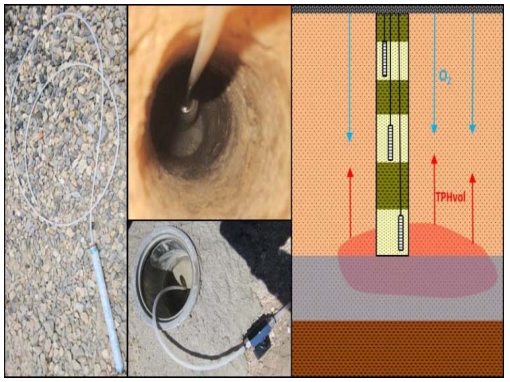
Natural Source Zone Depletion Investigation of a Paved UST Site in Spain



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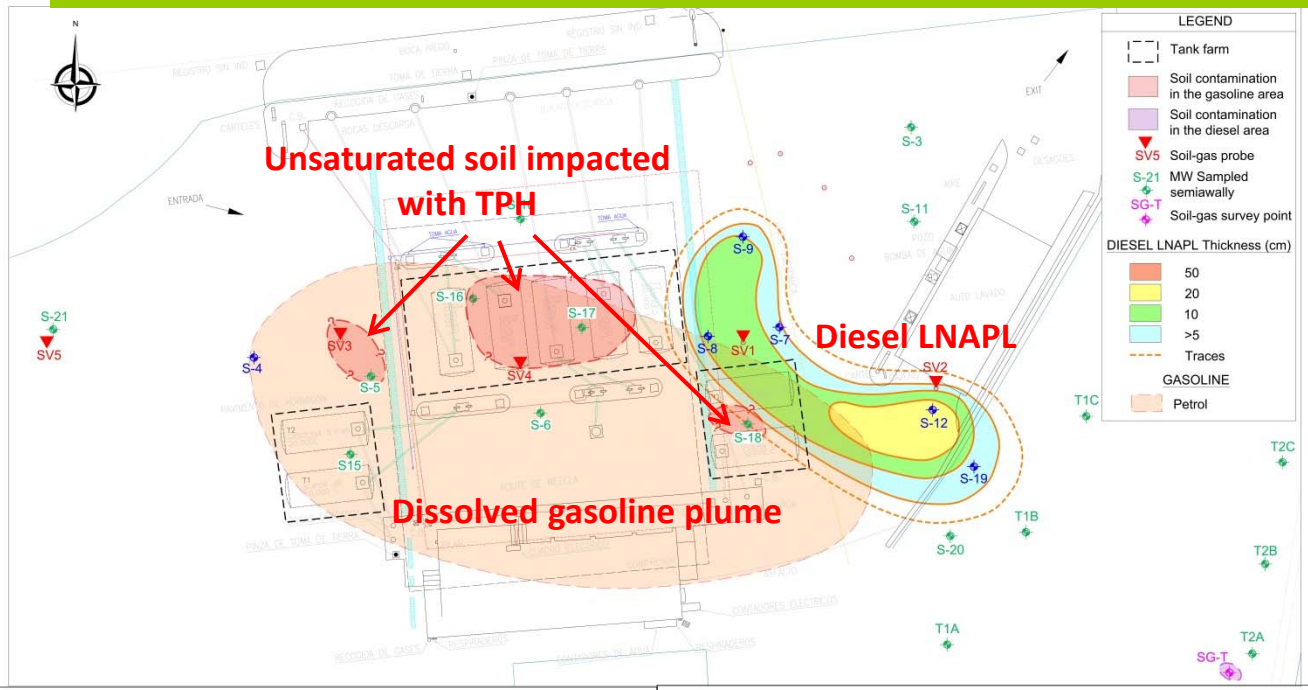
Site Description and Objectives



Site Description

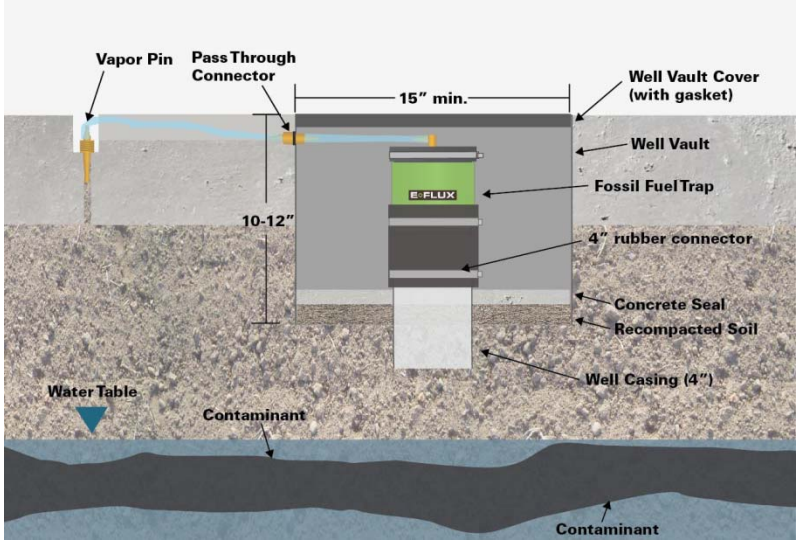
- Former urban Petrol Station
- Currently dismantled
- In service from 1966 to 2009
- 9 underground tanks
- Entire surface is asphalt pavement
- Perched water at about 10 m
- Diesel LNAPL plume < 0.5 m thick
- Gasoline dissolved groundwater plume

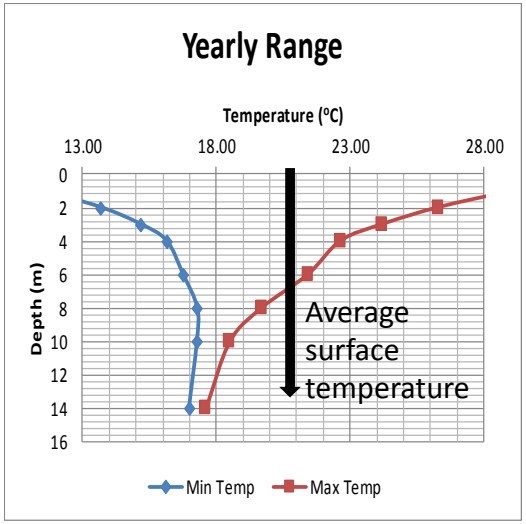
Objectives of study

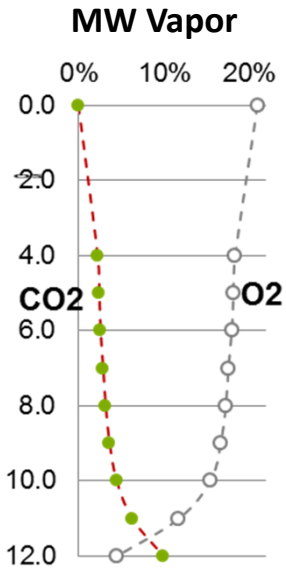
- Test recommended methods to quantify the NSZD rate at large LNAPL sites (API, 2017)
  - Gradient & CO_2 Efflux trap (surface cover)
  - Emerging methods -Temperature and ^{14}C of CO_2
  - New field methods – Monitoring well vapor analysis (Sweeney and Ririe, 2017), and shallow soil gas sampling

Topics for Discussion

- **First set of CO_2 Efflux Trap results**
  - Background and 2 traps each in diesel and gasoline areas
- **Comparison between Soil Gas probes and MW vapor results**
  - Multi-depth sampling of vapor from screened intervals in monitoring wells
  - Baseline and first round results – soil gas profiles background/diesel location
- **Temperature model and preliminary results**
  - Modifications to basic temperature model
  - Use of temperature monitoring data to determine the heat conductance of vadose zone

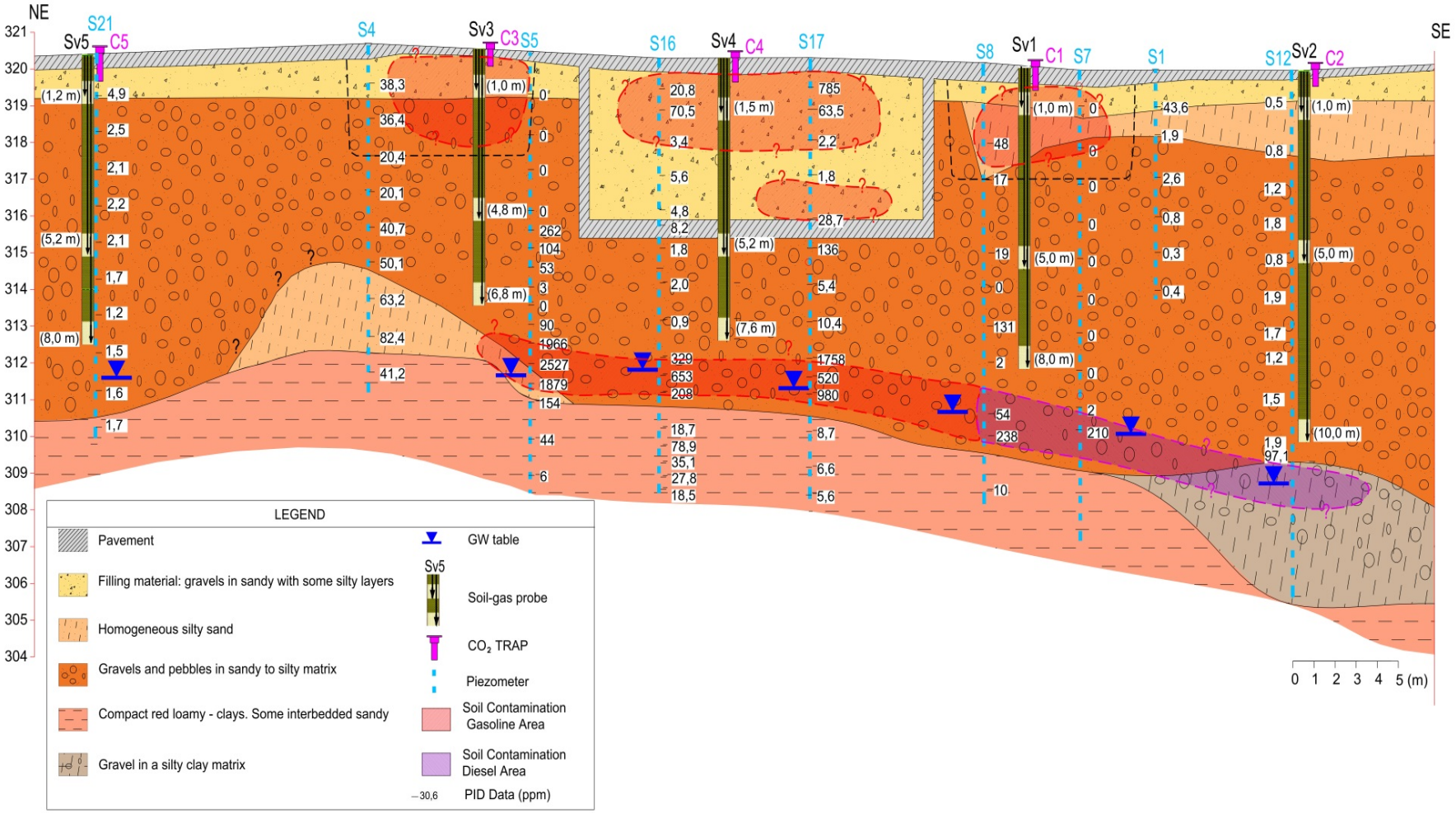






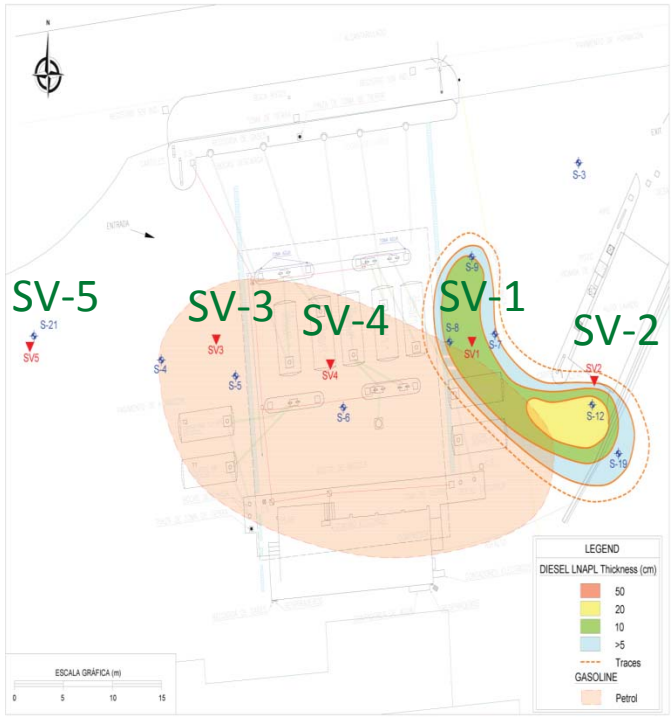
Sample locations: CO_2/O_2 Gradient and CO_2 Efflux Methods

Background Gasoline Area Diesel Area



NSZD rate from CO_2 Efflux results

CO2 Efflux Trap Location	NSZD rate Gallons per acre-year (gpay)	Contamination Type
SV1/ C1	74	Diesel
SV2/ C2	106	Diesel
SV3/ C3	8,113 13,663	Gasoline
SV4/ C4		Gasoline
SV5/ C5	2,006	Background



Traps in place for about 8 day

Fossil CO_2 flux determined after subtraction of 'trip blank'

- Calculated low efflux of CO_2 at diesel trap sites near SV-1 and SV-2, close to blank correction
- High efflux of CO_2 at gasoline sites SV-3 and SV-4 likely related to unsaturated soil contamination
- Unexplained elevated Efflux of CO_2 at background site SV-5 – lateral transport or other interference?

Soil Gas Probes and Monitoring Well (screened interval) Profiles

Background SV-5 Diesel Area SV-2 Diesel Area MW – S12

Depth (meters)

O_2

CO_2

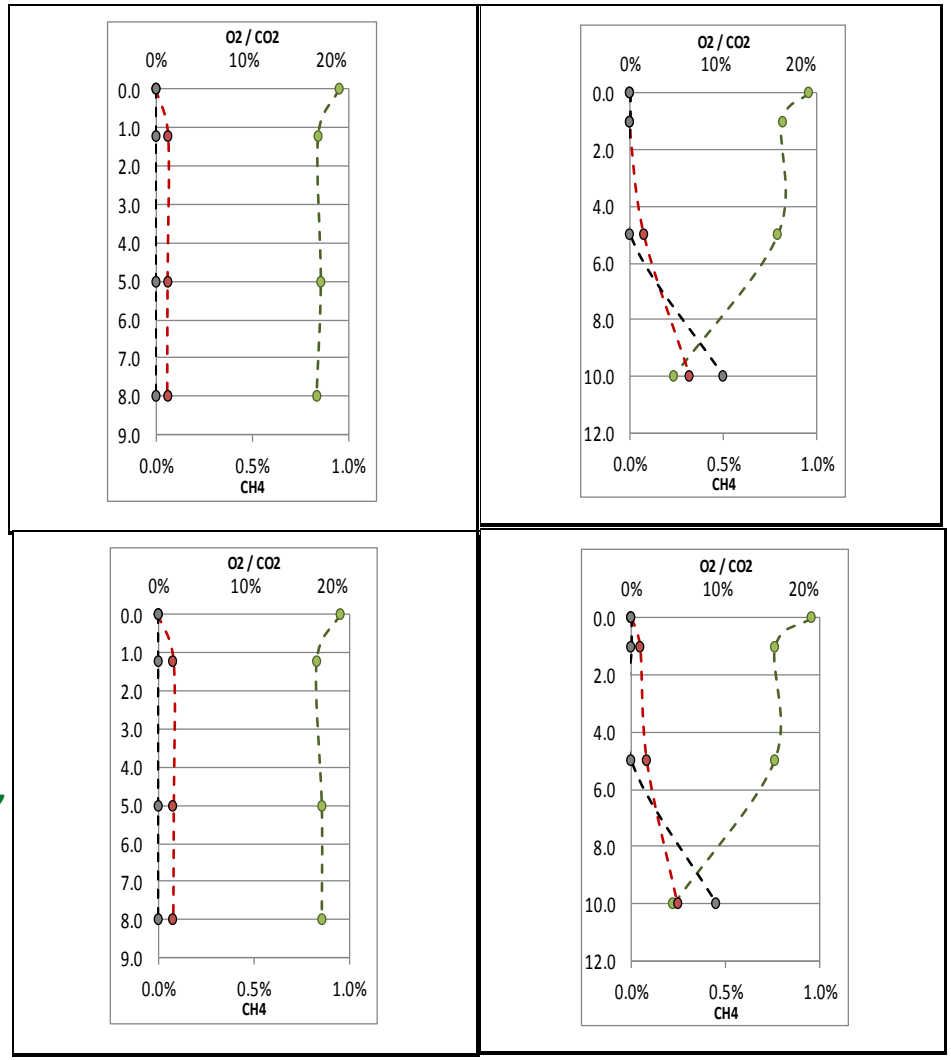
CH_4

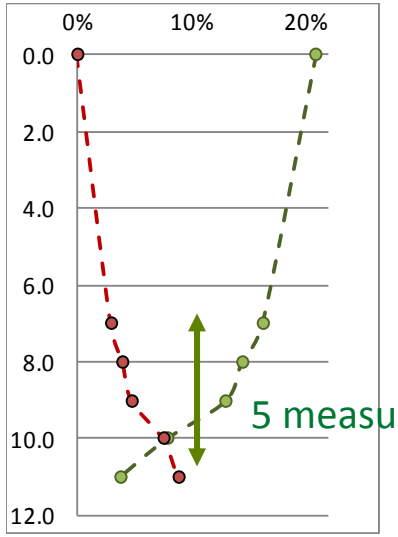
Base Line Results

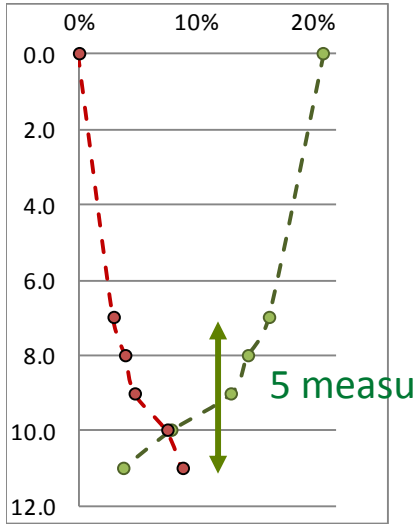
First Quarter Results

With Packer

Without Packer







NSZD from CO_2/O_2 Gradient

Depth (meters)

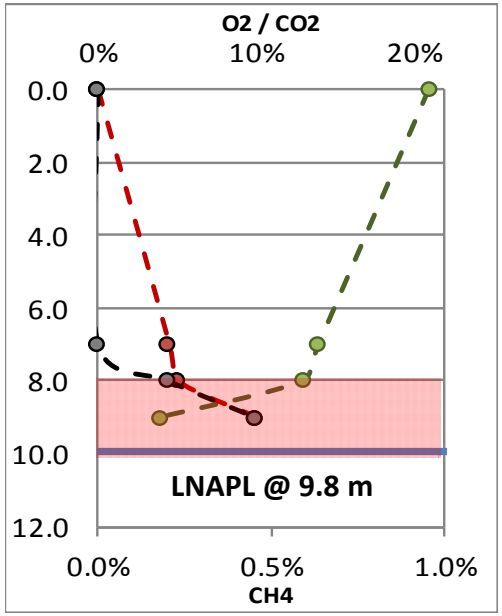
O_2

CO_2

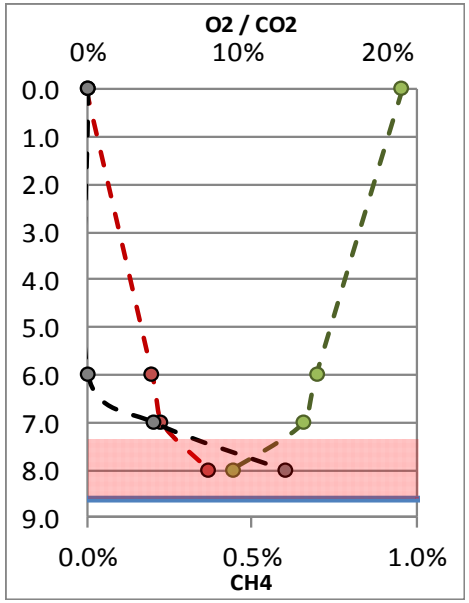
CH_4

Summer Measurements

Diesel Area MW S-8

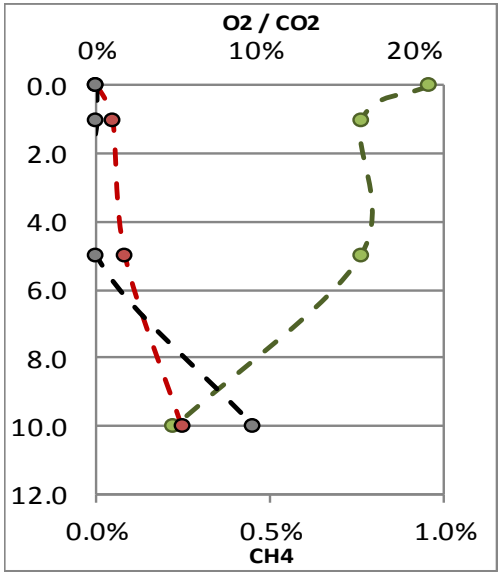


Gasoline Area MW S-17

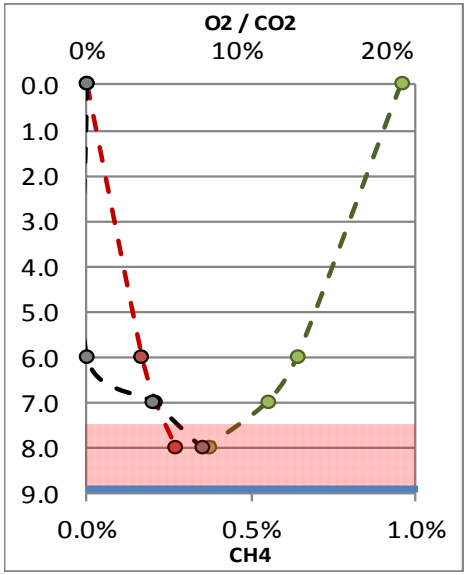


Fall Measurements

Diesel Area Soil Gas SV-2



Gasoline Area MW S-17



Observations

Two diffusivity layers in vadose zone

- Fluxes equal thru layers
- Above gradient change
- Below gradient change

NSZD rate

Above gradient change

Diesel Area (CO_2 gradient)

- S-8 = 292 gpay
- SV-2 = 252 gpay

Diesel Area (O_2 gradient)

- S-8 = 409 gpay
- SV-2 = 620 gpay

Gasoline Area (CO_2 gradient)

- S-17 (summer) = 207 gpay
- S-17 (fall) = 307 gpay

Gasoline Area (O_2 gradient)

- S-17 (summer) = 174 gpay
- S-17 (fall) = 527 gpay

NSZD from Temperature Monitoring

Temperatures sensors in monitoring wells

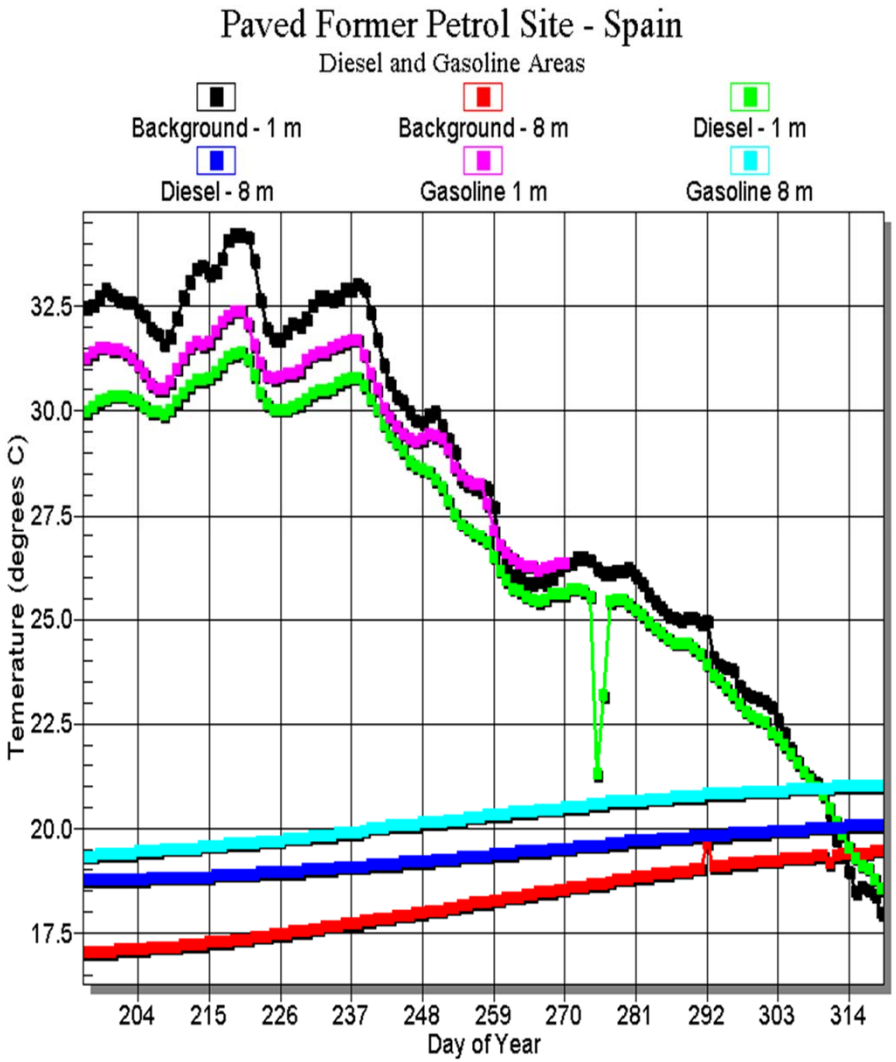
- Placed at 1 meter intervals
- Measurements every hour
- Plotted 11 PM results each day
- Readings at 0.1 degrees C

Results plotted vs Time

- Largest changes near surface
- At 1 m depth – atmospheric influence should be equal at each site unless 'surface cover' variable

NSZD rate:

- Using temperature difference at 8m depth between background and impacted area as thermal gradient (0.5 - 2^{o} C/8 m) then rate = 67 – 268 gpay



Summary and Conclusions

CO_2 Efflux Traps

- Documented gasoline in shallow soils near tanks/pumps
- Low CO_2 efflux (74 – 104 gpay) at diesel sites
- High CO_2 efflux at background site is unexplained

Use of Soil Gas Probes and Monitoring Well Vapor for Gradient Approach

- Baseline and first round results – non-linear O_2/CO_2 profiles at gasoline/diesel sites, implying that gas diffusivity changes with depth (due to lithology or moisture)
- Preliminary rates of NSZD - relatively low (174 to 620 gpay)

Temperature Model and preliminary Monitoring Results

- Monitoring data used to determine thermal heat conductance = 1.2 kJ/m-sec-K, consistent with site lithology
- Still have concern with variable temperature near the surface
- Using thermal anomaly at 8 meters, NSZD rate calculated as 67 – 268 gpay

Overall: NSZD relatively low (< 1000gpay) consistent with weathered fuel, still effective for site remediation