
Remediation of a Chlorinated Solvents Contaminated Site by Thermal Remediation

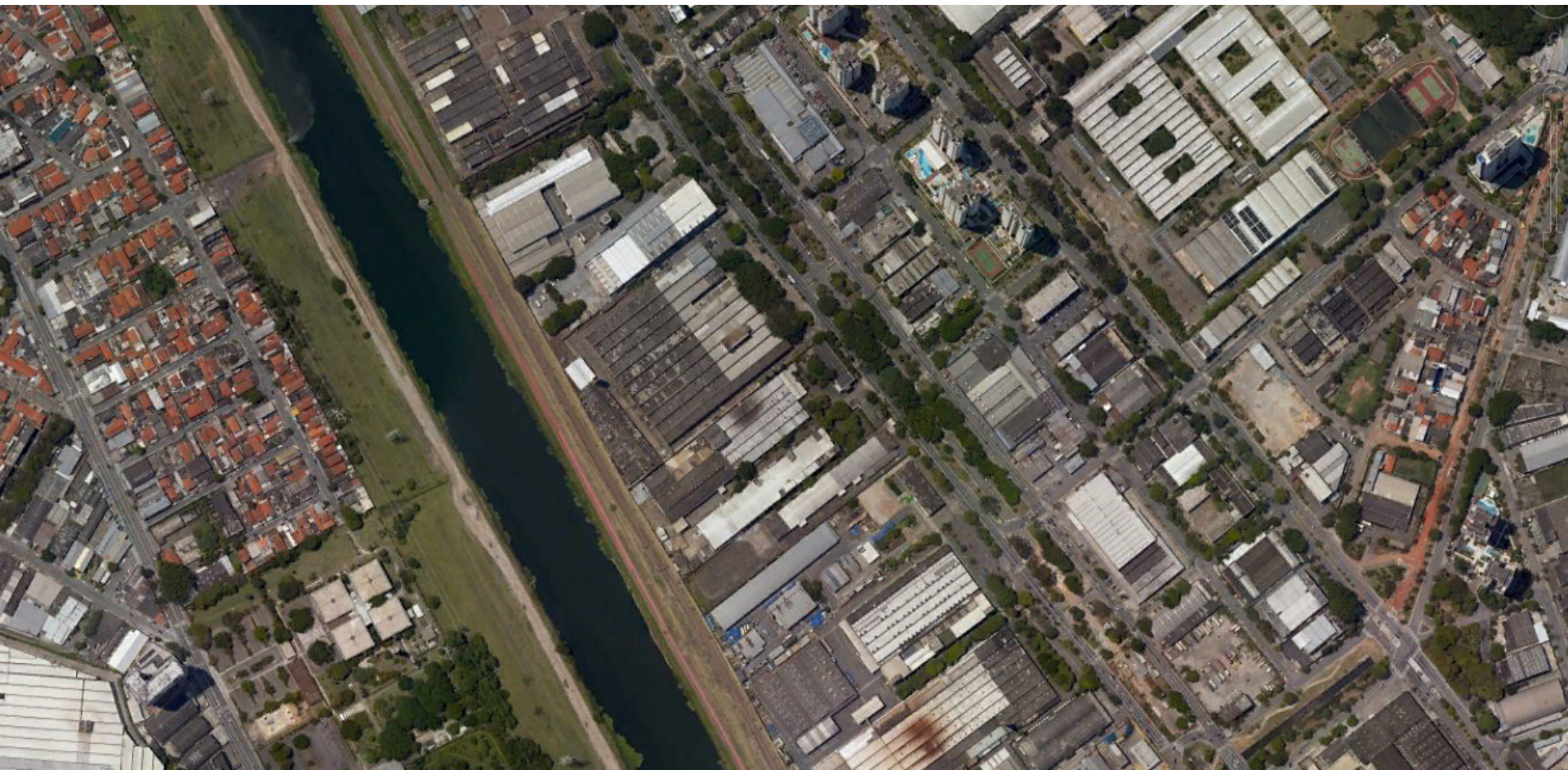
Session: H3.: Remediation of Legacy Contaminants using Thermal Conductive Heating

June 04, 2024

Norbert Brandsch

GENERAL

Geology, hydrogeology, plume, particularities, etc



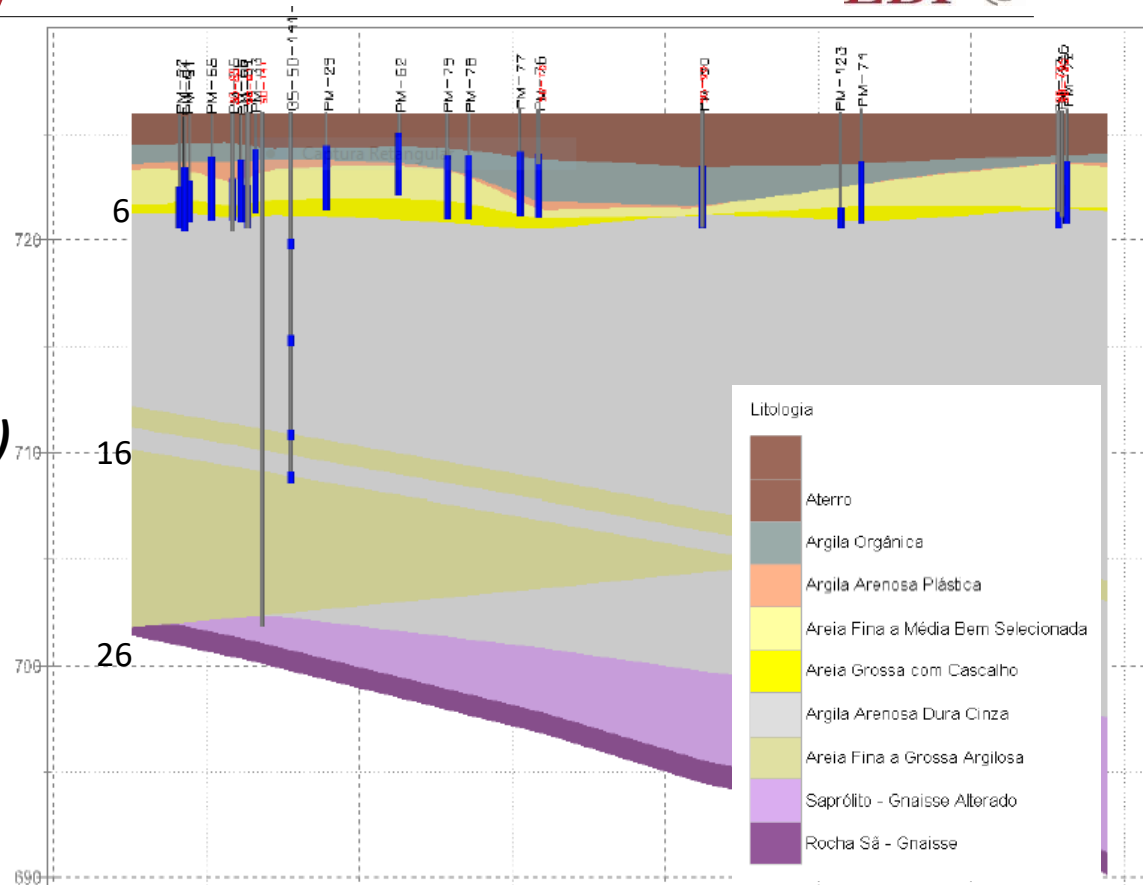


Alluvial aquifer (~6-8m)

- Clayey fillings
- Organic clay
- Fine sand
- Coarse sand

$K: 10^{-4} \text{ a } 10^{-3} \text{ cm/s}$

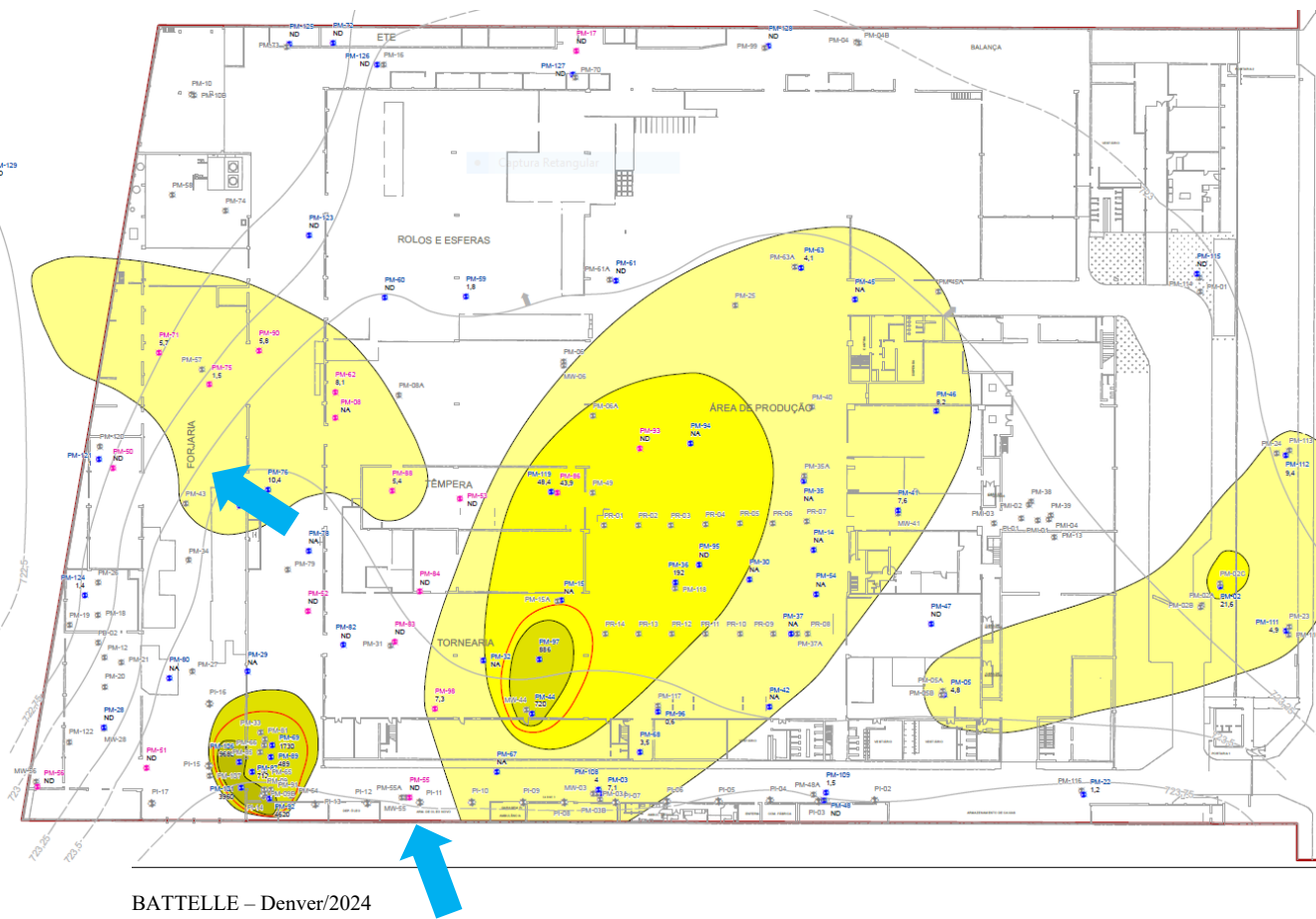
$GWL: \sim 2 \text{ a } 3 \text{ m}$



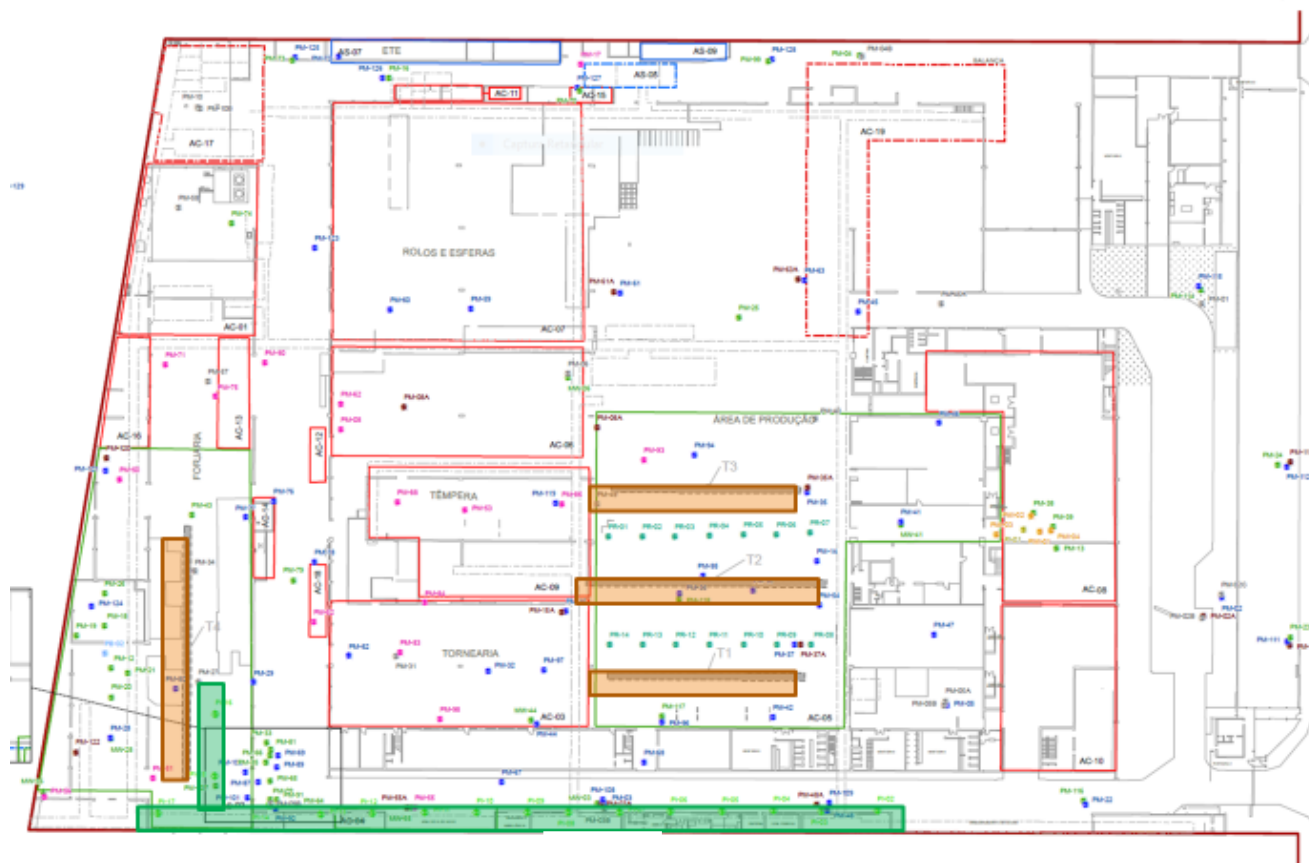
Plume situation

STATUS

- VC main substance
- VC > MAC

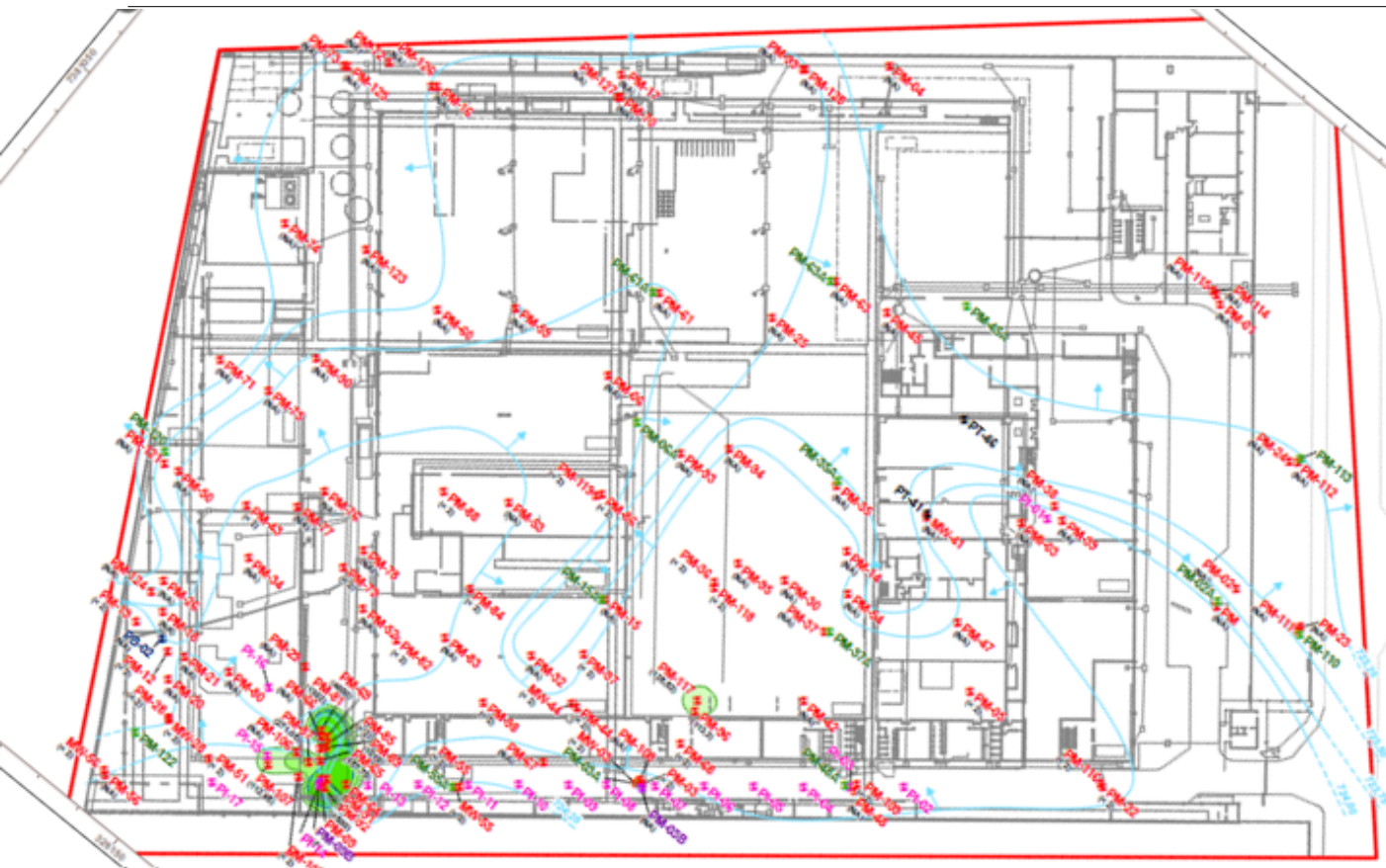


Former Remediation System



 Pumping & reinjection in trenches (2009-2017)

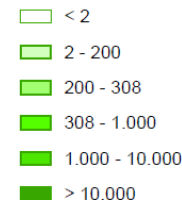
 Molasses injection (2011-2017)



Baseline 2020

- VC main substance
- VC > MAC
- Alluvial aquifer

Concentrações de Cloreto de Vinila (µg/L)



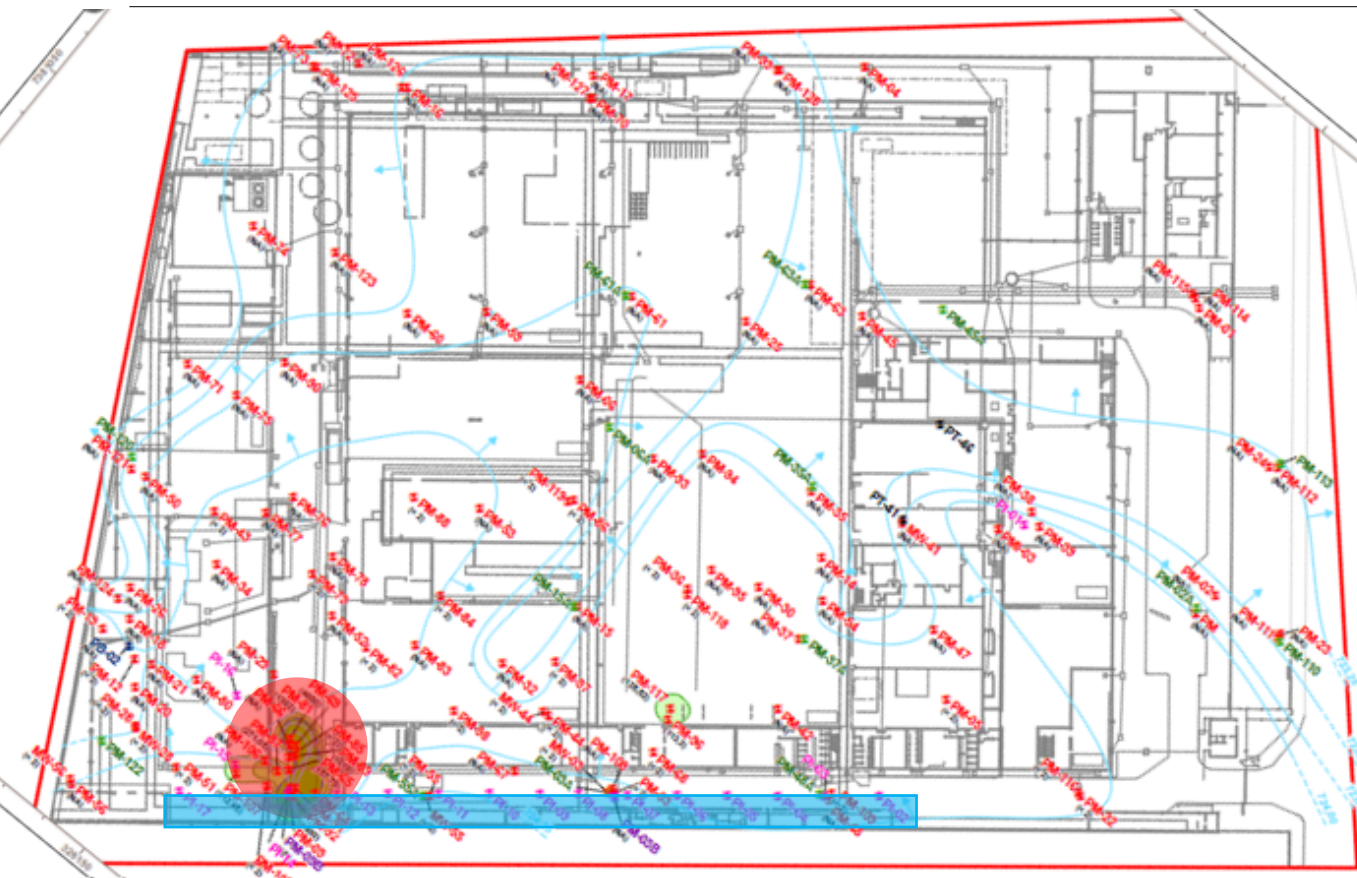
Padrão de Referência:

2 µg/L - CETESB, 2016

Concentração Máxima Aceitável - CMA (308 µg/L)

REMEDICATION

Remediation Concept



Thermal desorption (TCH) – mass center

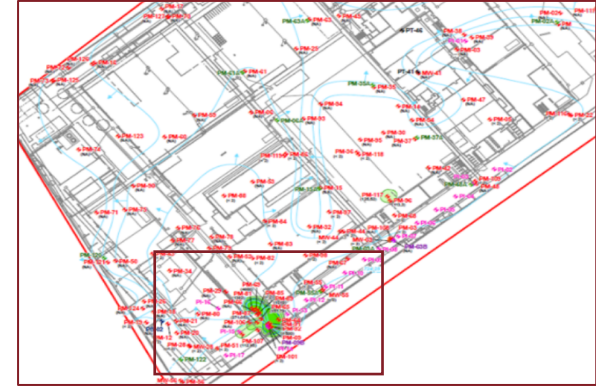
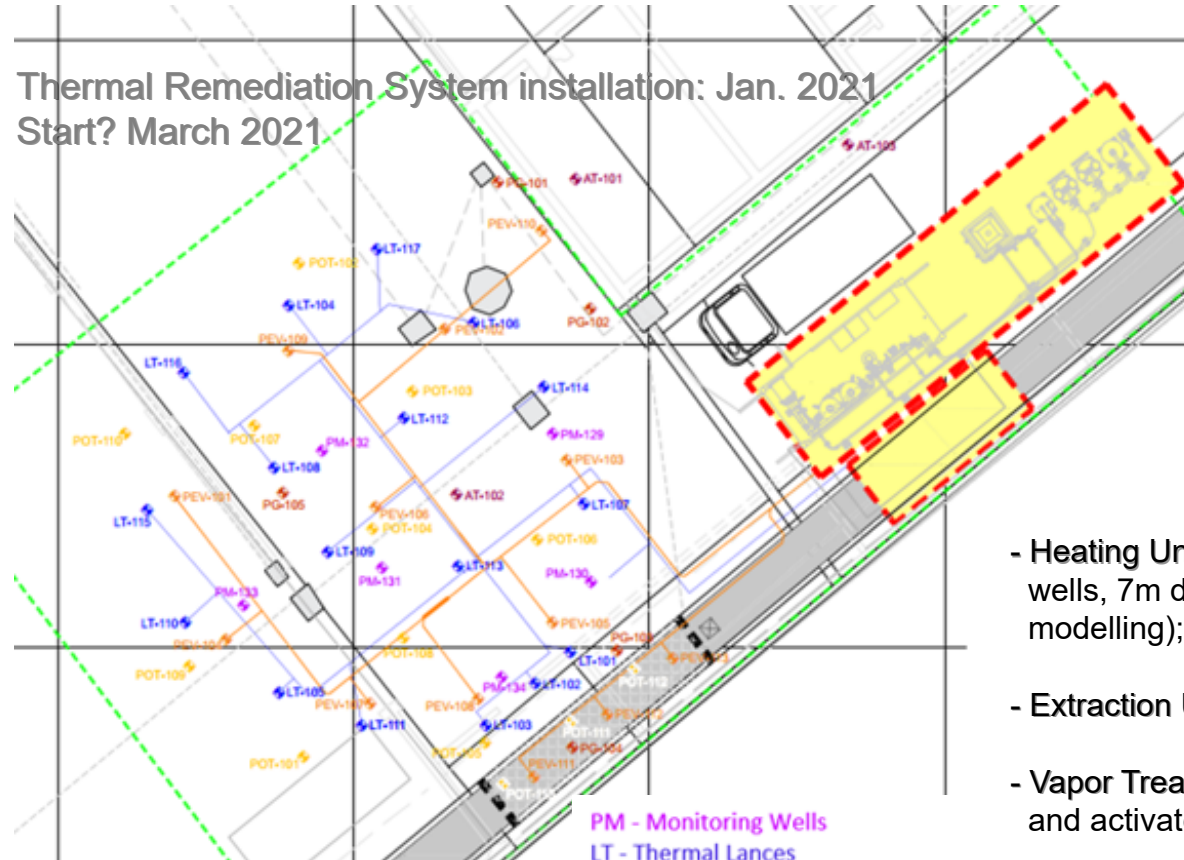
- Mass removal of VC and eliminating the risk to human health. Short term remediation.

Reactive barrier – Oxidant injection – *Preventive measure*

- Contain migrating compounds from the neighbor and reduce on-site concentrations

Thermal Remediation System (TCH)

Thermal Remediation System installation: Jan. 2021
Start? March 2021



- Heating Unit: 17 rods and 13 temperature monitoring wells, 7m depth (based on mathematical heat transfer modelling);
- Extraction Unit: 13 vapor extraction wells;
- Vapor Treatment Unit: cooling tower, heat exchanger and activated carbon adsorption columns.

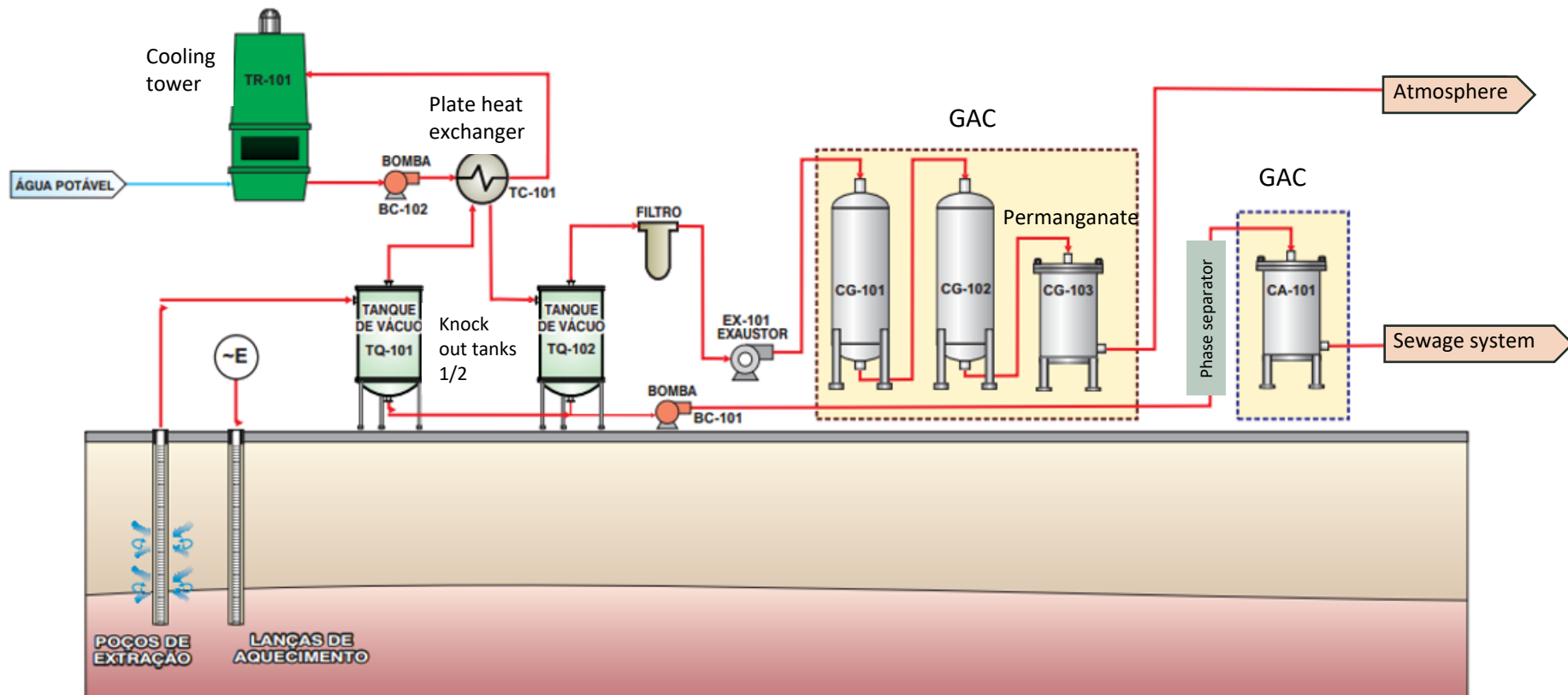


Reactive Barrier: Start Dec/21

Reactive Barrier

- 12 injection wells (PI)
- 11 new monitoring wells (PM)
- Blend: Persulfate+peroxide

Thermal Remediation System Process Flow Diagram

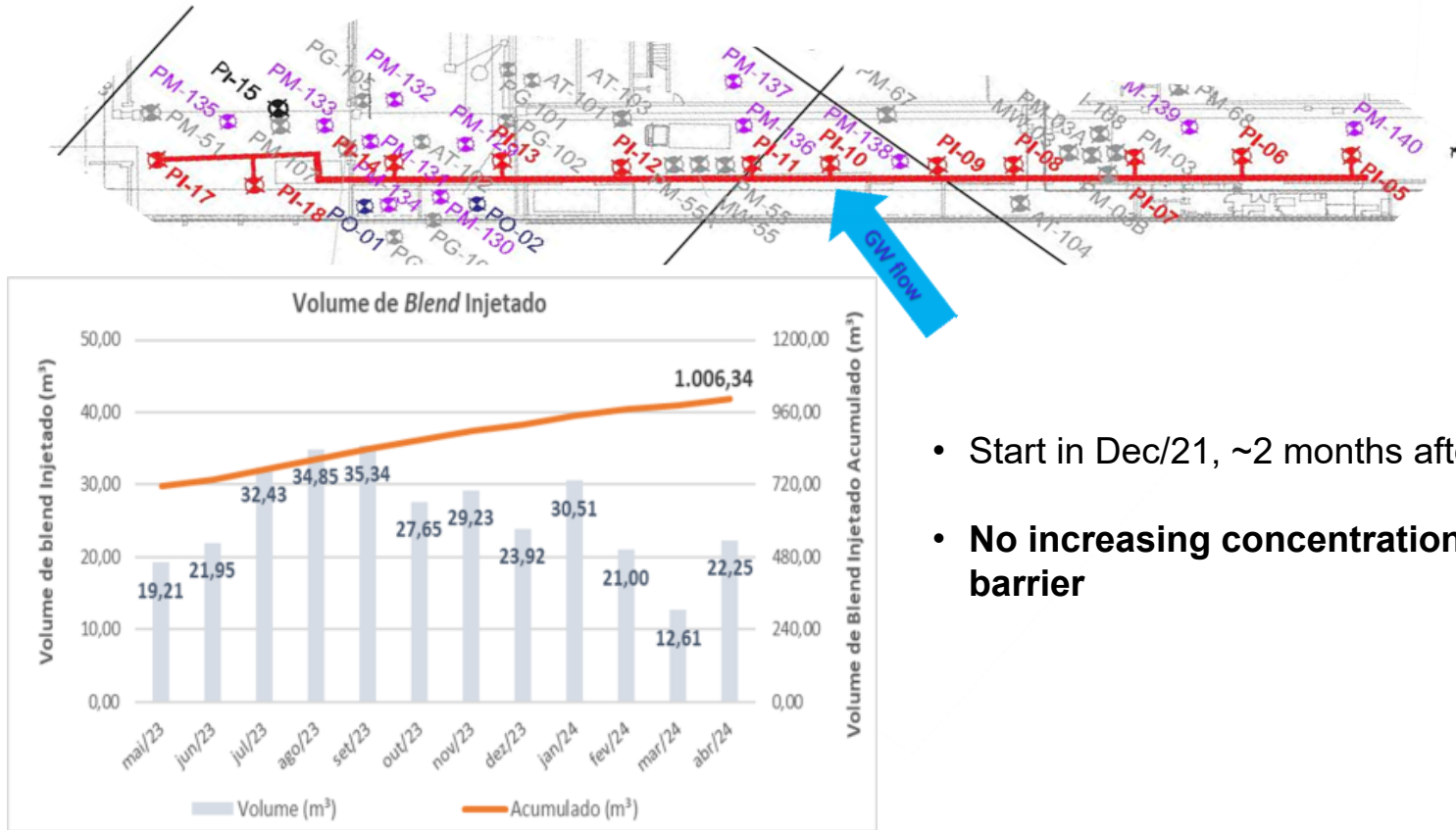


Thermal Remediation System



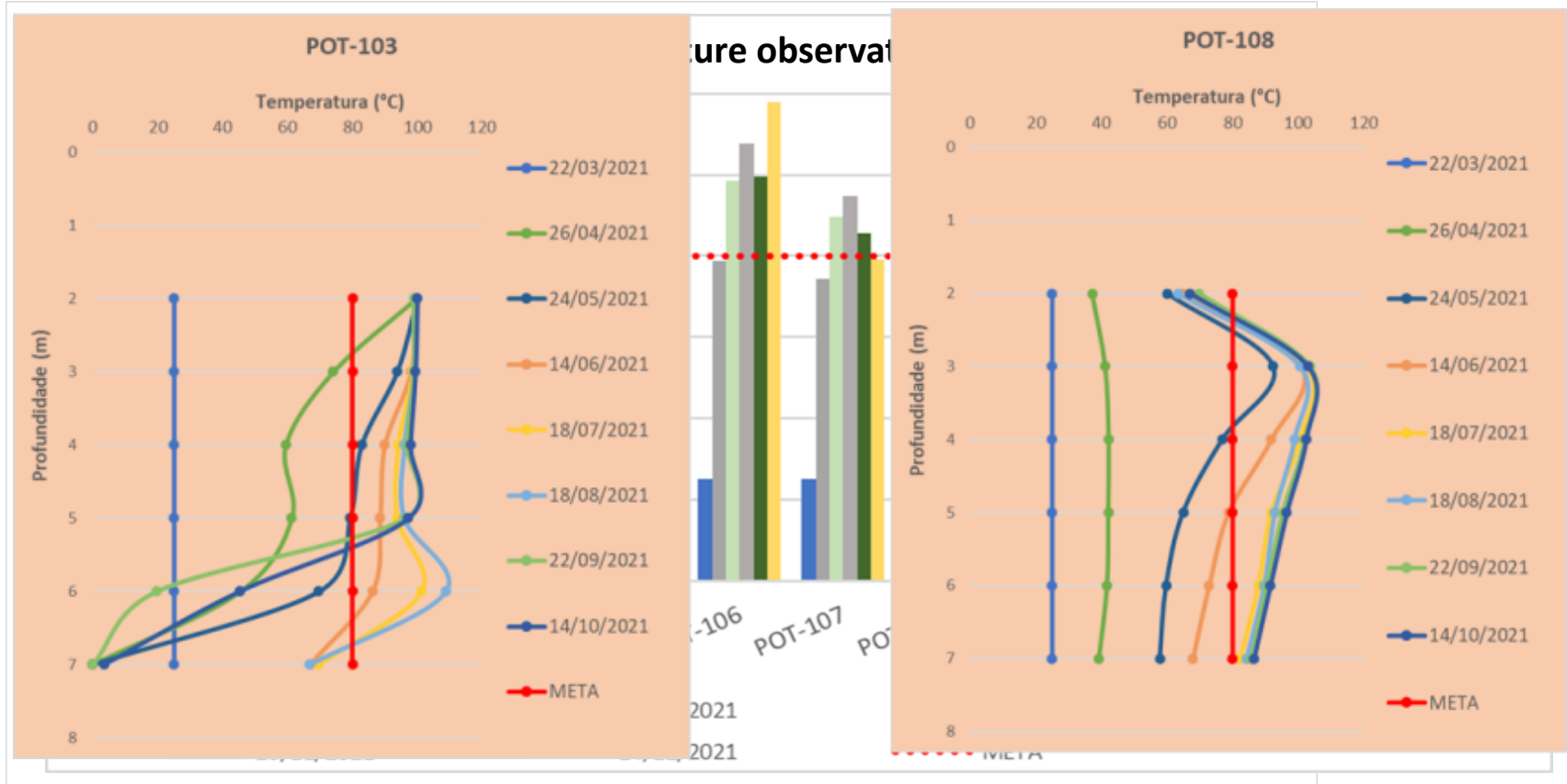
RESULTS

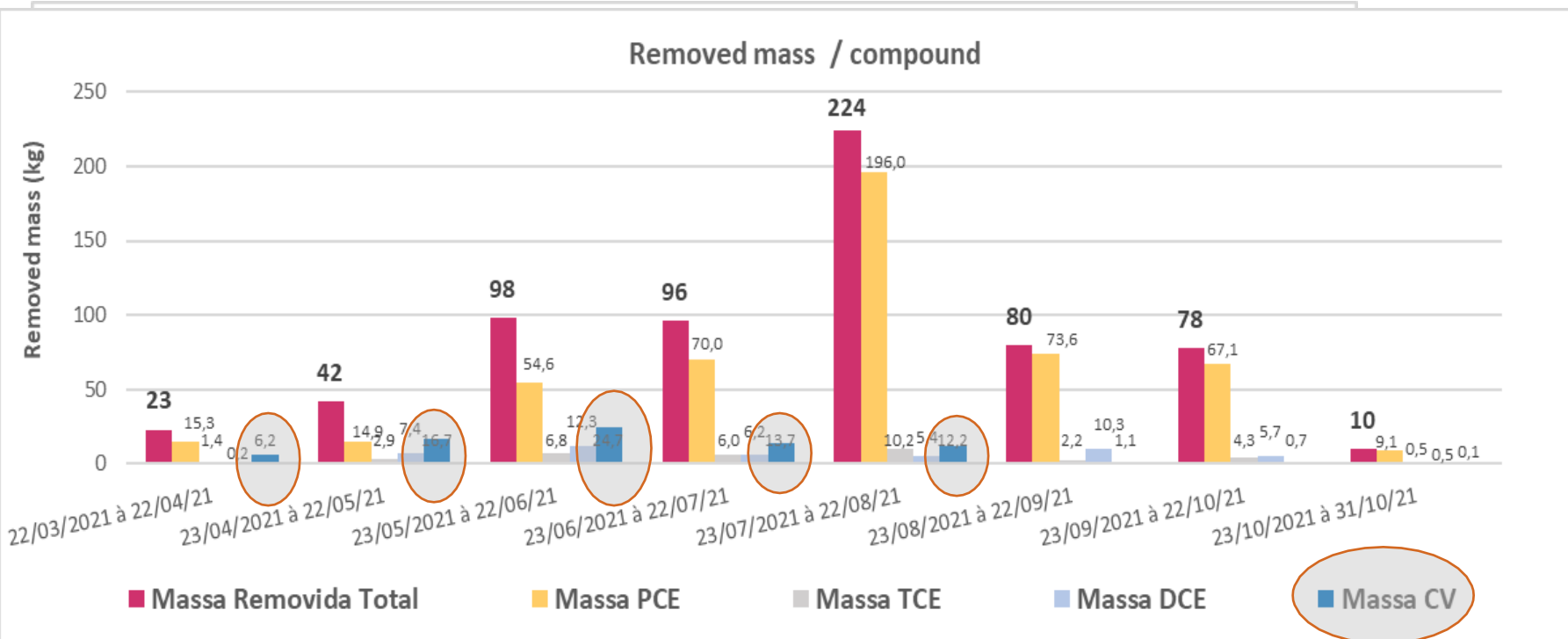
Results - Reactive Barrier



- Start in Dec/21, ~2 months after stop TCH
- **No increasing concentrations downstream the barrier**

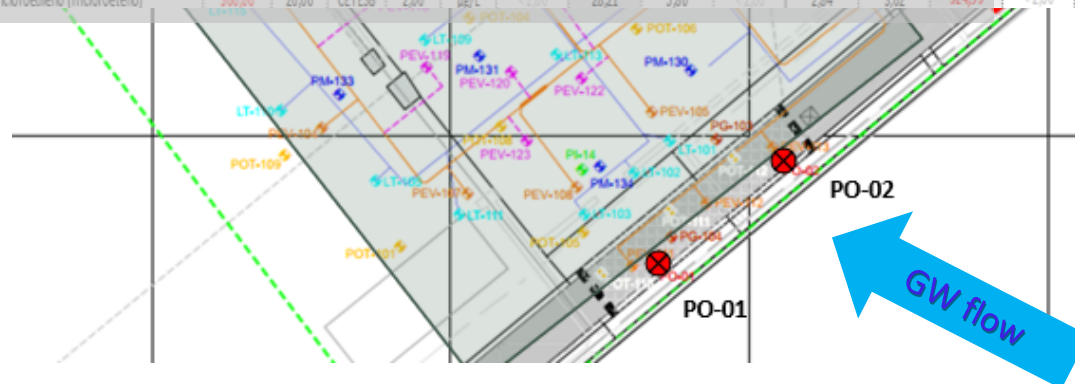
Results - TCH





Reduction in the concentrations of organochlorine compounds in the dissolved phase below the MAC and reference standards.

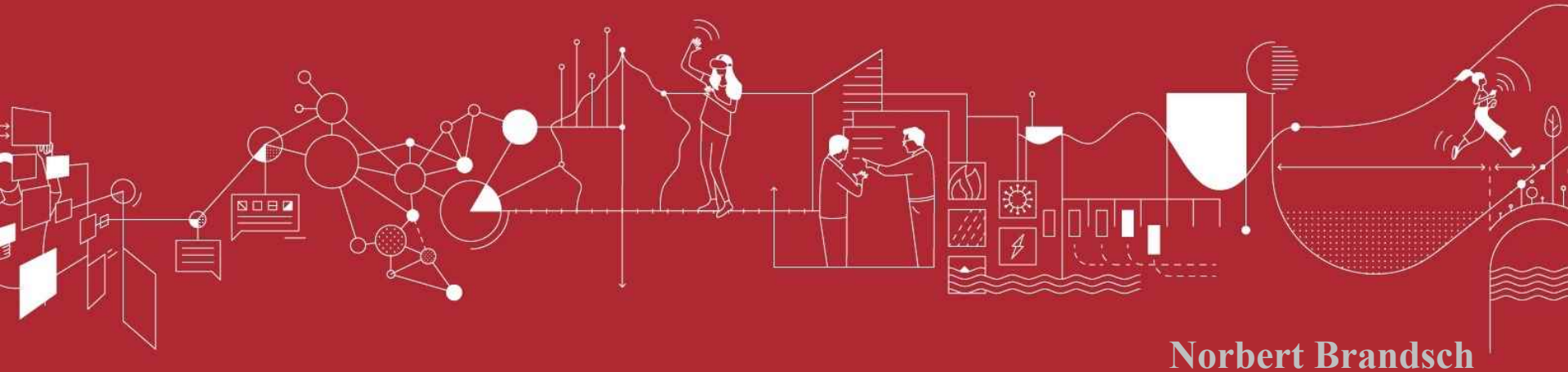
					PO-01															
PARÂMETRO	CMA	Padrão de Referência		LQ	Unidade	27/12/2021	02/02/2022	09/03/2022	30/05/2022	22/07/2022	21/09/2022	01/11/2022	05/12/2022	22/12/2022	17/01/2023	03/03/2023	07/07/2023	10/08/2023	14/11/2023	22/12/2023
cis-1,2-Dicloroeteno	-	36,00	EPA-RSL	2,00	µg/L	25.304,00	25.449,50	7.474,60	24.386,00	10.961,00	52,25	<2,00	11.907,60	34,66	119,83	<2,00	2.384,00	11.309,60	3.288,50	2.957,00
trans-1,2-Dicloroeteno	-	360,00	EPA-RSL	2,00	µg/L	38,20	30,17	9,65	15,72	13,52	<2,00	<2,00	4,21	<2,00	<2,00	<2,00	<2,00	13,65	6,43	5,22
Dicloroeteno [cis+trans-1,2-]	18.000,00	50,00	CETESB	3,00	µg/L	25.342,20	25.479,67	7.484,25	24.401,72	10.974,52	52,25	<2,00	11.907,60	34,66	119,83	<2,00	2.384,00	11.309,60	3.288,50	2.957,00
Cloreto de vinila	308,00	2,00	CETESB	2,00	µg/L	18.753,00	15.772,50	6.922,20	6.273,00	3.506,80	22,85	32,01	4.382,00	85,69	200,23	<2,00	584,36	7.449,60	734,00	10.595,00
Tetracloroetileno (Percloroetileno)	5.730,00	40,00	CETESB	2,00	µg/L	33.063,00	6.298,00	1.802,00	1.809,65	1.916,40	3.736,30	<2,00	802,00	6,34	788,10	445,59	248,78	191,35	172,73	188,48
Tricloroetileno (Tricloroeteno)	360,00	20,00	CETESB	2,00	µg/L	3.566,00	1.358,00	388,46	531,90	535,50	373,25	<2,00	155,17	2,54	58,83	97,07	94,37	46,52	51,66	85,79
					PO-02															
PARÂMETRO	CMA	Padrão de Referência		LQ	Unidade	28/12/2021	02/02/2022	02/02/2022	30/05/2022	22/07/2022	21/09/2022	01/11/2022	22/12/2022	17/01/2023	03/03/2023	07/07/2023	10/08/2023	14/11/2023	22/12/2023	
cis-1,2-Dicloroeteno	-	36,00	EPA-RSL	2,00	µg/L	134,46	4.208,40	188,10	636,00	359,73	3,60	1.600,60	117,53	99,47	<2,00	1.219,00	674,00	951,00	2.545,00	
trans-1,2-Dicloroeteno	-	360,00	EPA-RSL	2,00	µg/L	<2,00	4,71	<2,00	<2,00	2,68	<2,00	4,19	<2,00	<2,00	<2,00	2,64	5,01	3,44	2,25	
Dicloroeteno [cis+trans-1,2-]	18.000,00	50,00	CETESB	3,00	µg/L	134,46	4.208,40	188,10	636,00	362,41	3,60	1.600,60	117,53	99,47	<2,00	1.219,00	674,00	951,00	2.545,00	
Cloreto de vinila	308,00	2,00	CETESB	2,00	µg/L	53,07	1.030,10	344,33	645,30	1.787,60	40,94	2.355,40	102,75	52,58	1,38	2.080,50	1.732,70	441,10	2.969,00	
Tetracloroetileno (Percloroetileno)	5.730,00	40,00	CETESB	2,00	µg/L	<2,00	19,49	27,02	<2,00	3,06	33,46	2.313,00	<2,00	2,85	7,36	34,45	32,86	718,90	3466,00	
Tricloroetileno (Tricloroeteno)	360,00	20,00	CETESB	2,00	µg/L	<2,00	28,21	5,86	<2,00	2,84	3,62	524,95	<2,00	3,04	6,23	35,24	73,26	379,23	1.426,00	



- **Thermal Remediation (TCH):** Operation from April - Outubro/2021 → reached the target level for commercial use for VC, PCE
- **Reactive Barrier:** Start Dec/21 → no increasing concentration downstream → **but** upstream increasing concentrations (PO-01/02) → Continuing operation

- Performing baseline, but also should have been performed a High Resolution Investigation!
- Surprises happens (PCE appeared)!, Hidden sources → increase the temperature & remediation time → additional cost
- To implement the Preventive Measure (reactive barrier) was the right decision

Thanks



Norbert Brandsch