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Risk-Based Assessment of Soil and Groundwater Quality for BAPCO Refinery and Marketing Operating Facilities

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Presentation Outline

- Bapco in Brief
- Overview of Soil & Groundwater Contamination
- Soil & Groundwater Site Investigations:
 - Bapco Refinery, Sitra Tank Farm, Marketing Terminal & Sitra Wharf
 - Bapco Local Marketing Service Stations (LMSS)
- Conclusions & Recommendations



Bapco in Brief

- Bapco, wholly owned by the Government of Bahrain, is engaged in the Oil & Gas industry including refining, distribution of petroleum products and natural gas, sales and exports of crude oil and refined products.
- The Company owns a 260,000 BPD refinery, storage facilities for more than 14 million barrels, a marketing terminal, and a marine terminal for its petroleum products. 95% of refined products are exported.
- July 1936: Bahrain Refinery with a capacity of 10,000 BPD commissioned. The first unit is still running.
- Early 1970's: Establishment of Bapco Environmental Affairs and Environmental Committees.



Bapco in Brief

- 1997: Implementation of an Environmental Management System (EMS) by re-establishing EHS Policy & Environmental guidelines.
- 1999: New Bapco is formed (Bapco & Banoco).
- 2000: Agreement of Bapco Environmental Compliance Plan with Supreme Council for Environment (SCE).
- 2002: Launch of new Bapco Strategic Direction.
- 2007: Start-up of Ultra Low Sulphur Diesel Complex (LSDP).
- 2009: Bapco achieves internationally recognized Environmental Management System (ISO14001) Certification.



1949 View of Refinery
from South



2009 View of Refinery
from South

ENVIRONMENT, HEALTH AND SAFETY (EHS) POLICY



سياسة البيئة والصحة والسلامة

Bapco, an integrated oil & gas company, is committed to the protection of the environment and to the prevention of ill health and injuries to its employees, contractors, customers, the surrounding community and the general public.

Bapco believes that Environment, Health and Safety (EHS) are integral parts of its business and culture and is committed to achieving continual improvement in its EHS performance and to ensuring full compliance with the laws and regulations of the Kingdom of Bahrain. In the absence of relevant local rules and regulations, internationally accepted standards will be considered as appropriate to the local conditions. Bapco shall pursue the application of a caring culture and through sound EHS management systems and operating practices, prevent any risk or harm to personnel or the environment.

The primary responsibility for communicating and implementing this policy rests with Bapco Management. Accordingly, Bapco shall provide sufficient resources and shall encourage the involvement of all employees and contractors in implementing this policy. In addition, Bapco shall provide EHS awareness and training programmes to enable its Management, employees and contractors to fulfill their EHS responsibilities both within and outside of Bapco.

In pursuit of the objectives of this EHS policy, Bapco shall develop specific guidelines, standards and clearly defined procedures which shall be periodically reviewed. Effective communication channels shall be maintained with the Government of the Kingdom of Bahrain and other stakeholders including the general public.

Date July 22, 2014

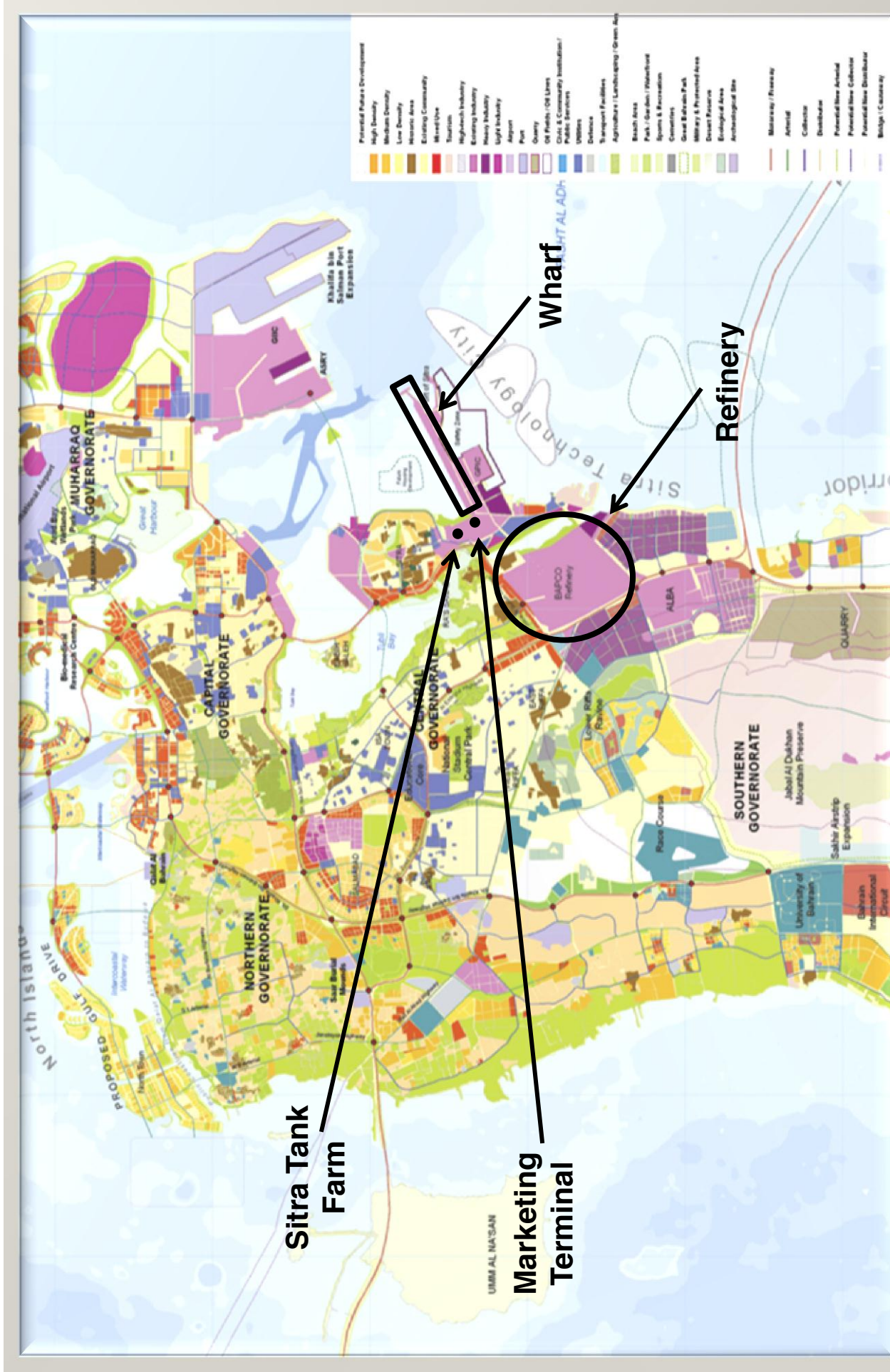
Dr. Peter Bartlett
Chief Executive

تلتزم شركة نفط البحرين (بابكو)، كشركة متكاملة في مجال صناعة النفط والغاز، التزاماً مطلقاً بحماية البيئة ومكافحة الأمراض والإصابات المهنية التي قد تقع لموظفي الشركة ومقاوليها وزبائنها والمجتمع بشكل عام.

وتؤمن شركة بابكو بأن المحافظة على البيئة والصحة والسلامة جزء لا يتجزأ من فلسفتها وأنشطتها وثقافتها المؤسسية، كما تلتزم الشركة بتحقيق التحسين المستمر في أداء البيئة والصحة والسلامة وضمان التأكد من توافرها التام مع القوانين والشرائح التي تصدرها حكومة مملكة البحرين. وإلى جانب الأنظمة والتشريعات المحلية، تحرص الشركة على الأخذ بعين الاعتبار الأنظمة المعتمدة دولياً في هذا المجال بما يتناسب مع الظروف المحلية، كما تولي الشركة جل الاهتمام بتطبيق ثقافة طموحة في منهجية العناية من خلال الاستعانة بأفضل النظم الإدارية ذات الصلة بجوانب البيئة والصحة والسلامة، فضلاً عن الالتزام بتطبيق أفضل الممارسات التشغيلية في هذا المضمار بغية درء المخاطر والأضرار التي قد تلحق بالأفراد أو البيئة.

إن المسؤولية الجوهرية في توصيل هذه السياسة وضمان تنفيذها تقع بشكل أساسي على عاتق إدارة بابكو. ومن هذا المنطلق ينعين على الشركة توفير الموارد الكافية وحث جميع الموظفين والقبولين على المشاركة الفعالة في تنفيذ هذه السياسة. وبالإضافة إلى ذلك، ستطرح الشركة برامج التوعية والتدريب التي تتيج للإدارة والموظفين والقبولين الاضطلاع بواجباتهم ومسؤولياتهم من أجل الوفاء بمتطلبات البيئة والصحة والسلامة داخل الشركة وخارجها.

وفي نطاق تنفيذ أهداف هذه السياسة، تقوم بابكو بتطوير إرشادات ومعايير محددة ويوضع إجراءات واضحة بحيث يتم مراعاتها بشكل دوري، وتعمل أيضاً على المحافظة على قنوات الاتصال الفعالة وتعزيز التنسيق القائم بينها وبين الجهات المختصة في حكومة مملكة البحرين وغيرها من الأطراف ذات الصلة بما في ذلك عامة الجمهور.

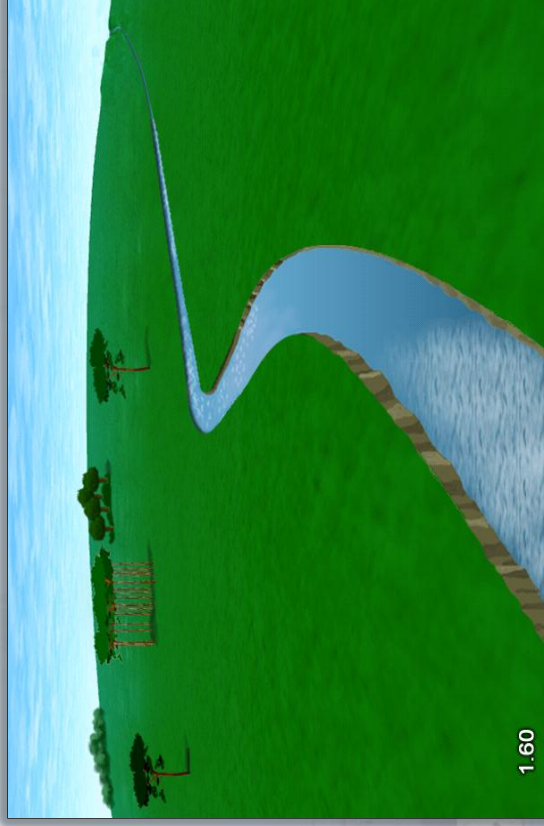


Location Plan of Refinery, Sitra Tank Farm and Sitra Wharf

We Care - Incident & Injury Free



How Soil & Groundwater Contamination can happen!



Groundwater

Groundwater

We Care - Incident & Injury Free



Bapco Refinery, Sitra Tank Farm, Marketing Terminal and Sitra Wharf

Background on Phase 1 Soil & Groundwater Investigation

- Phase 1 Site Investigation was completed in 2005.
- The purpose was to determine the extent and level of soil and groundwater contamination and to determine the potential impacts on known receptors by developing a Conceptual Site Model (CSM).
- Bapco adopted a risk based approach in order to devise an effective strategy to effectively mitigate the potential risks to human health and environment presented by the contaminated sites.



Bapco Refinery, Sitra Tank Farm, Marketing Terminal and Sitra Wharf

Background on Phase 1 Soil & Groundwater Investigation

- Phase 1 Investigation primarily included a desk study and detailed review of the historical information to identify the potentially contaminated areas and develop the CSM. Qualitative risk assessment was then conducted.
- The study recommended that an intrusive Phase 2 site investigation should be undertaken based on the findings of the desk study and potential sources identified.

Conceptual Site Model (CSM)

- Concept of Pollutant Linkage: International Best Practice
- Source-Pathway-Receptor form a Conceptual Site Model

Source



Hazard e.g. oil
filled tank,
storage areas for
chemicals

Pathway



E.g. groundwater,
inhalation,
drainage

Receptor



E.g. marine
environment,
human health



Bapco Refinery, Sitra Tank Farm, Marketing Terminal and Sitra Wharf

Background on Phase 2 Soil & Groundwater Investigation

- Phase 2 Site Investigation was completed in 2008.
- The objectives were to determine the type and level of contaminants present in the potentially contaminated areas and to carry out a quantitative risk assessment of the contamination.
- The study involved construction of over 20 boreholes and 40 window samples. Over 200 soil and groundwater samples were analyzed for heavy metals and hydrocarbons, and risk assessments were conducted.





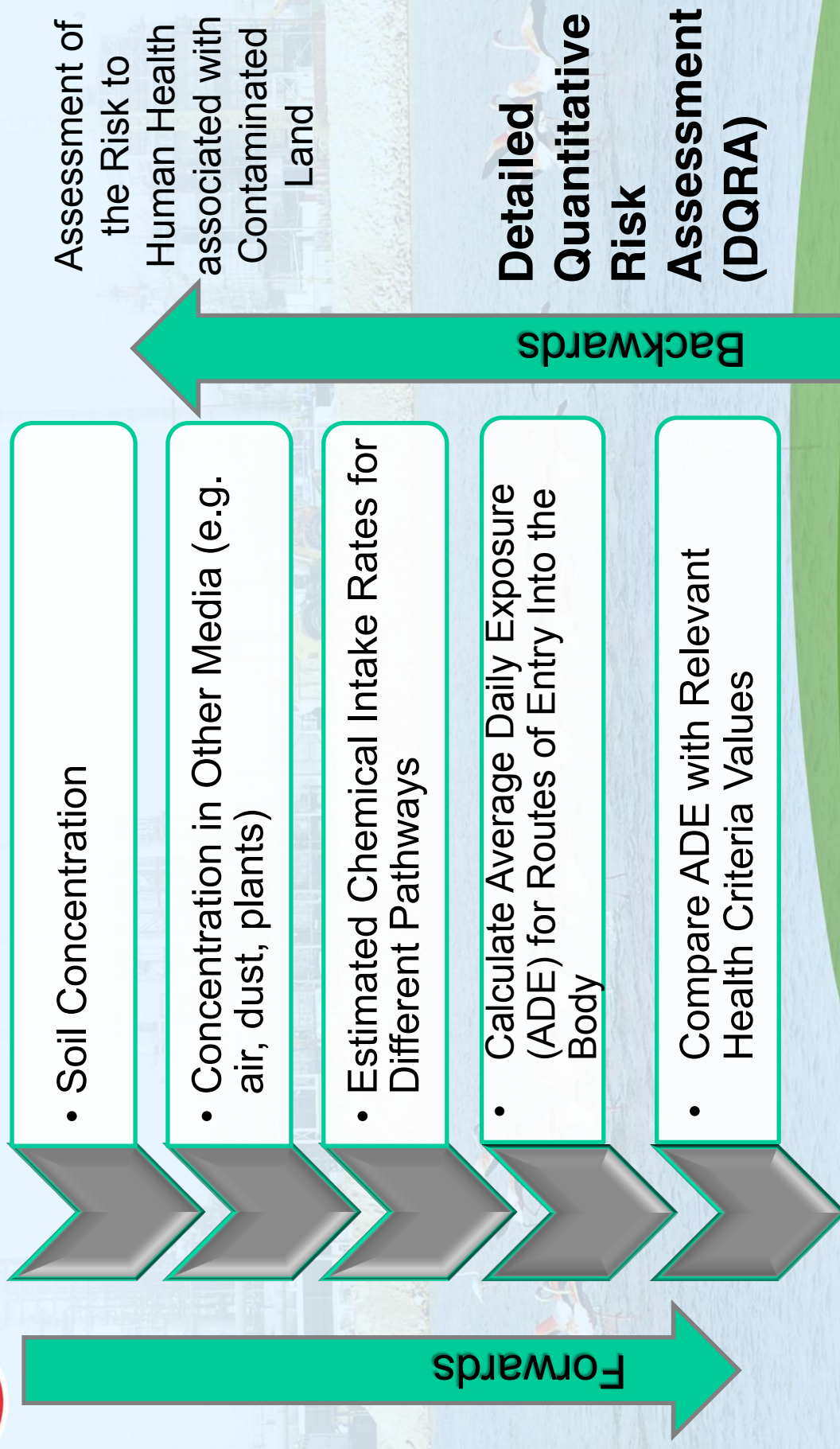
Bapco Refinery, Sitra Tank Farm, Marketing Terminal and Sitra Wharf

Supplementary Phase 3 Soil & Groundwater Investigation

- The key objectives were to:
 - Further delineate the areas that pose a high risk and are likely to require remediation.
 - Quantify soil and groundwater contamination.
 - Undertake additional Detailed Quantitative Risk Assessment (DQRA).
- A Remedial Action Plan (RAP) was proposed for each targeted contaminated site including a detailed remediation clean-up targets, remedial options and costing appraisal, and remediation design.



Bapco Refinery, Sitra Tank Farm, Marketing Terminal and Sitra Wharf





Bapco Refinery, Sitra Tank Farm, Marketing Terminal and Sitra Wharf

Supplementary Phase 3 Soil & Groundwater Investigation

- Scope Areas of Phase 3 Site Investigation Study (High & Medium Risk Areas):
 - Eastern Refinery Disposal Areas
 - Refinery Skim Ponds & oily water separators
 - Refinery Tank Farm & Process Area (Aquifer A)
 - Refinery Desalination Plant 5
 - Refinery Tank Farm and Hazardous Waste Management Facility Areas (Aquifer B)
 - Refinery Low Lift Pump House
 - Refinery Ground Gas
 - Sitra Tank Farm and Marketing Terminal
 - Sitra Causeway Gate Valve
 - Sitra Wharf Red Dye Manifold



Bapco Refinery, Sitra Tank Farm, Marketing Terminal and Sitra Wharf

Supplementary Phase 3 Study: Site Investigation Works

- Field works undertaken between April 2013 and March 2014
- Refinery: Total of 33 boreholes drilled to depths ranging from 2.3 - 9.35 m bgl (below ground level).
- Sitra: Total of 23 boreholes drilled to depths ranging from 2.3 - 8.0 m bgl.
- 50 mm (HDPE) diameter groundwater monitoring wells installed in all boreholes.
- Ground gas monitoring of selected well installations.
- Groundwater levels and LNAPL (Light Non-Aqueous Phase Liquid) thicknesses were measured.
- Soil samples for analysis selected based on olfactory and visual evidence of contamination. Selected soil samples were subject to leachate testing.



Bapco Refinery, Sitra Tank Farm, Marketing Terminal and Sitra Wharf

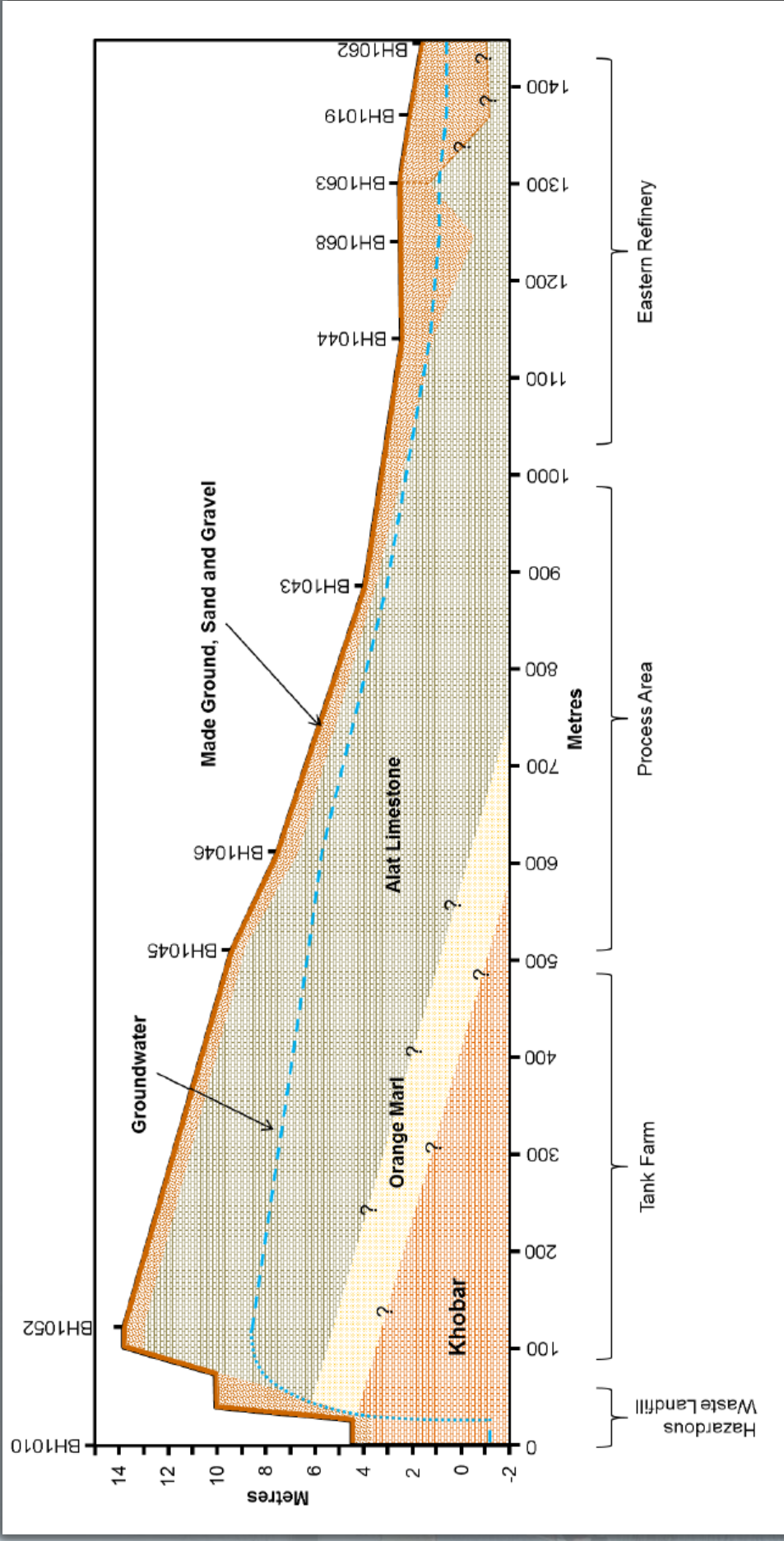
Supplementary Phase 3 Study: Key Findings

- Soil contamination levels are relatively low in comparison to the GAC values for protection of human health.
- The principal contaminants in soil were: Asbestos, Lead & 1,2,4 Trimethylbenzene (TMB).
- Leachate and groundwater show much higher frequency of contaminants exceeding their respective GACs (Heavy metals, PAHs, TPH fractions including LNAPL & BTEX)
- Lead was not a significant contaminant in groundwater despite the presence of high concentrations in some soil and leachate samples.
- Groundwater at Sitra site is grossly contaminated, principally with a middle distillate hydrocarbon as a floating layer (LNAPL).
- Soil gas contained elevated concentrations of gases and petrol vapours.





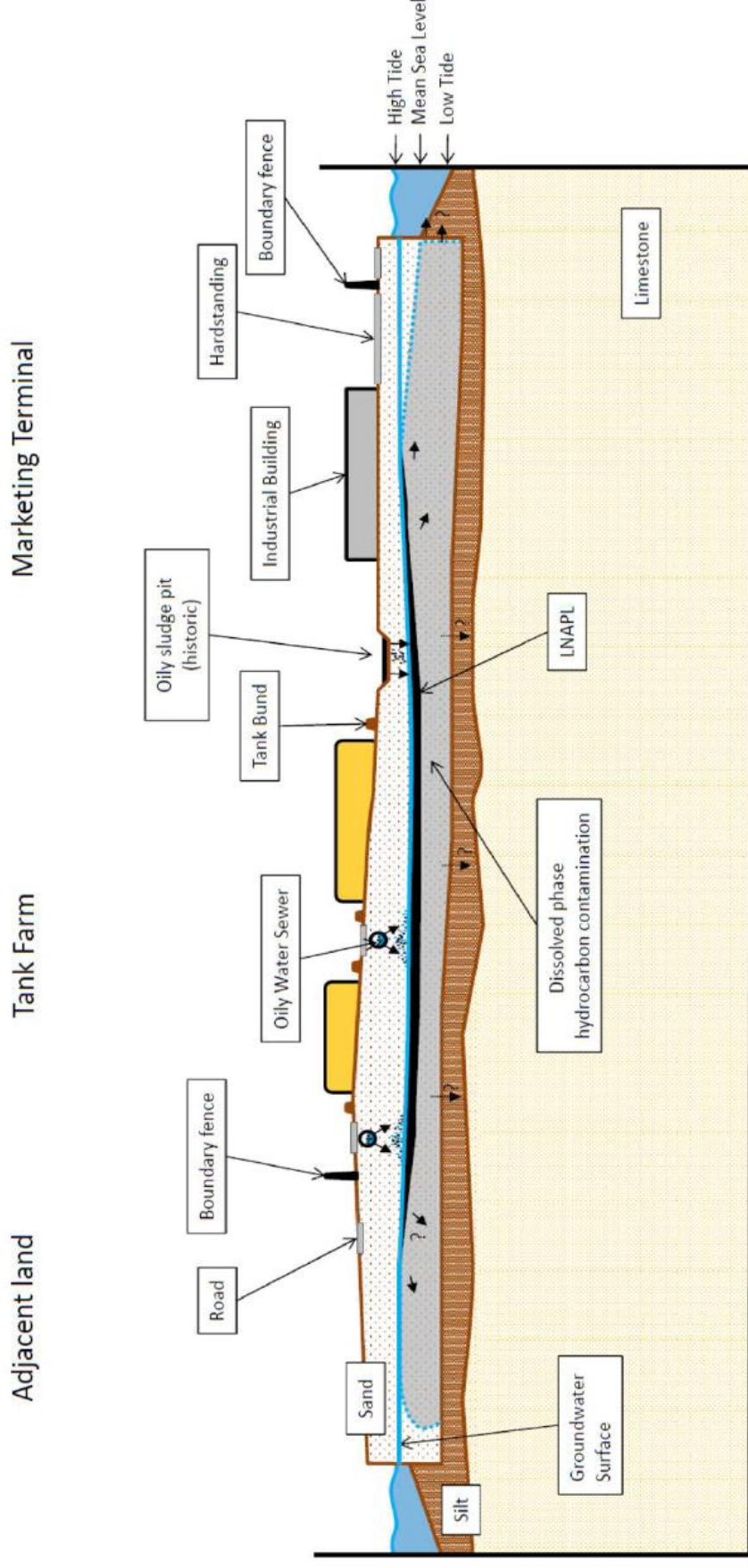
Bapco Refinery, Sitra Tank Farm, Marketing Terminal and Sitra Wharf



Refinery Cross Section - Geological & Hydrogeological Conceptual Site Model



Bapco Refinery, Sitra Tank Farm, Marketing Terminal and Sitra Wharf



Sitra Tank Farm & Marketing Terminal - Hydrogeological Conceptual Site Model

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Bapco Local Marketing Service Stations (LMSS)

- Bapco also undertook Phase 1 & 2 Soil and Groundwater Site Investigations for LMSS.



Bapco
currently
operates 16
LMSS in
Bahrain



Bapco Local Marketing Service Stations (LMSS)

Phase 1 LMSS Soil & Groundwater Assessment

- Phase 1 Site Assessment was completed in 2010.
- Assessment primarily included a desk study and detailed review of the historical information to identify potentially contaminated areas within the mentioned scope areas.
- A site walkover survey was conducted for all 16 Bapco owned service stations.
- Comprehensive soil and groundwater investigation questionnaire and checklists were developed.
- Surrounding nearby receptors were identified to create an environmental risk profile based on the source-pathway-receptor linkages, and a preliminary risk assessment was conducted.



Bapco Local Marketing Service Stations (LMSS)

Phase 1 Assessment: Key Findings

- Contamination may exist within the subsurface soil and groundwater of the surveyed LMSSs.

Potential Source	Relevant Chemicals
Commercial use of the site for the storage and retail distribution of gasoline, diesel and kerosene	• Benzene, Toluene, Ethyl benzene, Xylene (BTEX) • Volatile Petroleum Hydrocarbons (VPH) • Extractable Petroleum Hydrocarbons (EPH) • Waste oils
Surrounding land uses such as car care centre	• Benzene, Toluene, Ethyl benzene, Xylene (BTEX) • Volatile Petroleum Hydrocarbons (VPH) • Extractable Petroleum Hydrocarbons (EPH) • Volatile Organic Compounds (VOCs)
Surrounding land uses such as car wash facility	• Hydrocarbons • Wastewater • Detergents



Bapco Local Marketing Service Stations (LMSS)

Phase 2 LMSS Soil & Groundwater Assessment

- Phase 2 Site Assessment was completed in 2013.
- The Objective was to further assess soil and groundwater conditions in order to see if there are any unacceptable risks to human health or the environment related to Bapco's operations:
 - Identify LMSS sites most at risk of gross pollution.
 - Perform intrusive investigations to assess actual contamination levels.
 - Determine suitable remediation methods and costs.





Bapco Local Marketing Service Stations (LMSS)

Phase 2 LMSS Soil & Groundwater Assessment

- Site Assessment also followed a risk-based approach.
- The LMSSs differ in their age and environmental sensitivity.
- A Risk Ranking Model (RRM) was developed for 9 service stations.
- The RRM took into consideration the parameters below:
 1. Contamination sources
 2. Groundwater sensitivity
 3. Land use sensitivity
- Each parameter was assessed according to a specific scoring criteria, and an overall risk score was obtained.



Bapco Local Marketing Service Stations (LMSS)

Phase 2 Assessment: Key Findings

- No significant contamination found in four service stations.
- Slight groundwater contamination with petrol and diesel in one service station.
- Heavy groundwater contamination with diesel and slight groundwater contamination with kerosene in one service station.
- Heavy groundwater contamination with petrol and slight groundwater contamination with diesel in one service station.
- Slight soil contamination with petrol and slight groundwater contamination with petrol in one service station.
- Slight soil and groundwater contamination in one service station.
- Where soil and groundwater contamination identified in excess of GAC values, site-specific groundwater contamination risk modelling was carried out using the UK Environment Agency Remedial Targets Methodology.



Conclusions & Recommendations

Refinery

- Following contaminants were identified at concentrations where a significant environmental risk exists:
 - LNAPL in the Eastern Refinery Area in the vicinity of the API oily water separators.
 - Asbestos, associated with made ground and construction & excavation waste stockpiles located across the eastern part of the site.

Conclusions & Recommendations

Site Location	Sources – Pathways - Receptors	Environmental Risk
A) Refinery Soil Gas	Source: Soil Gas Pathway: Vapour migration through shallow soils Receptors: Buildings and Building Occupants	Not Significant Detailed quantitative risk assessment modeling identified that the concentrations of methane and VOCs present in soil and groundwater would not lead to the accumulation of toxic or explosive concentrations in buildings.
B) Eastern Refinery Skim Pond and Oil-Water Separator Areas	Source: PAH, Volatile Organic Compounds, Heavy Metals Pathway: Inhalation, dermal exposure Receptor: Human health	Not Significant Modelling of human health exposure scenarios applicable to the site demonstrate that concentration of these contaminants in soil would not have a significant impact on human health.
	Source: Hydrocarbons and heavy metals Pathway: Groundwater migration Receptor: Marine environment	Heavy metals - Not Significant Assessment of groundwater volumetric flows indicates that heavy metals would seep into the cooling water discharge but that dilution would reduce concentrations to an acceptable level and there would be no significant impact on the marine environment. Hydrocarbons – Significant There is LNAPL on groundwater in the vicinity of Bapco oil separators. The contamination is thought to be on-going due to spills during the unloading of tankers containing oily water.



Conclusions & Recommendations

Sitra Tank Farm and Marketing Terminal

- The DQRA demonstrated that there is no soil contamination which requires remediation work with respect to the protection of human health.
- Essentially the pathway for the migration of contamination in groundwater to the sea and to surrounding land is relatively weak, but the magnitude of the contamination present is extremely high.
- Hence, in qualitative terms, a significant risk still remains and therefore remediation is required.

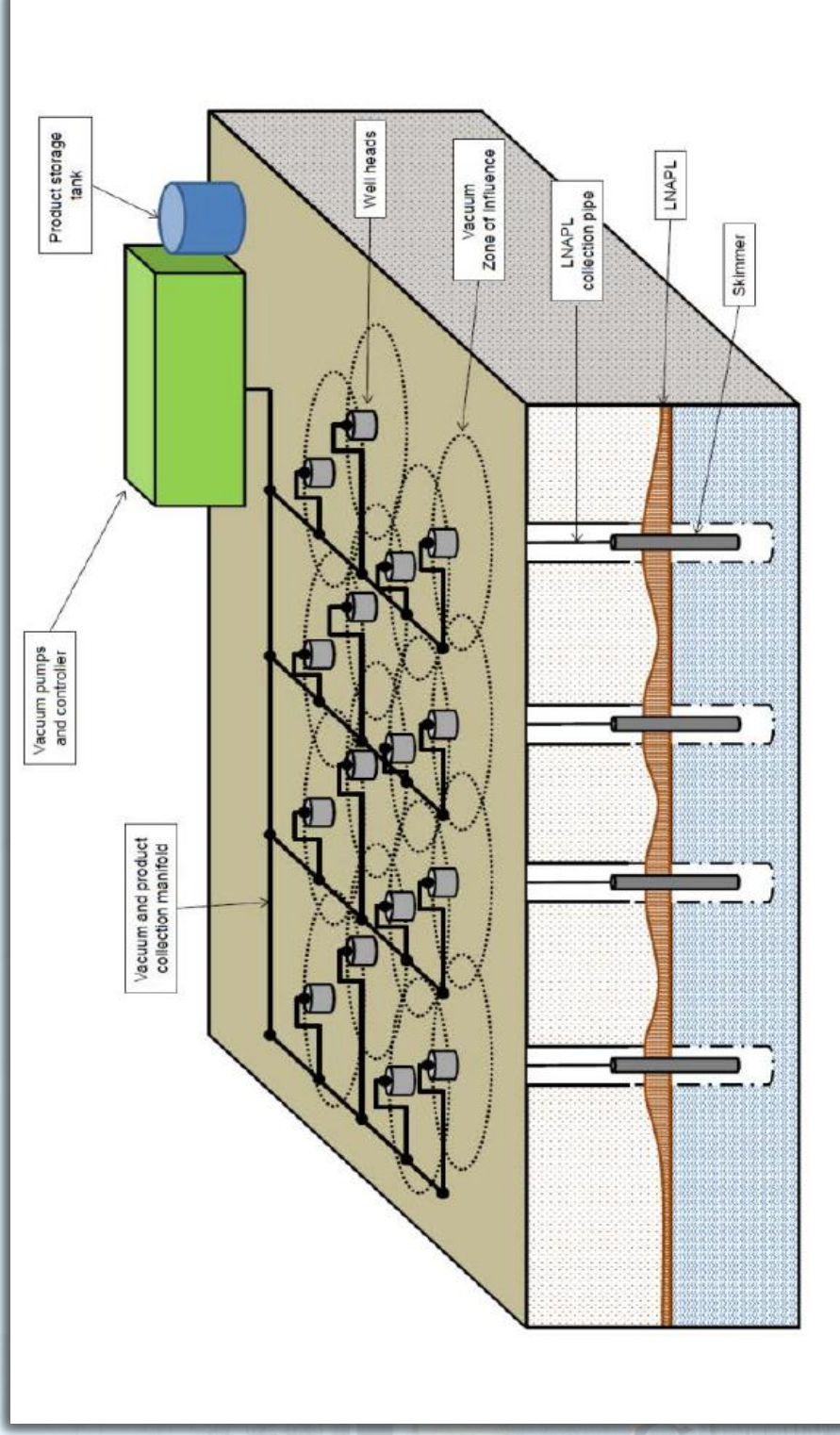


Conclusions & Recommendations

Remediation Action Plan (RAP)

- Preventative maintenance to stop any on-going soil and groundwater contamination.
- Reduction of the total quantity of LNAPL present (source reduction).
- Monitoring / groundwater polishing.
- The preferred remedial option is Vacuum Enhanced Skimming (VES) where small skimmers are deployed down an array of groundwater wells to skim off the LNAPL from the groundwater surface.
- The remediation program is expected to last decades and would require a sustained annual commitment and budget.
- Management of asbestos-contaminated construction waste.
- Establish groundwater monitoring program.

Conclusions & Recommendations



Remediation Options LNAPL- Schematic Layout for a Vacuum Enhanced Skimming (VES) Remediation System



Remediation Options LNAPL – Potential Areas for Vacuum Enhanced Skimming

Proposed for Sitra Tank Farm & Marketing Terminal



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Conclusions & Recommendations

Local Marketing Service Stations (LMSS)

- Impact to soil and groundwater is present at some LMSS areas.
- Preliminary risk assessment concluded that risks related to potential contaminated soil and groundwater are associated with the risks for vertical migration of contaminants.
- Modelling work carried out in the Phase 2 study provided a framework for logically selecting LMSS for site investigation.
- Two of the nine investigated LMSS were recommended for further site investigation and remediation studies.
- General recommendations made for LMSS design, which when employed together should reduce the impact of spills and greatly reduce the possibility of significant undetected leaks of fuels to soil and groundwater.



Conclusions & Recommendations

Local Marketing Service Stations (LMSS)

- Long term groundwater quality monitoring using the installed wells at the site perimeter recommended.
- New Bapco service stations are now being built with state-of-the-art systems:
 - Gasoline leak detection & prevention to identify releases from USTs.
 - Concrete foundations and/or containment vaults installations to prevent hydrocarbon releases to the surrounding subsurface/soil.



thank You ...

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