



In Situ Oxidation of PAH Contaminants Associated With Former Manufactured Gas Plants

Ron Jensen
Southern California Edison



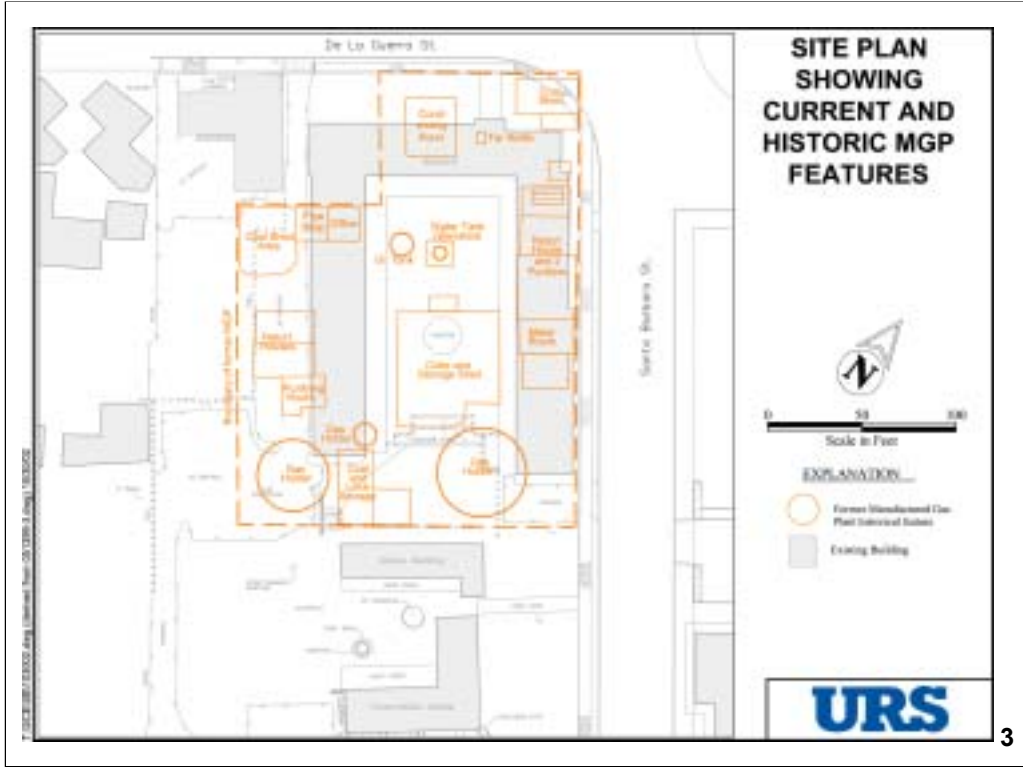
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Santa Barbara MGP Site



View of Santa Barbara MGP facility and adjacent 1930s structure. BSC 100



Historical Museum

- Main museum completed in 1965
 - Adobes made from onsite soil
- Courtyard used for public gatherings
- Two historic adobes dating to 1817
- 3 schools adjacent to site

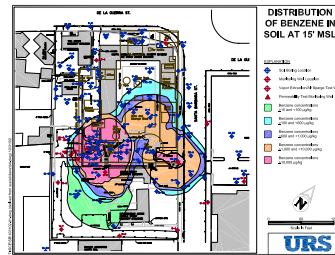
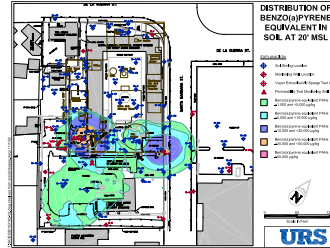


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Area of Contamination

Highest contaminant levels

	Maximum Concentrations (ppb)	
	Soil	Water
Benzene	145,000	59,300
Benzo(a)pyrene	133,137	91
Naphthalene	1,290,000	15,700
TPH	29,400	116,000



Gas Holder Excavation

- Excavated gas holder below parking lot
 - Source of groundwater contamination
 - Portion of holder base under museum wing
 - Vertical excavation next to buildings
- Removed 1,500 cubic yards of soil to 15 foot depth



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In-situ Ozone Sparging

- 27 Ozone sparge wells
- 11 Air sparge wells
- 34 Vapor extraction wells

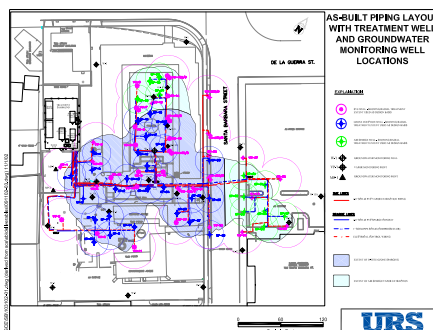


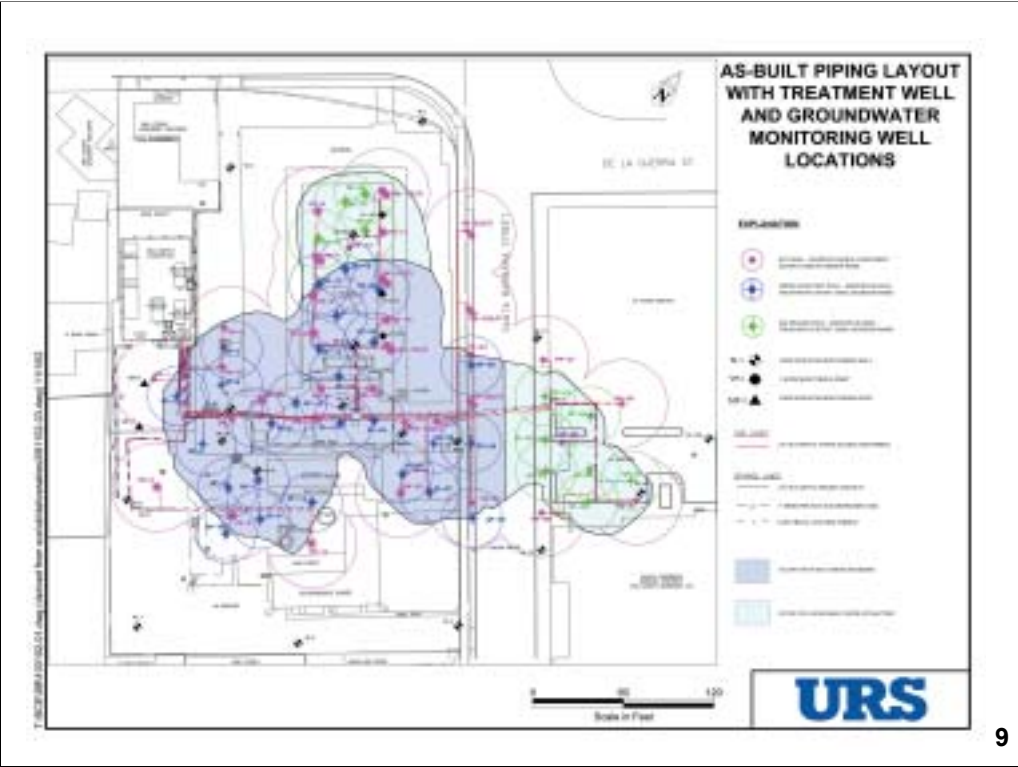
Rationale

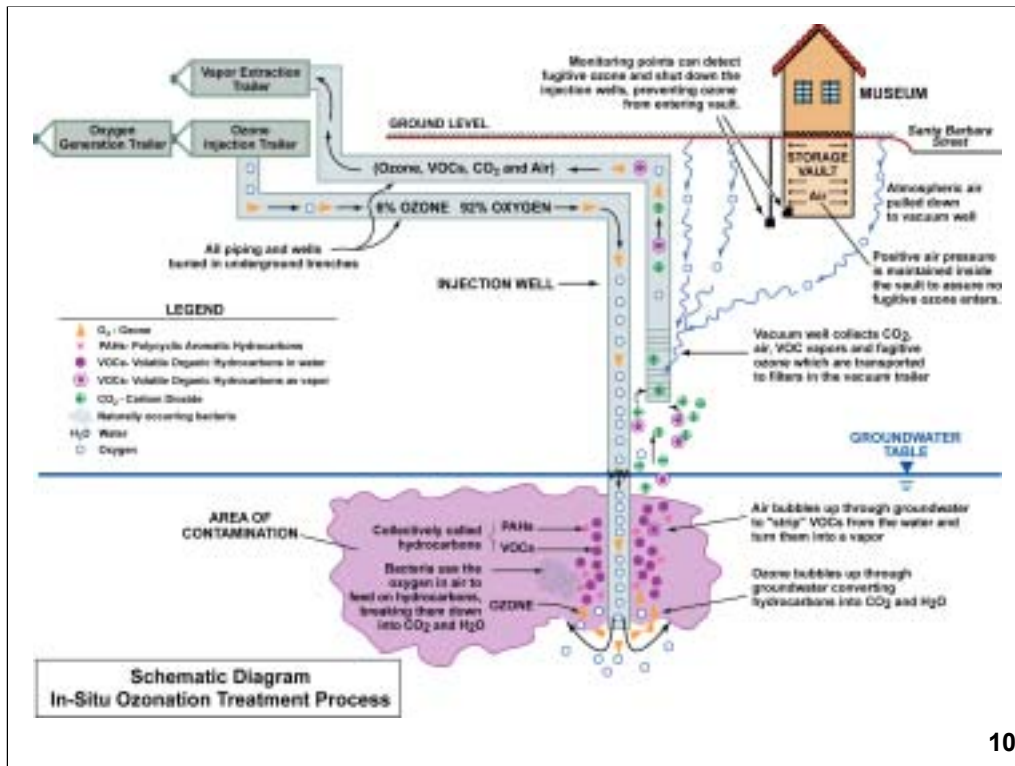
- Cannot disrupt current land use
- Dewatering and excavation not feasible because of historic structures

Treatment Zone Summary

- 27,000 cubic yards of soil treated by ozone sparging
- 10,000 cubic yards of soil treated by air sparging
- Treatment area = 65,000 square feet
- Depth to groundwater 20-25 feet below ground surface
- Thickness of treatment zone 15-30 feet







Treatment Compound Interior

- Secures equipment
- Self-enclosed trailers
 - Oxygen generation
 - Ozone generation
 - Vapor extraction
- Trailers customized to attenuate sound
- Two 2,000-pound carbon vessels
- Ozone destruct catalyst vessel
- Single permitted emission point from Air District
- Low-impact electric cart for well sampling and maintenance



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Treatment Compound - Exterior

- Wall is consistent with architecture of museum
- Wall mitigates visual impacts
- Designed to attenuate noise to 60 decibels at property line
- Sliding gate allows easy access to interior of compound



Oxygen Generation Trailer

- Produces oxygen feedstock for ozone generator
- Liquid oxygen - too risky



- Duplicate vessels containing a molecular sieve (zeolite) remove nitrogen from ambient air

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Oxygen Generation Trailer

- 90% pure oxygen stored in steel pressure vessel at 45-50 psi for ozone production
- Oxygen volume produced is 500 cubic feet per hour (12,000 cubic feet per day)
- System shuts off if oxygen levels exceed 25% inside trailer



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Ozone Generation Trailer

- Ozone generator produces 50 pounds per day
- Final gas stream comprised of 6% ozone and 92% oxygen
- Generator operates at 15 psi at 8 cubic feet per minute



Ozone Generation Trailer

- Produced gas is boosted to 45 psi by 2-stage oilless compressor
- Up to four valves can be activated at a time to distribute produced gas to wells
- Well pressures vary from 15 - 35 psi depending on tightness of formation



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Ozone Generation Trailer

- Ozone generator shuts down if ozone concentration inside trailer exceeds 300 ppb (alerts at 100 ppb)



- Each ozone injection well has dedicated 3/4-inch Teflon tube connecting manifold valve to sparge well



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Soil Vapor Extraction

- Moisture knockout vessel receives influent vapor
- Designed to operate at 400 cubic feet per minute
- Vapor concentration averaged 175 ppmv (as hexane) total reactive organic compounds upon startup. Concentrations decreased by 60% within 3 weeks of start up.
- SVE/air sparge only for first 30 days of treatment regime



Ozone Distribution

- 20,000 lineal feet of 3/4-inch teflon tubing
- All piping and tubing located below ground in PVC conduits
- Some wells have nested sparge points on 10 foot vertical increments
- Depths of sparge points vary from 30 to 55 feet below ground surface



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Ozone Distribution

- Wire-wrapped sparge screens (0.030 inch slots) are 30 inches long and made of 304 stainless steel
- Well vault lids coated with urethane glue and impregnated with decomposed granite
- Ozone monitors contained in piping distribution vault
- Ozone monitoring points positioned at 5 and 12 feet below surface around museum basement



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Ozone Monitoring and Control

- Continuous VES operation
- PLC shuts off ozone injection if:
 - Museum HVAC turns off
 - Museum monitors detect 100 ppb ozone
 - Power failure
 - VES shuts down
- Initially tested system with Helium
- Additional vapor wells near museum and screened below basement



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Cleanup Goals

- Groundwater
 - Benzo(a)pyrene: 0.2 ppb
 - Benzene: 1.0 ppb
 - Naphthalene: 21 ppb
 - TPH: 1.0 ppm
- Soil
 - Reduce contaminants to protect groundwater
 - Leaching tests used to assess acceptable endpoint to protect groundwater





Contingent Remedial Strategy

- Ozone treatment scheduled for two years:
July 2002 through June 2004
- In the event MCLs for groundwater are not met within allocated time frame, strategy will switch to monitored natural attenuation
- Land use covenant will be required to address residual deep soil contamination

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