

# TECHNICAL PROSPECTUS

## Brownfields information and common remediation strategies

The common challenge faced by the POSIDON buyers' group is identifying a soil (and eventually groundwater) remediation new, life-cycle, cost-effective technology, preferred as in-situ (and eventually on-site), to be capable of decontaminate heterogeneous anthropic soils in brownfield, composed by a mixture of industrial waste (like filling soils highly polluted by Petroleum Hydrocarbons and heavy metals) and soils consisting on clays and sands, highly polluted by Petroleum hydrocarbons (TPHs) and PAHs.

The present text summarizes the information available for each site (Trieste, Bilbao, Lisbon, Vitoria-Gasteiz and Liege), and outlines the characteristics and the issues for each individual brownfield.

### TRIESTE (exEZIT)

Surface = 144Ha, Dimensions = 200x200m, Coord. UGS84 UTM 33 |X: 291964,28 |Y: 4640618,73

Site description: Trieste Port Authority's exEZIT brownfield is located in an industrial area of 144Ha south to Trieste city, in Friuli Venezia Giulia region in Italy. The site constitutes an active industrial area located in the alluvial plane of Osopo River south to Trieste City. From 1950's to 80's a clay transformation industry operated, and after 1970-80 the site functioned as clay mining, furnaces and waste disposal. Present industrial land uses.

Geological and Hydrogeological context: Anthropogenic gravels and industrial waste (4-10m thick), over marine fine to medium sediments (silts to clays) >30m thick, over the rocky flysch type substrate (marls and sands interbedded). Human modified primitive coastal line, waste and filling materials deposition for area flattening and Osopo river channeling. Superficial free type aquifer (2,5m to 4m b.g.s.). Medium to low permeability sediments (silts and clays with sandy layers interbedded). Groundwater flux directed towards Osopo river. Poor or inexistent tidal influence.

Soil and water quality, and waste characterization: Anthropogenic layers and containing water level are most affected levels. Soil main pollutants: TPHs, PAHs and Heavy metals. Water main pollutants: TPHs, PAHs, and chlorinated solvents. BTEX and TPHs soil gas detection. Soil volumes characterized as non-hazardous waste composed by blast furnace slags, ashes, C&D waste and soil mixed with hydrocarbons. Waste no-reusable on the site for fillings.

Action Plan – Brownfield development: industrial redevelopment.



## BILBAO (Zorrotzaurre)

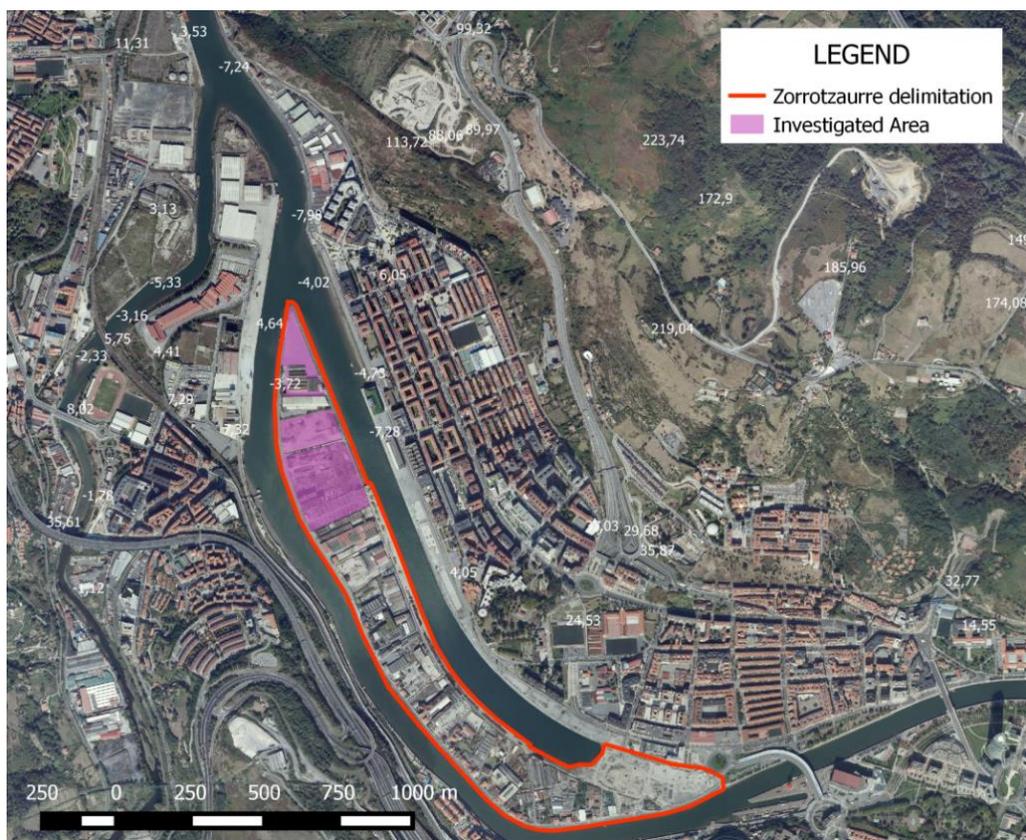
Surface = 49Ha, Dimensions =768x258m , Coord. UTM ETRS89 X:502692.383 | Y:4791606.094

**Site description:** Zorrotzaurre brownfield is located in the Basque Country region (Spain), and belongs, partly, to the Municipality of Bilbao (to be checked by Bilbao) (Bizkaia County). It is a peninsula of a 49 Ha surface and constitutes a densely industrialized area north to Bilbao. Industrial historical activities carried out in the site have been the following: steel transformation, wood processing, shipping and machine constructions, etc. since beginning of 20<sup>th</sup> century. The property is very fragmented, with more than 300 different private and public owners. Present industrial and residential land uses.

**Geological and Hydrogeological context:** Anthropogenic gravels and industrial waste (2,40m thick average), over estuarine quaternary alluvial sediments (silts and clays at top of this formation and gravels at basal levels) >18-20m thick. Grey marls as base. Free hypodermic aquifer at the Anthropogenic and upper alluvial layer levels. Medium to poor permeability soils. No exploitation of the aquifer is known. Average groundwater level = 1,10m (b.g.s). Gw. Flux direction very variable, and poor or locally no observable tidal influence.

**Soil and water quality, and waste characterization:** Anthropogenic layers and containing water level as most affected levels. Soil main pollutants: TPHs, PAHs, Heavy Metals (As, Pb). Water main pollutants: TPHs, PAHs, BTEX, and Heavy Metals (As). Hazardous and non-hazardous waste, composed mainly by blast furnace slags, and C&DW.

**Action Plan – Brownfield development:** Urban Plan designed for a mixture of industrial, residential, public and green areas.



## LISBON (Seixal)

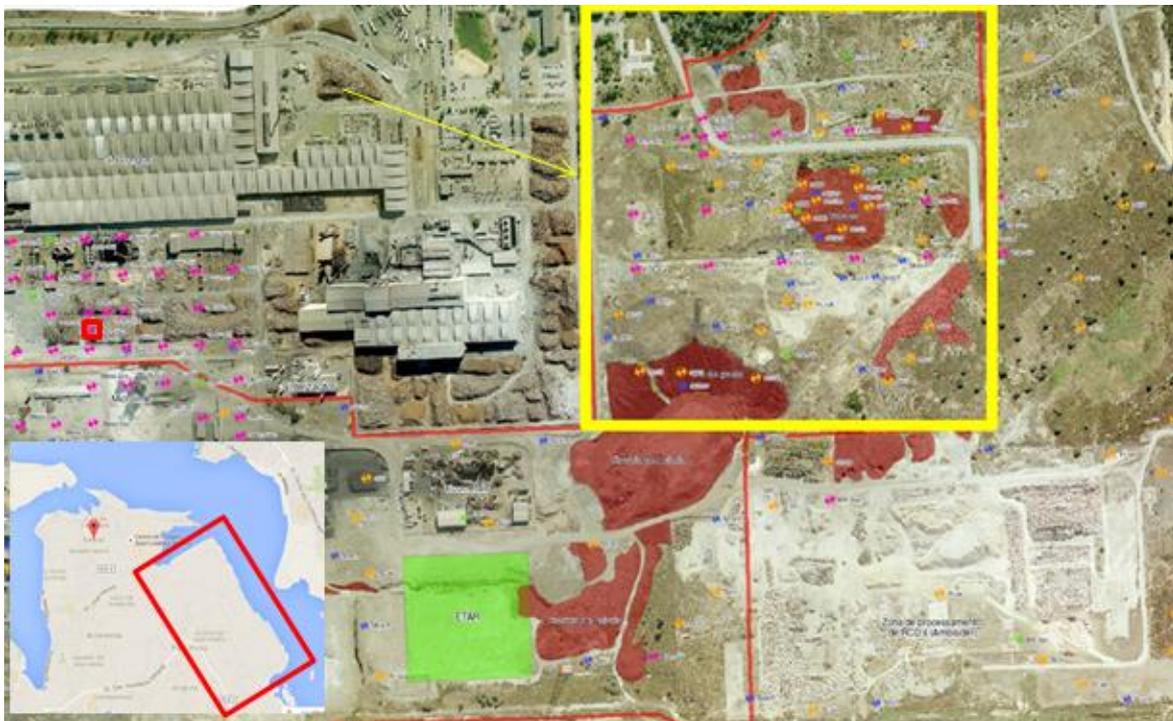
Surface = 32Ha , Dimensions =580x550m , Coord. PT-TM06/ETRS89 | X:-82423,90363 | Y:-114047,7535

Site description: Seixal brownfield is located the town of Paio Pires, Setubal, Lisbon (Portugal). The site is part of a 532 Ha former industrial complex of Siderurgia Nacional (steel-making plant). The property is composed by 7 private owners and 3 public owners. The area of interest has not a defined use at the present and a future industrial use is foresight.

Geological and Hydrogeological context: Anthropogenic gravels and industrial waste (3-5m thick), over estuarine alluvial and dunes of Quaternary and sandstones of the Pliocene (silts to clays) >60m thick. Sandstones as rocky substrate. Human modified primitive coastal line. Industrial waste (blast furnace slags, CD waste, etc.), deposition for area flattening. 3 type of aquifers: free Aquifer up to 90m thick (layer 1); Aquitard of 70m thick (layer 2); Captive Aquifer of 90m thick (layer 3). The two main aquifers (free and captive) are subjected to an intensive exploitation, mainly for public supply and industrial activities. Hypodermic free aquifer groundwater level = 2.55m (b.g.s.), gw main flux direction is towards Coina river. Poor or inexistent tidal influence on groundwater.

Soil and water quality, and waste characterization: Anthropogenic layers and containing water level as most affected levels. Soil main pollutants: PAH (in one soil sample). Water main pollutants: TPH and PAH. Waste volumes characterized as hazardous and non-hazardous waste (coal tar; coke fines; blast furnace slags and CDWs).

Action Plan – Brownfield development: future Installation of lighter industrial activities and logistic activities, attracting sustainable activities and private businesses to the site.



## VITORIA-GASTEIZ (Jundiz)

Surface = 23 Ha, Dimensions = 1.230 m x 220 m , Coord. UTM ETRS89 X: 520.281 | Y:4.742.461

Site description: Jundiz brownfield is located in the Basque Country region (Spain) and belongs to the Municipality of Vitoria-Gasteiz (Araba County ). Jundiz, although originally planned as green area, is degraded by uncontrolled fillings, dumping and abandonment. Formerly agricultural land it was used as a landfill during the 80's and 90's for dirt and excavation debris during the highway and industrial area development. In time, many heterogeneous illegal dumping has been deposited over this landfill (0,5 m average) including construction and demolition residues. Planned as a green area (public park) it remained abandoned until the last two years when some small phytoremediation projects with have been initiated (2 ha in the north part).

Geological and Hydrogeological context: anthropic landfill of dirt and gravels (2,50m thick average) over estuarine quaternary alluvial sediments (silts and clays at top of this formation and gravels at basal levels) No permanent aquifer below ground. Flux direction South to North.

Soil and water quality, and waste characterization: Soil main pollutants: TPHs, PAHs, Heavy Metals (As, Pb), and PCB. No pollution found in water. Non-hazardous waste (except for one point of sample) composed mainly by C&DW.

Action Plan – Brownfield development: restoration for green area (public park).



## LIEGE (Wallonia)

Site description: in Wallonia region there are many partially pollutes sites with similar characteristic (situated in an extended residential area for renovation), most of them owned by SPAQUE. They are considered as historical pollution resulting from disposal of waste from coal mining industries (forming the coal mining slag) and residues from iron works.

Action Plan – Brownfield development: residential according to the urban planning.



## Brownfields' characterizations

We provide below a synthetic sites 'comparative matrix which highlights the similar characteristics of the sites engaged in POSIDON project : exEZIT in Trieste (I), Zorrotzaurre in Bilbao (E), Horloz in Liege (B), Seixal in Lisbon (P) and Jundiz in Vitoria Gasteiz (E).

SITE:	exEZIT TRIESTE	Zorrotzaurre BILBAO	Horloz LIEGE	Seixal LISBON	Jundiz VITORIA
<b>Main environmental issues</b>	Petroleum hydrocarbon affectation to soils and groundwater, mainly PAHs and Heavy Hydrocarbons C>12.	Deposits of wastes (piriyte transformation ashes containing arsenic and lead, C&DW, anthropic gravels), and punctual oil spills (TPH and PAHs). Polluted soils and groundwater.	Deposit of waste from coal mining activities and from construction demolition. Soil and groundwater pollution.	Deposits of a mixture of wastes from the steel process, including coal tars. Polluted soils and groundwater.	Landfill with heterogeneous dumpings.
<b>Geology and soil profile</b>	Anthropic layer between 3-9m thick, over a natural soil composed by clays and sands interbedded of 4-10m thick. Rocky substrate formed by flysch type marls and sandstones.	Anthropic layer between 0-6 m depth over a natural soil composed by silts, and occasional clays and sands interbedded over basal gravels up to 19-22m deep. Rocky substrate formed by flysch type massive marls and occasional sandstone.	Anthropic layers: 0.00 – 2.8 m of thickness: construction and coal embankments, gravel, silty sand, sandy loam; 5 – 7.5 m of thickness: of silt fluvial; 7.5 – 14.00 m of thickness: unrefined alluvial sands; > 14m of thickness: clay, schists and stoneware	Anthropic layer up to 6m thick over a natural soil composed by 10-15m clays and sandy clays interbedded. Rocky substrate formed by sandstones.	Anthropic layer between 0,5-5 m thick, over a natural soil composed by clay marls. Rocky substrate formed by marls.
<b>Hydrogeology and hydrogeological parameters</b>	Hypodermic free aquifer at anthropic level. Gw level=2,5-4m (b.g.s.) Medium to poor permeability. No gw exploitation. Tidal effect in GW = <5cm pH=7,16; Ec=4357µs/cm;	Free aquifer at anthropic level. Gw level = 1-3m (b.g.s.). No Gw exploitation. Tidal effect is observed.	Certain formations located on the right of the zone of investigations may establish an aquifer.	Hypodermic free aquifer at anthropic level. Gw level = 2-4m (b.g.s.) Medium permeability. Gw exploitation at a deeper aquifers.	No permanent aquifer. Groundwater only present after heavy rains in some points.

<b>Main pollutants</b>	Heavy Hydrocarbons C>12, PAHs and Heavy metals (Pb, Cu, Zn)	Heavy metals (As, Pb), PAHs, TPHs.	Heavy metals, PAHs, mineral oils, cyanide, benzene	PAHs and TPHs	PAHs, TPHs, PCBs and Heavy metals (As, Pb),
<b>Main pollutants in Soils - Max. Concentration (*)</b>	<p>Heavy Hydrocarbons (1.847 mg/kg<sub>s.s.</sub> in the vadose zone)</p> <p><b>PAHs</b> – Indeno(1,2,3,-c,d)pyrene (5,3 mg/kg<sub>s.s.</sub>), benzo(b)fluoranthene (12,1 mg/kg<sub>s.s.</sub>), benzo(a)pyrene (5,03 mg/kg<sub>s.s.</sub>)</p> <p><b>TPAHs</b> (46,0mg/kg<sub>s.s.</sub>)</p> <p><b>Heavy metals:</b> Cu (820 mg/kg<sub>s.s.</sub>) Pb (1.977 mg/kg<sub>s.s.</sub>) Zn (2.951 mg/kg<sub>s.s.</sub>) 1</p>	<p><b>TPHs</b> (3.400mg/kg, occasionally 36.700 mg/kg),</p> <p><b>PAHs</b>-Benzo(a)pyrene (84 mg/kg, occas. 690 mg/kg), Benzo(b)fluoranthene (110mg/kg, occas.650 mg/kg), Dibenzo(a)anthracene (130mg/kg, occas. 950 mg/kg), Fluoranthene (350 mg/kg, occas. 2800 mg/kg), Naphtalene (420 mg/kg, occas. 6900 mg/kg)</p> <p><b>Heavy Metals:</b> Pb (6.100 mg/kg), As (2.000 mg/kg).</p>	not known yet (will be reported in the end of 2018)	<p><b>TPHs</b> (151 mg/kg), <b>PAH</b> (2.970 mg/kg), naphthalene (483); acenaphthylene (221); acenaphthene (259); fluorene (303); phenanthrene (554); anthracene (1.290); fluoranthene (344); pyrene (236); benz(a)anthracene (98,3); chrysene (75,2); benzo(b)fluoranthene (64,6); benzo(k)fluoranthene (61,7); benzo(a)pyrene (74); indeno(1.2.3.cd)pyrene (31,3); benzo(g.h.i)perylene (30,4); dibenz(a.h)anthracene (8,38)</p>	<p><b>TPHs</b> (100mg/kg), <b>PAHs</b>-Benzo(a)pyrene (0,28mg/kg), Benzo(b)fluoranthene (0,37mg/kg), Dibenzo(a,h)anthracene (0,04mg/kg), Benzo(a)anthracene (0,34mg/kg)</p> <p><b>Heavy Metals:</b> Pb (280 mg/kg), As (52 mg/kg), PCBs (1,4 mg/kg).</p>

<sup>1</sup>Following the Italian law, compound concentrations in soils must be determined as provided by *Allegato 2 al Titolo V, Parte Quarta del D.Lgs. 152/2006* (more specifically, see paragraph *Metodiche Analitiche*)

<b>Pollutants Spot</b>	Heavy hydrocarbons C>12 and PAHs spots in an area with the presence of waste in the antropic layers	Remarkable As+TPHs/PAHs having pyrite ashes clays.	“Buraco” zone, 1,2ha that compresnes a high concentration of Hydrocarbons and wastes from the Steel Mill activity and tars deposition: high conc on PAHs and long chain TPHs, and phenols, fluorides, Pb, As, Hg, and elevated TOC.	None.
<b>Waste Characterization</b>	Non-hazardous to inert.	Not available.	Hazardous and non-hazadous	Non-hazardous to inert.
<b>Infrastructures</b>	Access roads, docks, no underground pipes underneath the remediation interest area.	Access roads, docks, no underground pipes underneath the remediation interest area.	Access roads and nearby docks. No underground facilities underneath the remediation objective area.	Dirt roads, underground pipes (gas), electricity towers. Industrial environment.

In Wallonia region there are other different sites with similar characteristics.



## Functional and performance requirements

Fundamental functional and performance requirements for POSIDON buyer's group are:

	Functional Requirements	Performance Requirements
<b>Land uses</b>	Technology reduces risks linked to pollutants.	Clean-up levels will reach the local quality reference values and/or site remediation objectives that will be described in each brownfield development plan.
<b>Geological context</b>	Technology works in different geological contexts. An in-situ technology is preferred or eventually an on-site one.	Issues related to soil heterogeneity must be overcome. Soils ranging from clays to gravel, and soil mixed with industrial waste (anthropic gravels with tars, pyrite ashes) would be capable to be treated with efficiency. Operating depths up to 8m. Both vadose and water saturated soil column.
<b>Target Pollutants in SOIL</b>	Technology reduces concentration of several pollutants altogether in soils.	Remediation targets will be soils highly affected by Petroleum Hydrocarbons (PAHs and TPHs) and heavy metals. [+PCBs of possible interest]
<b>Site area-scale</b>	Technology works in medium to large scale sites.	Remediation technology will be flexible enough to adapt and operate from medium to large scale sites with a similar performance.
<b>Hydrogeological context</b>	Technology works in the presence of groundwater.	The technology will operate with groundwater at around 2-4m deep, low hydraulic gradient, medium to poor permeability soils, moderate to high salinity conditions, mainly reductive ORP conditions, moderated to elevated electrical conductivity water, neutral pH, groundwater and temperatures around 15°C. It will not depend on tidal influence.

Another functional and performance requirement of interested is:

	Functional Requirements	Performance Requirements
<b>Target Pollutants in GROUNDWATER</b>	Technology reduces concentration of several pollutants altogether in groundwater.	The technology eventually addresses the main groundwater pollutants: PAHs, TPHs and Heavy metals.



## Local regulations: threshold limit values

Field tests for the validation of the intended technologies will be conducted only on the sites of Trieste and Bilbao. As for Trieste, an industrial use of land is envisaged, for Bilbao a residential one.

As a mere example, threshold limit values for contaminants of possible interest are shown below, in relation to the specific intended land use and according to the various local regulations.

Information about Wallonia's threshold limit value are inserted as a site from Spaque should be considered as potential third site for field testing.

Threshold Limit Values: (mg/k ppm)	for residential use in Italy (I)	for industrial use in Italy (I)	for residential use in Basque Country (E)	for residential use in Wallonia (B)
Arsenic	20	50	30	40
Lead	100	1000	150	200
Copper	120	600	>10.000	110
Zinc	150	1500	>10.000	230
TPH (heavy C>12)	50	750	50	40 (C>12-16)
pyrene	5	50	60	3.6
benzo (a) anthracene	0.5	10	2	9.5
chrysene	5	50	100	9.7
benzo (b) fluoranthene	0.5	10	2	0.3
benzo (k) fluoranthene	0.5	10	20	1.3
benzo (a) pyrene	0.1	10	0,2	0.5
indeno (1,2,3-c, d) pyrene	0.1	5	3	0.2
dibenzo (a, h) anthracene	0.1	10	0,3	0.6

### INFO

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