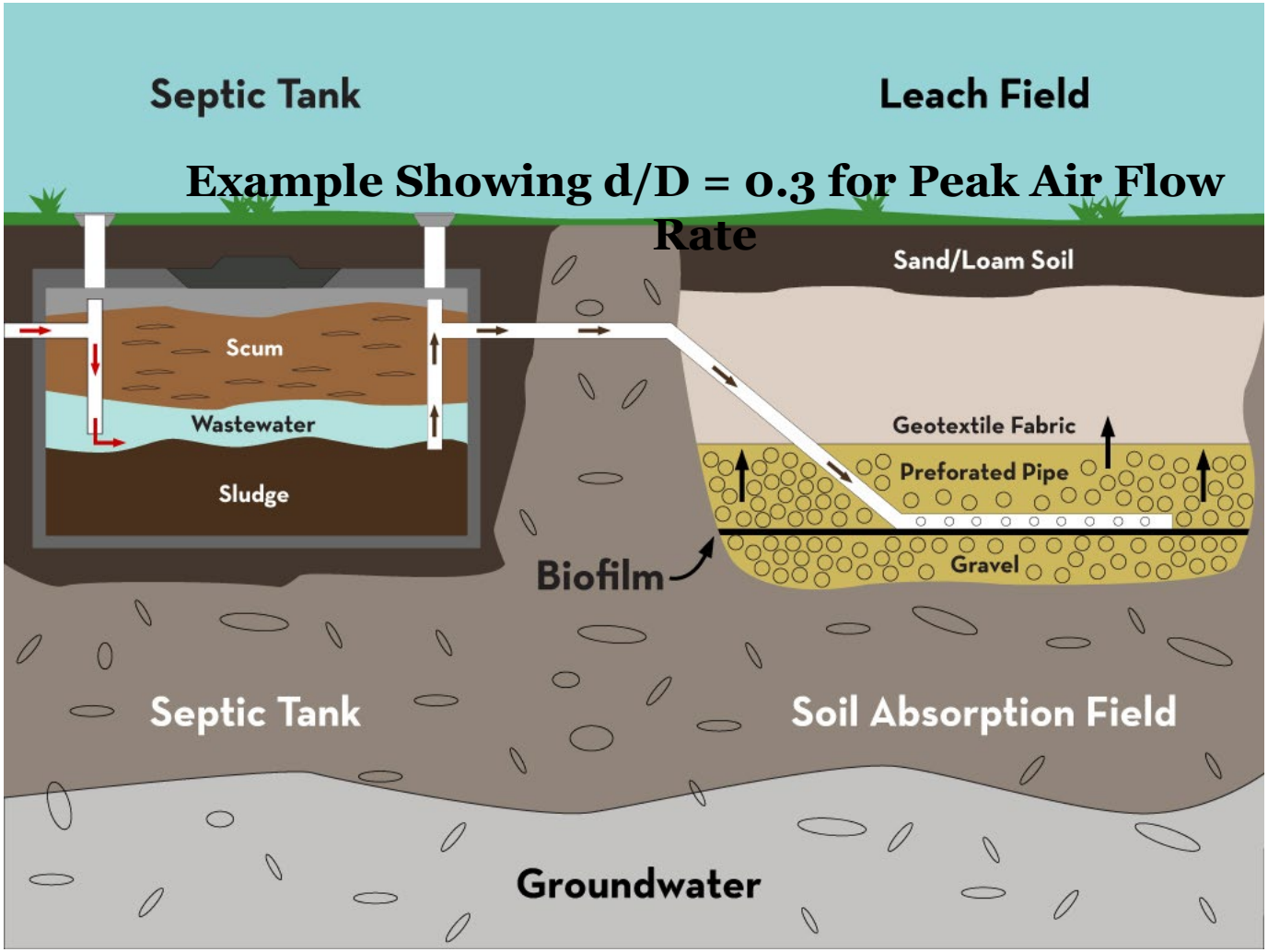


- Colmation Layer (clogging layer)
- Accumulation of suspended solids and biomass
  - 1 to 5 cm thick
  - Reduces K and porosity
  - Exfiltration decreased or eliminated
- Referenced in several publications:
  - UK study
  - German study
  - OCSD/UC Irvine study

Testing for Exfiltration with Water

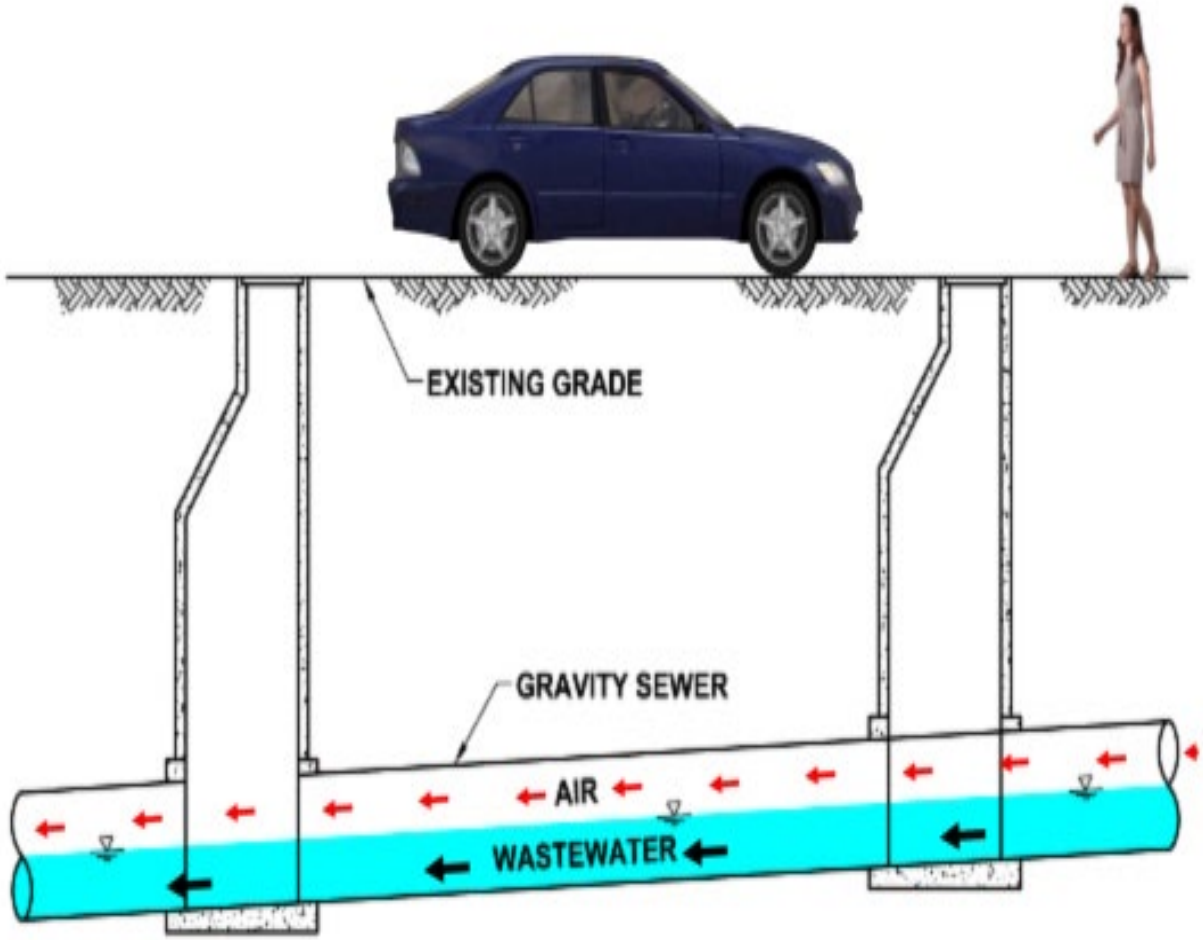
- ELAP Certified Lab
- 500 ml of sewage and water
- .45 micron filter
- 500 ml water passed in 20 seconds
- 70 ml sewage passed after 30 minutes
- After 30 minutes no visible flow
- 120 ml sewage passed after 14.5 hours

Learning from Failing Septic Systems

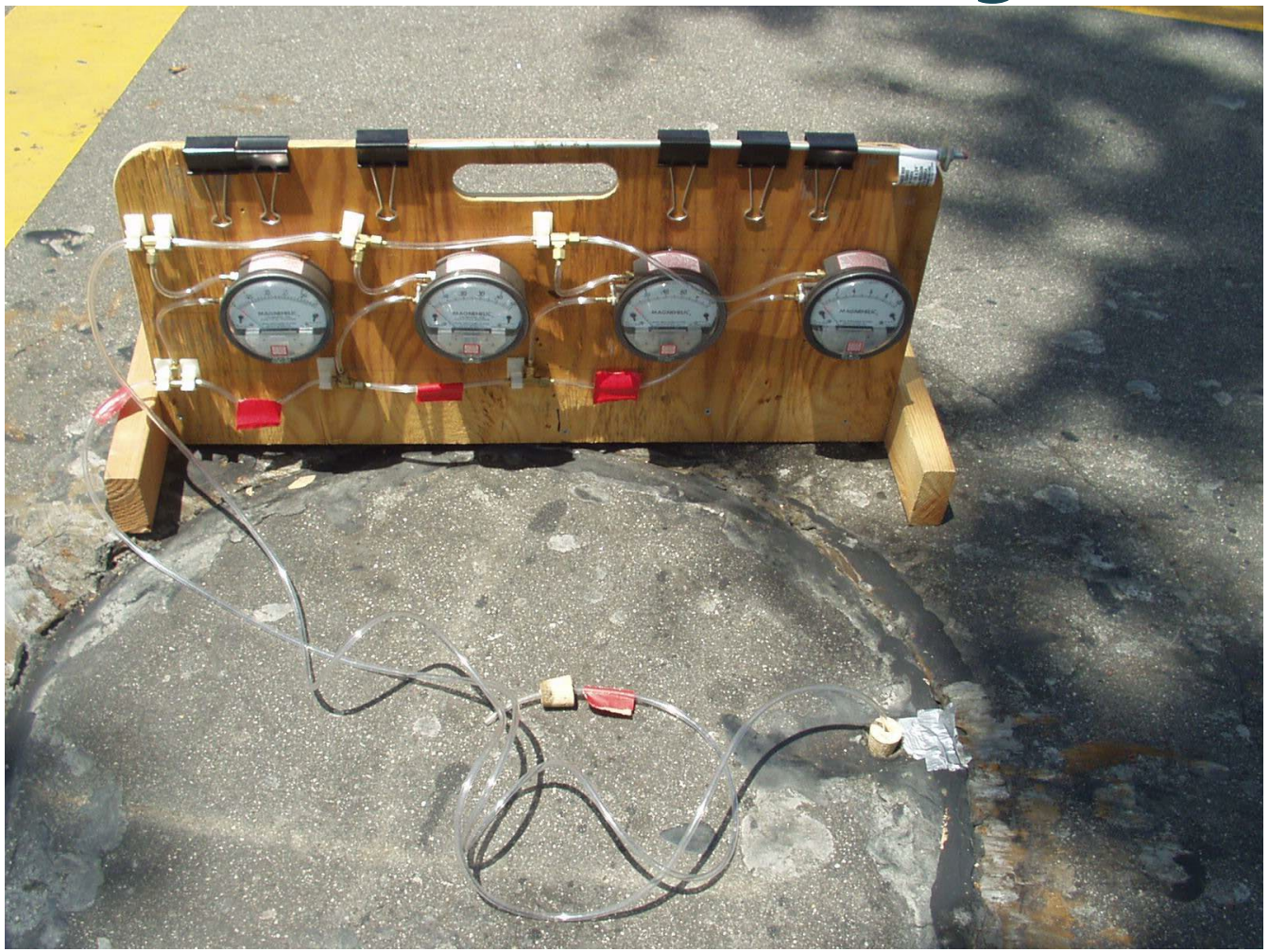


Normal Open Channel Sewer – Headspace Air Travels with Sewage

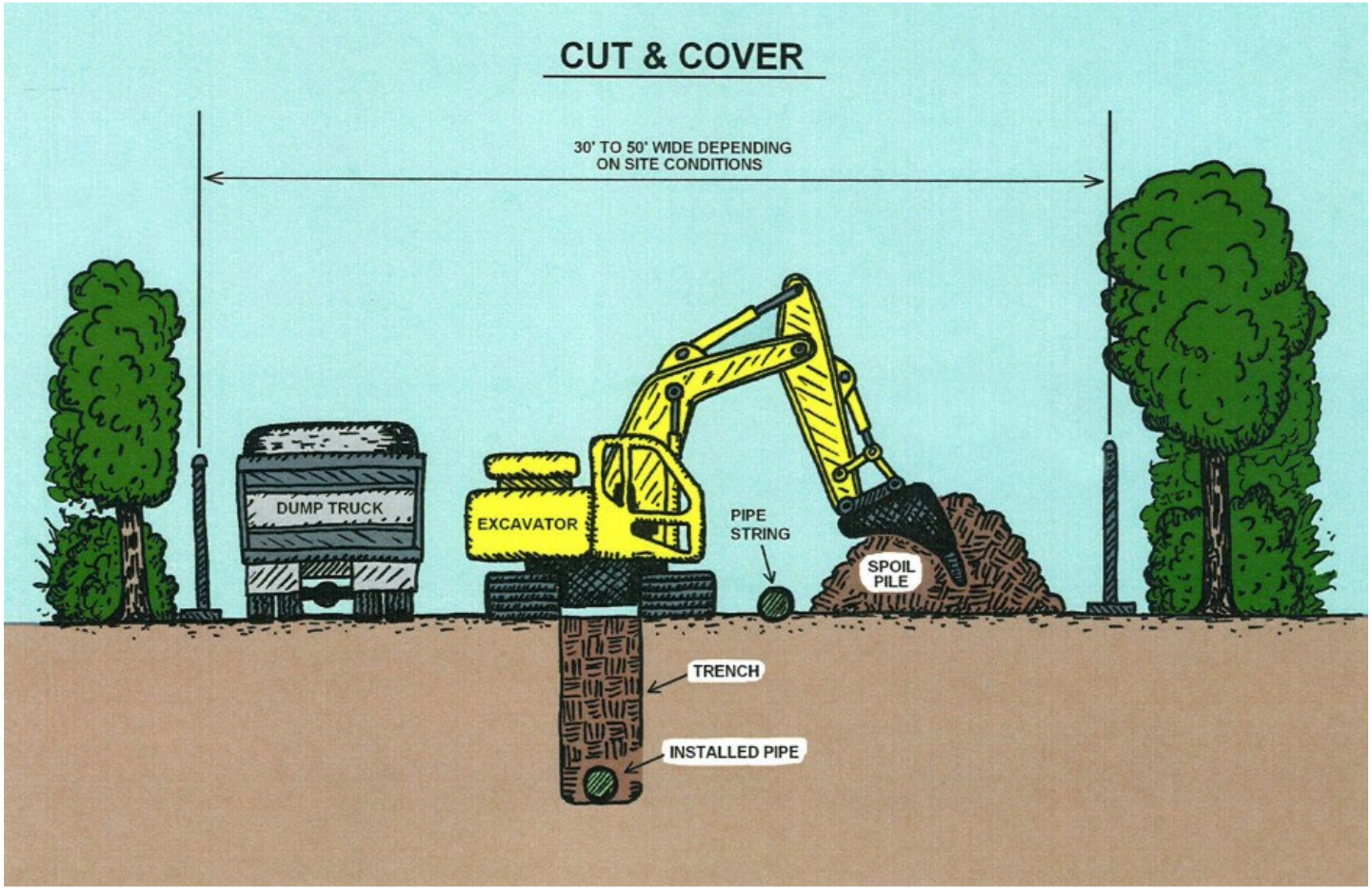
- Sewers Flow Partially Full
- "Headspace" = Air Above Water Surface
- "Headspace" Conducts Foul Air
- Creating Negative Pressure



Dwyer Instruments – Magnehelic Pressure and Vacuum Gauges



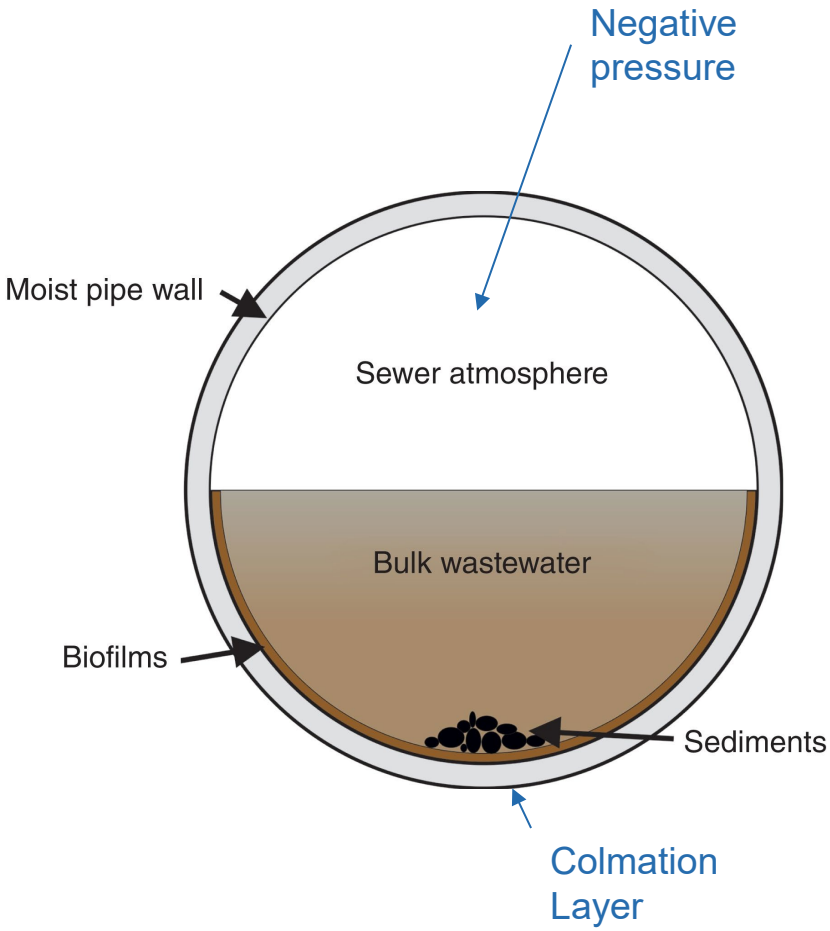
Sewer Construction



Pipe Zone Bedding

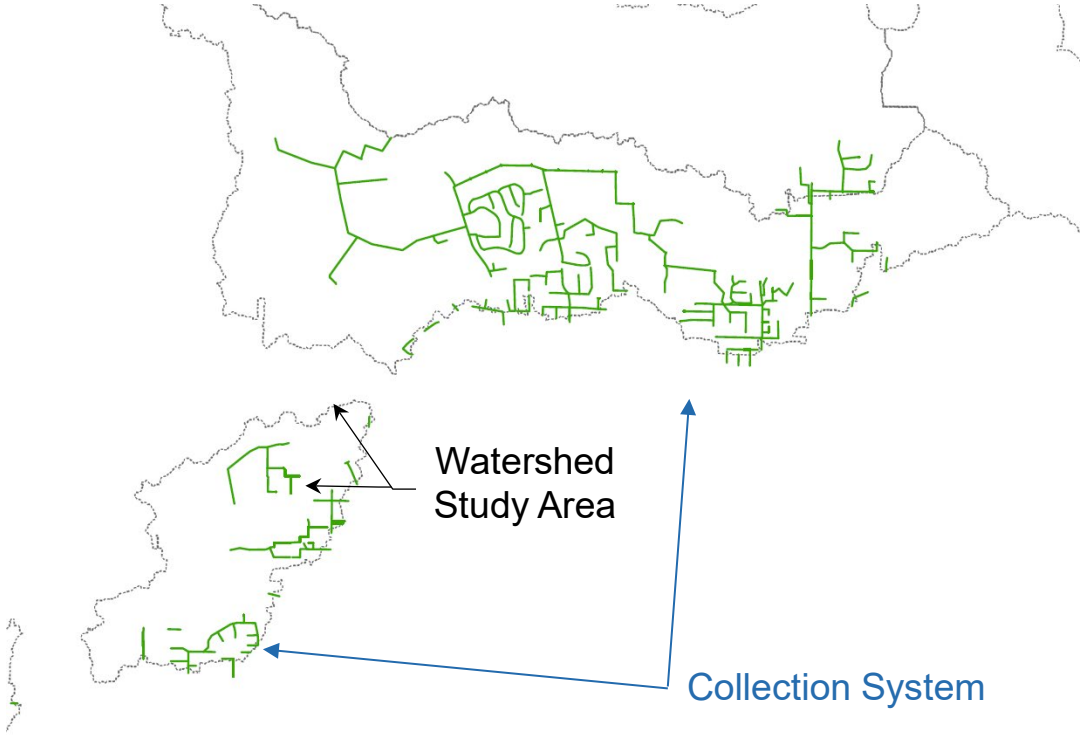
Conditions Preventing Exfiltration

- Colmation layer
- Gravity sewer at zero or negative pressure
- Half full is usually maximum design flow
- Normal peak flow is less than half full
- Diurnal flow patterns create daily low flow periods far below half full most of the time
- High groundwater creates positive pressure into pipe favoring infiltration during rain
- Compacted trench bottom not conducive to percolation from trench zone
- Declining flow = higher grease and suspended solids content
- Modern joints and pipe materials
- Effective natural treatment occurs in soil
- Finally, the sewage must push through soil and through the stormdrain pipe wall



Desktop GIS Approach

- **507 pipes**
- **93,000 ft (18 miles)**



- Contributing Factors
  - Pipe Crossings
  - Vertical Separation
  - Sewer Pipe Material/Age/Condition
  - Sewer Flow
  - Storm Drain Material/Age
  - Soil Type

Desktop GIS Priority Ratings

- Scoring matrix-based
  - 19 of 507 (4%) sewer pipe segments above storm drain
  - 12 of 19 (2%) also cross storm drain
  - 6 of 12 (1%) also have defect
  - 2 of 6 (0.3%) also in sandy soil → highest rating

Site ID	Spatial Relationship				Ground Water					Sewer Pipe Priority Rating					Storm Drain Pipe Priority Rating					Soil Priority Rating			FINAL	Rank
	Vert. Dist.	Horz. Dist	Avg	Total	In Valley?	Swr Depth	Vert. Dist.	Avg	Total	Flow Depth	Defect	EMA	Avg	Total	SD Mat'l	Size	Age	Avg	Total	Perm. (in/hr)	Avg	Total	SCORE	
116	5	1	3.0	**9.0**	3	3	5	3.7	**3.7**	1	0	0	0.3	**1.7**	2	3	2	2.3	**2.3**	3	3.0	**6.0**	22.7	8
176	5	3	4.0	**12.0**	3	2	5	3.3	**3.3**	2	2	0	1.3	**6.7**	2	5	2	3.0	**3.0**	1	1.0	**2.0**	27.0	3
223	5	3	4.0	**12.0**	3	1	5	3.0	**3.0**	1	0	0	0.3	**1.7**	2	5	2	3.0	**3.0**	1	1.0	**2.0**	21.7	10
225	5	2	3.5	**10.5**	3	2	5	3.3	**3.3**	2	0	0	0.7	**3.3**	2	5	2	3.0	**3.0**	1	1.0	**2.0**	22.2	9
257	4	3	3.5	**10.5**	3	1	5	3.0	**3.0**	1	2	0	1.0	**5.0**	3	3	2	2.7	**2.7**	1	1.0	**2.0**	23.2	7
277	5	3	4.0	**12.0**	3	1	5	3.0	**3.0**	1	2	0	1.0	**5.0**	2	3	2	2.3	**2.3**	1	1.0	**2.0**	24.3	5
302	5	3	4.0	**12.0**	1	1	5	2.3	**2.3**	0	3	0	1.0	**5.0**	2	2	2	2.0	**2.0**	1	1.0	**2.0**	23.3	6
333	5	3	4.0	**12.0**	3	2	5	3.3	**3.3**	2	4	0	2.0	**10.0**	3	4	3	3.3	**3.3**	3	3.0	**6.0**	34.7	1
368	5	1	3.0	**9.0**	3	2	5	3.3	**3.3**	1	4	0	1.7	**8.3**	4	1	3	2.7	**2.7**	1	1.0	**2.0**	25.3	4
590	4	3	3.5	**10.5**	1	1	5	2.3	**2.3**	1	3	1	1.7	**8.3**	3	2	2	2.3	**2.3**	3	3.0	**6.0**	29.5	2

Field-based Approach

Air Knife Technology

Excavated Hole (to pipe bedding)

Conclusions

* Bacteria are a frequent constituent of concern in watersheds
* Stormwater quality practitioners and scientists don't always understand collection systems and assume they are leaking
* Sewer Exfiltration to MS4 Infiltration is a prime suspect, there are rare but documented cases where it has occurred
* Sometimes there is a rush to judgement based on a lack of understanding of collection system operation/construction
* We need to get out in front of this issue and:
  * Educate the public, regulators and stormwater quality practitioners
  * Design economical focused exfiltration investigation and remediation practices for our collection systems

What about the reissued SSS WDR?

3.2.4. Underground Sanitary Sewer System Leakage
Portions of some sanitary sewer systems may leak, causing underground exfiltration (exiting) of sewage from the system. Exfiltrated sewage that remains in the underground infrastructure trench and/or the soil matrix, and that does not discharge into waters of the State (surface water or groundwater) may not threaten beneficial uses.

Underground exfiltrated sewage may threaten beneficial uses if discharged to waters of the State. Exfiltrated sewage that discharges to groundwater may impact beneficial uses of groundwater and pollute groundwater supply. Additionally, if in close proximity, exfiltrated sewage may enter into a compromised underground drainage conveyance system that discharges into a water of the United States, or into groundwater that is hydrologically connected to (feeds into) a water of the United States, thus potentially causing: (1) a Clean Water Act violation, (2) threat and impact to beneficial uses, and/or (3) surface water pollution.

What about the reissued SSS WDR?

8.1 System Evaluation and Condition Assessment

The Plan must include procedures to:

- Prioritize the condition assessment of system areas that:
    - o Hold a high level of environmental consequences if vulnerable to collapse, failure, blockage, capacity issues, or other system deficiencies;
    - o Are located in or within the vicinity of surface waters, steep terrain, high groundwater elevations, and environmentally sensitive areas;
    - o Are within the vicinity of a receiving water with a bacterial-related impairment on the most current Clean Water Act section 303(d) List;

Next Steps:

- Workshops, Workshops, Workshops
- Outreach, Outreach, Outreach

Steve Jepsen
Clean Water SoCal
sjepsen@cleanwatersocal.org