

[Sustainable Environmental Economic Development (S.E.E.D)]

# Unexploded Ordnance Survey and investigation of contaminated features filled with weathered crude

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# THE ISSUE

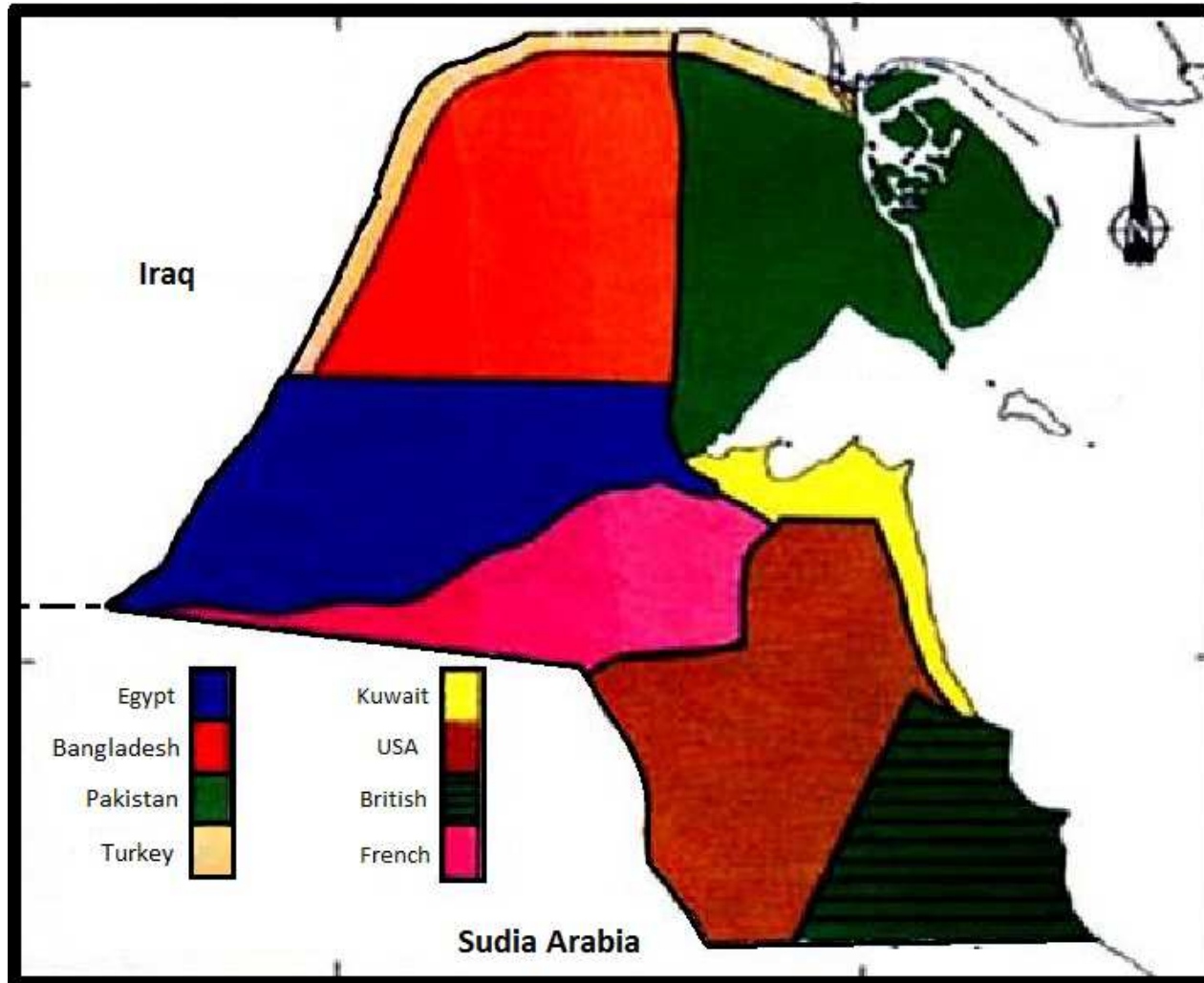
- ◆ Historical legacy of KOC Oil & Gas Exploration & Production operations have given rise to environmental pollution and damage to the natural desert environment.
- ◆ Typical non-operational redundant polluted features include the following:
  - ◆ Effluent Pits
  - ◆ Sludge Pits
  - ◆ Contaminated Soil Piles
  - ◆ Gatch Pits
- ◆ In addition, UXO remnants of war are potentially associated with these polluted areas.



# History

- UXO/EOD clearance operations took place from 1992 to 1997.
- Most of the clearance investigations conducted for a depth no more than 30 cm (1ft).
- Un-accessible areas (deep pits, sludge Pits & wet effluent pits) clearances were not obtained.
- Some Pre-war Production operation activities records, and features history, were lost.
- The above conditions created an uncertainty of the UXO clearance status of the to-be remediated features located in Kuwait Oil Fields, and the working site area surrounding the Features.

# Post-War Mines & UXOs Clearance Operations:

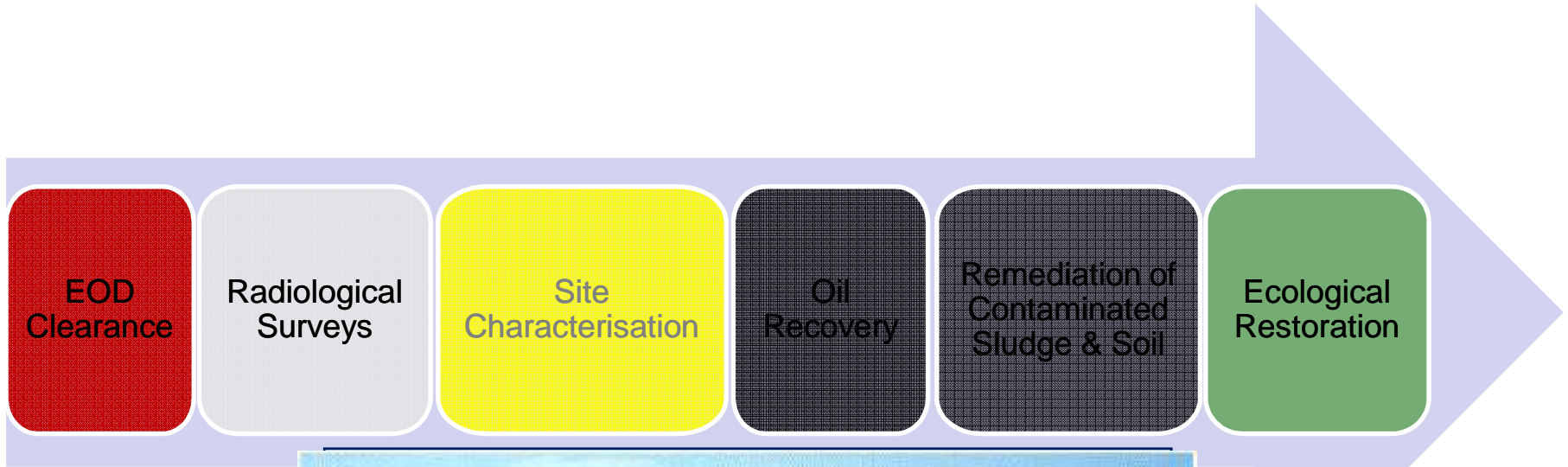


# SEED: PROJECT OBJECTIVE

- ◆ To remediate a number of contaminated features to acceptable levels and restore ecological function.
  - Remediate – Treatment to remove contaminants (Hydrocarbon & Salt)
  - Acceptable Level – Contamination not reduced to zero but to a level not harmful to human health / environment
  - Ecological Function – Following remediation, soil to be capable of supporting native plant growth



# REMEDIATION : SCOPE OF WORKS



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# Kuwait Climate and weather

- summer, average daily high temperatures range from 42 to 49 °C (108 to 120 °F); But can reach 53°C (129°F)
- winter weather sets in, dropping temperatures to as low as –4 °C (21 °F) at night. On the other hand, daytime temperature is between the 10–17 °C (50–63 °F).
- Dust and Sandstorms conditions often occur, where some years have recorded more than 112 days of dust.



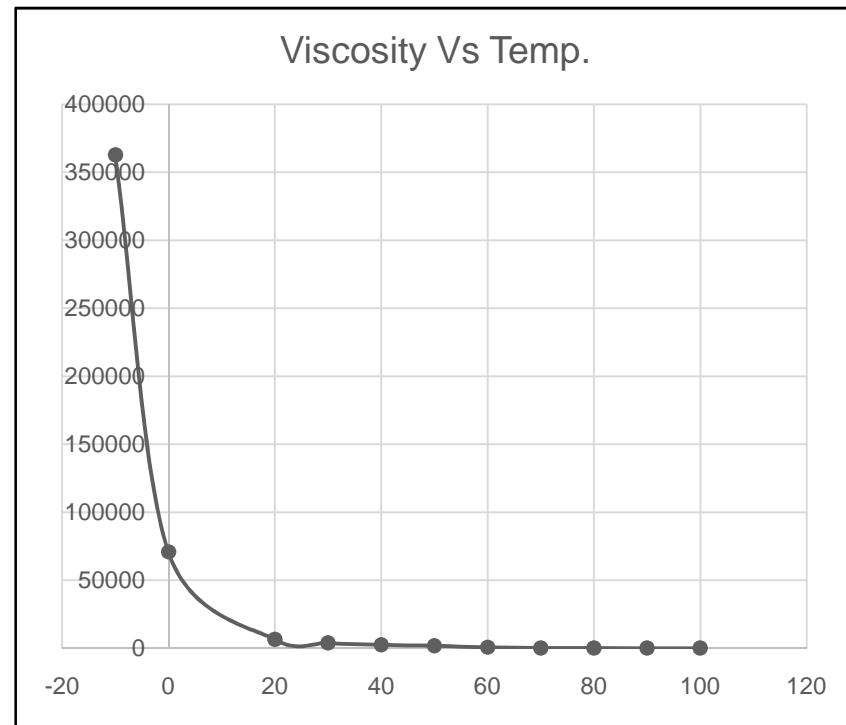
# Kuwait Climate and weather

- Ambient conditions had a major effect on EOD/UXO operations conducted even on slightly wet areas, where as the viscosity decreases with the rise of ambient temperature throughout the day it becomes extremely difficult to access wet areas.
- To avoid risks daily assessment of the targeted wet area is to be conducted before commencement of the survey.



# Viscosity:

Kinematic viscosity at temperature C	Viscosity (cST)
-10 C	362718
0 C	70760
20 C	6377
30 C	3810
40 C	2458
50 C	1810
60 C	670
70 C	163.3
80 C	103.1
90 C	68.16
100 C	46.5



# EOD/UXO: Scope of Works

- To Safely and efficiently detect and clear wet, hydrocarbon contaminated areas of the features from potential unexploded ordinance (UXOs).

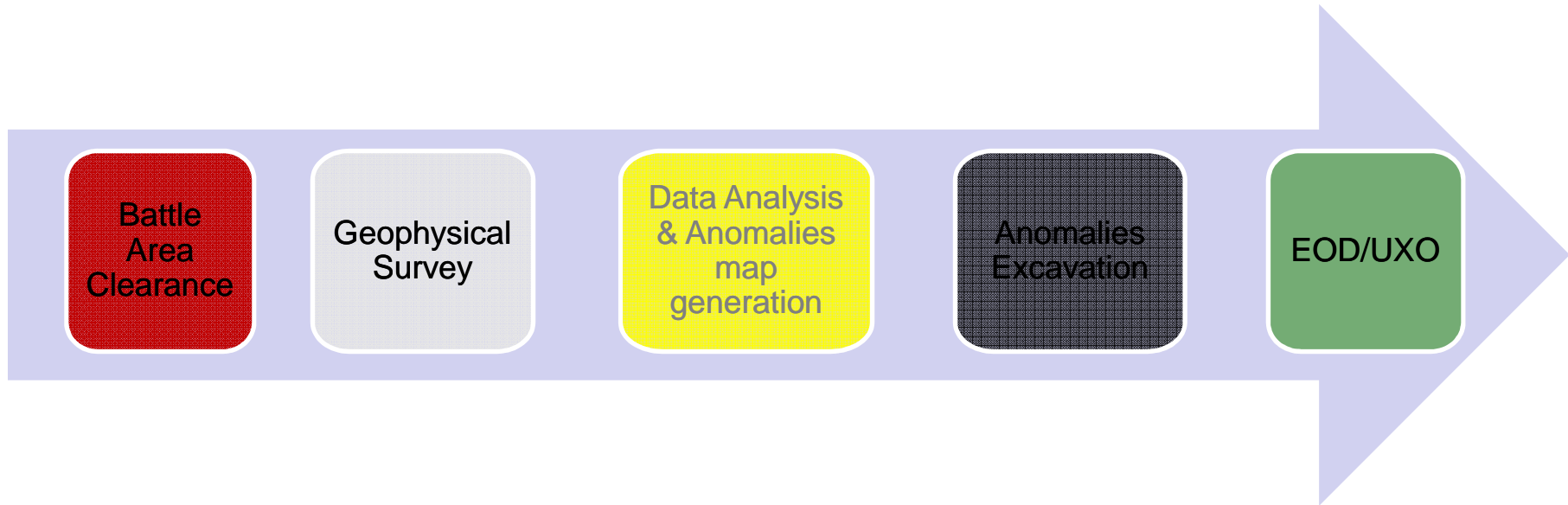
## Area of Contamination (Features) :

- 1) Effluent Water Pits.
- 2) Sludge Pits.

## Executed Works:

- 1) Battle Field & Visual Clearance.
- 2) Geophysical Survey & Anomalies Identification.
- 3) Anomalies Excavation & Explosive Ordinance Disposal.

# EOD/UXO: Scope of Works



# Features:

- **1) Effluent / Evaporation Pits:**
- Constructed for the evaporation of effluent water associated with Oil Production Process at the Gathering Centers (GCs), that contains small amounts of oil which over time accumulates to form a layer of sludge/weathered oil.

## Effluent Pit



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# Effluent Pit



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# Features: Sludge Pits (Holding Pits)

- Contains a mixture of heavy sludge, oil & water which forms separate layers throughout the Pit's landscape. Depth can vary in different pits reaching 2m deep in some.

## Sludge Pit



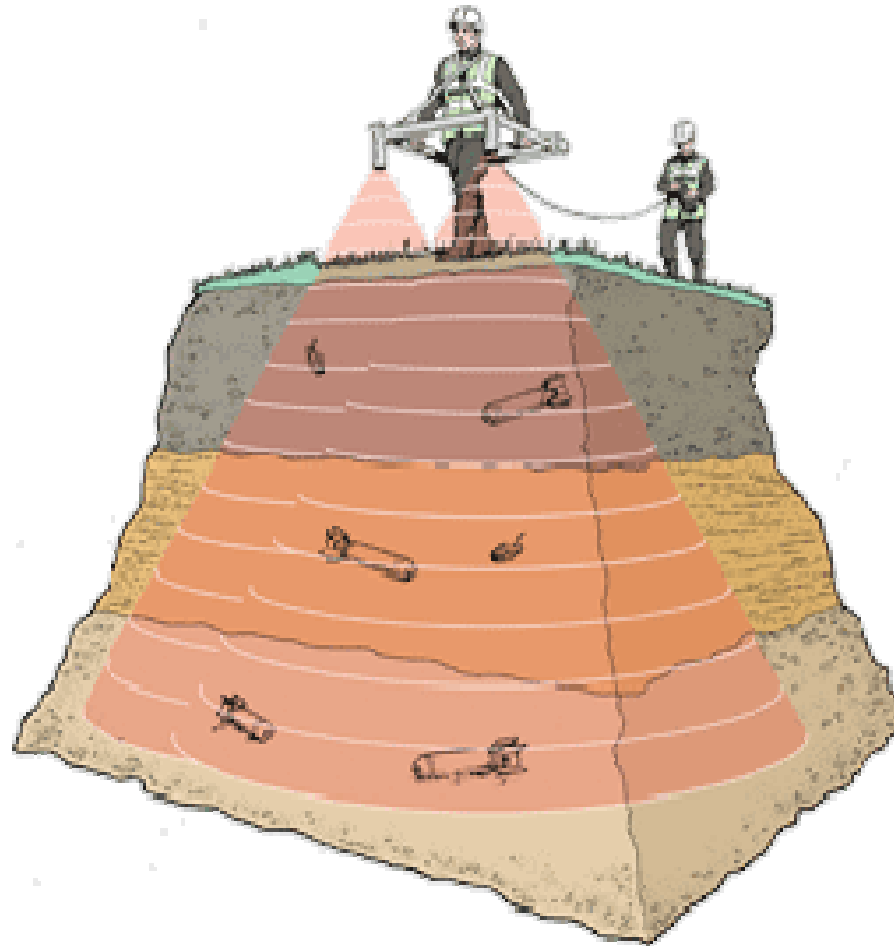
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# Battle field Clearance (BFC)

- It's the first clearance that is both visual and subsurface detection of UXOs stretching to a depth of 30 cm to minimize the risks of harm to the Geophysical Survey Crew
- It involves locating and disposing of the surface anomalies & UXOs (EOD) and can be done only in walking accessible areas utilizing metal detectors such as F3 Metal Detector.



# Geophysical Survey



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# Geophysical Survey

- Is the subsurface investigation operation to identify possible UXOs (anomalies) to be investigated.
- post-data analysis can identify anomalies to a depth of 5m depending on the assessment of expected anomalies.
- Can be conducted with the use of advance metal detectors such as EM-61 Metal Detector linked to GPS device.



# Geophysical Survey

## Verification & Calibration Strip:

- Metallic objects or defused projectiles are buried at different depths.
- Signals from the detected objects can be used as a basis for target selection & anomalies elimination.
- Prior to the geophysical survey, it is tested to assure the equipment functionality and Quality Assurance.

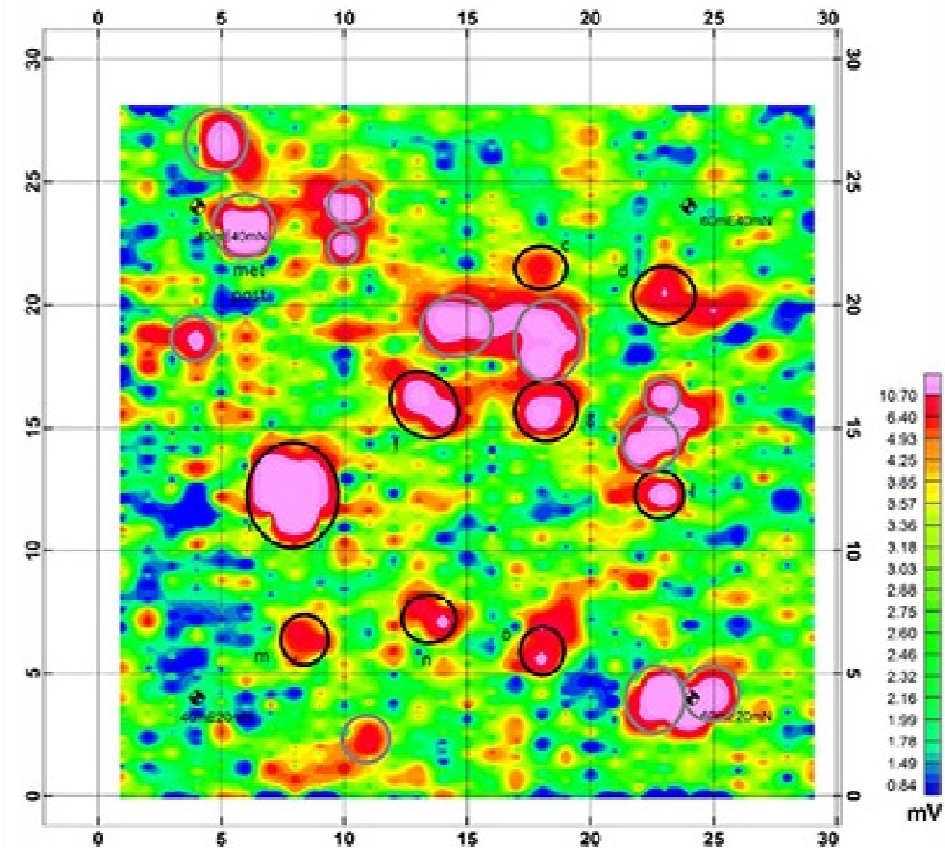




# Geophysical Survey

## Anomalies Map:

- 1) Data is Processed
- 2) Targets are identified



# Geophysical Survey

## UXO Excavation:

- The suspected anomalies are carefully excavated with the aide of metal detectors to anticipate the remaining depth.
- Once the anomaly is identified as a UXO it is to be disposed-of via KMOD's EOD/UXO Team.



# Geophysical Survey \ Pull Raft

- A customized fiberglass boat to fit the geophysical survey equipment on was utilized in effluent/sludge pools containing highly viscos tarlike effluent residual that can be pulled manually (assuring a safe distance is maintained for technicians pulling the boat), or by a vehicle.
- Maintenance of accurate lines throughout the shifting of the start & end point of the line is essential to ensure full survey is maintained with no gaps.

# Pull Raft

## Advantages:

- 1) Eliminating risks of UXOs to EOD Technicians (including fragments & fire).
- 2) Full access to the wet parts of Pits.

## Disadvantages:

- 1) Risk of encountering a possible UXO when used for shallow wet areas due to absence of Battle-field Clearance. (minimized through the working area UXOs assessment)

# Pull Raft



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# Pull Raft



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# Hover-craft

- The man-mounted hovercraft was utilized to survey effluent and sludge covered areas and relatively deep and large areas. exerting pressure of approximately  $6.7 \text{ g/cm}^2$  & maintaining a minimal speed of 5 knots, the hover craft risk of detonating a UXO is most unlikely, thus minimizing the risk exerted to the pilot and surveyor while still maintaining good data quality and vast area.
- With the aide of Flagmen the hovercraft coverage of defined gridlines can be completed in a short period.

# Hover-craft



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# Hover-craft

## Advantages:

- 1) Minimizing the risk of UXOs detonation.
- 2) Provides full access to unaccusable wet, deep & highly viscos areas of effluent/sludge Pits & Spill.
- 3) Short Time/Area coverage.
- 4) Can be deployed for rescue operations and utilized for sample collection.



# Hover-craft



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# Hover-craft



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# Limitations:

- 1) Accessibility is Oil/sludge viscosity & surface condition dependent.
- 2) Extreme weather conditions (Example: strong wind) may affect data integrity.
- 3) Flash Point of the Hydro Carbon to be determined prior to operation.
- 4) The necessity of a standby Hovercraft for rescue support.

# Results achieved

Lot	Dry Area Cleared (m <sup>2</sup> )	Wet Area Cleared (m <sup>2</sup> )	Anomalies Investigated
Lot A	228,235	239,496	3900
Lot B	154,780	-----	1,331
Lot C	331,637	93,815	2096

- The methods of works conducted can provide safe operations for similar future projects such as the remediation of oil lakes in Burgan oil fields or north Kuwait as well as various contaminated features in Kuwait oil fields.

## QUESTIONS ?



Thank you

