



# SOLUTION PROVIDED

Solar based heat  
enhanced remediation

**Solution Provider**  
in Environmental Asset Management

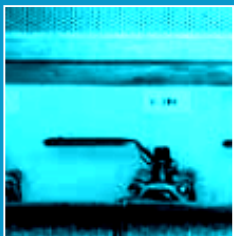
*Leading in soil and groundwater remediation*



# ISSUE

Industrial site, chlorinated contamination  
in clay to 9 m below grade

- Contamination underneath industrial premisses
- Shut-down not acceptable (major disruption of production)
- Excavation impossible (too deep, too much on top)





# ISSUE (2)

- Chlorinated hydrocarbons DNAPL, at and in the top of a clay layer
- Permeability too low for regular treatment

Compound	Max Concentration ( $\mu\text{g/l}$ )	Remediation Goal ( $\mu\text{g/l}$ )
Trichloroethene	1.900.000	3.000
Dichloroethene	340.000	8.400
Vinylchloride	12.700	36



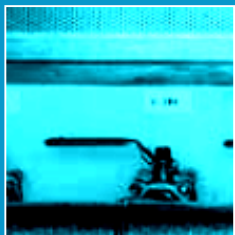
# Site

Solar Thermal Remediation Site

Legend



Google Earth









# SOLUTION

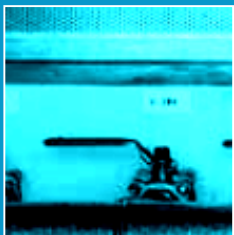
Heat soil gradually to 30 – 50 C

Heat will increase reaction speed 4-fold

Heat will increase permeability of clay 2 – 5 fold

High-vacuum extraction will be effective to remove bulk of contamination

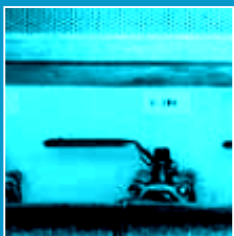
In situ chemical reduction and biodegradation will treat the rest





# Options to heat soil

- Electrical (resistivity) Heating
- Hot Air injection
- Steam injection
- Conductive Heating
  - Electrical
  - Hydraulical

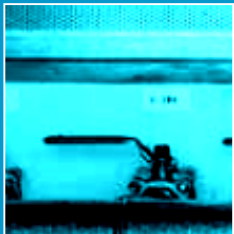




# Option selected

## Hydraulic conductive heating with high vacuum extraction

- Solar system to provide most of energy for heating; gas fired heater as back-up
- High-vacuum, extraction system to remove contamination
- Carbon for treatment of effluent





# Energy calculations steam

## Heating using an gasoil fired boiler

Quantity of steam supplied by facility 100 kg/hr

100 kg/h

Thermal energy contained in 100 kg/h vapour

251.040 kJ / h

System efficiency

95%

Thermal energy effectively used

238.488 kJ / h

Thermal energy required to heat & evaporate influx water 0 m3/hr

16.736 kJ / h

Energy available to heat the soil

221.752 kJ / h

Time theoretically needed to heat the soil to 50C (excluding evaporation of water)

8 days (theoretical)

Time effectively needed to heat the soil to 50C (excluding evaporation of water)

8 days (effective)

Time theoretically needed to heat the soil to 50C (including evaporation of water)

8 days (theoretical)

Time effectively needed to heat the soil to 50C (including evaporation of water)

8 days (effective)

Duration HOT

150 days

Energy Consumption : 56 - 64 kg oil/1000kg steam

Total oil consumption

Heat-up phase (8 days)

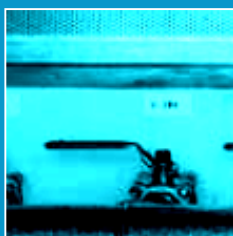
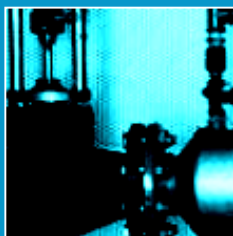
1.460 l

Hot phase (150 days)

8.641 l

Total oil consumption

10.101 l



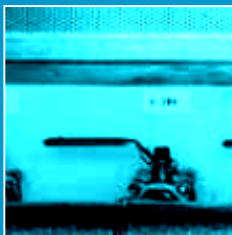
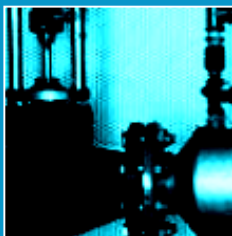


# Energy calculations

## Conductive Hydraulic Heating

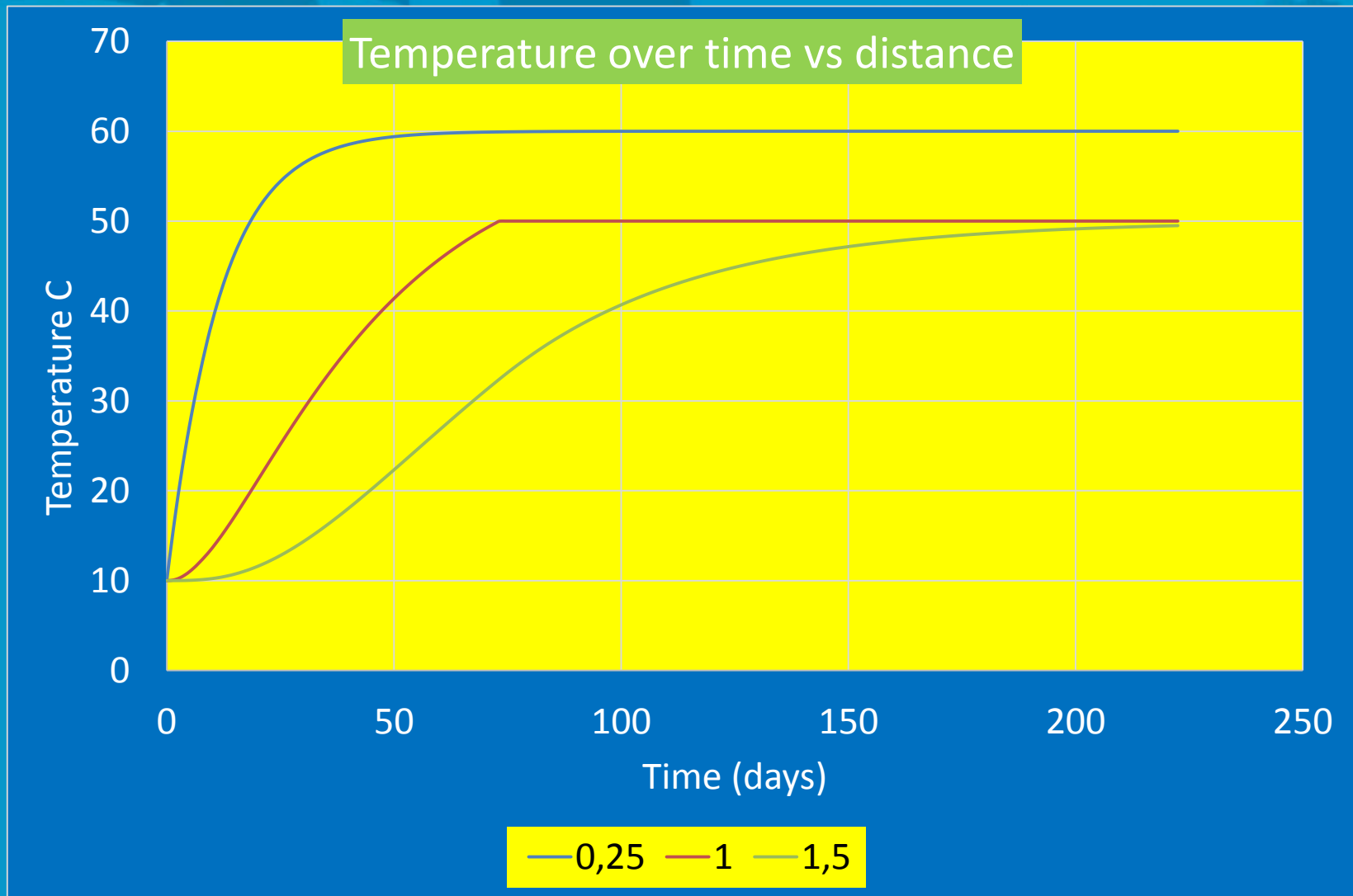
### Heating using 6 solar panels

Number of panels	6	number
Thermal energy delivered by 6 panels	11.232,9	kJ / h
System efficiency	95%	
Thermal energy effectively used	10.671,2	kJ / h
Thermal energy required to heat & evaporate influx water 0 m3/hr	-	kJ / h
Energy available to heat the soil	10.671,2	kJ / h
Time theoretically needed to heat the soil to 50C (excluding evaporation of water)	158	days (theoretical)
Time effectively needed to heat the soil to 50C (excluding evaporation of water)	158	days (effective)
Time theoretically needed to heat the soil to 50C (including evaporation of water)	158	days (theoretical)
Time effectively needed to heat the soil to 50C (including evaporation of water)	158	days (effective)
Duration HOT	180days	
Total Remediation time	338	days



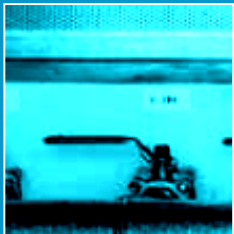
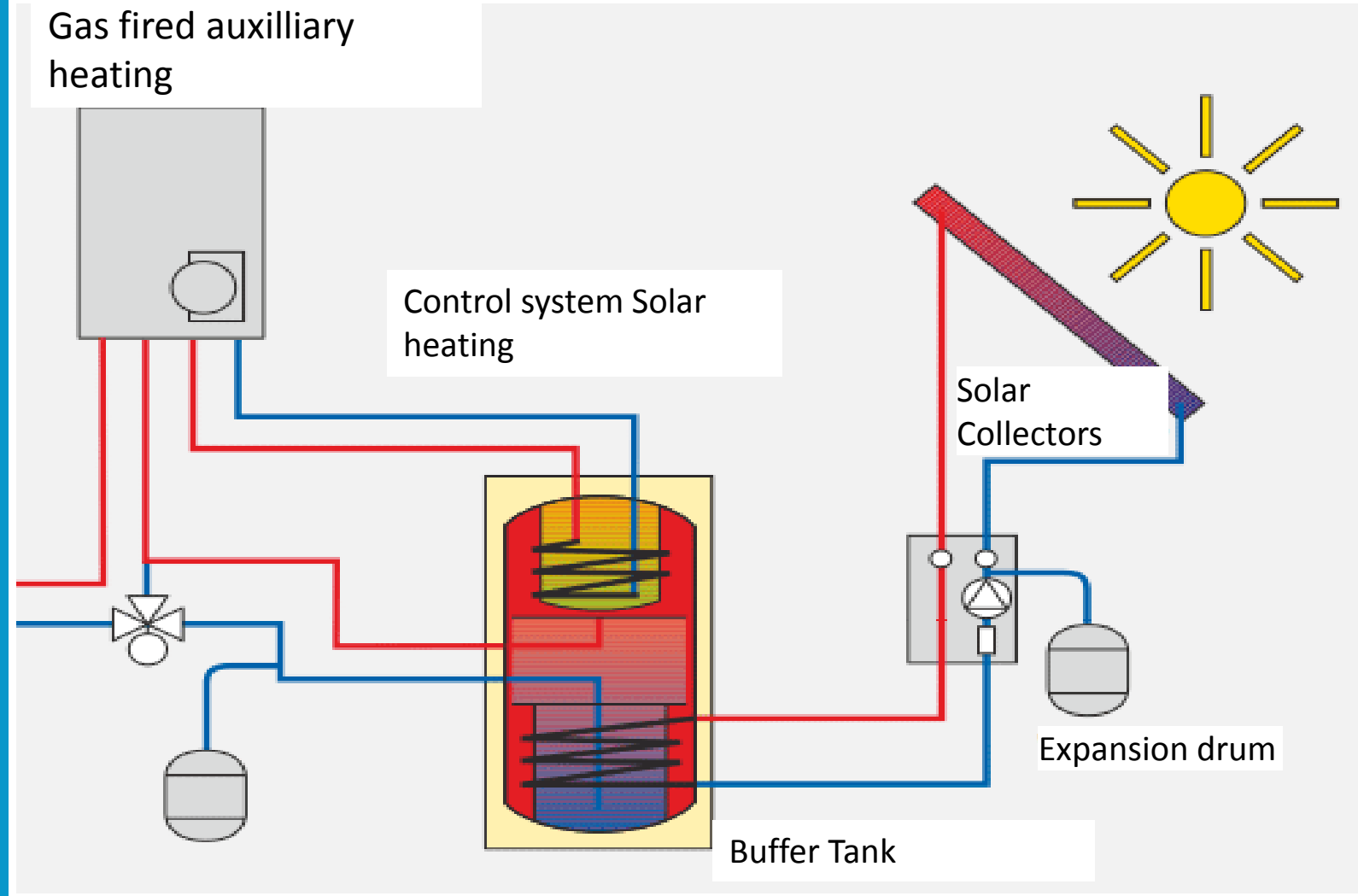


# Energy calculations steam (2)



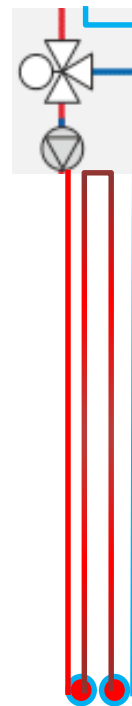
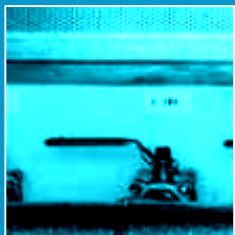


# Heat Collection System





# Down Well Unit

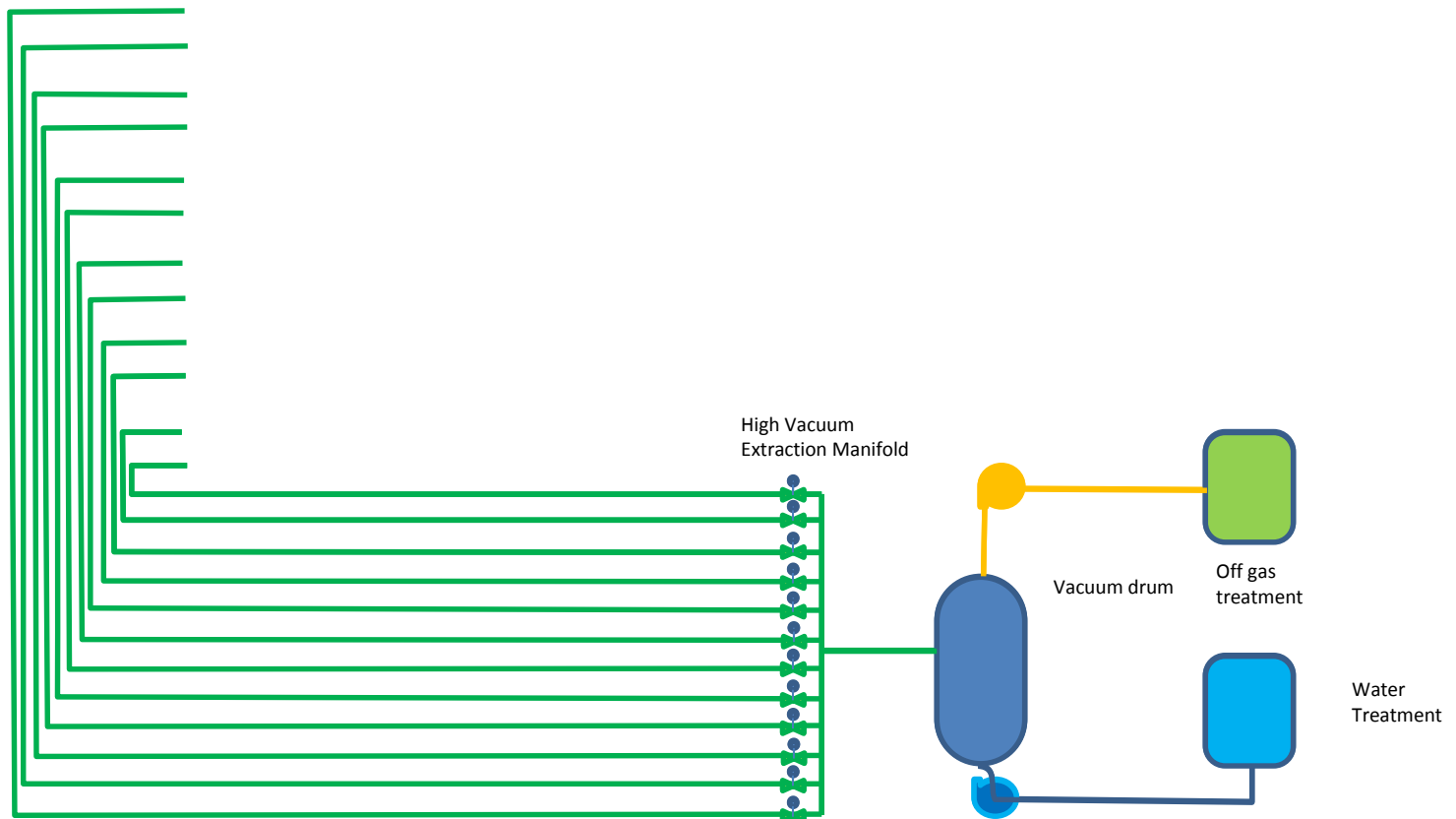
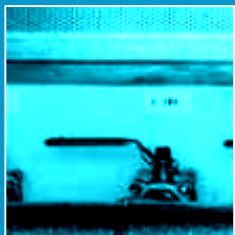


Control Block

Down Well Unit for two wells

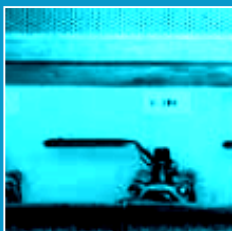
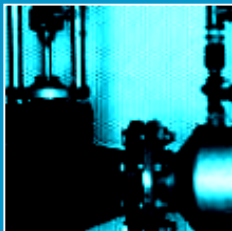
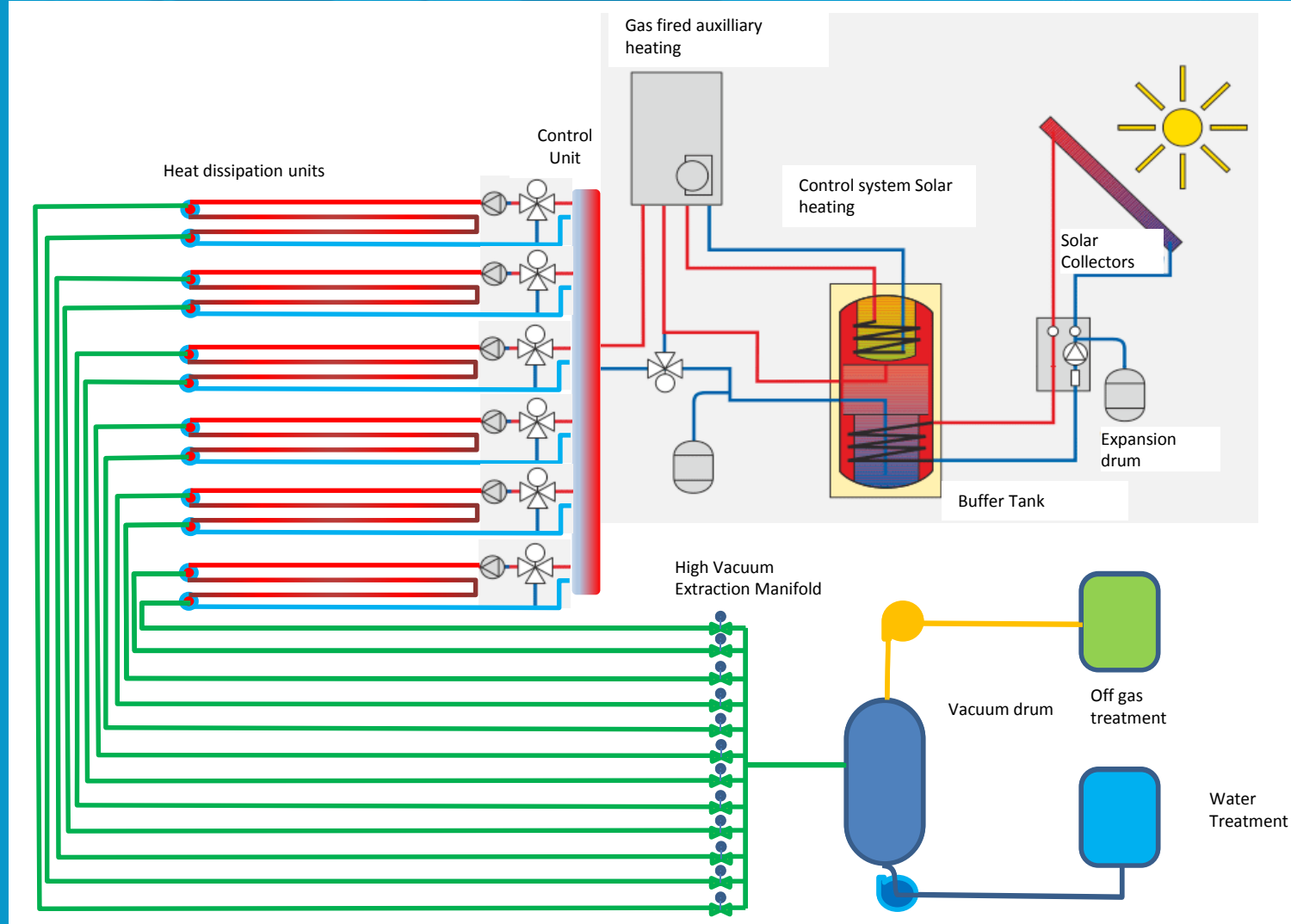


# Extraction System



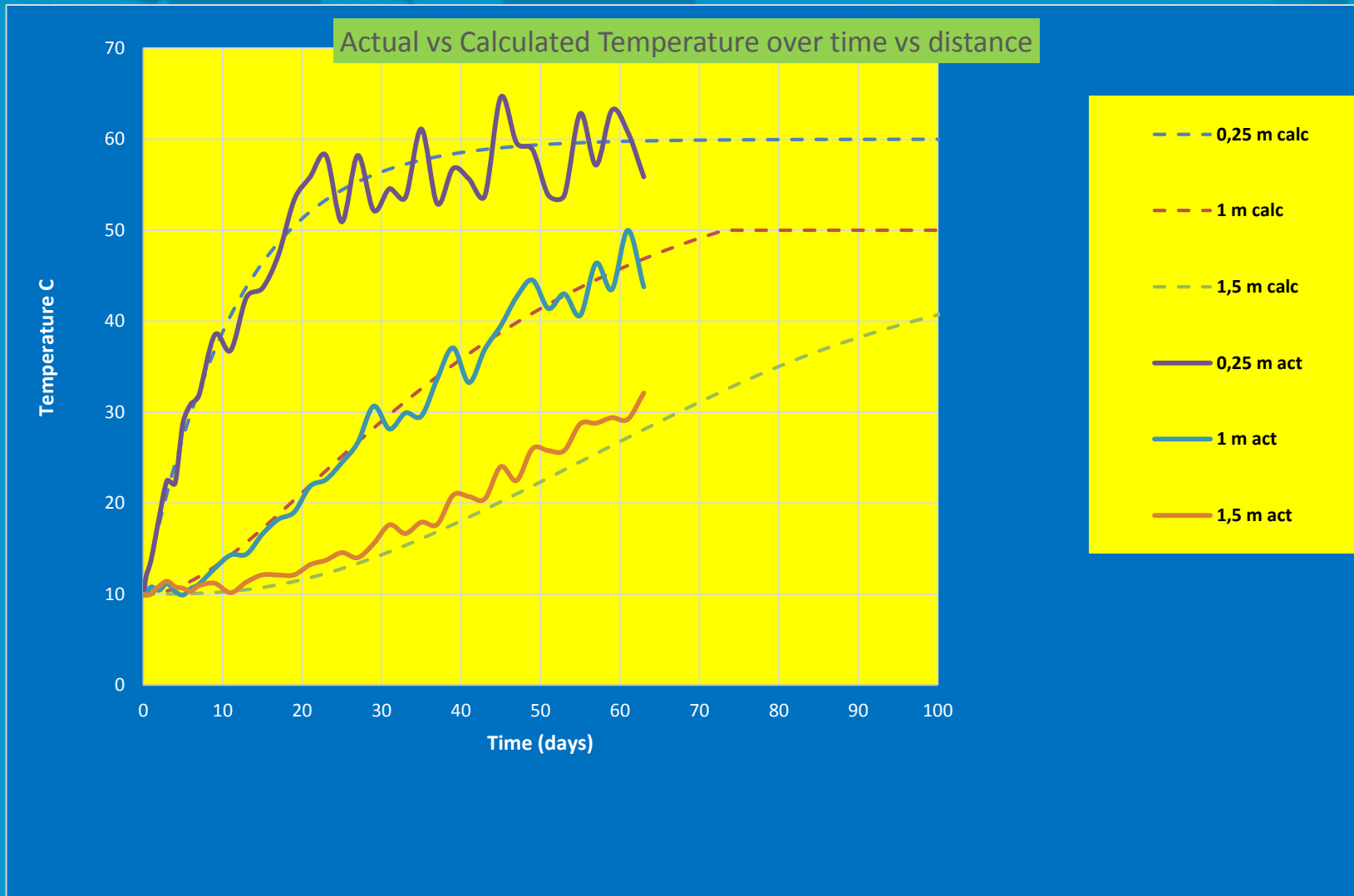


# System



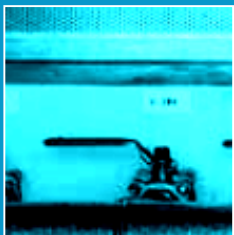
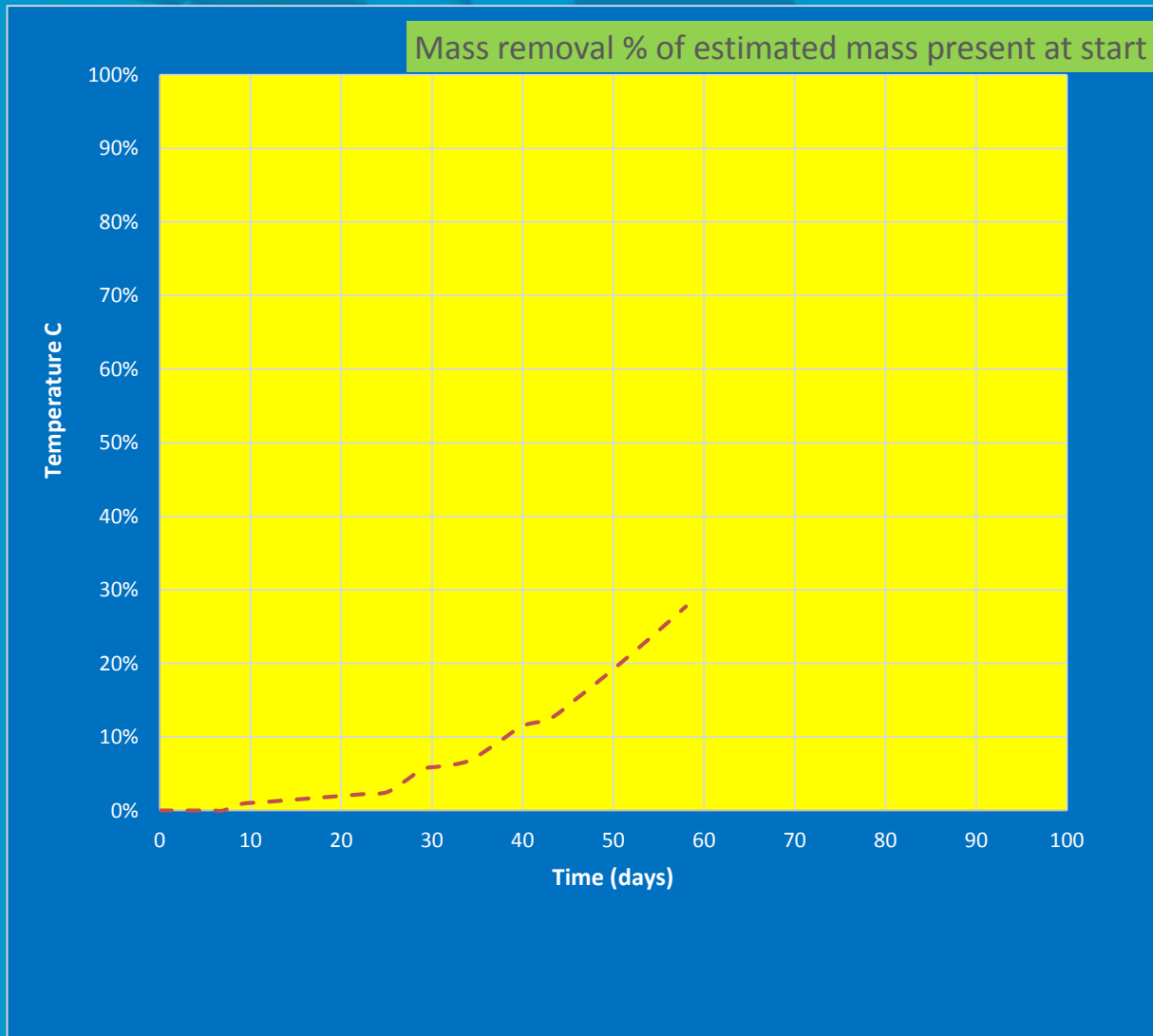


# Actual temperature gain





# Actual temperature gain







# Thank you for your attention

## Groundwater Technology

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in Environmental Asset Management

*Leading in soil and groundwater remediation*

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