

Prediction of Sanitary Sewer Overflow Conditions and Mitigation Using a Remote Telemetry System Network



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Thank You

Lorien Fono, Ph.D., P.E., Executive Director
Bay Area Clean Water Agencies (BACWA)

Mary Cousins, Ph.D., P.E., Regulatory Program Manager
Bay Area Clean Water Agencies (BACWA)

for inviting us to give the talk

Mark Grushayev, Wastewater Treatment Plant Director
Sewerage Agency of Southern Marin (SASM)

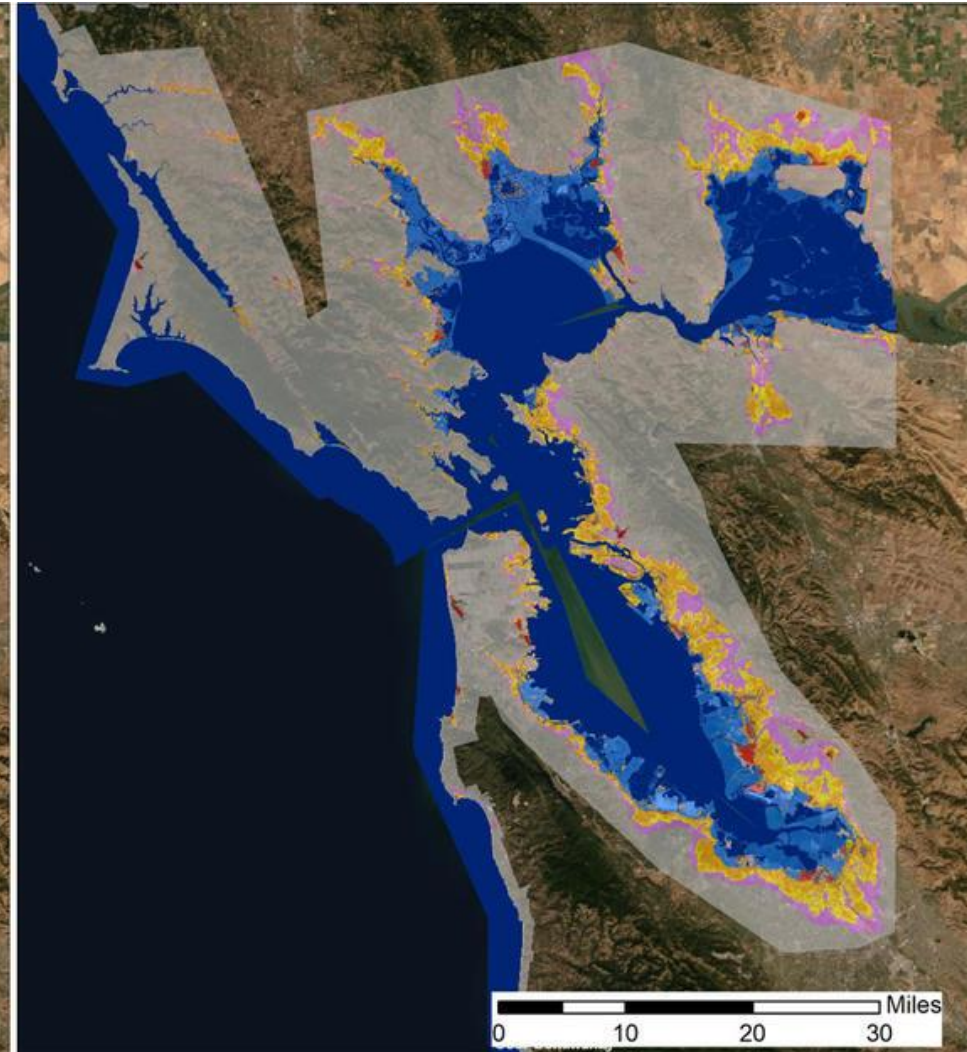
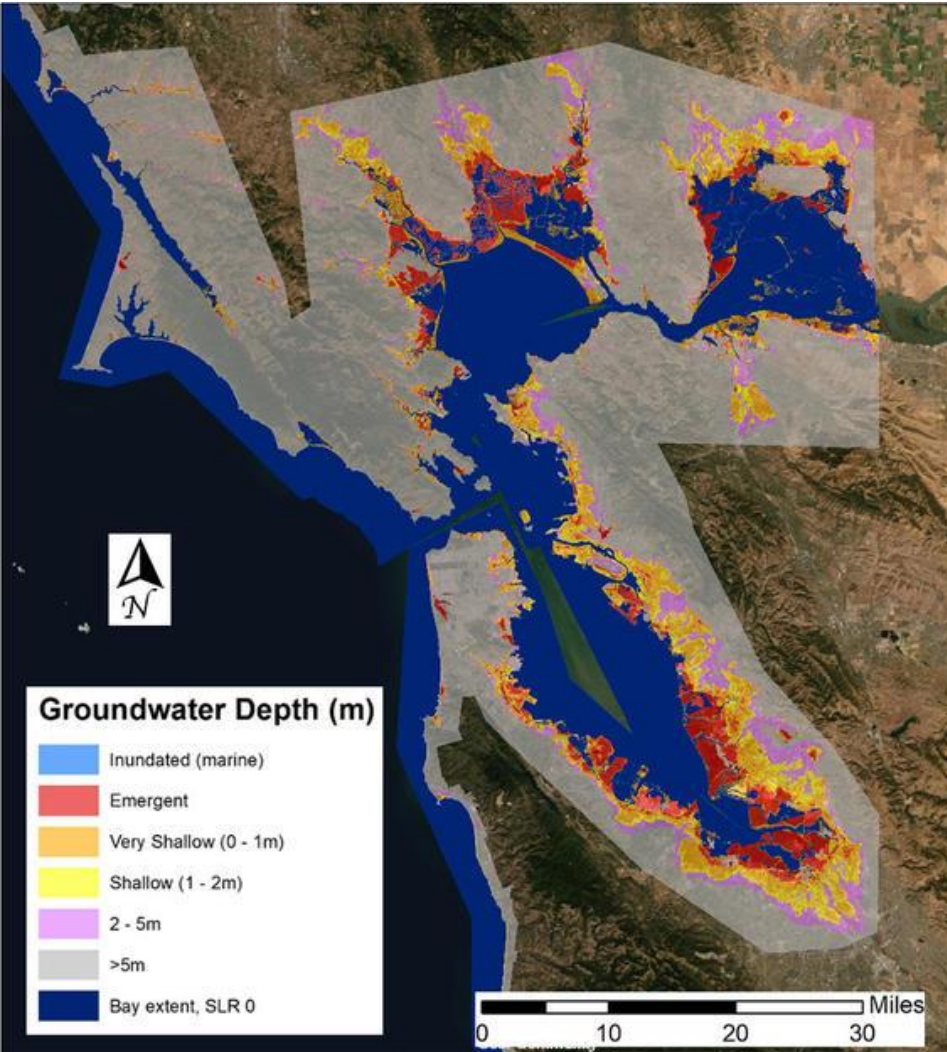
Heather Abrams, General Manager
Tamalpais Community Services District (TCSD)

for encouraging us in sewer-groundwater issues

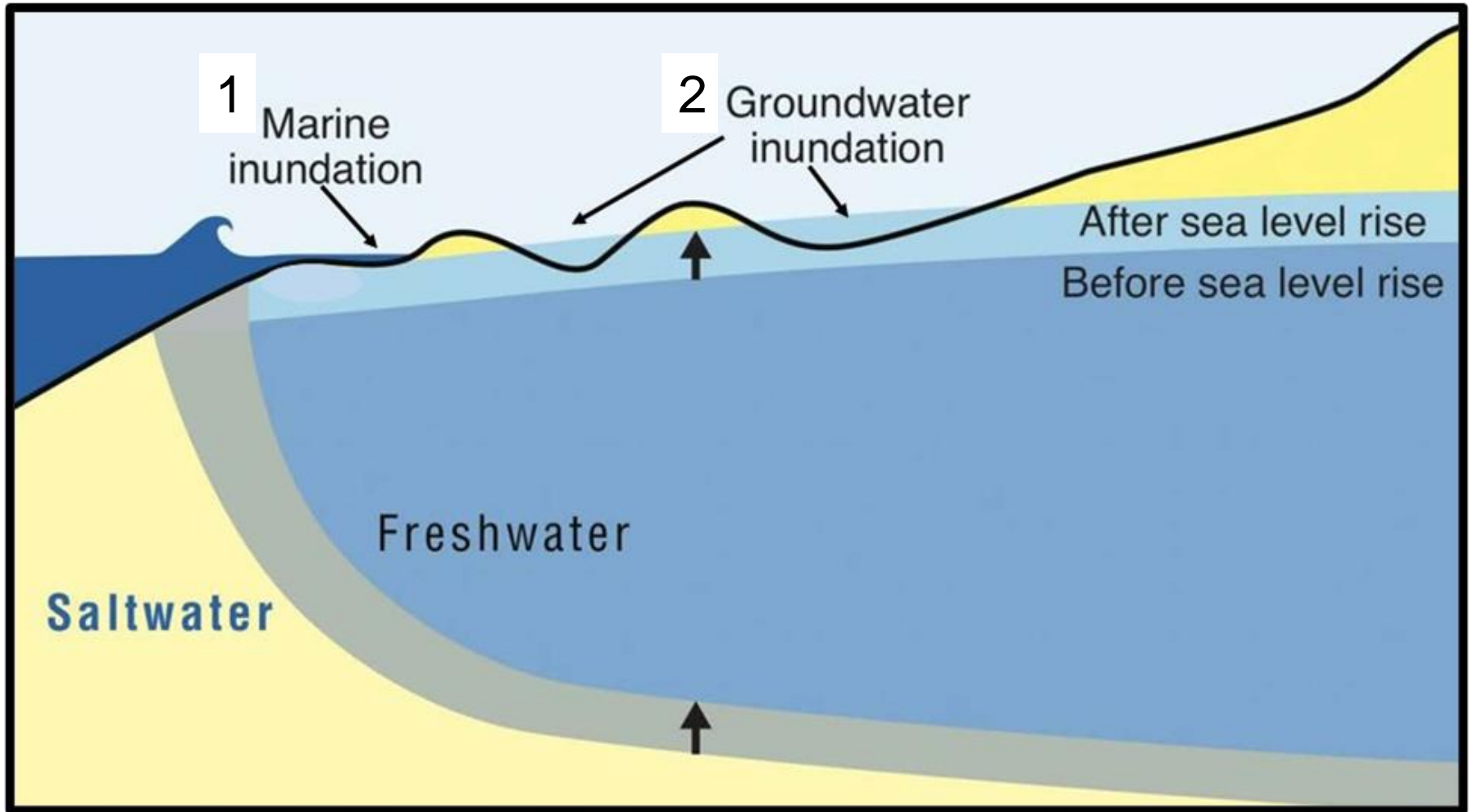
Sea Level Rise, Extreme Storms and Groundwater Inundation Based on Topography and SLR Changes

Current groundwater, groundwater inundation in red

Groundwater with 6 ft sea-level rise



Sea Level Rise, Extreme Rain, and Groundwater Inundation: Two Manifestations of Sea Level Rise



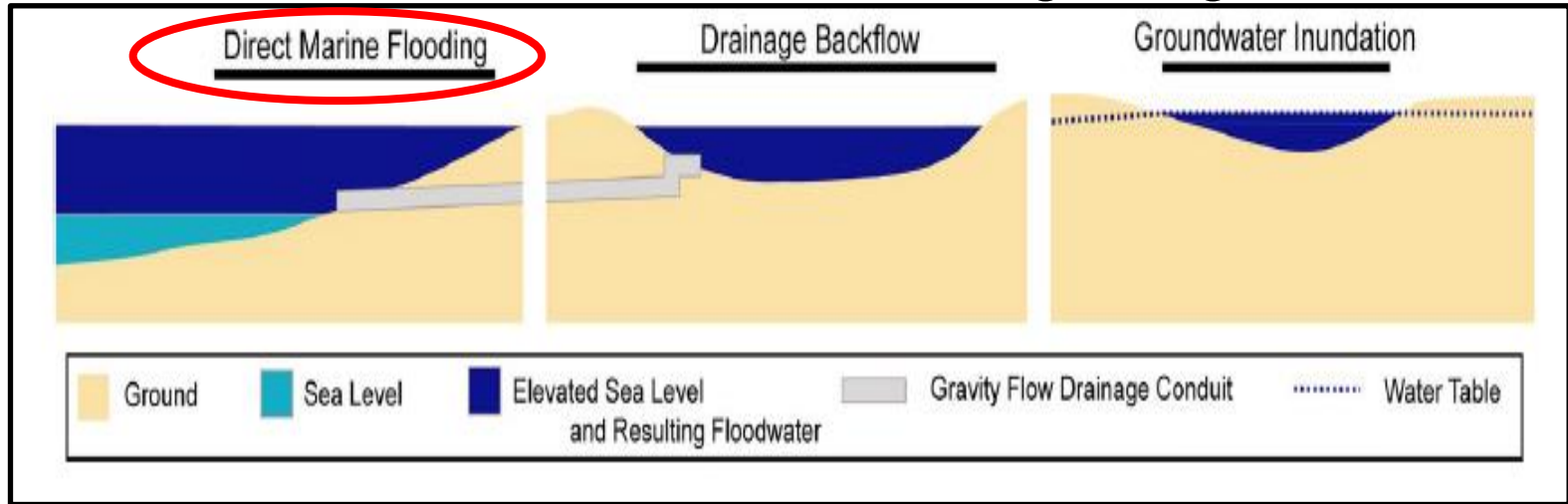
From Univ. Hawaii, Manoa, Coastal Studies Group

Daily Tidal Effects predict what we should experience with SLR.

Evidence of Sea Level Rise and Extreme Storms Tamalpais Valley, Southern Marin County, California

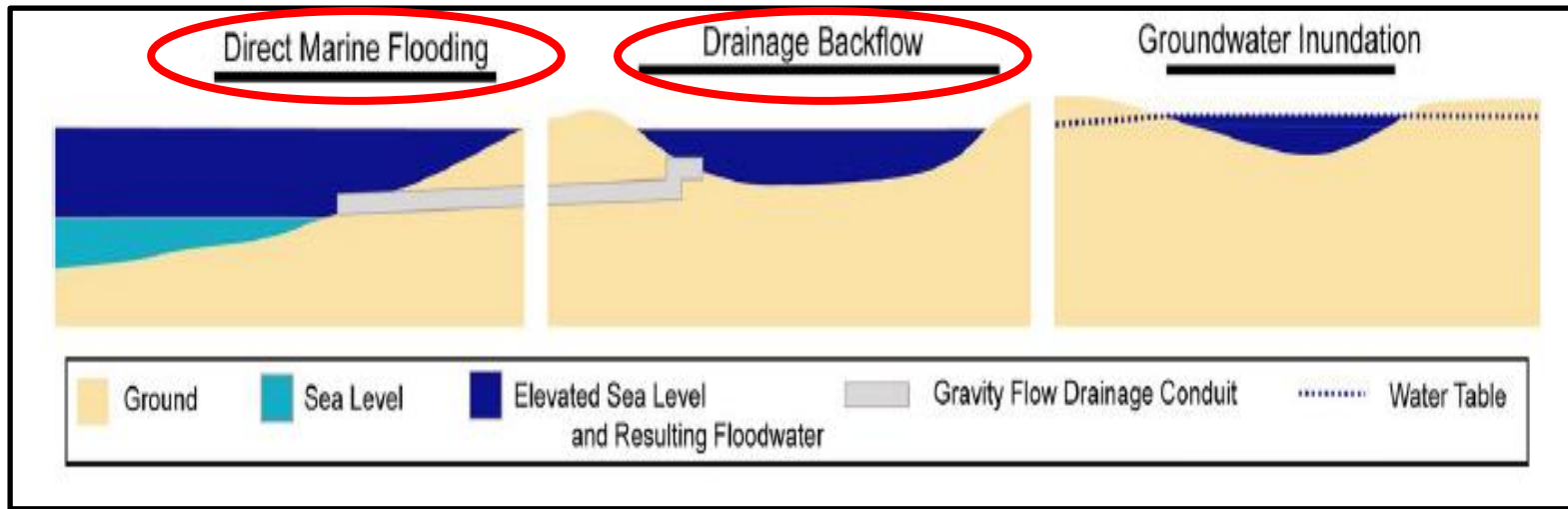


Evidence of Direct Flooding “King Tides”

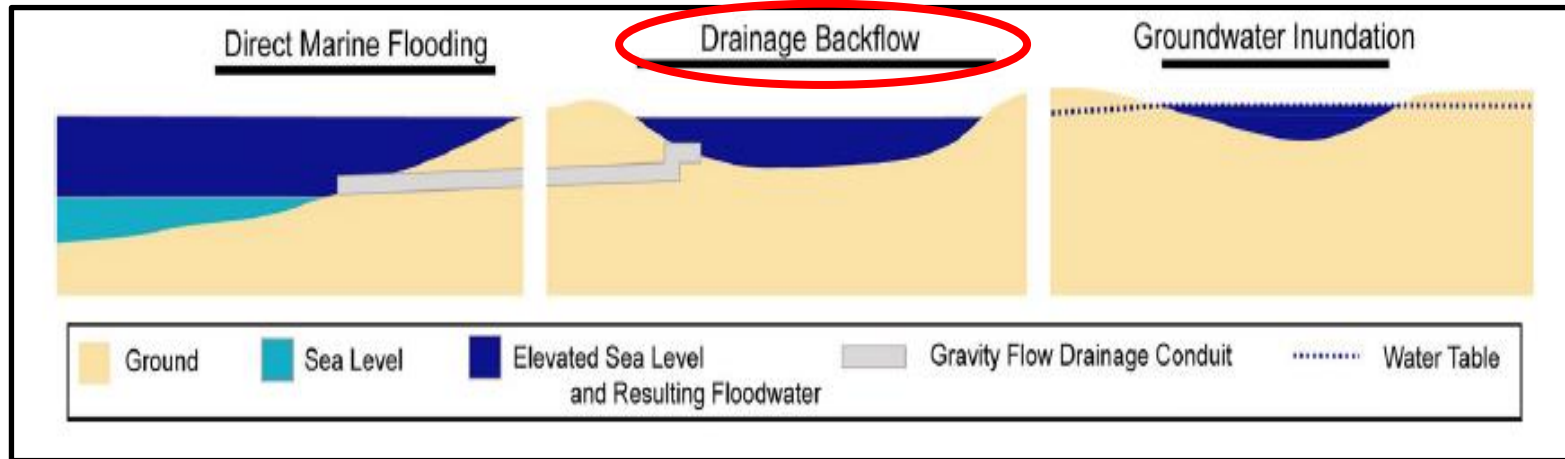


Flooded Bike Path (former RR bed)

Evidence of Direct Flooding “King Tides”



Evidence of Direct Flooding “King Tides”



Beginning of Drainage Backflow



During Drainage Backflow: 10-inches

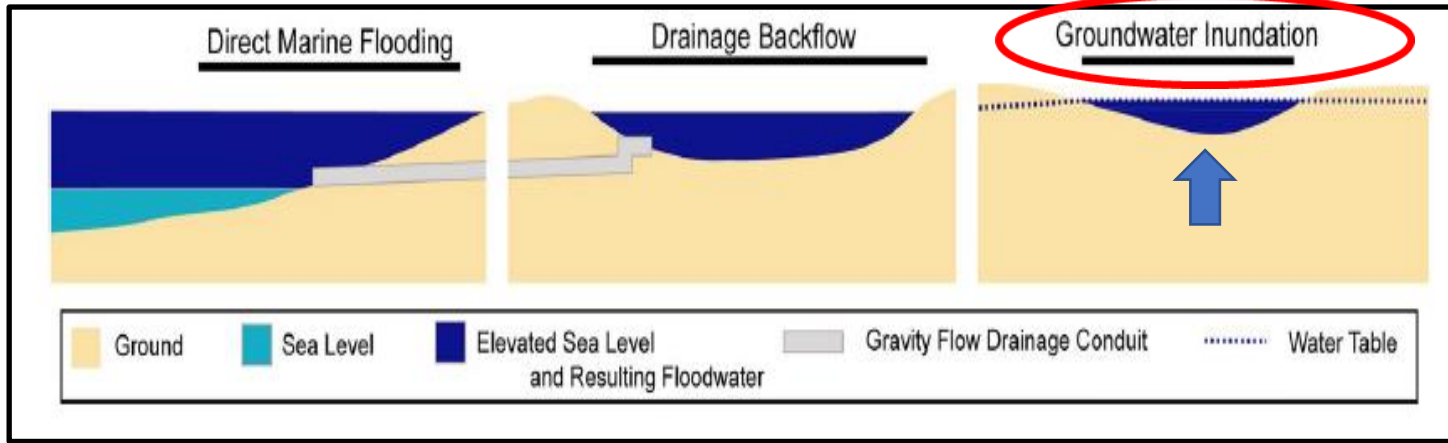


End of Drainage Backflow



- Drainage backflow into parking lot
- Nearby, Caltrans ponded water does not match high tides
- Complex subsurface water connections

Evidence of Groundwater Inundation



- Ponding during period of drought
- Pondered water does not match high tides
- Complex subsurface water connections

Evidence of Groundwater Inundation (During Drought)

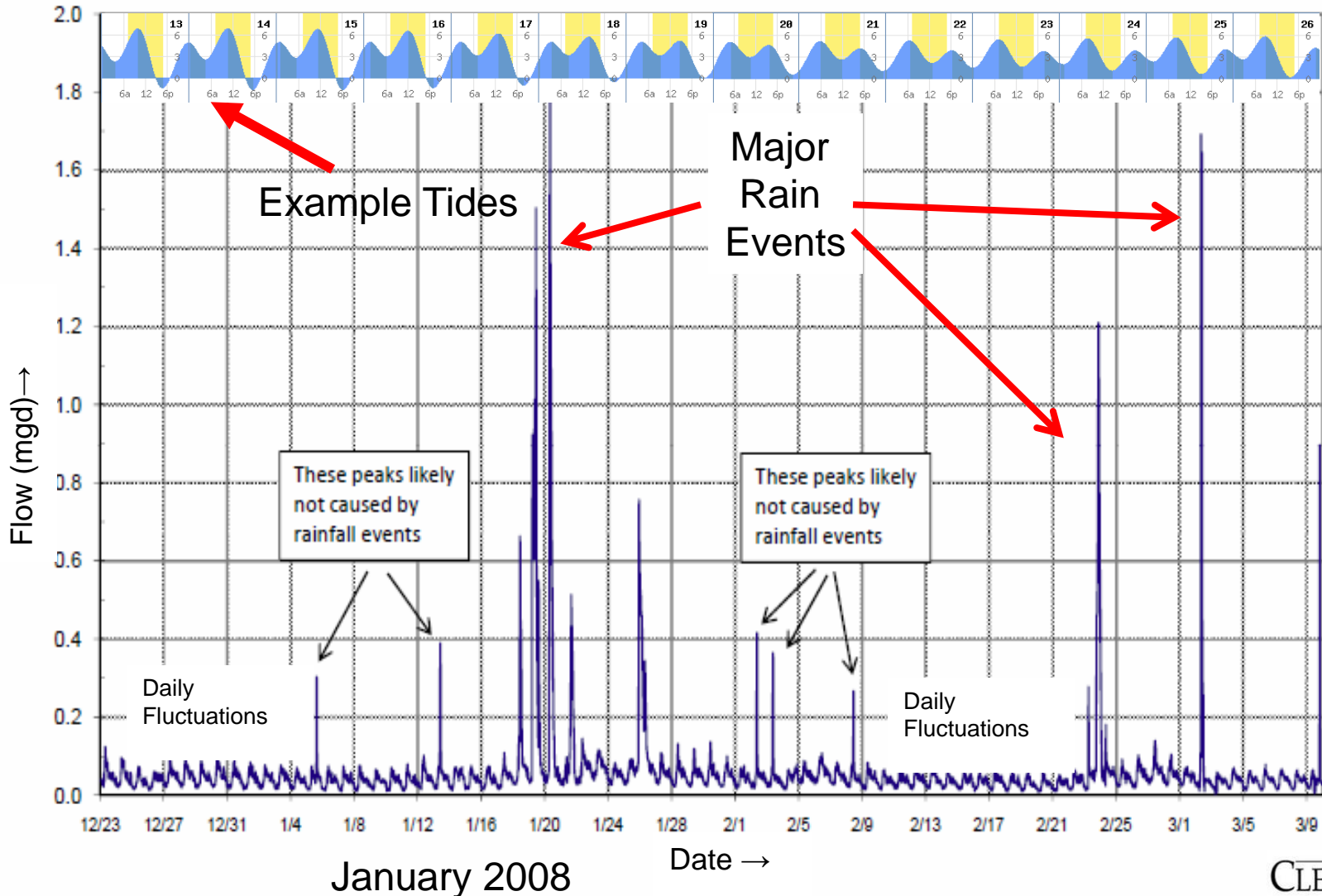
Also Called: Groundwater Flooding, Emergent Groundwater



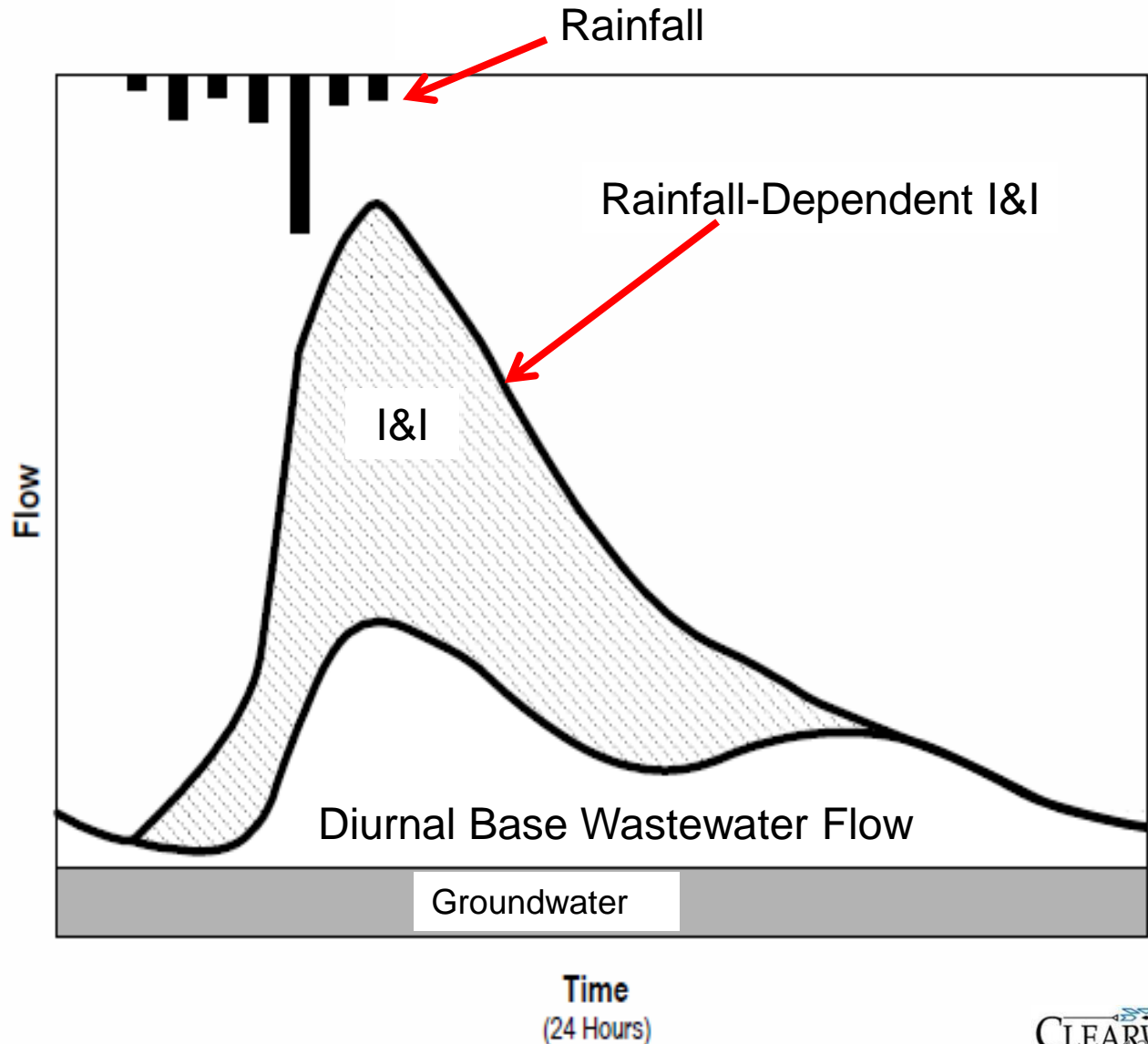
Groundwater Inundation: Sump Pumps and Standing Water



Consider Wide Tidal Ranges (Surrogate for Future Sea Level Rise) and Severe Storms Should Be Correlated with Real-Time Data



Extreme Rain: Wastewater Flow Components: Peaking Factor: 8 to 33 Times Normal Flow (Jan, 2008)

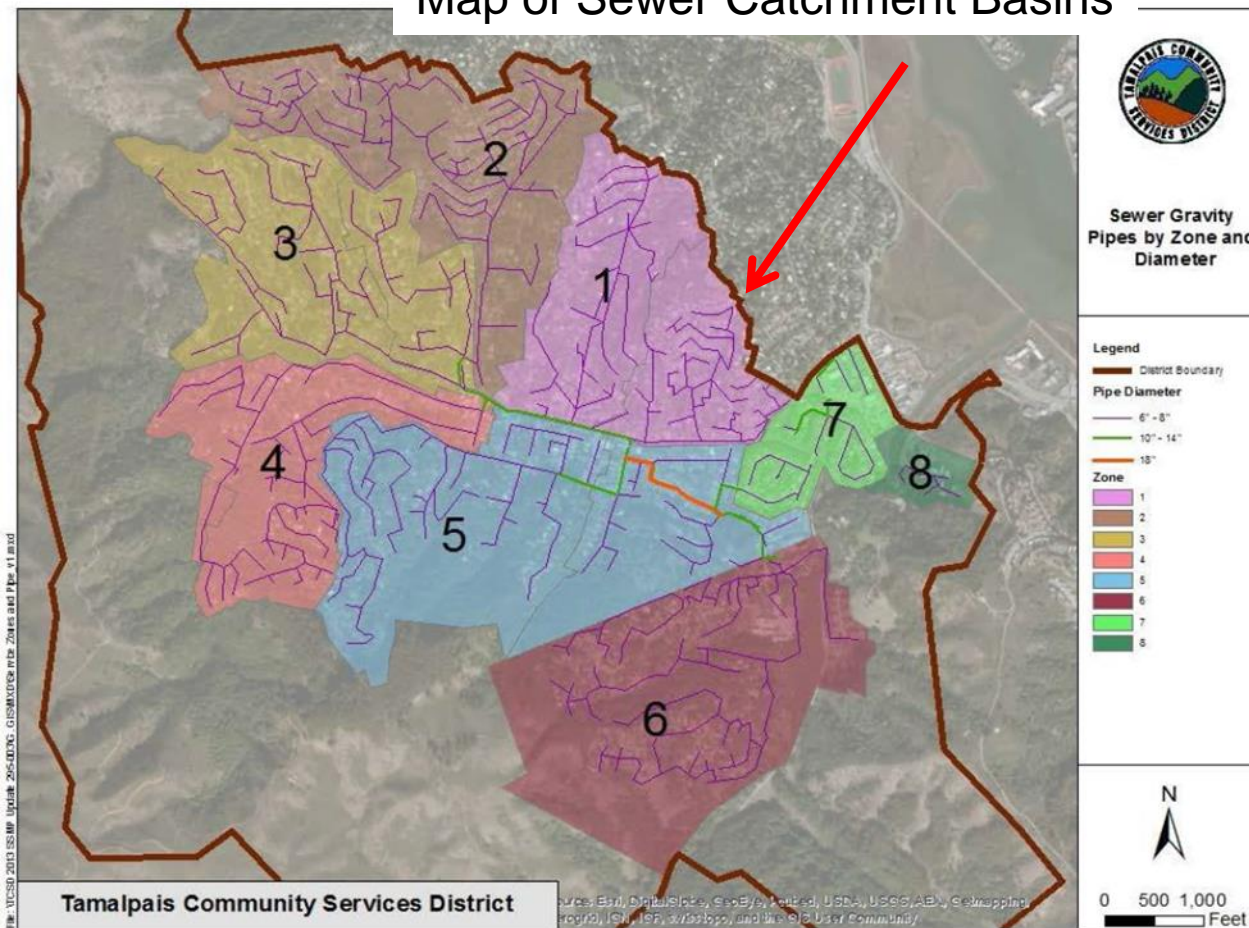


(SASM SSR; RMC; 2010)

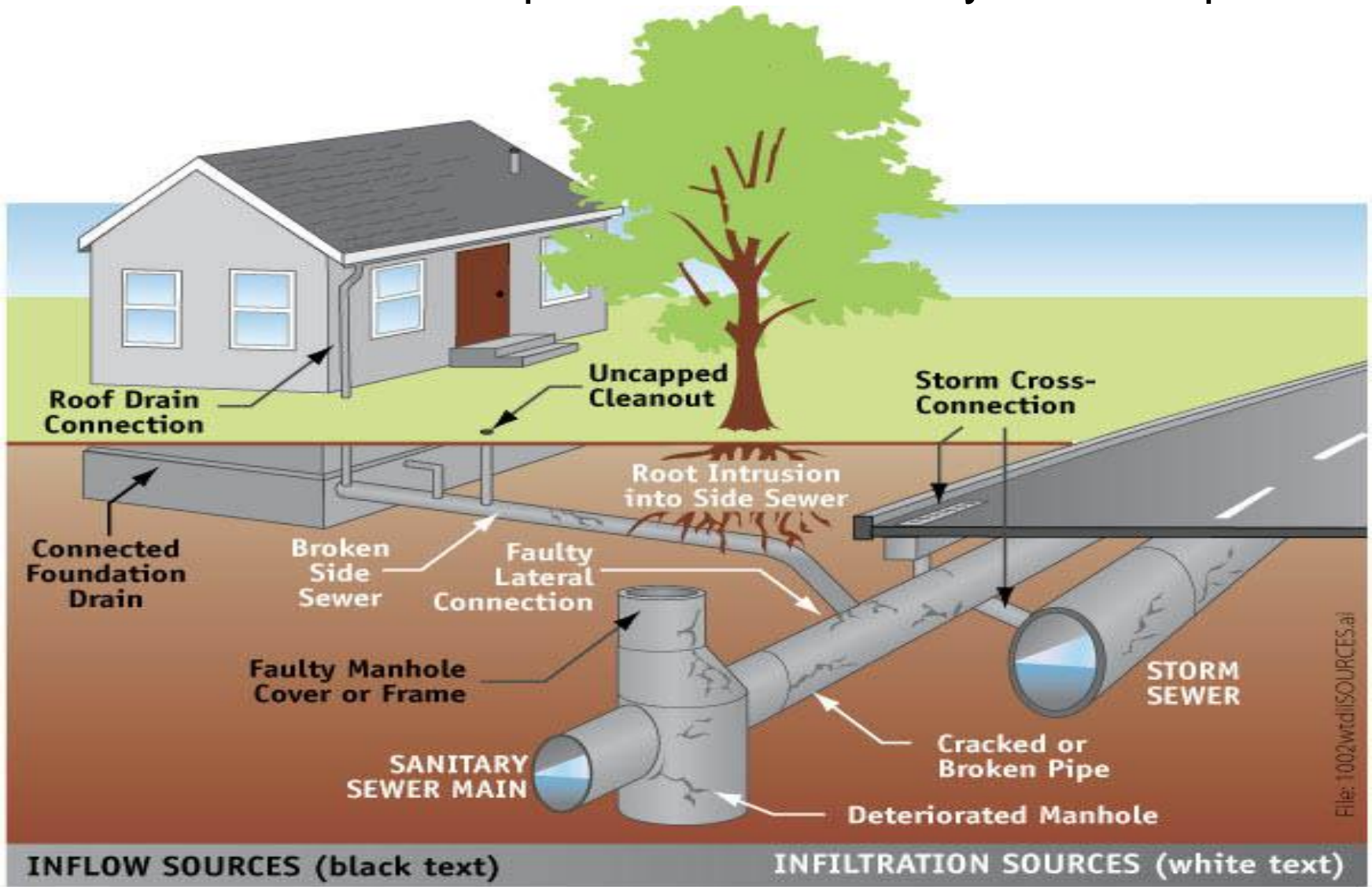
Groundwater Inundation Meets Sanitary Sewer Infrastructure

Figure 4-1: Sewer Service Zones and Pipe Diameter

Map of Sewer Catchment Basins

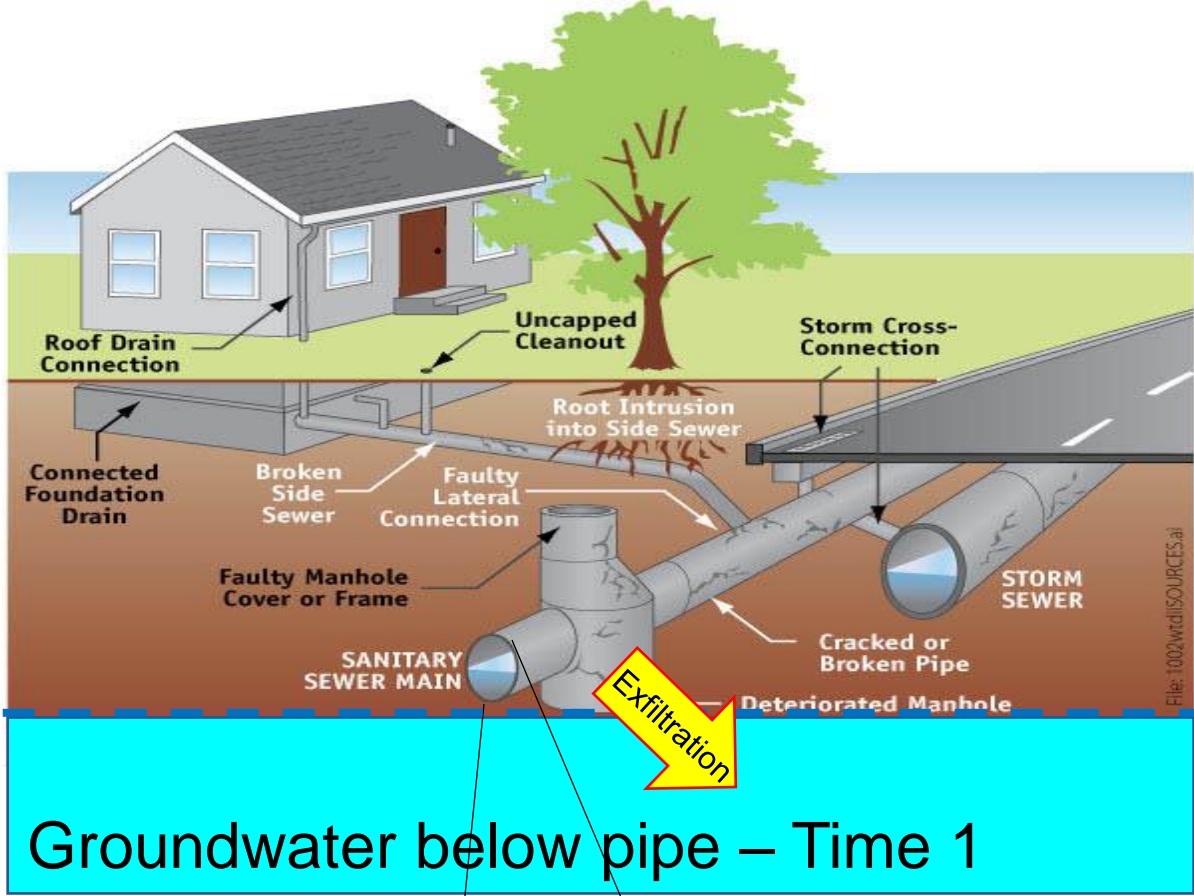


Current Site Conceptual Model of Leaky Sewer Pipes



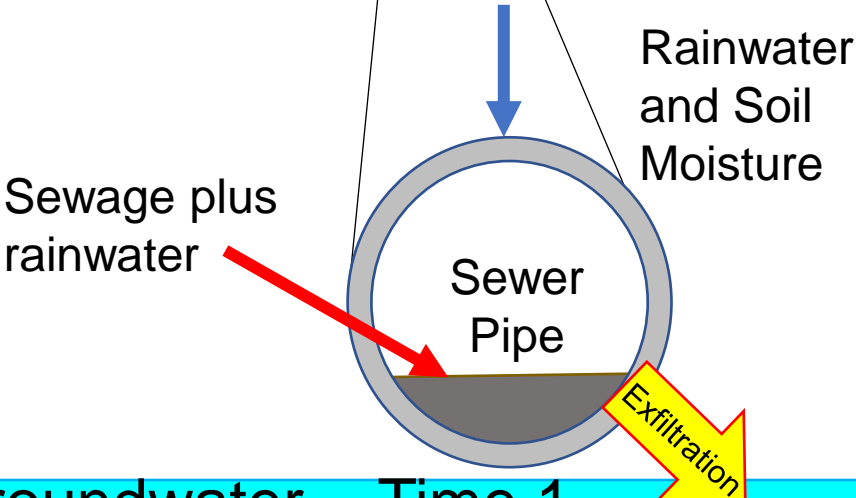
Leaky Sewer Pipes

Where pipes and junctions lie above groundwater, only rainwater and soil moisture enters pipe breaches.



Groundwater Elevation

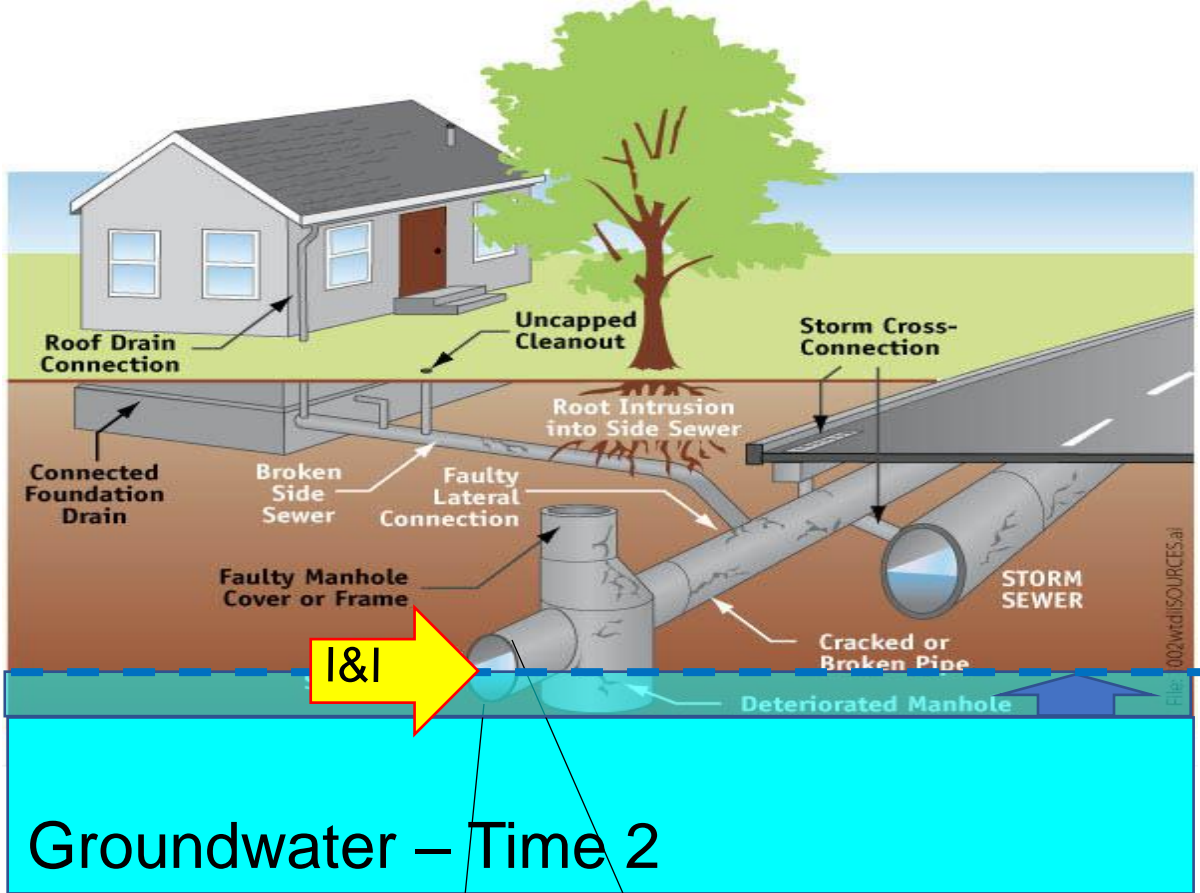
Groundwater below pipe - Time 1



Groundwater - Time 1

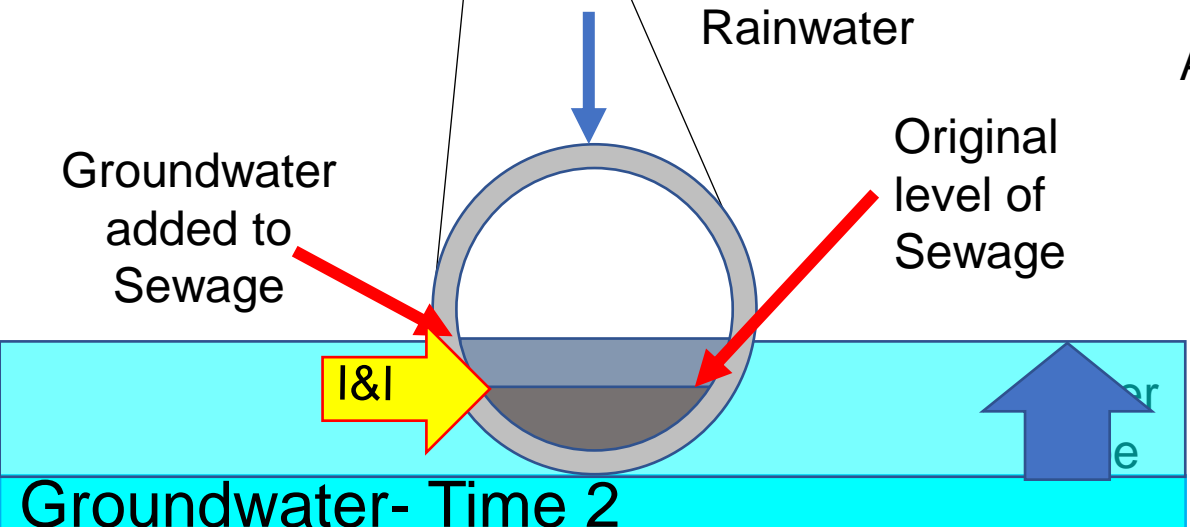
Leaky Sewer Pipes

Where pipes lie in saturated soil, groundwater enters sewer pipes as inflow and Infiltration (I&I) at pipe breaches

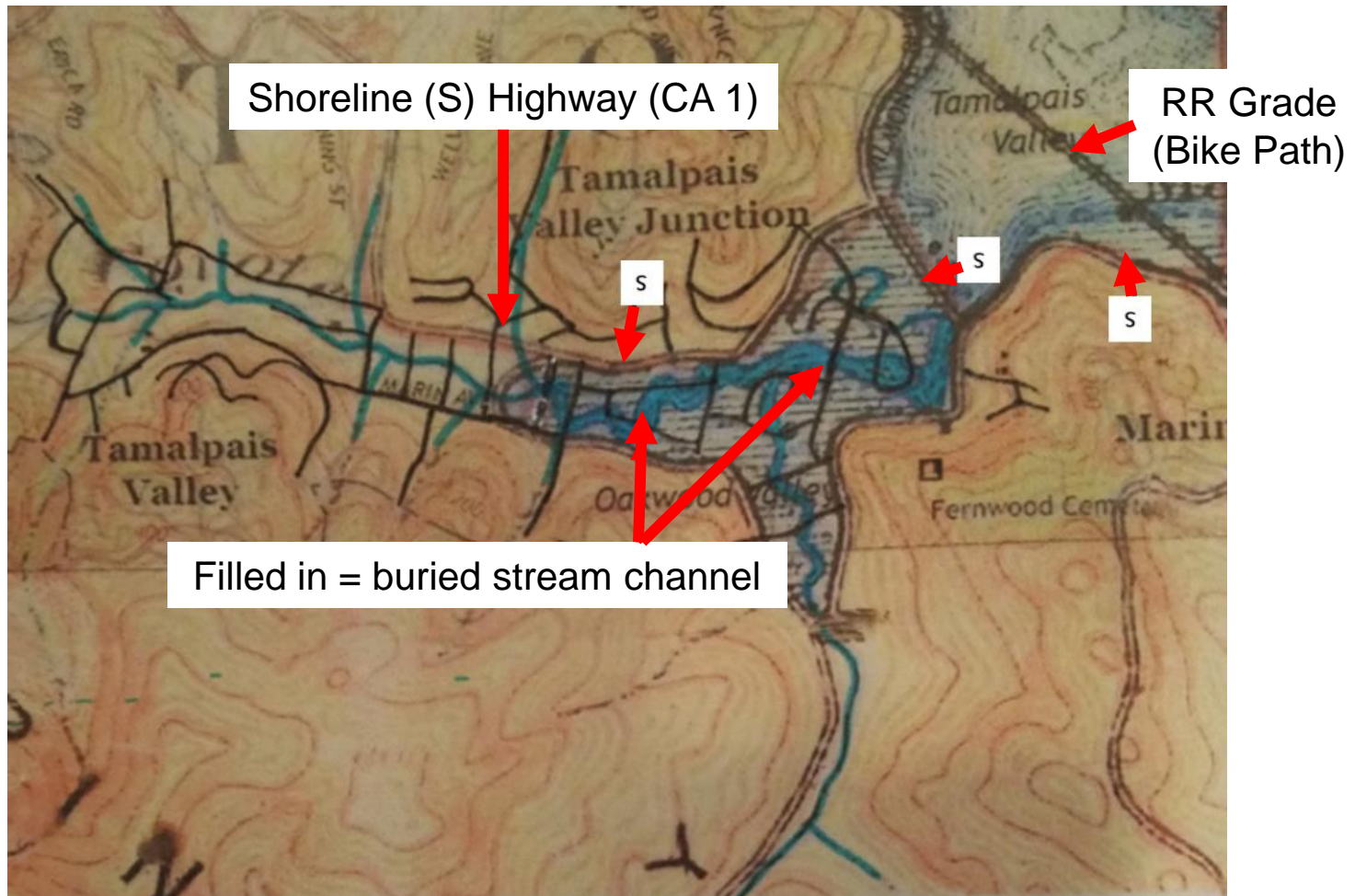


Groundwater – Time 2

Assumes homogeneous porous, “layer-cake” sediments



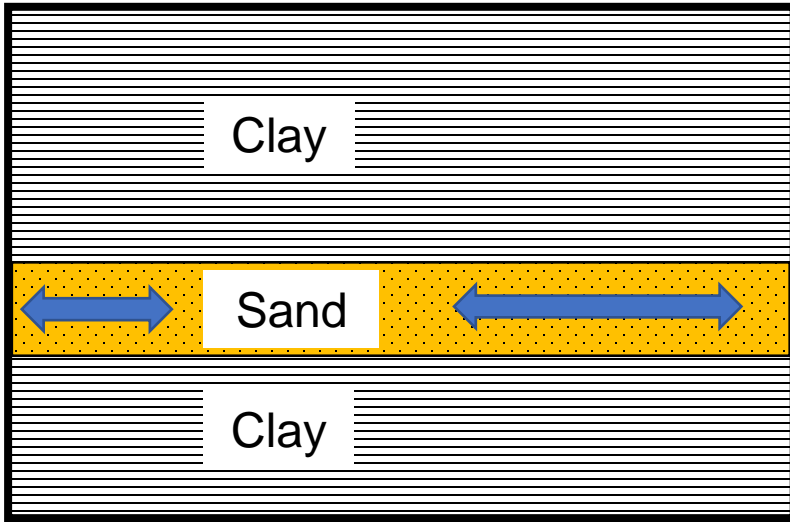
Tamalpais Valley – Filled Wetlands and Buried Stream Channels



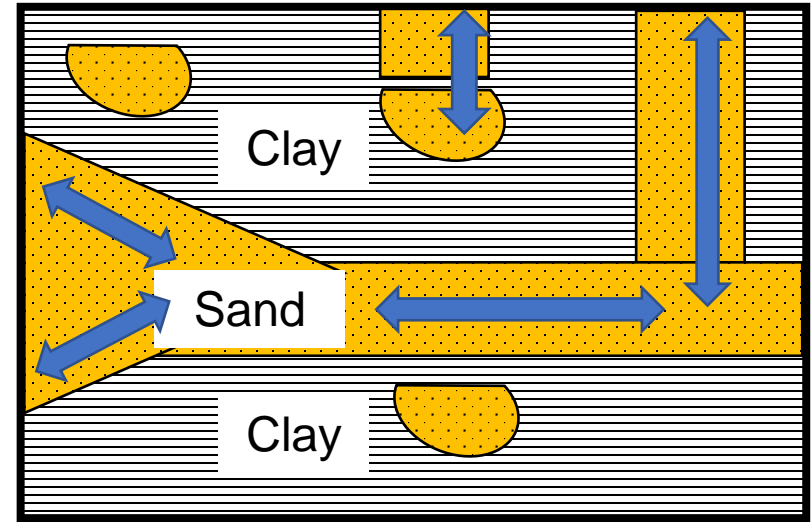
1911 historic map is overlain with current street locations (in black). Shoreline Highway is (S) (State Route 1) and the railroad (RR) causeway is now a bike path.

Complex Hydrogeologic Conditions: Cross-Sections

Simple Layer-Cake Geology



Actual Complex Subsurface



↔ Groundwater Flow

 Buried Stream Channels

 Utility Trench, French Drains

Measuring Water Elevation, Conductivity, and Temperature

Gas

Airborne and Ground



Remote Sensing



Thermal Imaging



Satellite
(ash hotspots
and InSAR)



Cameras

Earthquake &
Lahar Sensors



Deformation



Tiltmeter



GPS

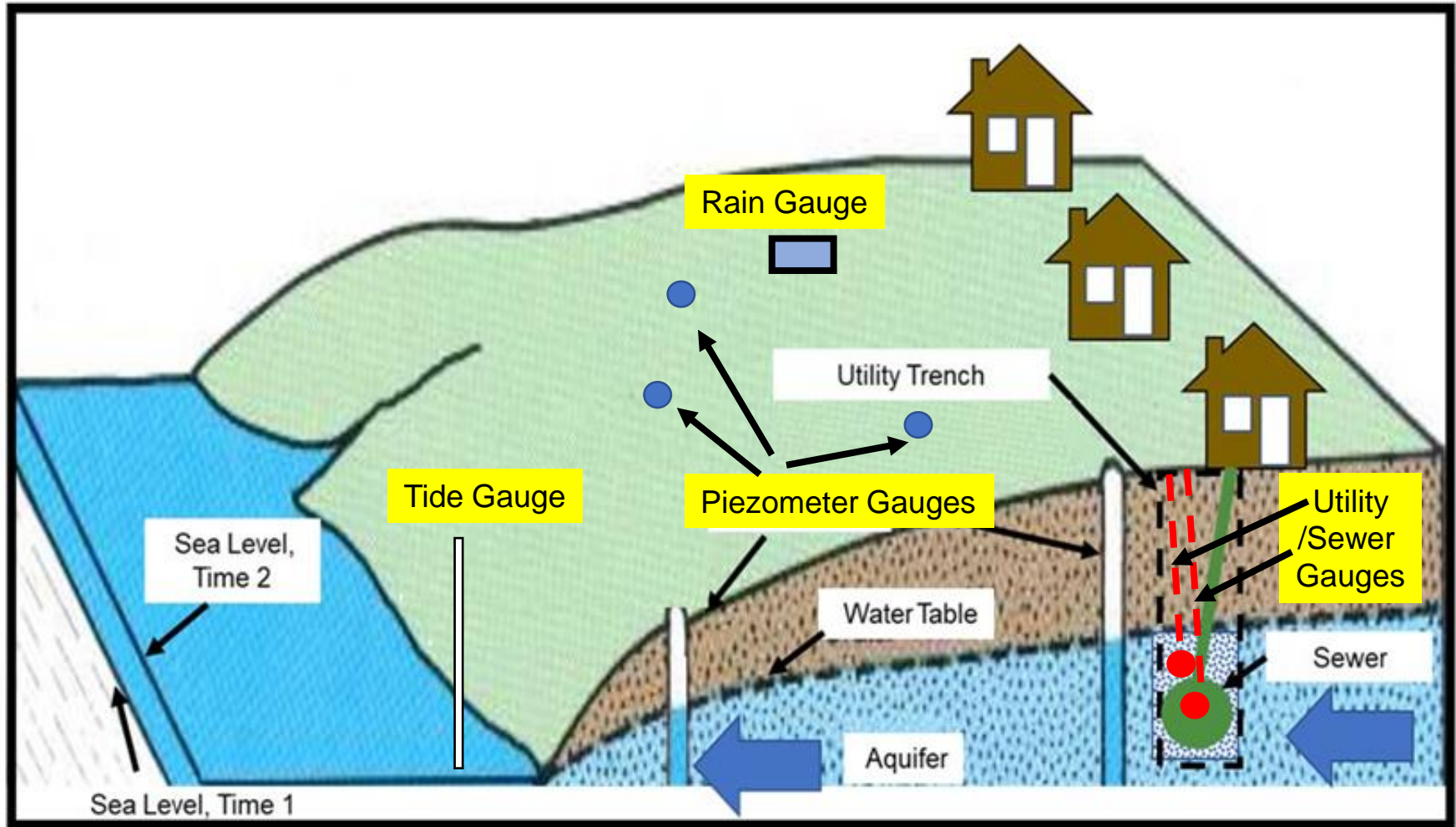


Surveying

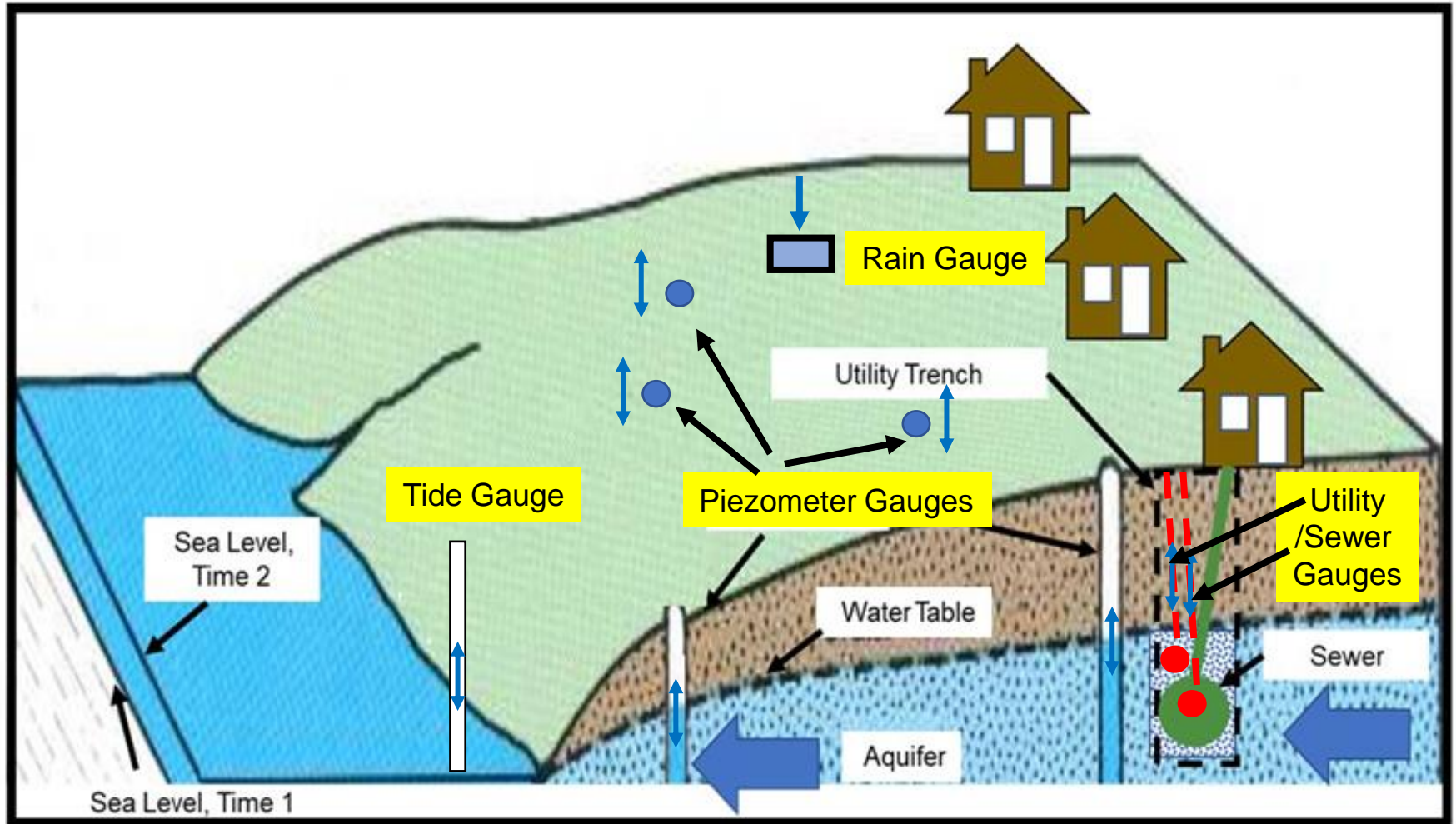
Ground Vibration

(USGS)

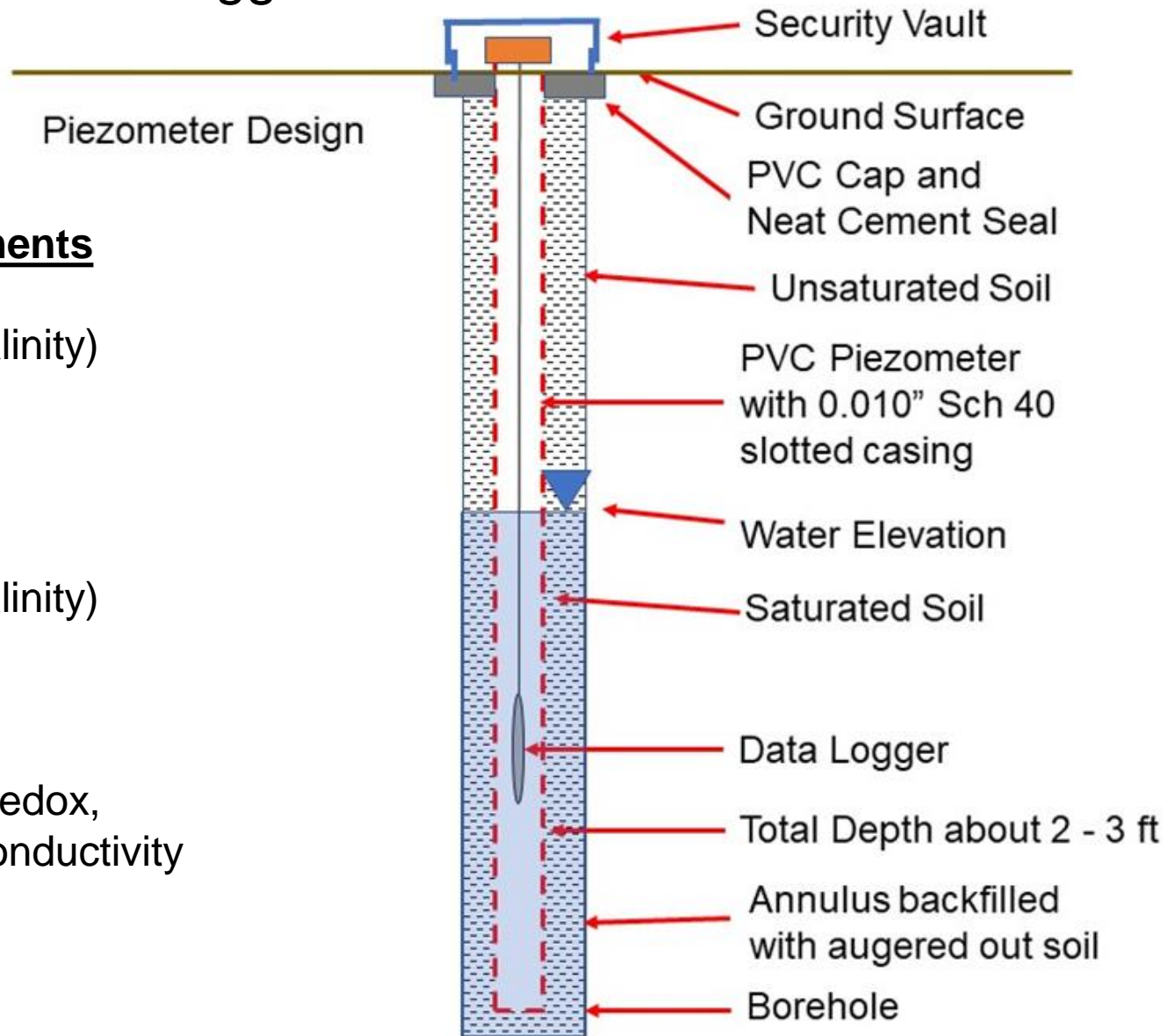
Concept: Piezometers with Battery-Powered, Cellular, Real-Time Data Loggers



Concept: Piezometers with Battery-Powered, Cellular, Real-Time Data Loggers



Piezometer with Data Logger



Manual Measurements

- Water Depth
- Conductivity (Salinity)
- Temperature

Dataloggers

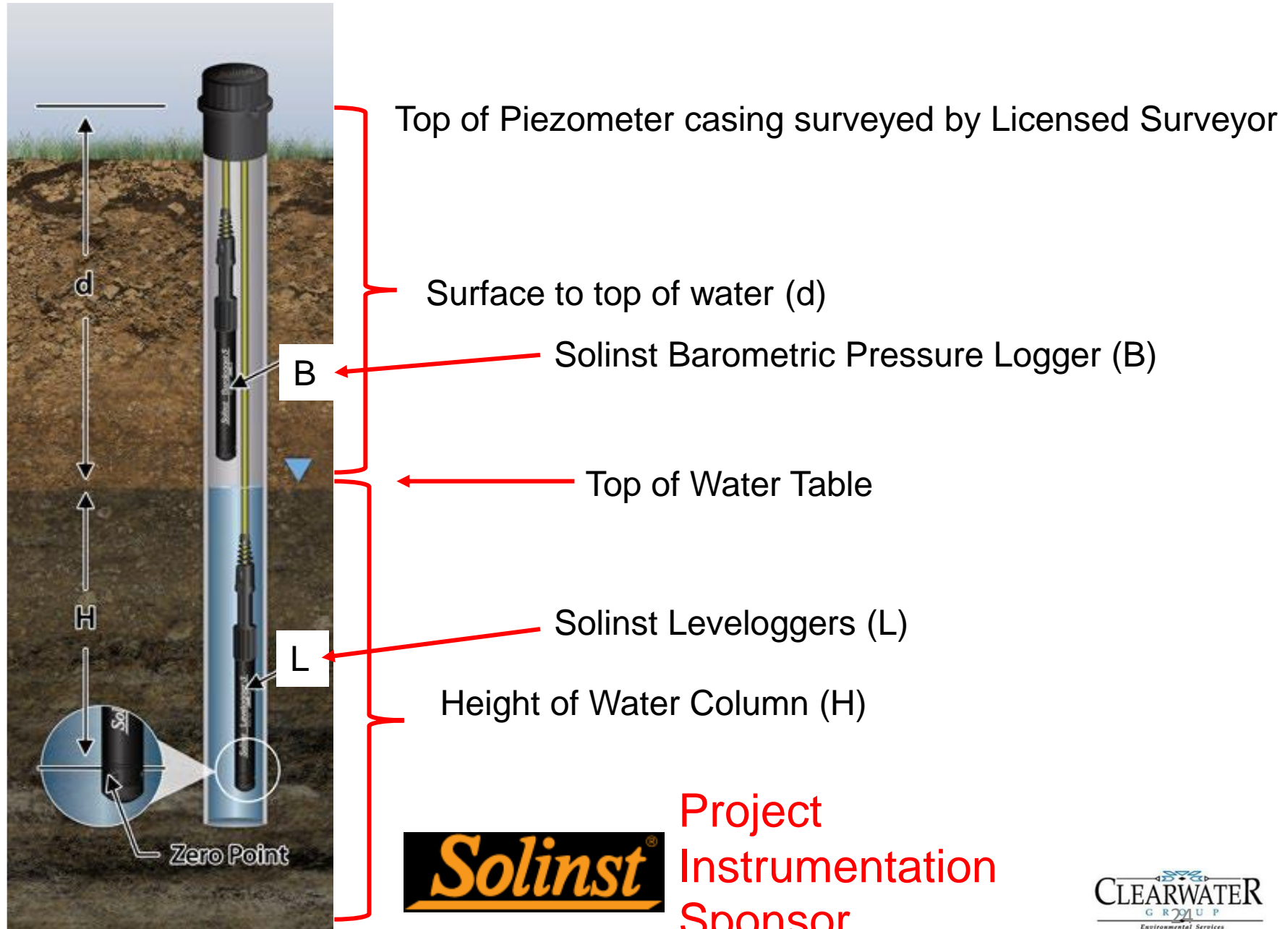
- Water Depth
- Conductivity (Salinity)
- Temperature

Field Meters

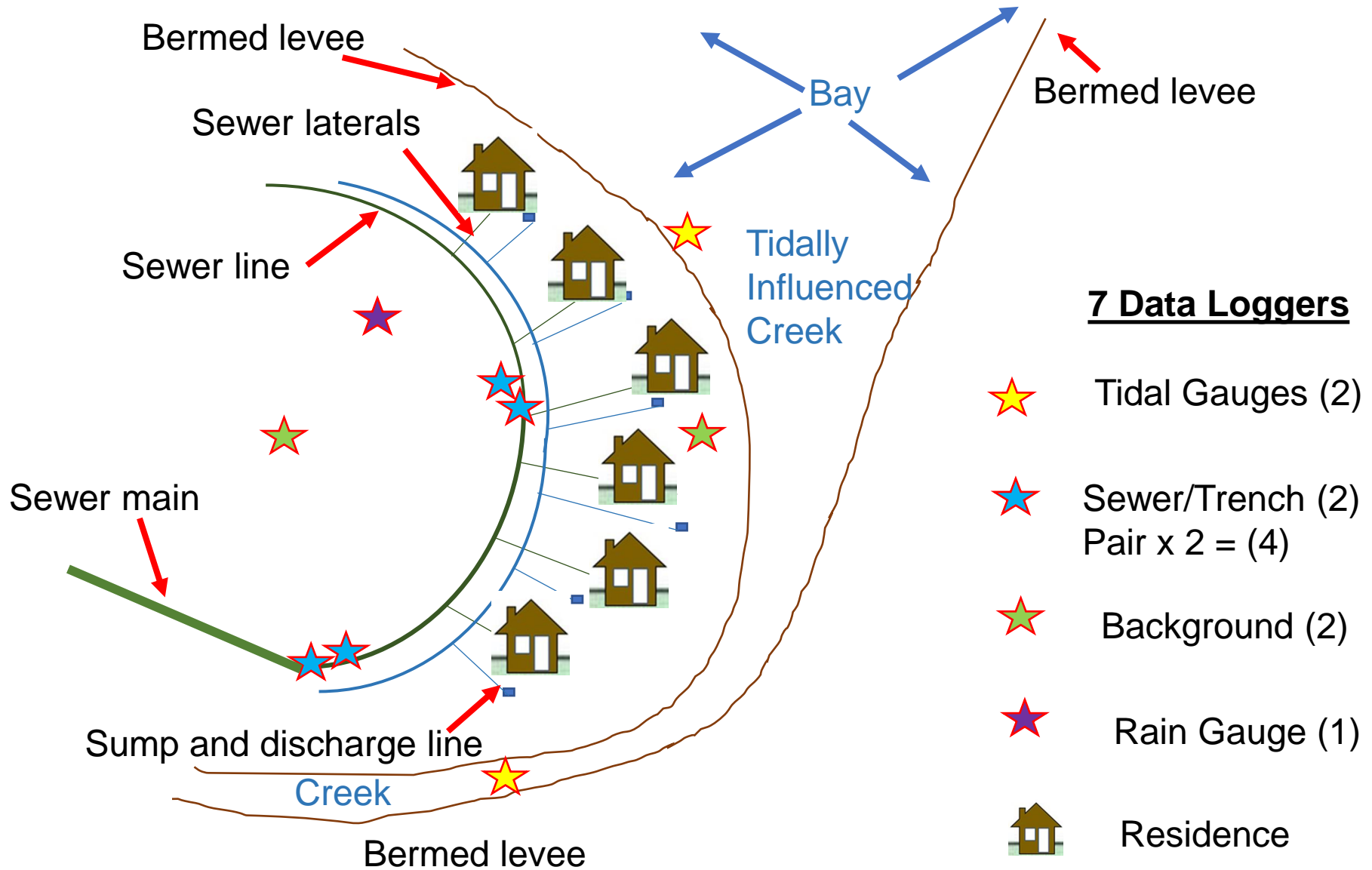
- DO, pH, ORP, Redox,
- Temperature, Conductivity

Total Depth will vary based on project details

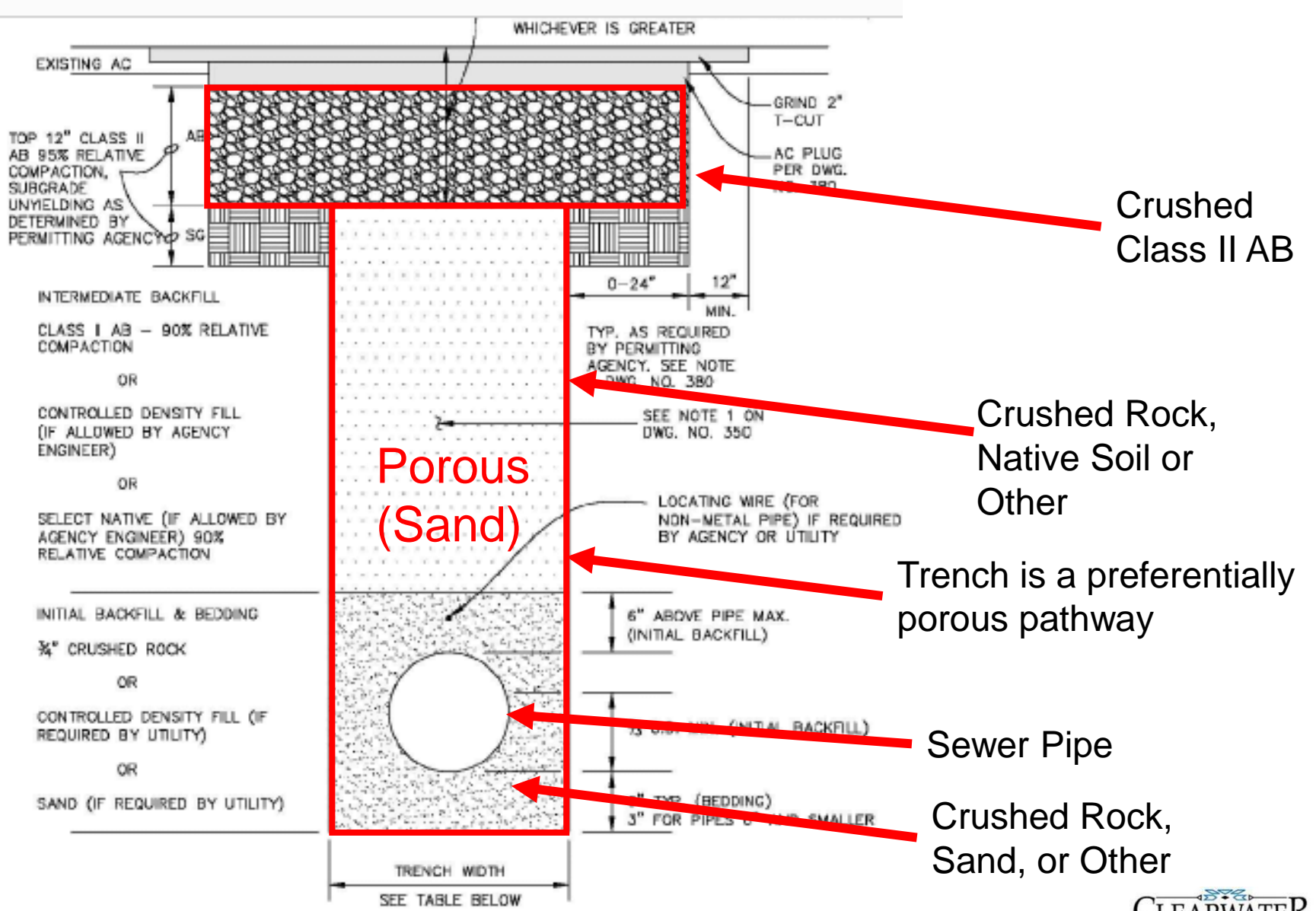
Piezometer with Data Logger: Automated, Remote Monitoring



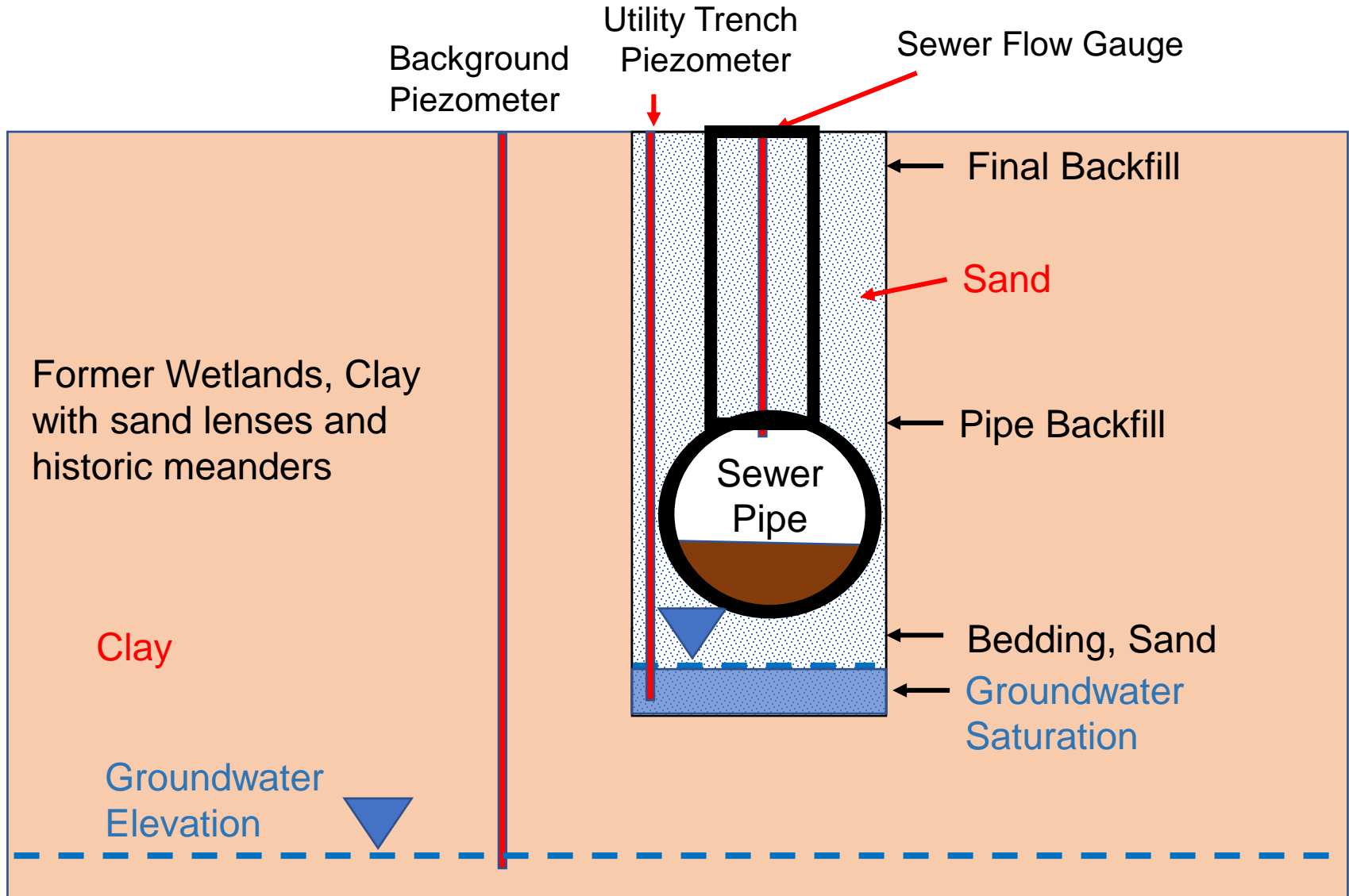
Example Study Project Layout For Real-Time Data Collection



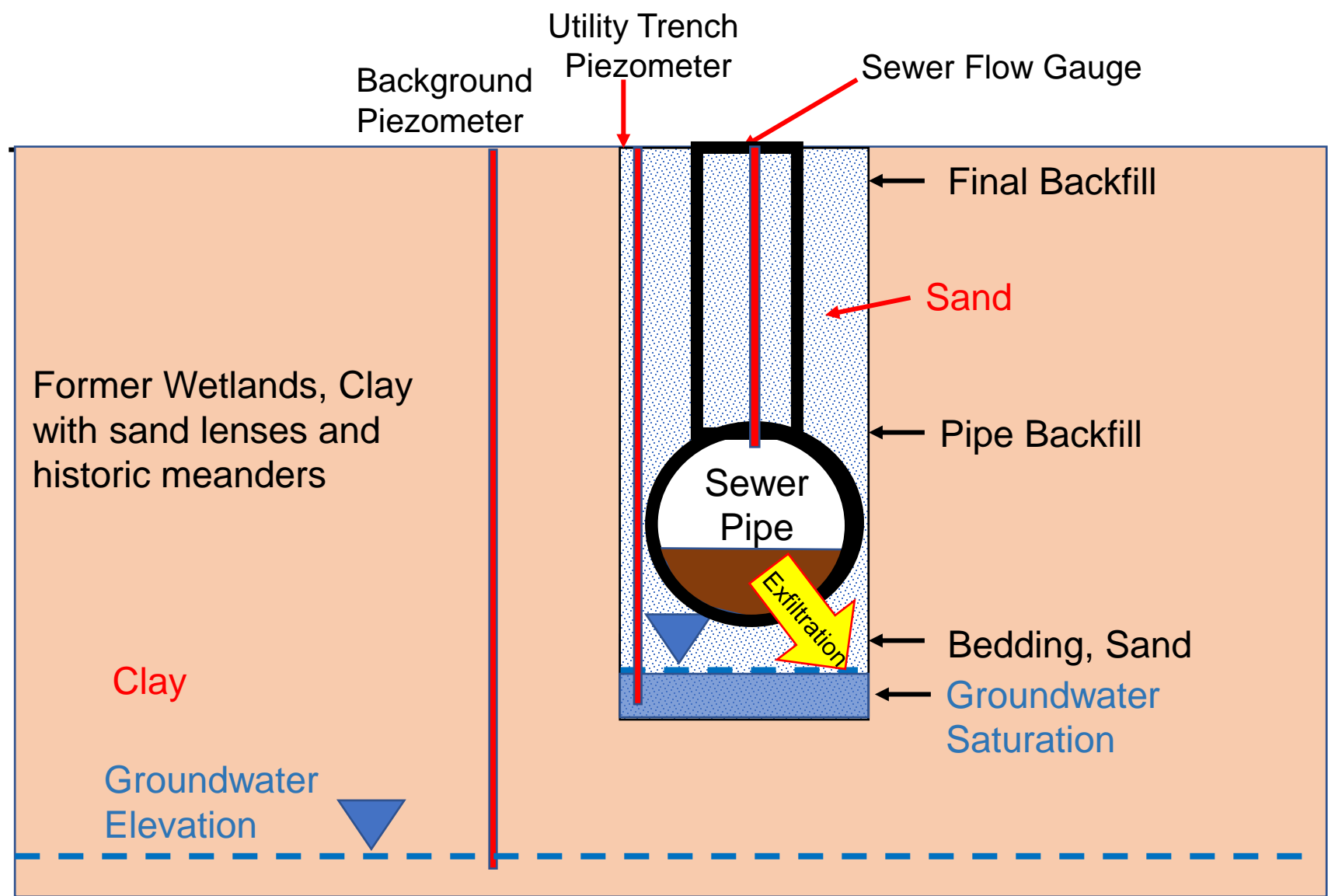
Utility Trench as a Water Conduit or Preferential Pathway



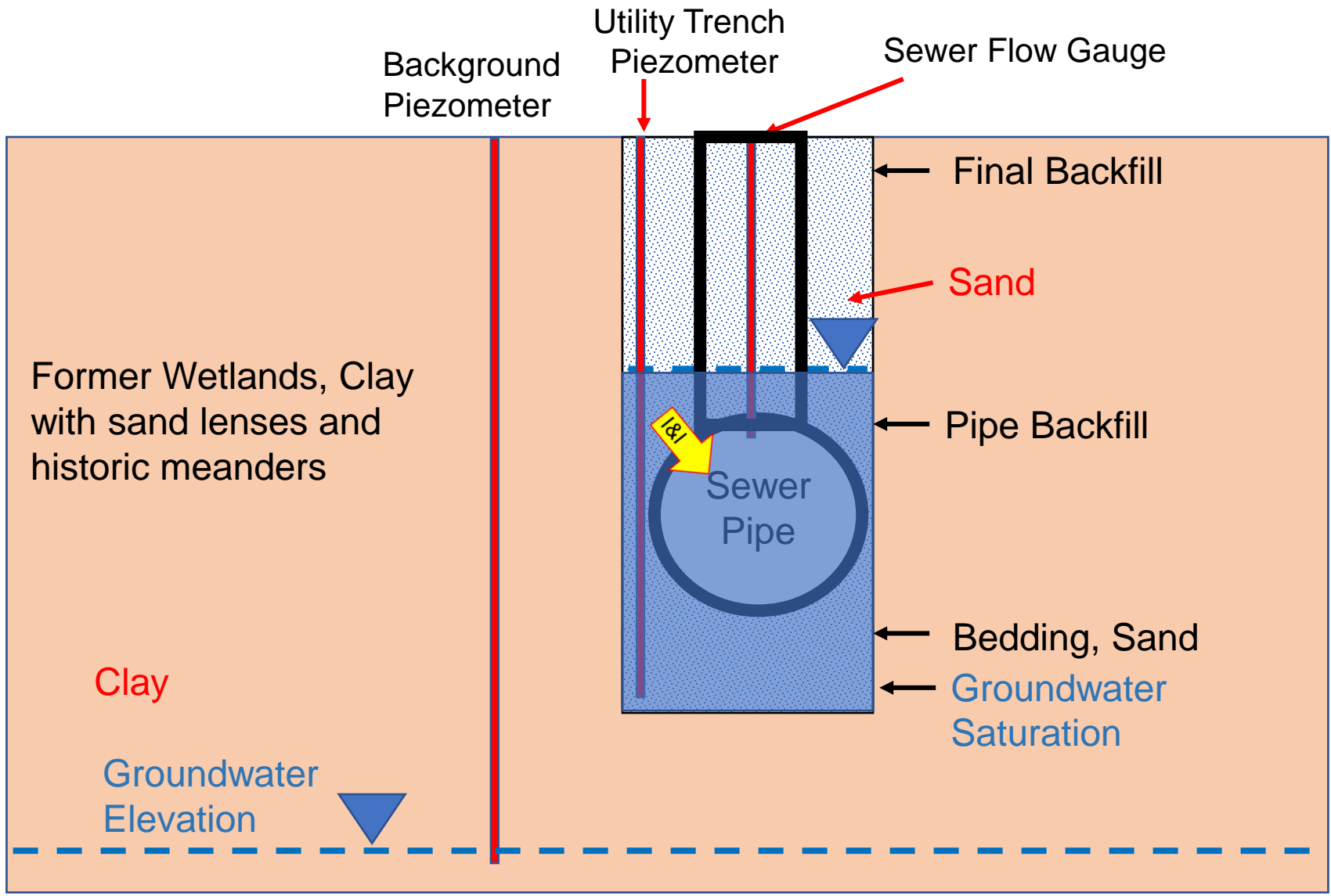
Ex. 1 - Groundwater Below Sewer Pipe, Trench contains Water



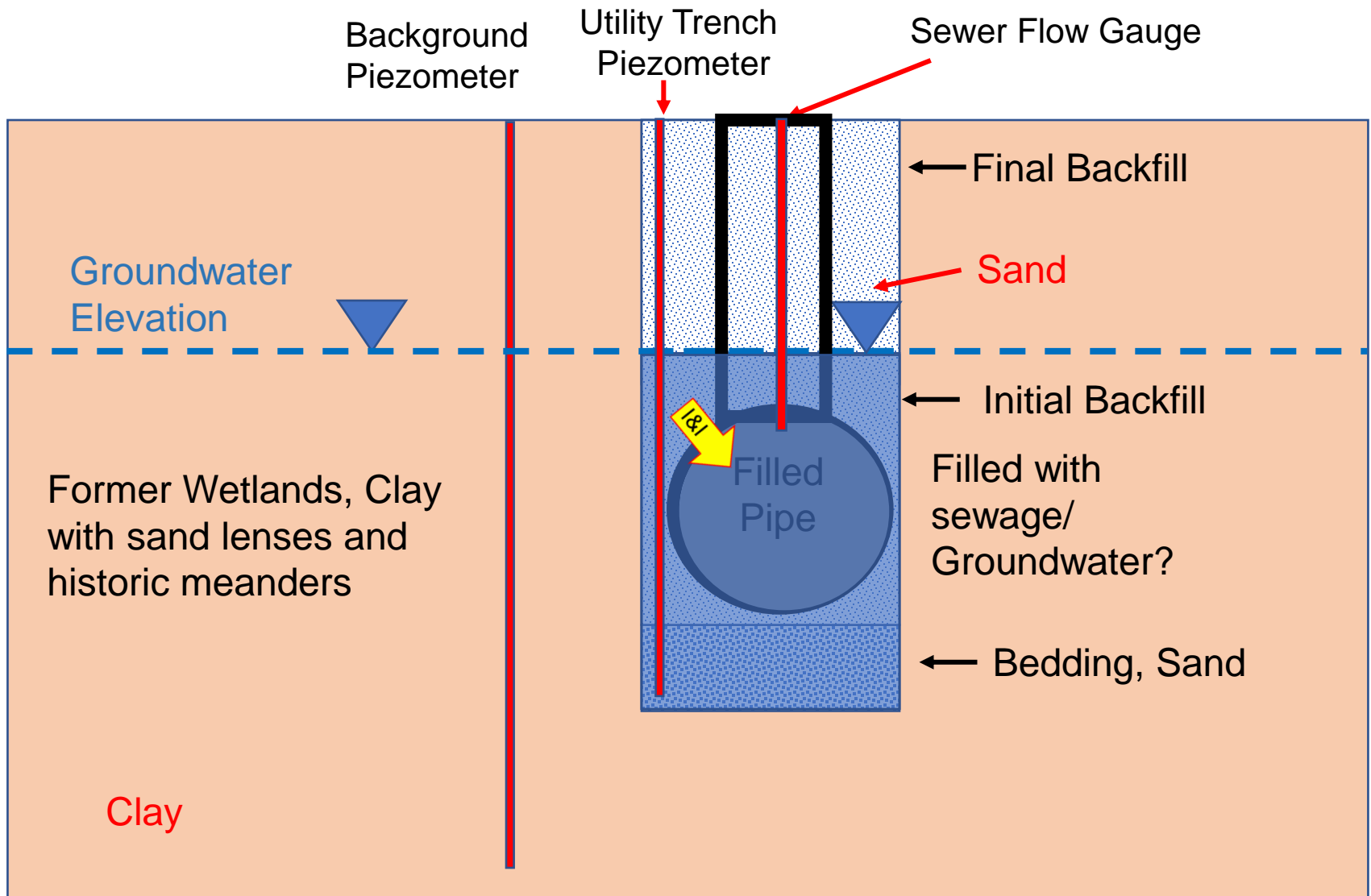
Ex. 2 - Exfiltration Below Leaking Sewer Pipe



Ex. 3 - Groundwater Above Sewer; Area-Wide Groundwater Lower

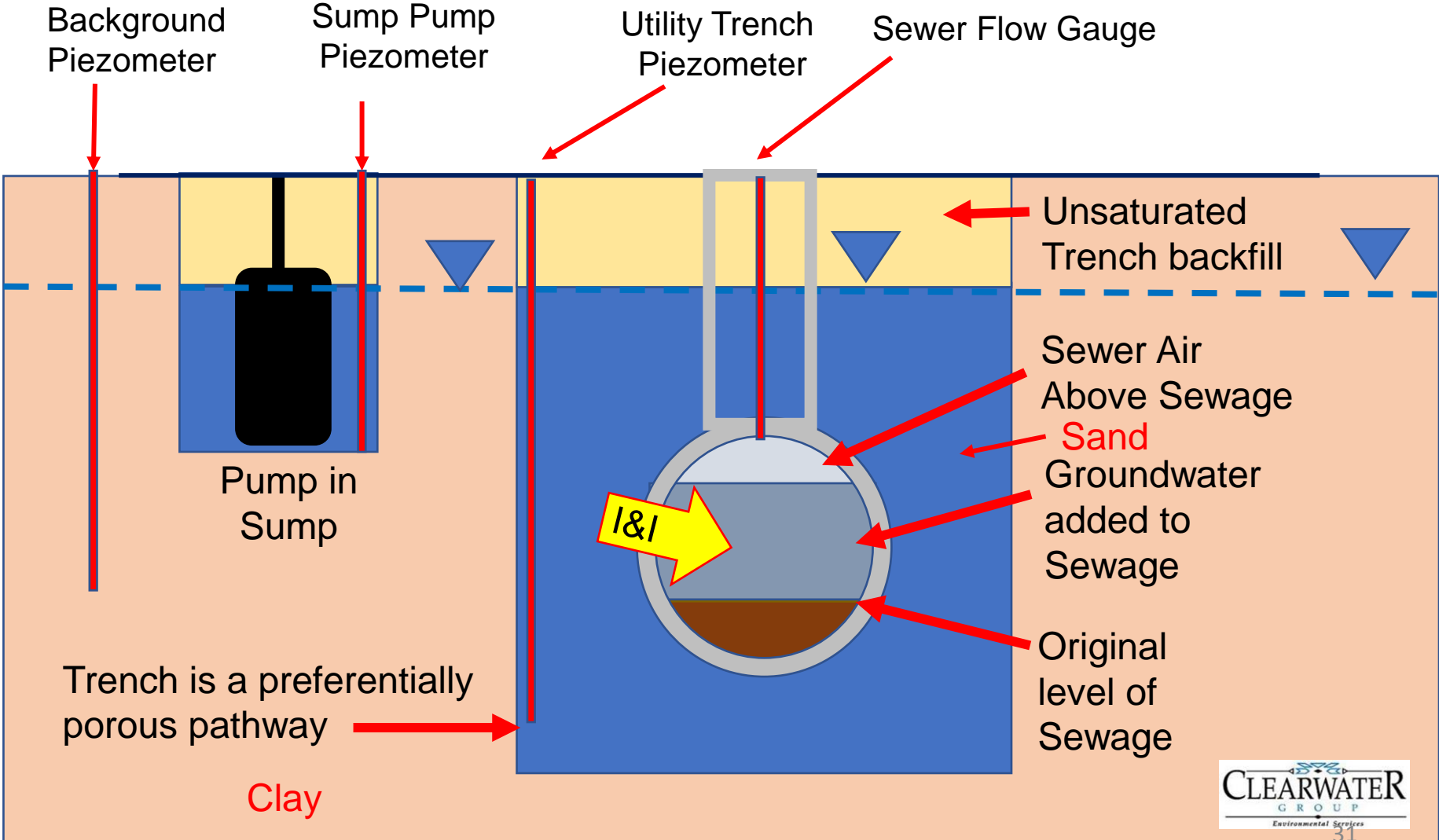


Ex. 4 - Groundwater Elevation: Area-Wide, Rises with Rain or Tides

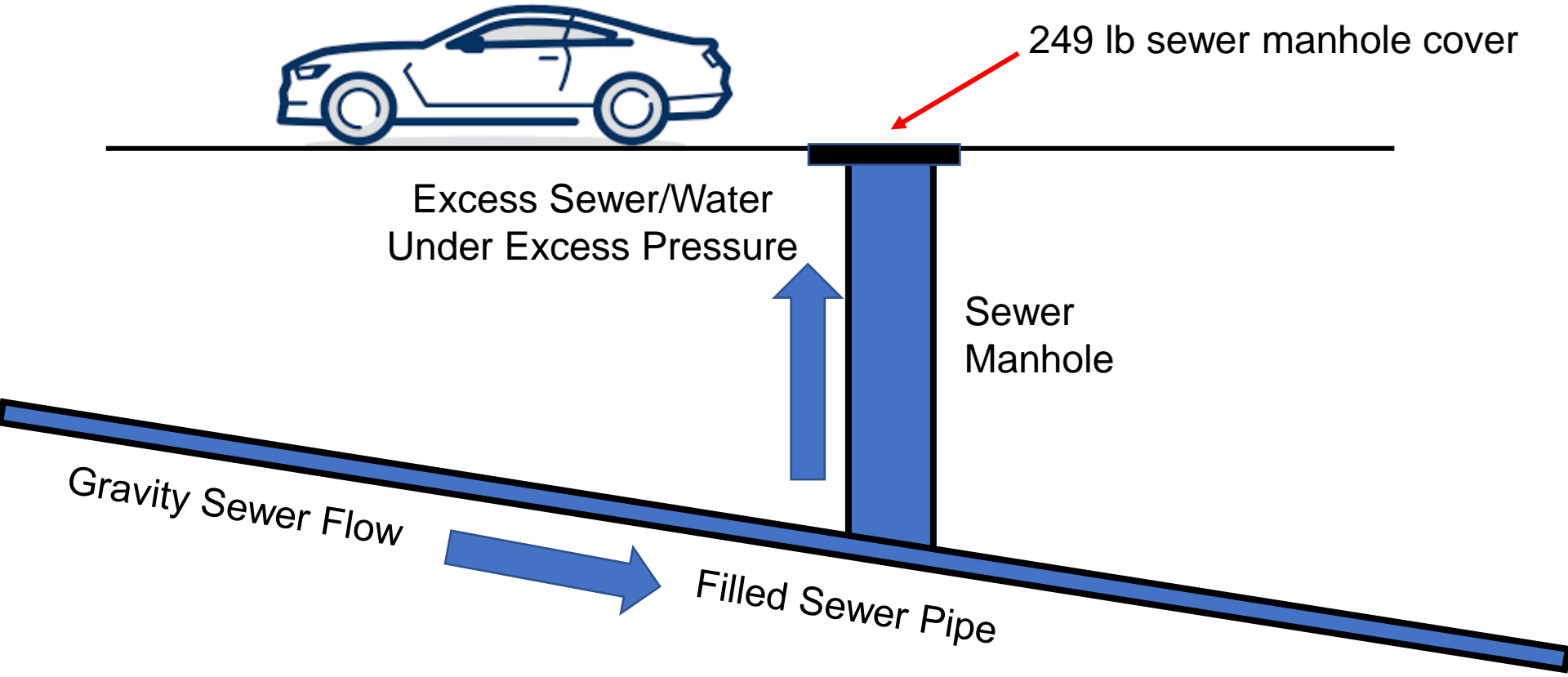


Time 2 – Groundwater Above Sewer Pipe

Ex. 5 - Area-Wide Groundwater with I&I Entering Leaking Sewer Pipe



Causes of Sanitary Sewer Overflows (SSOs)



Ex.1 - Causes of SSO: Filled Sewer Pipe

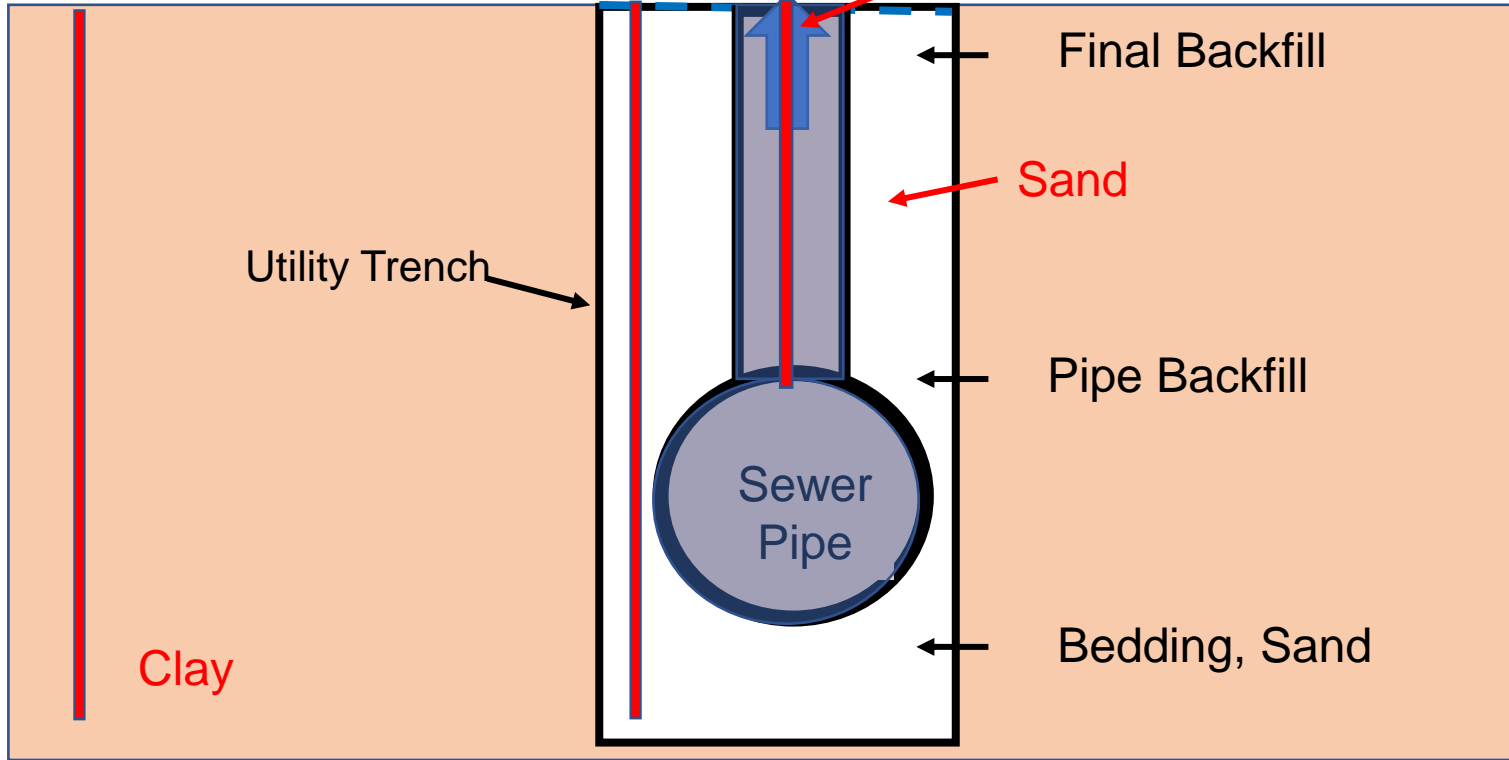


Lifting 249 lb sewer manhole cover

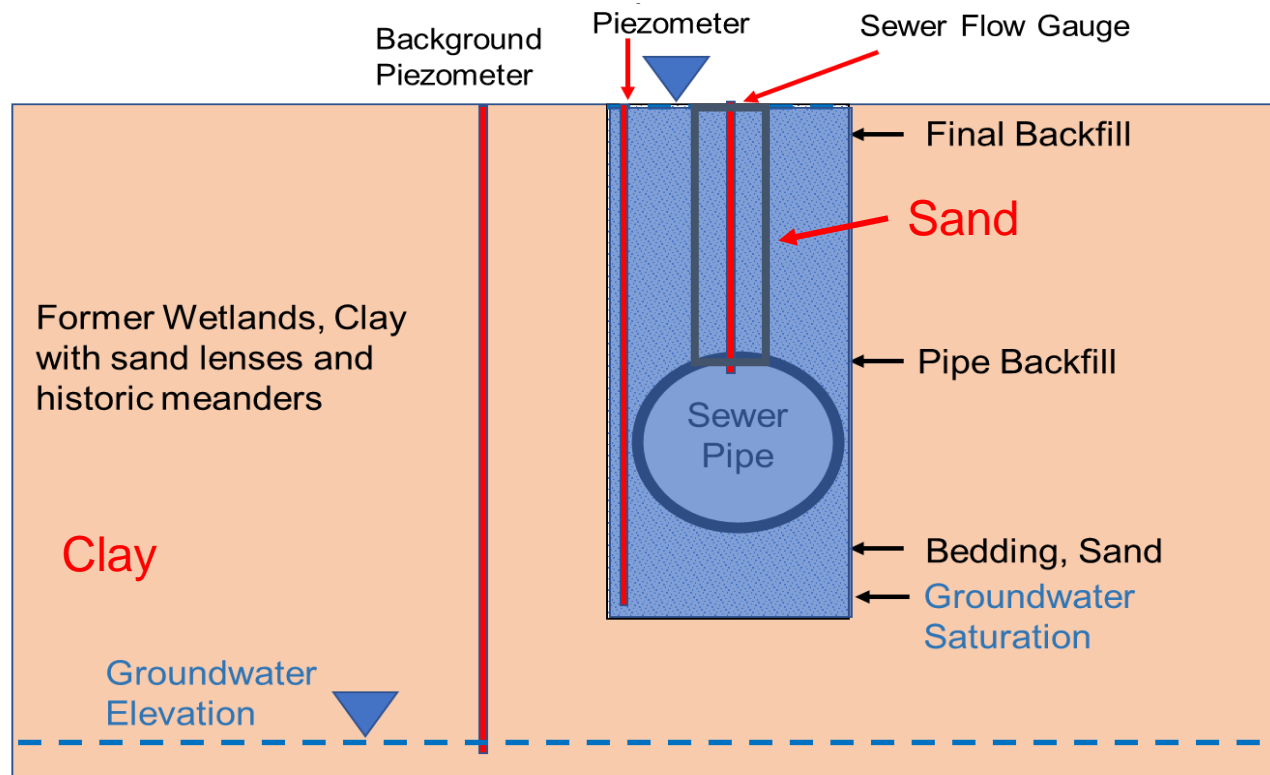
Background
Piezometer

Utility Trench
Piezometer

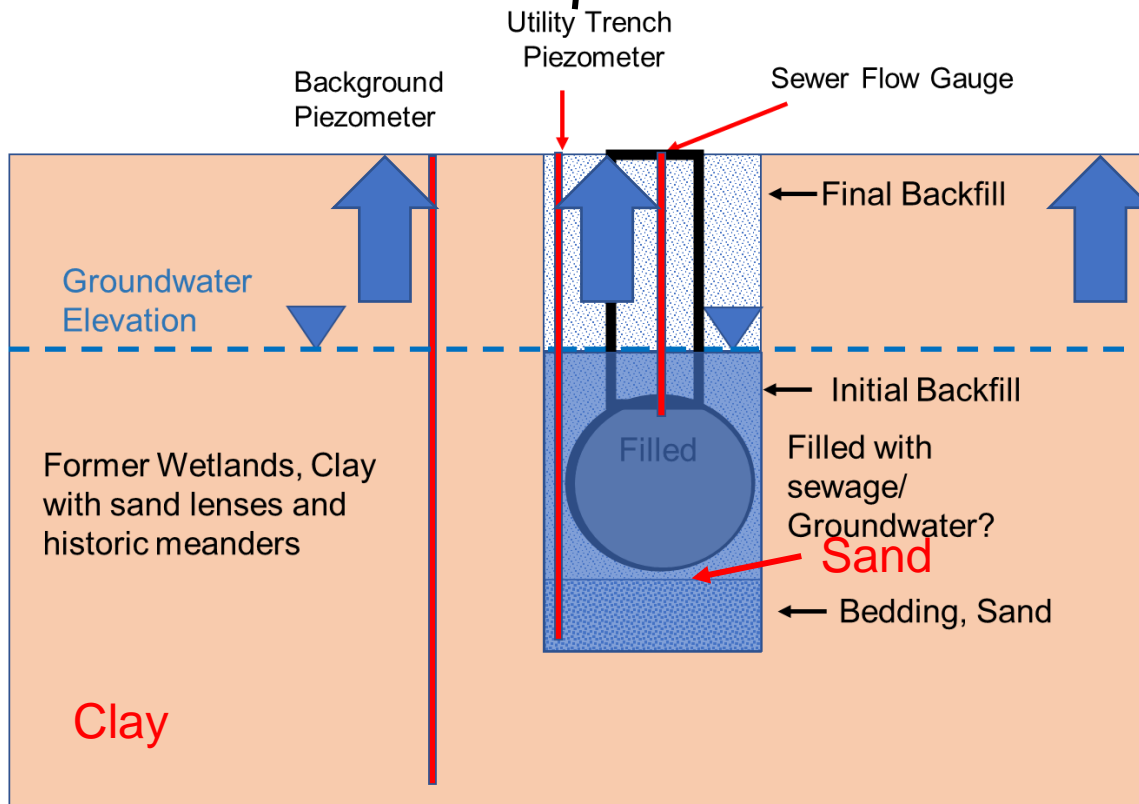
Sewer Flow
Gauge



Ex. 2 - Causes of SSO: Filled Sewer Pipe and Utility Trench

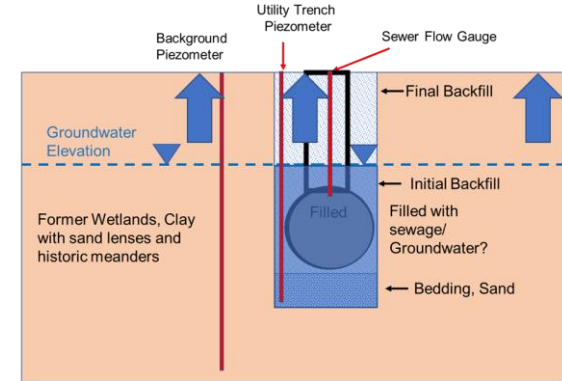
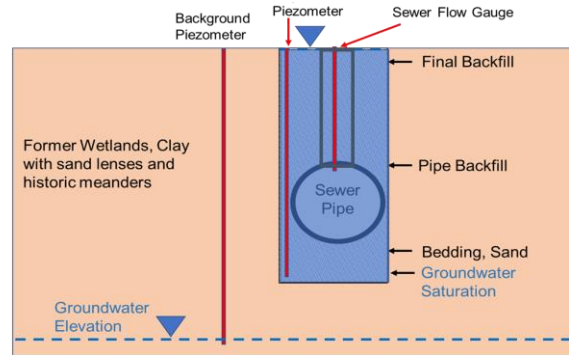
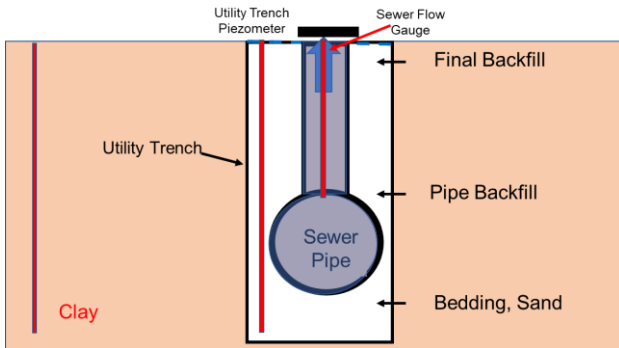


Ex. 3 - Causes of SSO: Upwelling Area-Wide Groundwater



Goal – Identify Causes of SSOs Through Real-Time Monitoring

- Source Of Water
- Rainwater
- Groundwater Inundation
- Sea Water
- Irrigation Water/Leaky Water Pipes
- Surface Water (creeks)



Only Sewer Pipe Flooded

Trench and Background not flooded

Issue: Root ball

Mitigation: Remove sewer clog

Only Utility Trench Flooded

Background not flooded

Issue: Preferential Pathway Flooding

Mitigation: Strategic Pumping

Entire Area Flooded

Too Much Groundwater and Rain

Mitigation: Large-Scale Pumping

Preemptive pumping

Aquifer storage – preemptive gentle pumping prior to a flooding event to create subsurface capacity for excess rainwater or high tides

Concept: Integrated, Real-Time Data for Preventing SSOs

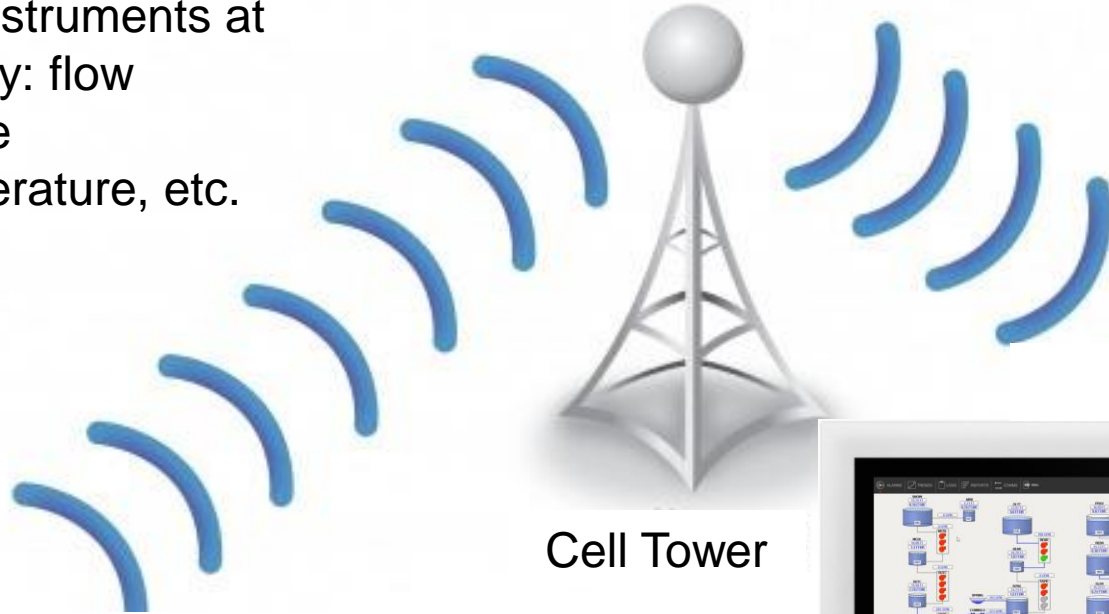
The Team designed and installed remote monitoring instruments at biogas facility at dairy: flow meters, pH, methane concentration, temperature, etc.

Piezometer

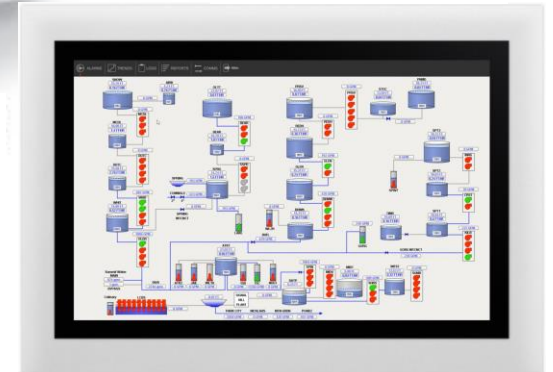
Threshold



- Groundwater Gauges (Elev., Cond., Temp.)
- Rainwater Gauges
- Tidal/Bay Gauges
- Barometric Pressure Gauges
- Sewer Flow Meters (touchless)
- Other parameters: methane, pH, etc.



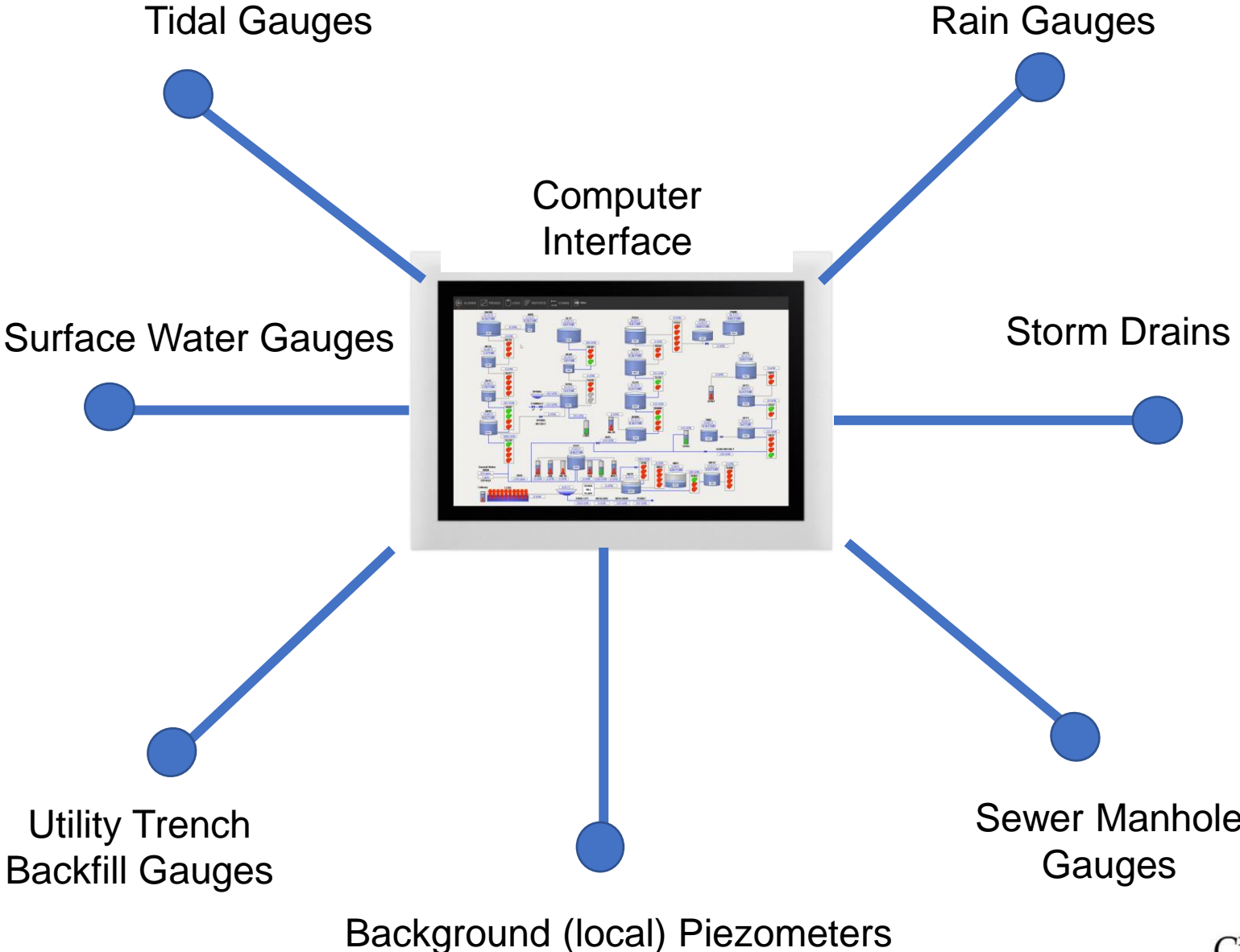
Cell Tower



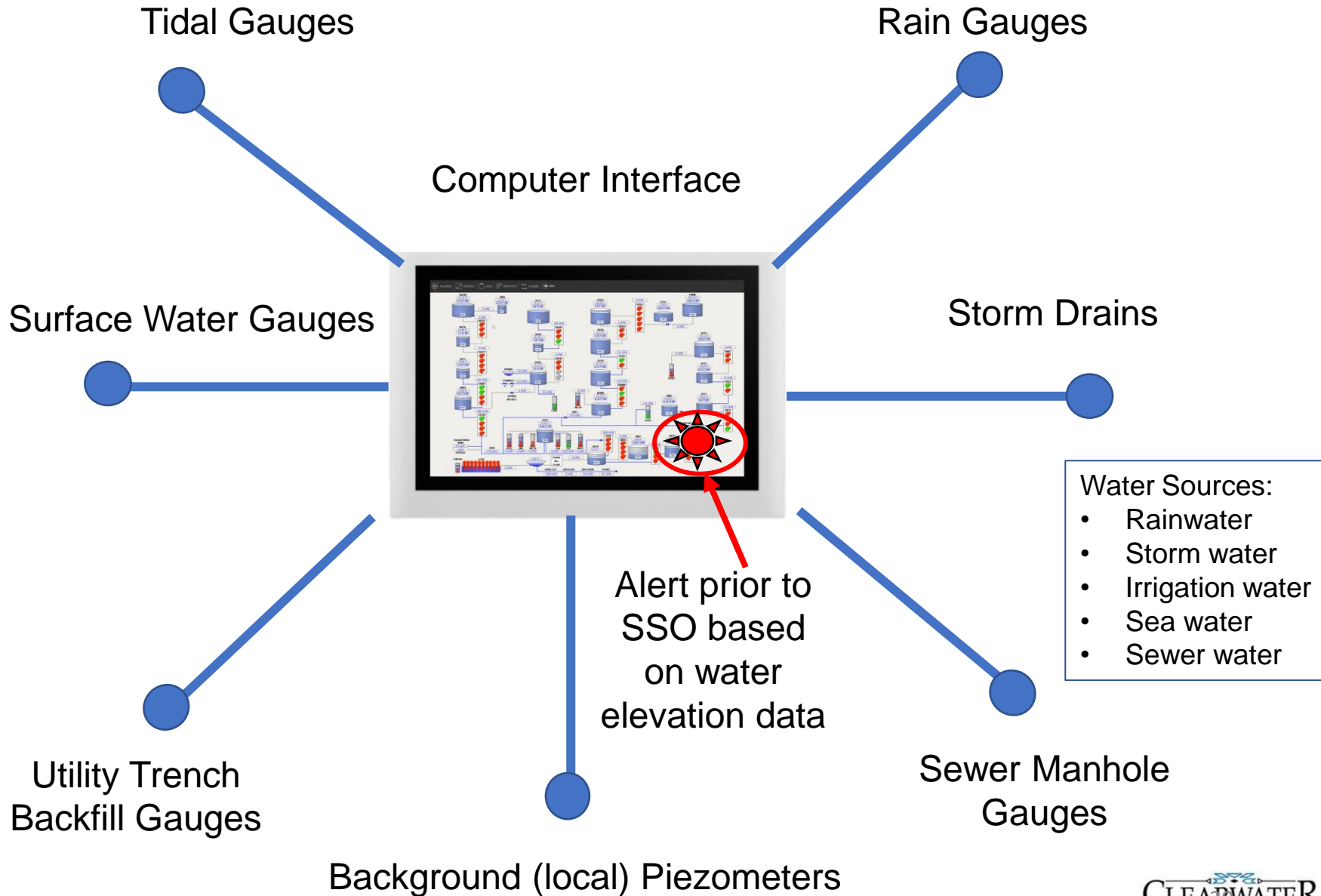
Computer Interface

Alert prior to SSO based on water elevation data

Concept: Integrated, Real-Time Data for Preventing SSOs



Concept: Integrated, Real-Time Data for Preventing SSOs



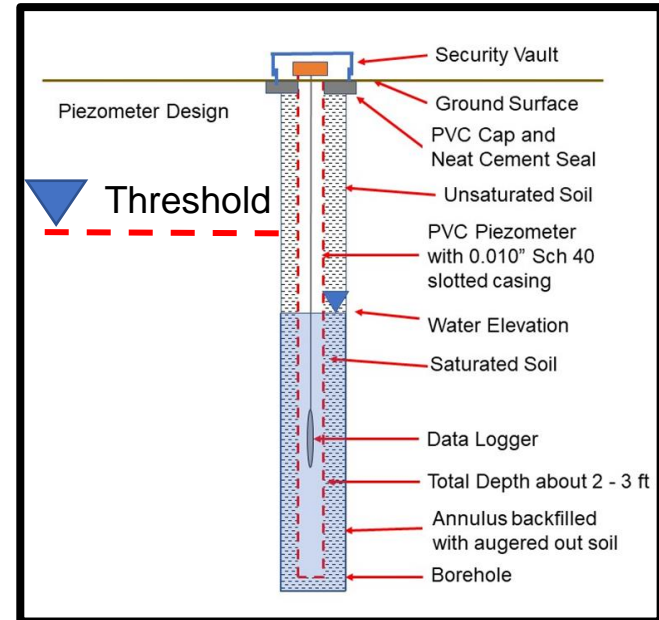
Conclusion: Integrated, Real-Time Data for Preventing SSOs

Impacts of the Future:

- Sea Level Rise (SLR)
- Groundwater Inundation
- Extreme Rain (ER) Events

Using These Integrated Tools:

- Prevent SSOs
- Improve Water Quality
- Mitigate/Warn of Area Flooding
- Monitor for security of system



Decisions based on Data:

Identify Subsurface Conditions in Real-Time

- Dataloggers: Water Elevation, Temperature, Conductivity, Barometric Pressure
- Field Meters: DO, ORP, Conductivity, pH, Turbidity, etc.

Identify Subsurface Conditions with a Short Turn-Around Time

- Lab: *e coli*, groundwater contaminants

Conclusion: Eliminate I&I and SSOs Using Accurate Data

1. The Team to customize projects for device automation to control and monitor remote water/parameter monitoring instruments
2. Research project with corporate and agency sponsors with emphasis on investigating subsurface water flow, preferential pathways, and groundwater inundation
3. Collect data using State-of-the-Art Instrumentation for real-time analysis
4. Integrated information sent to decision makers/emergency workers
5. Prioritize repairs of leaky sewer using real-time data
6. Mitigation Actions: based on improved information
 - Trenchless Sewer Repair (Epoxy - Pipe Hardening) to reduce I&I
 - Design and install strategic pumping (gentle) and dewatering
 - Design and install groundwater flow barriers, as needed

Thank You

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