INTEGRATED REMEDIATION TECHNIQUES IN HANDLING COMPLEX CRUDE OIL IMPACTED SITE AT EJAMA EBUBU – NIGER DELTA, NIGERIA.

Presented at the 21st International Petroleum Environmental Conference in Houston, TX - October 14-16, 2014

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INTRODUCTION

- The Ejama-Ebubu spill site of about 15.6 hectares located in Ogoni land Rivers State, Nigeria,
- The spill site was impacted in 1969, during the Nigeria civil war due to an explosive damage to the Trans Niger Pipeline (TNP) at Ejamah.
- The incident was accompanied by fire.
- Efforts by The Shell Petroleum Development Company of Nigeria Ltd (SPDC) to clean up the sites was denied by host Community until in 2006.
- SPDC purchased 9 ha of land from community to enable access.

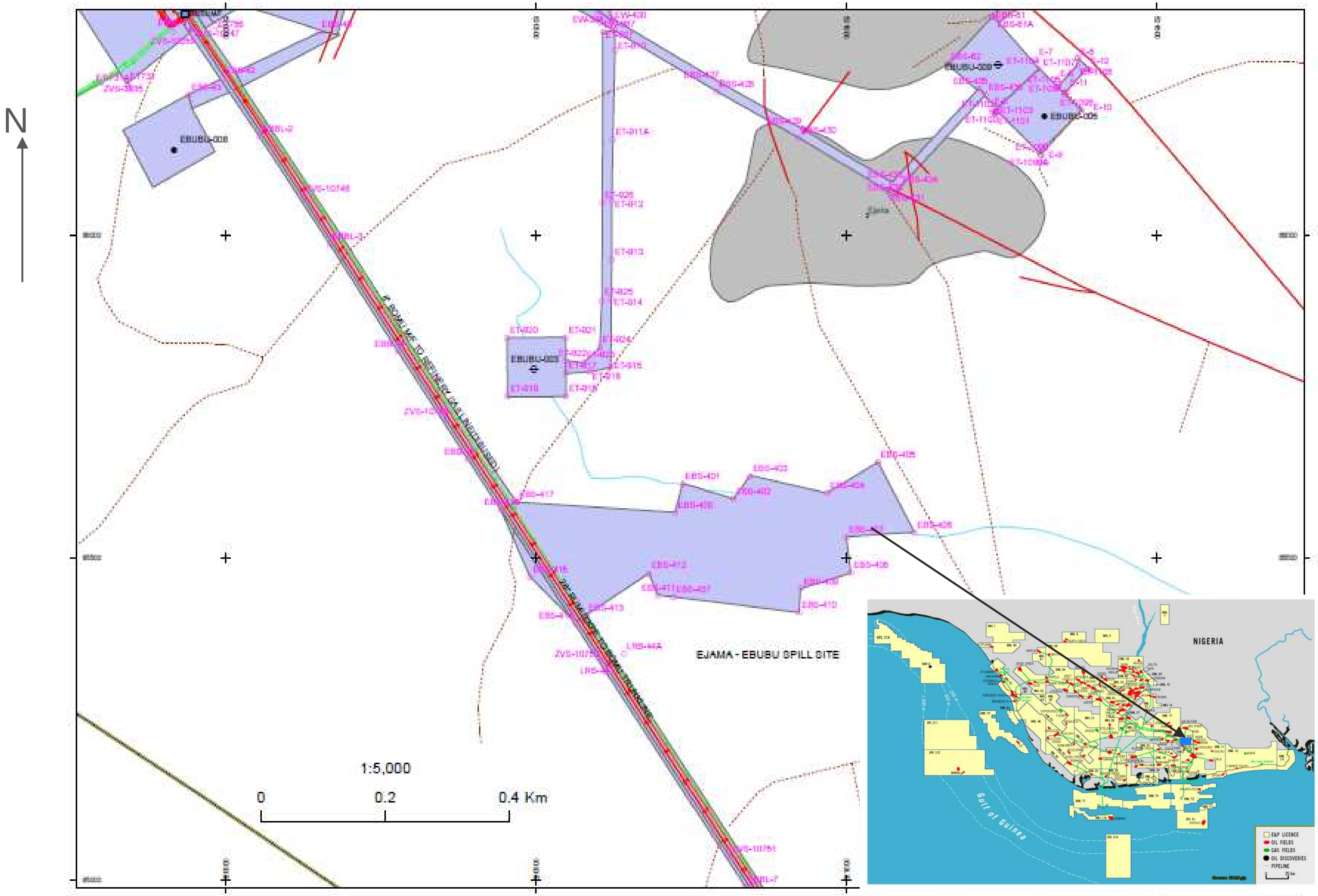


Fig. 1. Location Map of Ejama Ebubu Spill impact site

Geology and Hydrogeology

- Like most parts of the Niger Delta Ejama spill impact s area is made up of Recent / Quaternary sediments of clayey silt and clayey sand Formation.
- From 2m to 10m below the ground surface, the sand/silt formation is intercalated with clay. The clay content increases from the western part (upland area) of the site towards the eastern part (swamp area).
- From the borehole lithology logs, the stratigraphic sequence is highly variable, and this implies non uniformity of the hydraulic conductivity across the site. Measurements indicate hydraulic conductivity values in the range of 1.27×10^{-5} to 8.7×10^{-3} cm/sec .
- Field observations show higher vertical permeability than horizontal permeability. This implies slow fluid transmission in the horizontal direction toward the downstream area.

Geology and Hydrogeology

- Unconfined shallow groundwater levels fluctuate between 6 m below ground level (bgl) in dry season to surface level in rainy season.
- The perennial spring pond located at the centre of the site is recharged slowly by a groundwater baseflow.
- The hydraulic conductivity of the silty clay formation which was impacted is very low.
- The groundwater flow direction determined from observed groundwater elevations at existing wells indicates that the flow is towards the perennial pond which is the lowest point in the area.

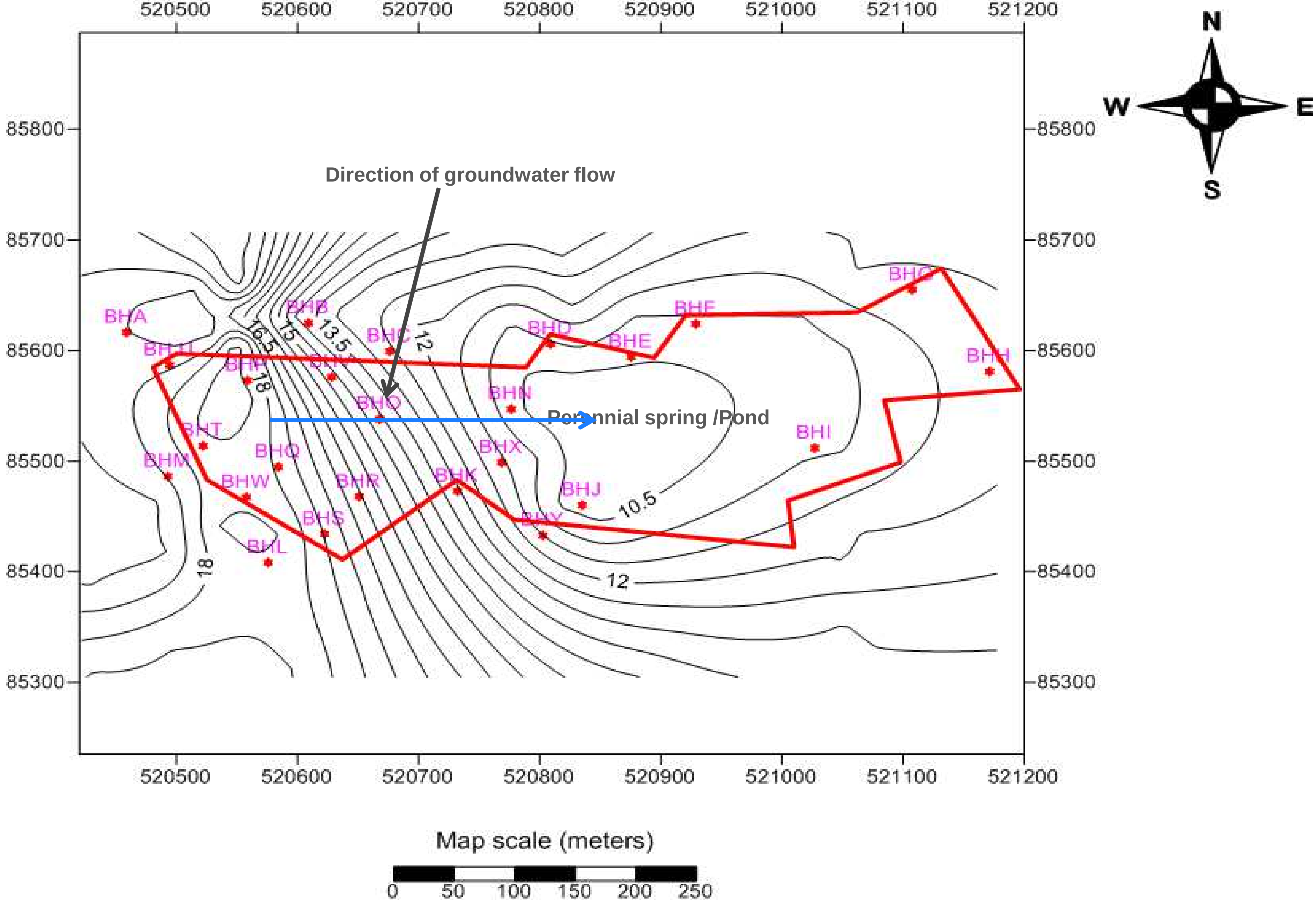


FIG. 2 EJAMA EBUBU GW SAMPLING MAP

TYPES OF WASTE/CONTAMINANT STREAMS

The spill incident was accompanied by fire and the following waste/contaminant streams were generated:

- Partially burnt bituminous sludge – about 4000m^3
- Oily sandy sludge, - about 10,000m^3 TPH (160,000 mg/kg)
- Impacted Soil - about 340,000m^3 TPH range (20,000, to 100,000 mg/kg)
- Impacted shallow groundwater with floating free phase crude oil
- Surface water , with free phase crude oil and oily sludge at pond bottom.

Pre-remediation view of Ejama spill site - 2006

Stock pile of excavated oily sludge and burnt carbonized residue at Ejama spill site - 2007

Oil seepage from a hot spot Ejama spill site - 2010

Oil sheen on Down Stream Ochani stream - 2010

Remediation Objectives

- The remediation objective was to restore the impacted site as close as possible to a fit for purpose condition, in line with the principles of sustainable development in a safe and environmentally friendly manner.
- The remediation is governed by the clean-up/remediation standards stipulated in the Environmental Guidelines and Standards for Petroleum Industries in Nigeria (EGASPIN) and International best practice.

REMEDIAL ACTION PLAN

- The remediation techniques were selected on the basis of the following:
  - The nature and type of contaminant or waste stream.
  - The nature and type of the impacted media.
  - The depth of impact below ground level.
  - The prevailing climatic conditions.
  - The sensitivity of the ecosystem.
- Based on the above, three main remediation techniques were selected and used. These include:
  1. Enhanced Bioremediation
  2. Fixation / stabilization
  3. Incineration / Thermal treatment.

REMEDIAL ACTION PLAN

Enhanced Bioremediation - Soil

- In the case of biodegradable waste stream, such as hydrocarbon impacted soil, enhanced bioremediation technique was used.
  - The technique was selected because of the tropical climatic conditions with temperatures ranging from 28^{o}C to 38^{o}C, twelve hours sunlight, abundant atmospheric aeration and sufficient hydrocarbon degrading microbial load.
- Biodegradation of hydrocarbon compounds was achieved by systematic tilling of the impacted soil to increase the surface area for atmospheric aeration and microbial activities. The process was complimented by biostimulation process in the form of application of nutrient amendment.

REMEDIAL ACTION PLAN

Enhanced Bioremediation - Soil

- Areas with impact depth of less than 0.5m, in-situ tilling/land-farming was adopted. For areas where depth of impact was between 0.5 to 10m, ex-situ on-site land-farming was used. Heavy duty excavators were used to excavate the impacted soil which were transferred to an engineered biocell on site for tilling/land-farming.

WORK DONE

- Ex-situ Bioremediation in Engineered Biocell accounted for degradation of circa 6,000m^3 of sandy oily sludge.


- On-site ex-situ Bioremediation accounted for treatment of circa 330,000m^3 of impacted soil. Impacted soil excavated to depth between 6m to 10m.


- In-situ Bioremediation handled about 10,000m^3 of impacted soil.

REMEDIAL ACTION PLAN

Enhanced Bioremediation - Groundwater

- Shallow groundwater was encountered at depth of between 4m to 5m during the dry season. In rainy season the groundwater table may be encountered at depth of less than 0.5m. Artesian effects were observed at some points within the site.
- Like the soil, the impact on groundwater was not uniform. There were points with little or no impact, while there were areas with heavy impact.
- The shallow ground water was remediated through excavation of trenches to depth below the groundwater table. The trench created a low pressure zone that allow free flow of crude oil trapped in the shallow aquifer into the trench.
- The accumulated crude oil was them removed by use of transfer pumps or skimmers and transferred to discharge points. The oil sheen was removed by use of absorbents and surfactants.

REMEDIAL ACTION PLAN

Enhanced Bioremediation - Groundwater

- Over 500 bbls of free phase crude oil was recovered from shallow groundwater in excavated trenches and returned to the flow station.
- The clean groundwater was allowed to stand for about 2 to 3 weeks in order to allow sufficient time for atmospheric aeration required to promote biodegradation of the dissolved phase of hydrocarbon compounds.




REMEDIAL ACTION PLAN

Fixation /Stabilization

- About 4000m^3 of burnt carbonized sand grit was excavated from about 4 hectares of the impacted area, where the fire was intensive at the time of the spill incident.
- This type of waste material was essentially burnt and immobile and therefore did not constitute potential contamination threat to the environment. However, it was a waste that needed to be properly disposed or managed.
- We decided to transform this carbonized waste material into leach proof concrete cement blocks. This was achieved by the following process:
  - The carbonized waste material was crushed into fine grain size.
  - The crushed aggregate was mixed with an appropriate portion of clean sand, cement and water.
  - The mixer was used to mold various sizes of blocks.

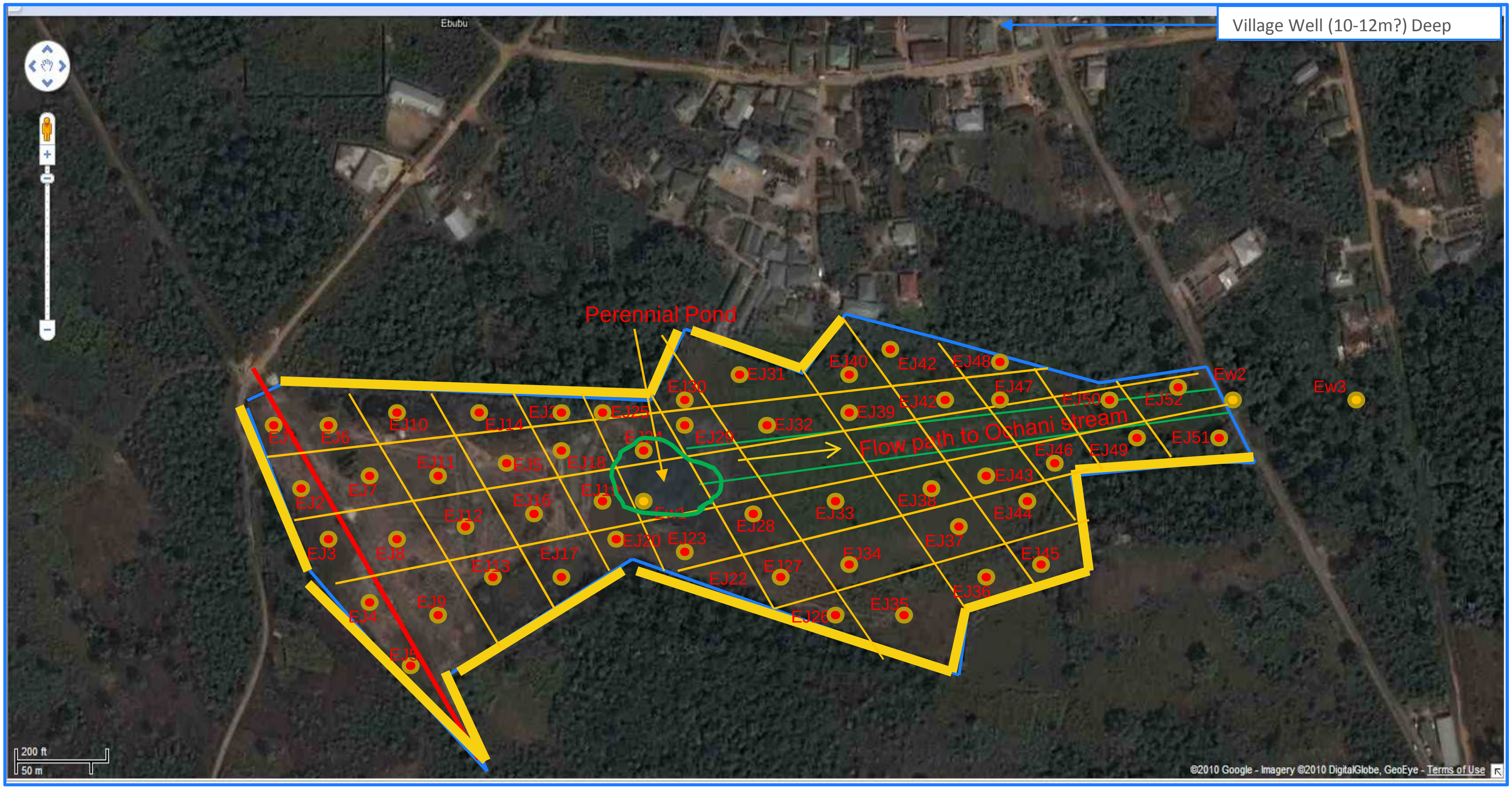
WORK DONE

- About 4000m^3 of burnt carbonized sand residue were fixed into 40,000 cement blocks at the DPR leach-proof approved standard.

- About 4000m^3 of sand oily bituminous sludge was treated by TDU.

Sampling and Chemical Analysis

- Soil sampling protocol involved dividing the site into 12 sampling zones. Fig. 3. Each zone has 4 to 5 sampling points. Thus we had about 52 sampling points. At each point, samples were collected at various depth intervals from 0m to 4.0m below the ground surface. Point averages of TPH of samples from 0m to 4m were computed and are represented in histograms, Fig. 4
- Total Petroleum Hydrocarbon levels in the soil were reduced from an average of about 100,000 mg/kg to about 3,000 mg/kg (against DPR EGASPIN intervention limit of 5000mg/kg) and from 50,000 µg/l to less than 20 µg/l (against DPR EGASPIN intervention limit of 600 µg/l) in shallow groundwater. BTEX levels were reduced from about 5 mg/kg to less than 1 mg/kg in soil and from about 400 µg/l to less than 3 µg/l in groundwater. PAH levels were reduced from about 700 mg/kg to about 5 mg/kg in soil and from about 10 µg/l to <3 µg/l in groundwater. An estimated volume of 350,000 m^3 of soil was treated and the contaminant level was reduced by approximately 95%.



KEY

Surface water Sampling points

Soil Sampling points

FIG 3. SAMPLING POINTS AT EJAMA REMEDIATION PROJECT SITE

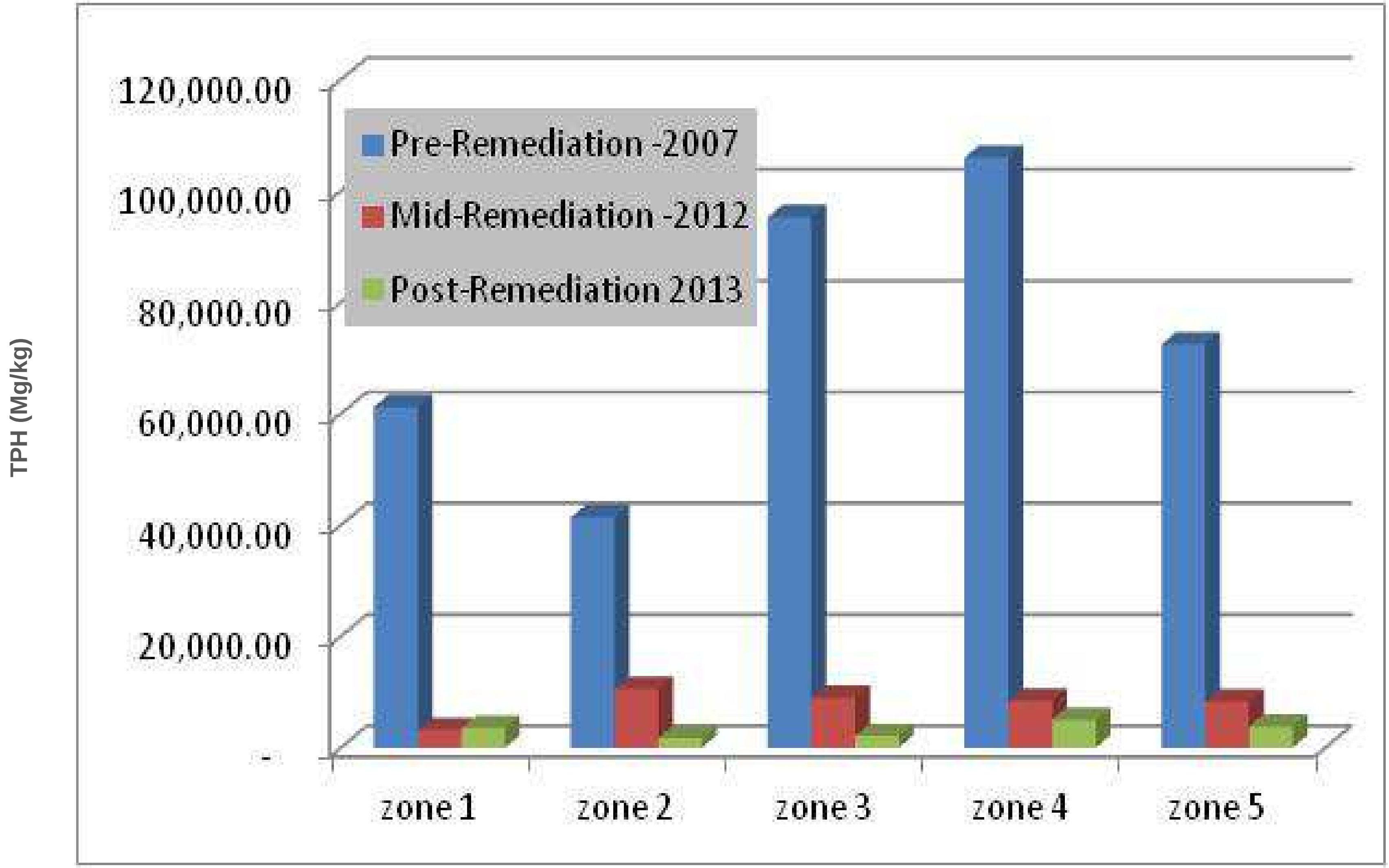


Fig. 4 Degradation Trend of Soil TPH (mg/kg) Levels at various Zones in Ejama Site – 2007 to 2013

Field Evidences of Remediation & Conclusions –

- The site has continued to recover after remediation was completed in June 2013.
- There is no visible oil seepage on site as was seen prior to remediation.
- The site now naturally support flora/vegetation growth
- The hydraulic gradient also slopes from west to east to towards the pond which marks the beginning of the swamp area.
- The absence of oil sheen in the central pond at the site, for over 12 months after the completion of the remediation process, is an indication of absence of leachate migration from the upstream through base-flow or surface runoff.
- Since the pond is the prime Receptor on the site, its cleanliness is a major evidence of adequate risk mitigation of the site.

Field Evidences of Remediation & Conclusions contd.

- The absence of TPH is the analyzed fish and frog tissue buttresses the effective risk mitigation on the site.
- Pond is currently a source of food for ducks, birds and aquatic animals. J6
- Furthermore, there are plans to transform the site into a recreation and sport centre.
- Monitoring of the groundwater in the boreholes and surface water in the pond will continue to ensure risk is effectively mitigated.
- Bioremediation is a continuous process. Attenuation of the residual hydrocarbon will be monitored occasionally.

Slide 22

J6 Do you have photos of this? That would be very helpful.
Julius.Ejikonye, 10/9/2014

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