Section 7. Selected Decommissioning Option for the Maureen Platform and Drilling Template

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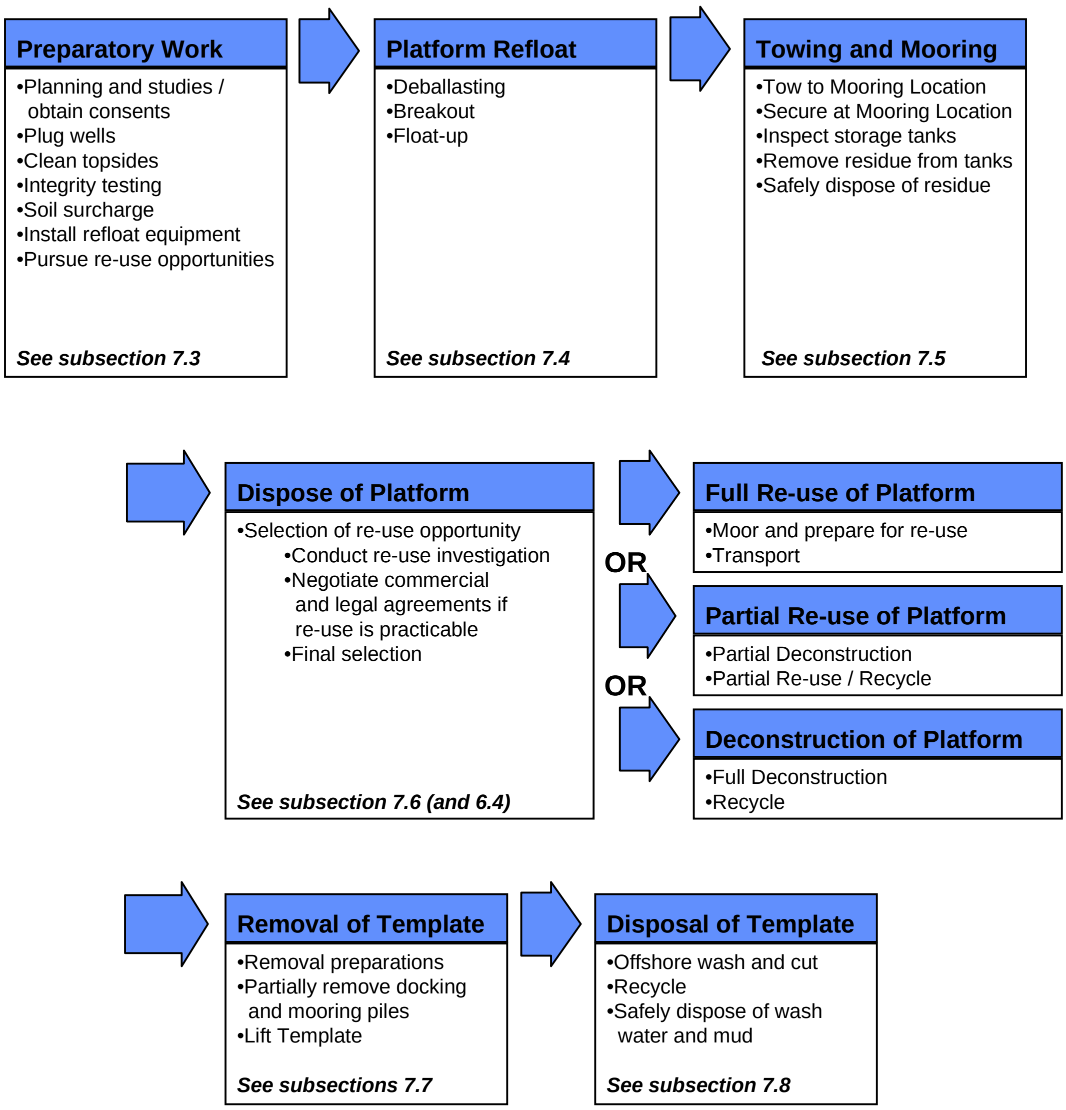
7.1 Introduction

This section provides a description of the Selected Decommissioning Option for the Maureen Platform and Drilling Template.

7.2 Overview of the Selected Decommissioning Option



7.3 Preparatory Work for Removal

The sequence of events for preparation for refloat of the Maureen Platform includes:

- Planning and Studies/Obtain consents and approvals
- Well plugging and abandonment
- Removal of Hydrocarbons from and cleaning the topsides
- Integrity testing
- Placement of the soil surcharge
- Installation of refloat equipment
- Template preparation.

7.3.1 Planning and Studies/Consents and Approvals

Years of planning and study have been spent in preparation for the Maureen Platform refloat project. These studies were used to plan and engineer the detailed technical solutions and assess the environmental impacts of the decommissioning options. Furthermore, the technical solutions and estimated environmental impacts have been reviewed and verified by independent third party experts (see Section 14). The main studies are listed in Section 17.

A number of consents and approvals will be required to carry out the decommissioning works as described in this document. The main approval required is DTI's approval of this Decommissioning Programme.

7.3.2 Well Plugging and Abandonment

The plugging and abandonment of the 23 Maureen wells is not part of this Decommissioning Programme, as it has been approved under the relevant regulatory framework and most of the work has already been completed. The following description, however, is supplied for information.

All open perforations have been plugged with cement and additional plugs have been set in the wellbore. The programme was designed in accordance with UKOOA guidelines to eliminate the risk of any subsequent leakage of hydrocarbon to the surface. All tubing will be cut at or below mudline and recovered. As part of the well plugging and abandonment work scope the conductors were severed at two locations. These were at 3 m below seabed and above the wellhead. This activity was intended to facilitate the removal of wellheads as part of the Template decommissioning activity.

More detail on the Maureen Well plugging and abandonment operations is provided in the Report for the Maureen Application for Consent to Plug and Abandon the Maureen Platform Wells[1].

7.3.3 Removal of Hydrocarbons and Cleaning the Topsides

Removal of hydrocarbons from the topside's crude oil processing and treatment facilities commenced after cessation of production. The crude oil processing system was cleared of hydrocarbons by flushing the vessels, heat exchanger, pipework and pumps. The flushing liquids were routed to the three Platform storage tanks. The crude oil that remained in the storage tanks, plus 200,000 barrels of oily water, were loaded onto a tanker, via the Loading Pipeline and the Loading Column, for treatment and disposal at an onshore oil/water treatment facility. This loading operation also served to flush the Loading Pipeline with the water from storage tanks. The topsides' crude oil process vessels were then cleaned by high pressure water jetting to remove residue and scale. The wash water was re-injected back into the reservoir via disposal wells until the Maureen Wells were plugged. After the Maureen Wells were plugged the oil residues were taken to shore for disposal.

Low Specific Activity (LSA) scale is a by-product of naturally occurring radioactive material in the water which was produced with the oil from the reservoir. An LSA survey of the Maureen Platform topsides was completed in 1999[2] to determine de-scaling requirements of piping and/or vessels. All vessels found to contain LSA scale were cleaned, in parallel with well plugging and abandonment activities, and any LSA scale was disposed of under the existing disposal license agreements.

7.3.4 Removal of Structural Fill Water

The Maureen Platform structure is protected by a passive fire proofing (PFP) system, which encompasses the topside deck framing and upper substructure (above the splash zone). The PFP is provided by a structural fill water system fed by four header tanks. The fill water is "inhibited" seawater, which protects against internal corrosion and acts as a heat sink to prevent structural collapse in the event of a major fire. The hydrocarbon fire risk was significantly reduced, however, when the Platform ceased production and the hydrocarbons were removed from the topsides. The need for the PFP system, therefore, has been removed.

The structural fill water (approximately 1350 te) must be removed as part of the preparatory work for the refloat to reduce the weight in the upper part of the structure and lower the centre of gravity of the Platform. The fill water is almost evenly distributed between the topside framing and the upper substructure. It is possible to drain down the topside framing via the existing Platform drain system, but it is difficult to remove the fill water from the upper substructure (below the level of the lower deck). An engineered system is therefore being designed to remove the remaining fill water from the upper substructure. The intent is to pump the structural fill water out of the structural members of the upper substructure into holding tanks on the Platform and then into a marine vessel for transport ashore for treatment at a specialist disposal facility.

7.3.5 Integrity Testing

Pre-refloat tests and inspections are being carried out to prove the integrity of the Platform and the performance of existing equipment required for the refloat. Final checks will be carried out prior to refloat to supplement the extensive inspection and testing work which has been carried out in 1997, 1998 and 1999.

Prior to the refloat of the Platform, all spaces that will be relied upon for buoyancy will have been pressure tested to verify their integrity. This includes the main oil storage tanks, associated secondary spaces and the lattice frame structure, which are all below sea level. In the event that a loss of integrity is established a leak location test will be carried out. Non-hazardous fluorescent dye (fluoresceine), will be added to the seawater in a concentration of approximately 35 ppm for the test. This type of dye is used regularly both onshore and offshore when using water to check for system leaks in environmentally sensitive areas, such as underground drainage systems, sub-sea pipelines, etc.

7.3.6 Equipment Testing

All new equipment required for refloat will be extensively tested at the supplier's factory prior to delivery and installation.

7.3.7 Reasons for and Method of Placement of the Soil Surcharge

The steel skirts under each of the Platform's tank bases are buried in the seabed to a depth of around 3.4 m. To refloat the Platform these skirts must break out of the seabed. To achieve this operation in a controlled manner, the Platform must be deballasted down to a minimum on-bottom weight and fluids must be pumped under each tank base to create enough hydraulic pressure to gradually jack each tank out of the surrounding seabed soils.

Extensive tests and surveys of the soils around the Platform tank bases have been undertaken and the results used to calculate the hydraulic pressures required to jack the bases from the seabed[3]. In 1997 and 1998, hydraulic pressure tests were conducted offshore by injecting seawater under the tank bases. These tests confirmed that sufficient hydraulic pressure could be applied and maintained to overcome the adhesion and friction forces during the jacking operation[4]. These tests were performed in a static environment, however, and one concern identified was whether sufficient pressure could be maintained in a dynamic environment once the skirts started moving out of the seabed through different types of soils.

If the injected water escapes through the surrounding soil prematurely during the hydraulic jacking process, either through channels that develop in the soils ("piping") or owing to soil upheaval, the hydraulic pressures would reduce and the entire refloat operation could fail. Concerns about potential soil failure were confirmed when bids for the refloat contract were received, and every bidder identified a requirement to implement remedial measures to guard against possible soil failure.

During the bid clarification process the Operator required potential refloat contractors to further study the soil failure issue. At the same time it commissioned Fugro, a specialist geotechnical consulting firm, to study the same issue through model testing. Two main remedial measures were studied: either using a viscous fluid (mud) rather than water as the injection medium, or placing some kind of material on the seabed around the tank bases to consolidate the soil (called a "soil surcharge"), thereby making the potential leakage pressure higher than the jacking pressure brought about by the water pumped under the bases.

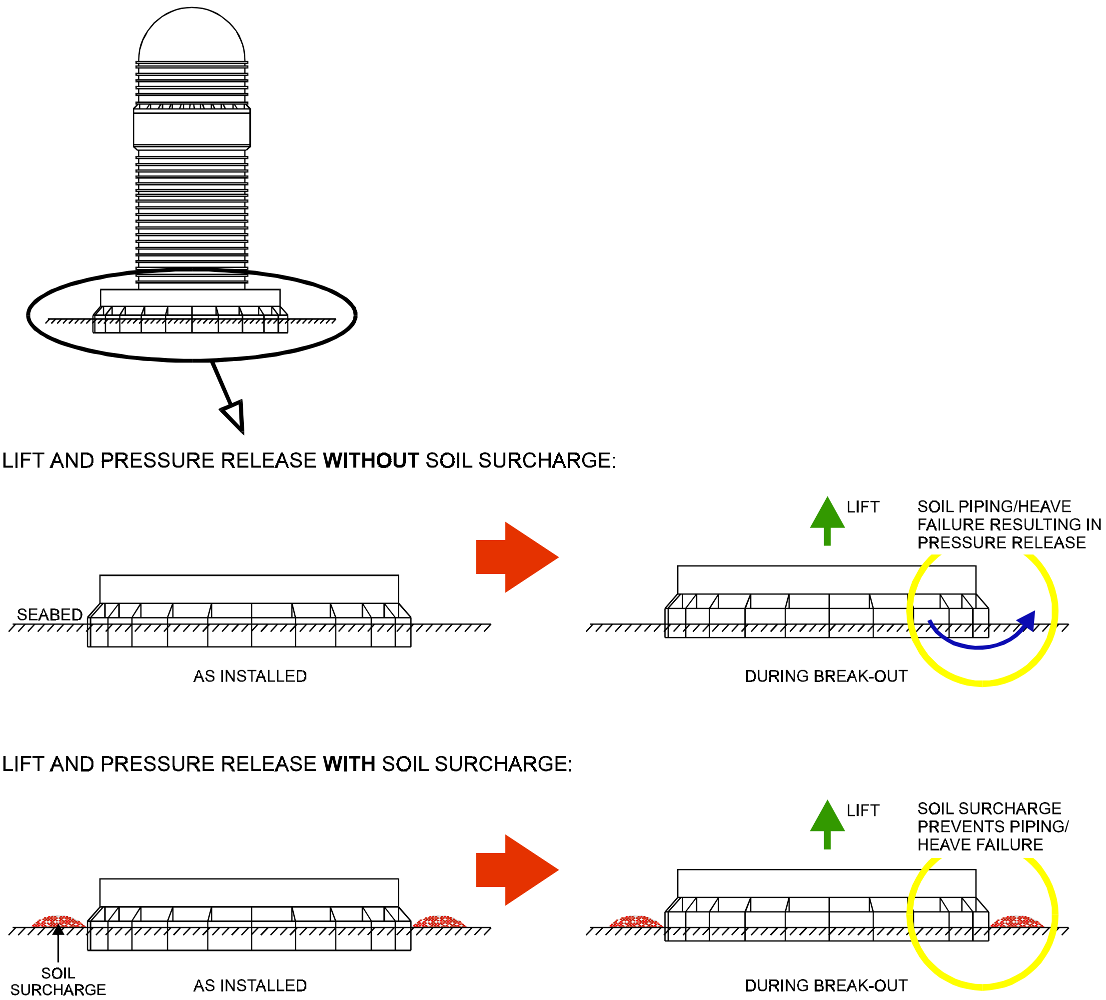
Rock material, concrete mattresses and pre-cast concrete berms were evaluated as potential materials for the soil surcharge. The latter two alternatives were ruled out because they do not provide a uniform continuous loading and they are impermeable, technical difficulties that prohibit their use. On the other hand, crushed rock material was found to have the additional favourable attribute of sealing piping channels that develop during skirt extraction.

Fugro initiated a four-phased laboratory testing programme in which progressively larger models of the Platform tank bases were jacked out of a simulated seabed using either water or a variety of muds, and also applying a soil surcharge. The results of these tests are described in reports issued at the conclusion of each Phase[5]. The Fugro programme confirmed that without remedial measures, there is a possibility that during the hydraulic jacking operation the soils around the tank bases will fail (i.e. will not contain the pressure), through soil upheaval and/or development of cavities (“piping”), resulting in an inability to refloat the Platform successfully. Phase II of the testing programme identified a potential problem with using mud as the injection fluid under the bases. It was observed that the stiffeners on the outer skirt walls tend to create an open channel that allows loss of pressure, and the use of mud tended to keep these voids open, thereby preventing a natural closing of these voids as the skirts are progressively extracted from the soils.

The Fugro Phase III and Phase IV tests confirmed that the injection of mud under the bases was not a viable option. The Fugro modelling and testing programme, did confirm, however, that a soil surcharge was an effective remedial measure against potential piping or soil heaving. The Fugro work also concluded that graded naturally occurring rock material or magnetite would plug any possible piping channels that developed during the skirt extraction operation. The Fugro results were verified and confirmed by Det Norske Veritas and Norwegian Geotechnical Institute (NGI), each of whom ruled out mud injection under the bases as an appropriate remedial measure against soil failure and confirmed that the use of a soil surcharge would be very effective in reducing the risk of soil failure to an acceptable level[6].

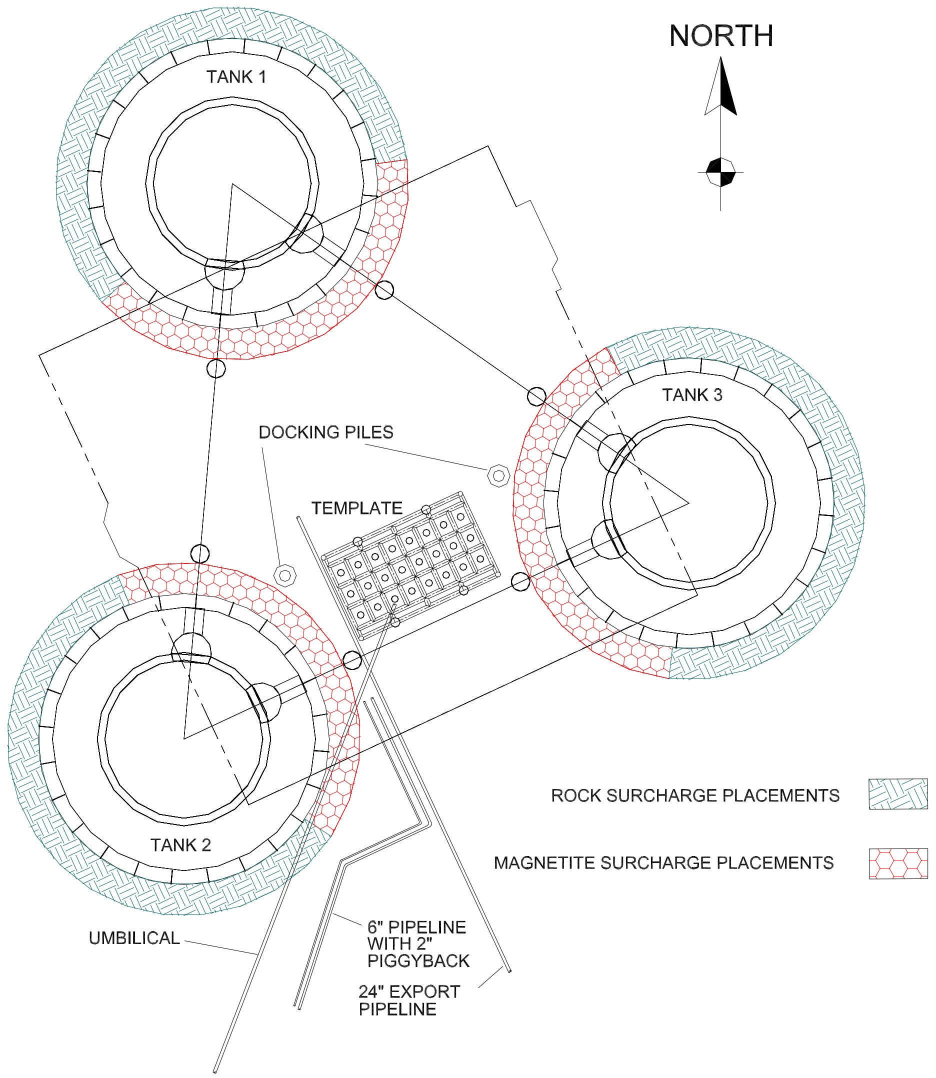
The diagram below illustrates the principles by which the soil will improve the skirt breakout process.

Figure 7-1 Pressure Release from Tank Base With and Without Soil Surcharge



Two types of naturally occurring material for the soil surcharge will be used, standard rock/gravel material and magnetite ore (natural iron ore, Fe_3O_4). The material will be placed around the outside of the three tanks as shown in Figure 7-2. The rock material will be placed around the outer 220^o of the circumference of each tank by a fall-pipe from a fall-pipe vessel. Magnetite ore will be placed around the inner 140^o of the circumference of each tank by divers, as there is no access for the vessel fall chute.

Figure 7-2 Plan View of Soil Surcharge Placement



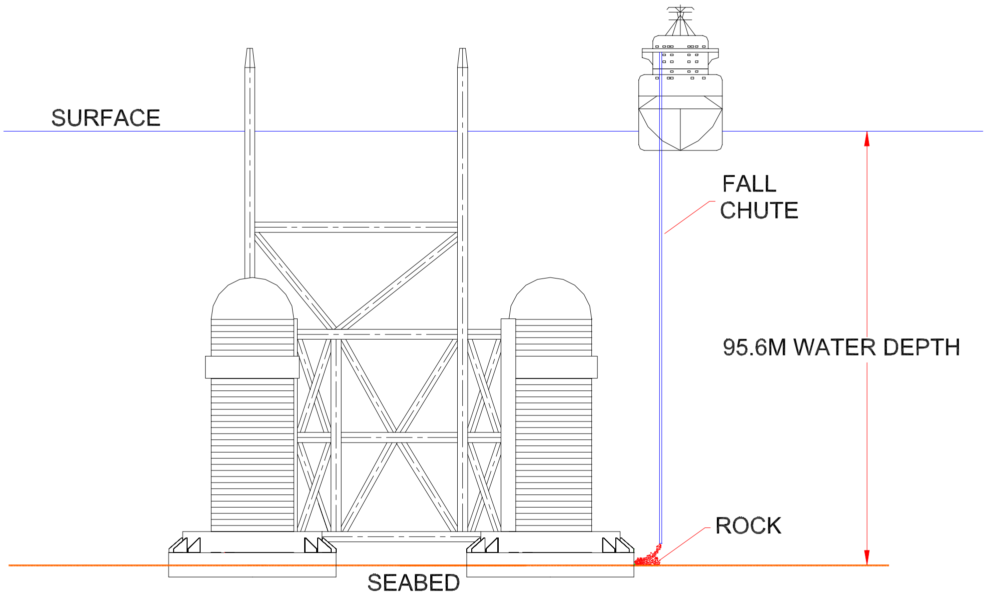
The preferred, and anticipated, method of placement of soil surcharge is over existing drill cuttings.

Methods for the placement of materials are described below.

Rock (Gravel) Placement

The chosen method allows accurate placement of rock material without encroachment onto areas that do not require to be covered. The vessel involved will be a dynamically positioned fall-pipe vessel (DPFV) equipped with a polyethylene fall-pipe to guide the material to the seabed as shown in Figure 7-3.

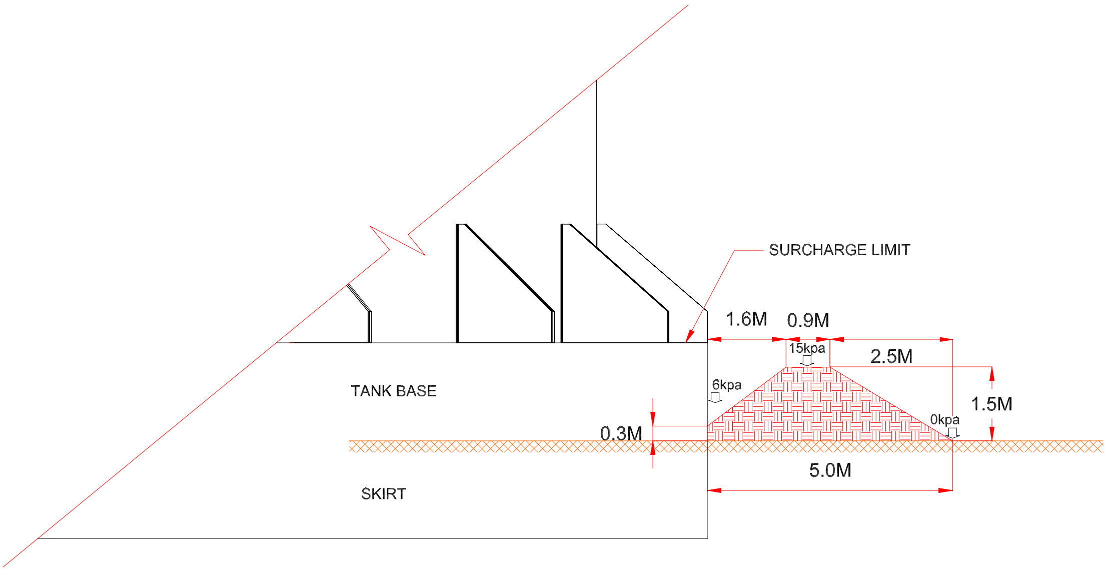
Figure 7-3 Rock (Gravel) Surcharge Placement



At the lower end of the fall-pipe, there is a "Spider" framework which consists of a dead-weight and a framework on which is mounted an extensive electronic instrumentation package, together with a hydraulic system and thruster configuration, for monitoring and controlling the position of the fall-pipe end. The lower end of the fall-pipe will be approximately 6 m to 7 m above the seabed. The rock material will be poured down this pipe onto the precise area required. The average feed rate of materials is approximately 350/400 te/hour. The grain size of the material will be between 2 mm to 100 mm, and approximately 1500 te of rock material will be placed around the outer 220^{o} of the circumference of each tank, as shown in Figure 7-2 above. ROV survey sweeps will be carried out before and after the rock/gravel placement operations. This is to assess the start and stop points for the planned placement operation and to compare the deposited profile which is achieved with the planned specifications.

A schematic of the preliminary profile of the deposited rock material is shown in Figure 7-4.

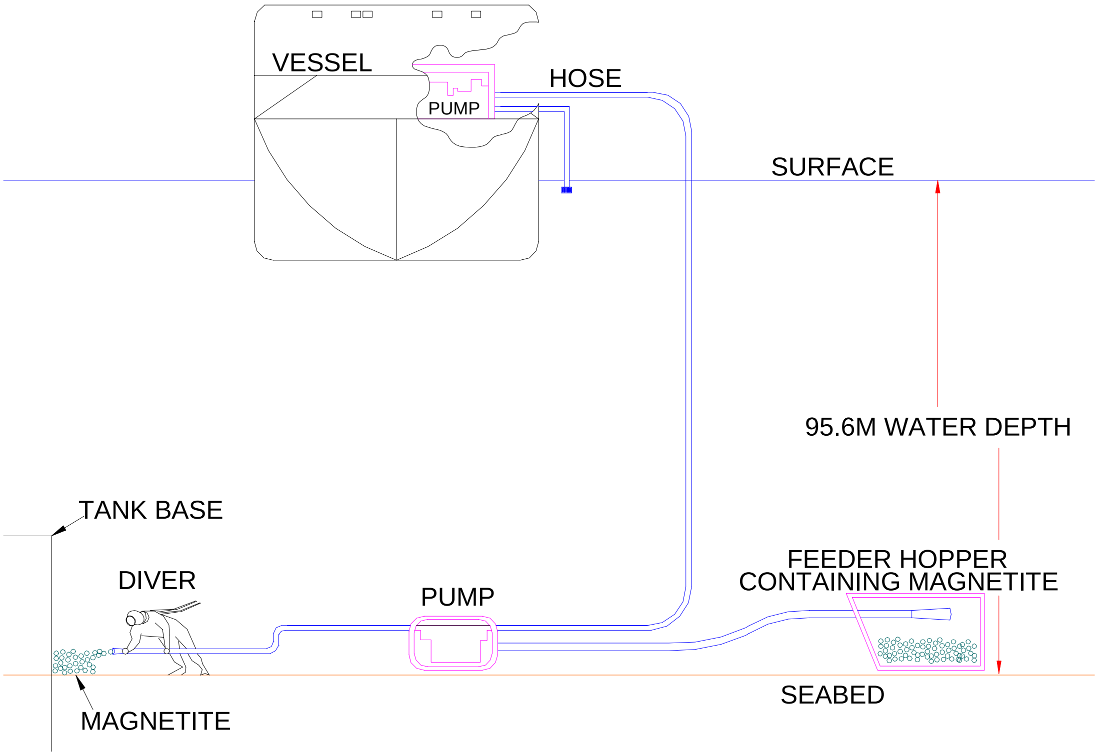
Figure 7-4 Profile of Depositional Rock Material



Magnetite Placement

Divers will carry out the distribution of magnetite by pumping it to the appropriate locations. This is a proven technique capable of providing the level of controlled distribution that is required. Prior to the deposition of material, a survey of the area at each tank base will be carried out. The area will be staked out to indicate the depth requirement and the distribution area. Divers will then prepare and position containment shuttering in local areas where and if necessary. A subsea jet-pump system, feeder hopper and the magnetite will then deployed to the seabed as shown in Figure 7-5.

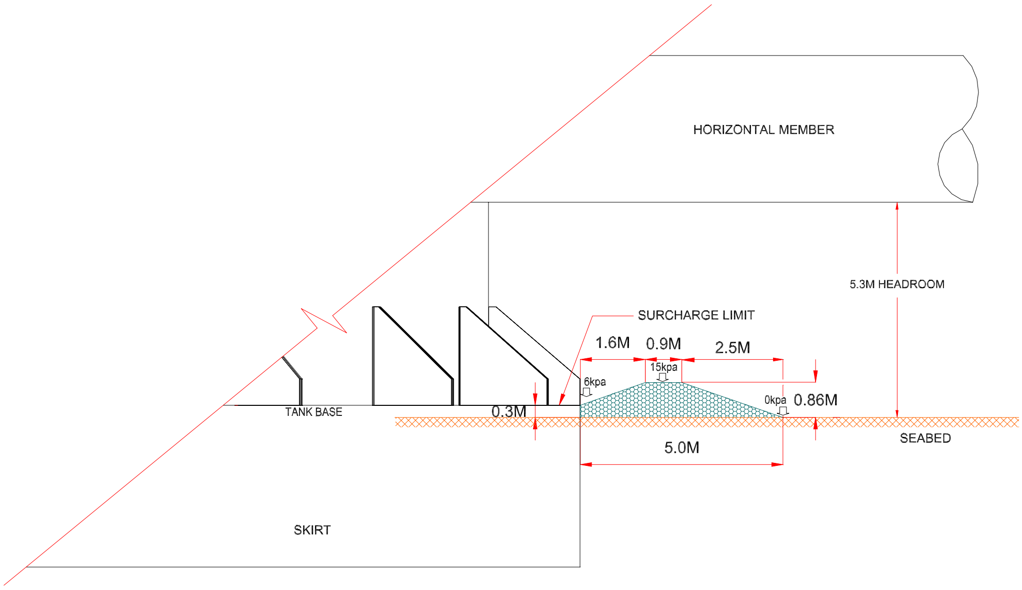
Figure 7-5 Magnetite Surcharge Placement



The magnetite will be loaded into the hopper and the distribution hose and nozzle deployed within the required area. Covering operations will begin from the centre of the area out to the edge. The jet-pump system pumps the magnetite from the hopper through a 200 mm discharge hose, which is positioned by divers. On completion, a survey will be carried out to evaluate the distribution of the magnetite and any necessary remedial work will be undertaken if required. The overall operation will be controlled from a dive support vessel on the surface.

Prior to the operation, the magnetite will be sieved and graded to ensure good distribution of material on the seabed. The in-place soil surcharge will have an adequate grain size distribution to provide a filter mechanism or alternatively a filter will be provided, if necessary, by placing a biodegradable geotextile material prior to placement of surcharge. Approximately 500 te of magnetite ore will be placed around the inner 140^{o} of the circumference of each tank, as shown in Figure 7-2 above. A schematic showing the preliminary profile of the deposited magnetite is shown in Figure 7-6.

Figure 7-6 Profile of Depositional Magnetite Material



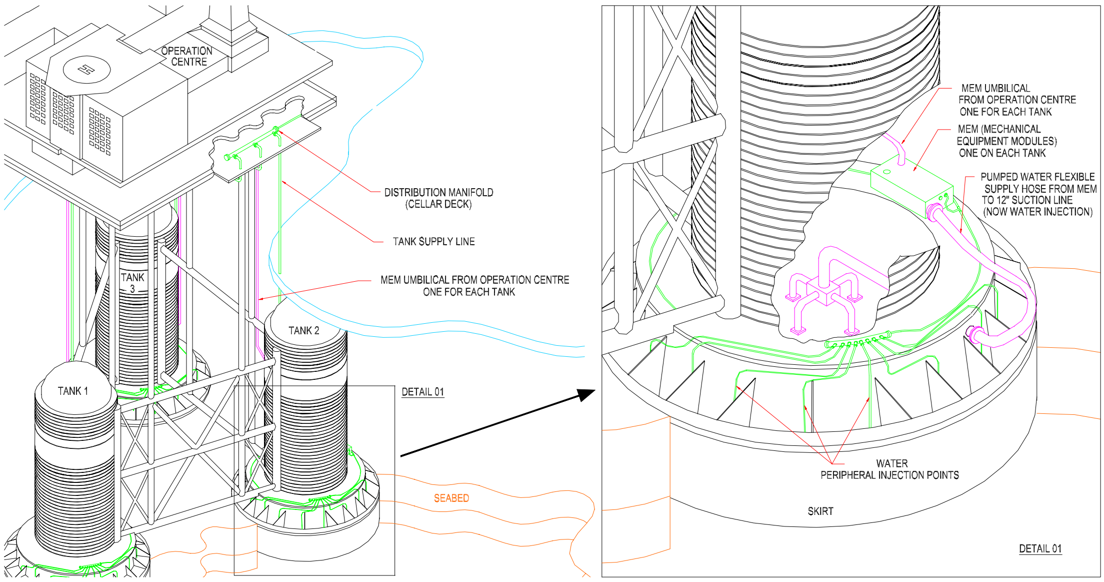
7.3.8 Installation of Refloat Equipment

The following equipment will be installed on the Platform prior to the refloat:

- Water deballasting system
- Water injection system for underbase pressurisation
- Nitrogen supply and injection system for the tanks
- Subsea and topsides control system.

Equipment has been designed to deballast/ballast the storage tanks and control the underbase water injection. One underwater pumping skid will be located at the base of each tank using a Diving Support Vessel crane and underwater floatation devices. The pump skids will be used to direct and control the flow of water (ballast/deballast/injection) as required (see Figure 7-7 below).

Figure 7-7 Underbase Injection Systems



The refloat systems will be controlled and monitored using equipment located in an operations control centre on the Platform, and later by remote control from a remote operations control centre located on the operations control vessel.

7.3.9 Subsea/Diving Activities Pre-Refloat

Prior to refloat, a range of diving activities will take place, including:

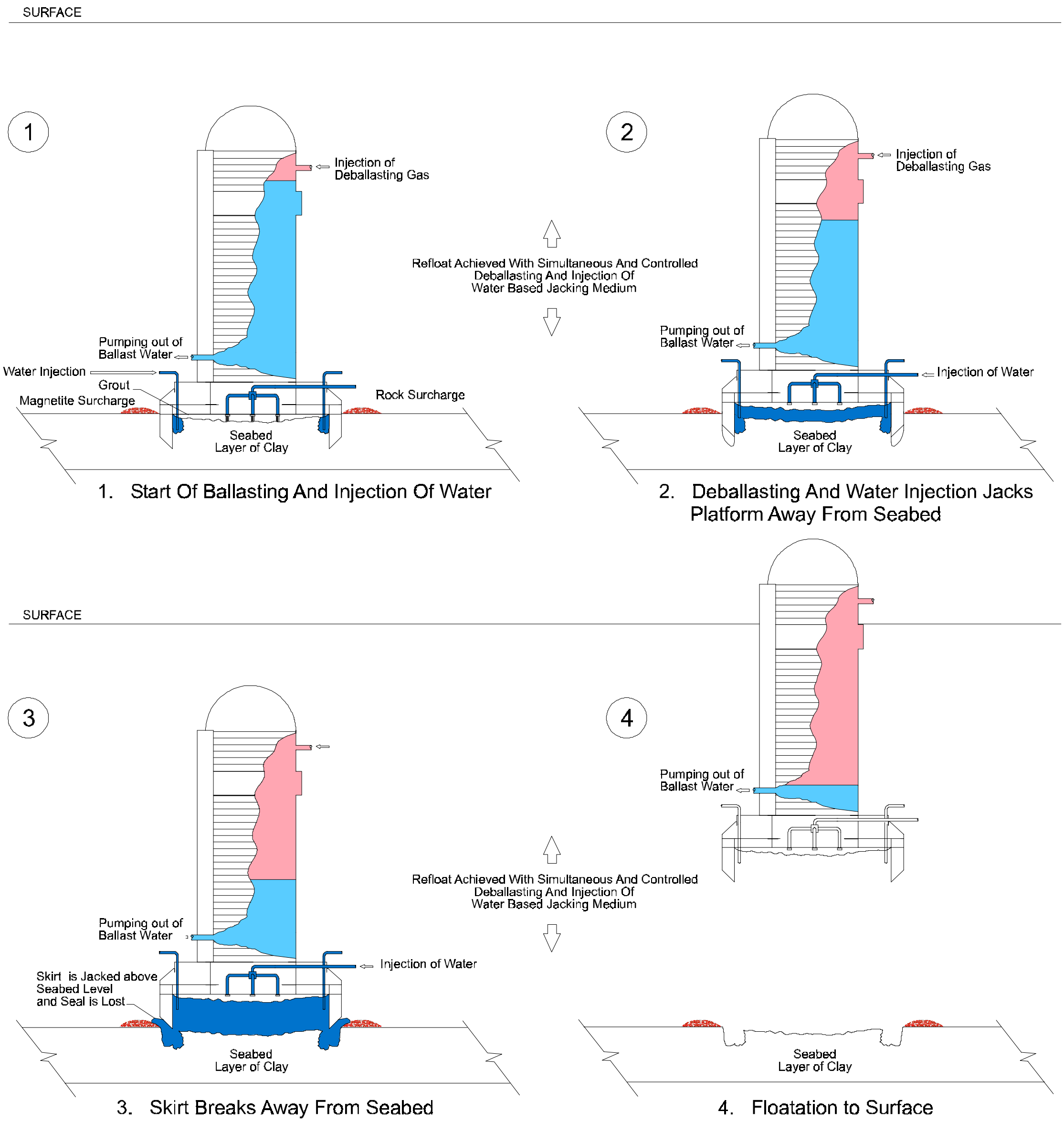
- Pre-activity surveys and removal and recovery of debris
- Removal and recovery of the concrete protection mats over pipelines
- Installation of soil surcharge (see subsection 7.3.7 above)
- Disconnection and plugging of the pipelines (see Sections 9 and 10)
- Installation and connection of the equipment on the base of each tank (see subsection 7.3.8)
- Installation and deployment of the tow equipment systems.

7.4 Refloat Sequence

7.4.1 Overview

Figure 7-8, below, provides an overview of the refloat operation. The refloat sequence is described in more detail in the following subsections.

Figure 7-8 Overview of Refloat Operation



7.4.2 Deballasting

Deballasting is carried out to reduce the water volume in the tanks and thereby decrease the on-bottom weight. Pump modules mounted on the skirt bases are used for this purpose.

Initial deballasting is carried out by pumping water out of the tanks and simultaneously injecting nitrogen into them. The nitrogen is supplied from nitrogen generation equipment packages which will be located on the Platform deck. This nitrogen will be at a pressure required to equalise the internal tank pressure with the outside sea water pressure ensuring that the stresses placed upon the tanks themselves during refloat do not exceed the design parameters of the structure. Initially a small volume of water (approximately 100 m^3) must be discharged from each tank to allow the nitrogen gas charge to be introduced in the voids at the top of each tank. This water will be pumped into a marine vessel for transport ashore for treatment at a specialist disposal facility.

The plan is to discharge all the remaining water from within the storage tanks to a tanker moored at the Maureen Loading Column. This tanker will subsequently transport the water to an onshore ballast water treatment facility.

The nitrogen will be supplied from equipment which will be located on the Platform deck. Following this stage, the Platform manning will be reduced so that only the minimum number of specially trained refloat operations control crew remain onboard.

7.4.3 Breakout (Skirt Extraction)

The skirts will be extracted from the seabed after placement of the soil surcharge by controlled use of the underbase injection systems (see Figure 7-7) and by partial deballasting, as shown in Figure 7-8. The major steps will be as follows.

First, the skirts will be extracted from the seabed by injecting sea water into the underbase skirt compartments below each tank. At several stages during the skirt extraction small amplitude cycles of extraction/penetration of the skirts out of/into the soil will be carried out in order to calculate the actual weight and the weight distribution of the Platform and to estimate residual skirt friction. This will allow correct trimming of the structure for the float up.

Next, a combination of underbase seawater injection and deballasting of the storage tanks will further extract the skirts and trim the Platform.

The Platform will then be fully de-manned, and the further refloat operations remotely controlled and monitored from the operation control vessel.

Water injection will continue until no further vertical movement is possible. By this point the Platform skirts will be free from the seabed and float-up can begin.

Personnel will only be permitted to return to the Platform during this phase (or during float-up) in exceptional circumstances, such as an equipment failure or malfunction that prevents the continuation of the refloat process. Detailed safety procedures and emergency response plans are being developed to cover this eventuality.

7.4.4 Float-up

After breakout the Platform will be further deballasted, raising it to the correct towing draught, all the time trimming the ballast to maintain the Platform on an even keel. During the initial refloat while the Platform is still close to the seabed the upward movement of the structure will cause significant water movement. This is likely to cause disturbance to drill cuttings beneath the Platform. The effects of this have been simulated by BMT Marine Information Systems Limited (BMT)[7]. The conclusion of this prediction indicates that drill cuttings will not be redistributed beyond the existing cuttings layer.

Following the refloat the Platform will be held on location by an arrangement of towing vessels (see subsection 7.5.2).

Computer simulations carried out in 1999/2000 by Offshore Design Engineering Ltd[8] and the selected refloat contractor have determined that the Platform will be stable under all phases of this operation. Even in the unlikely event of an unexpected failure of the operation, the water depth at Maureen and the geometry of the Platform dictate that the worst the Platform could tilt is 14^{o} whilst one base rests on the seabed. Structural calculations have shown that even in a worst case this would not cause the Platform to suffer significant damage and recovery from this position could be effected. All equipment will be secured to withstand a tilt of 20^{o}, even though a 14^{o} tilt is the maximum possible tilt during the refloat.

7.5 Maureen Platform Tow to Deep Water Mooring

The Maureen Platform will be towed to a deep water location for mooring, inspection and residue removal (Appendix F summarises the estimates of trapped oil and oily residues), followed by reuse or deconstruction. Possible locations for the deep water mooring will be limited owing to the demating draught requirements (125 m) of the Platform. The mooring will require deep, near-shore, waters. The location will be selected through careful evaluation of contractor bids, taking into account environmental, health, safety, technical and economic factors.

7.5.1 Marine Operations

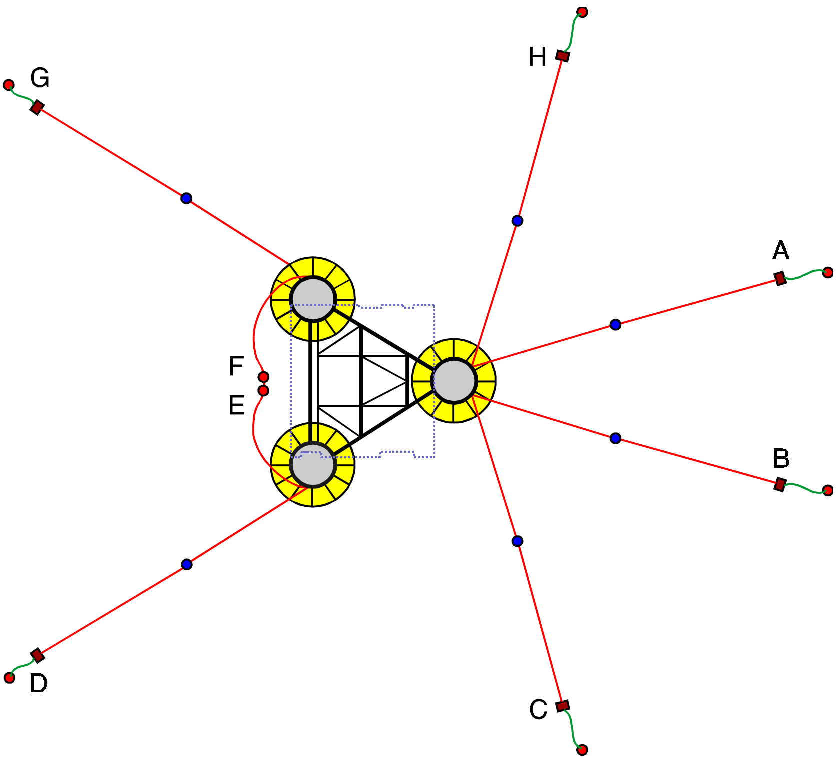
All marine operations on the United Kingdom Continental Shelf will be conducted in accordance with the Maureen Operator's established procedures[9].

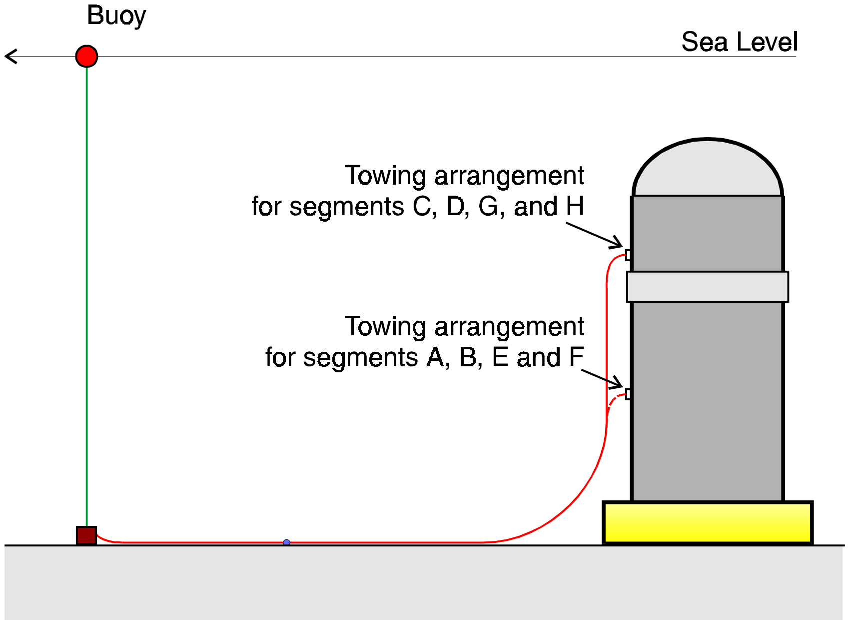
7.5.2 Initial Deployment of Towing Vessels

The Maureen Platform will be towed by six vessels having a total combined pull of not less than 700 te. No one tow vessel will have a pull of less than 100 te.

The six towing vessels will be hooked up to the Platform on completion of the nitrogen filling of the storage tanks. They will be connected using pre-installed towing pennants which will be laid out on the seabed and buoyed to the surface as shown in Figure 7-9.

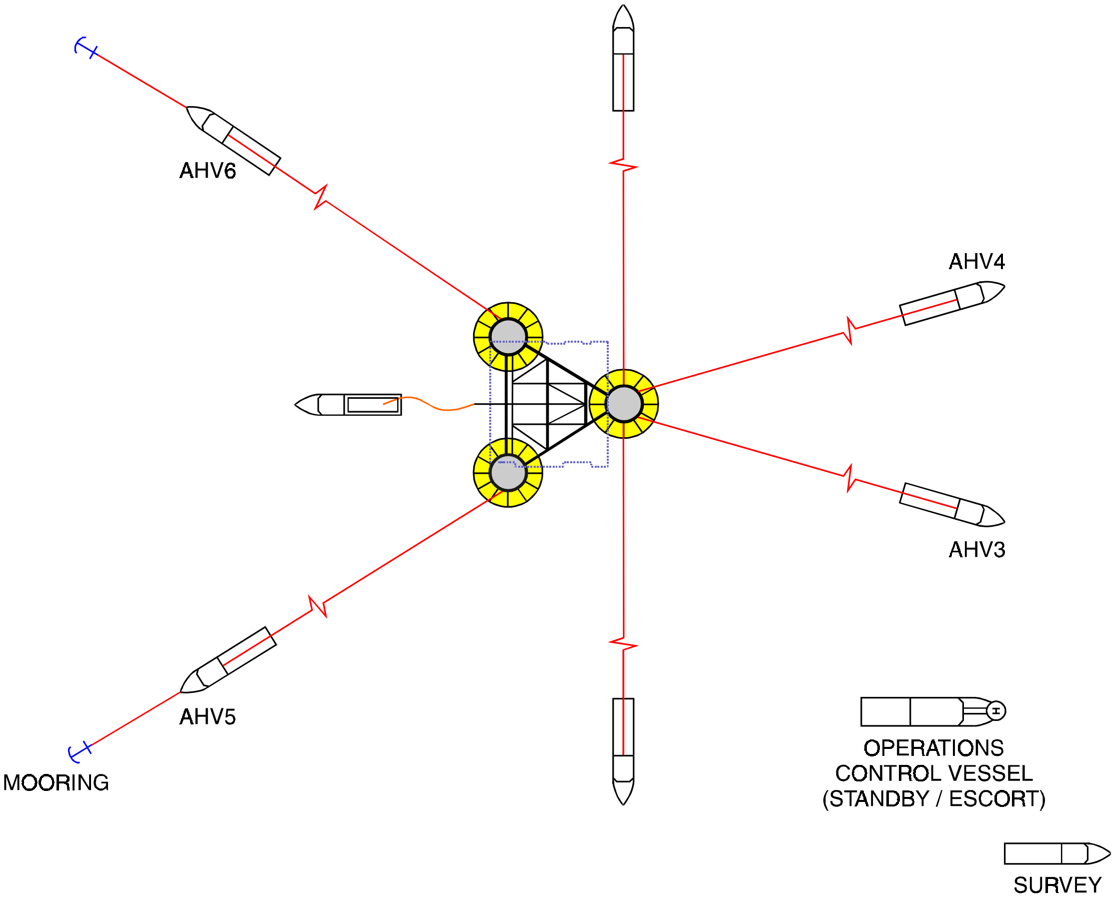
Figure 7-9 Layout of Tow Equipment





The towing vessels will initially be deployed in a "star" configuration to provide necessary station keeping during the float up operation. This is shown in Figure 7-10 in which it can be seen that towing vessels, AHV5 and AHV6, are also connected to two mooring on the seabed.

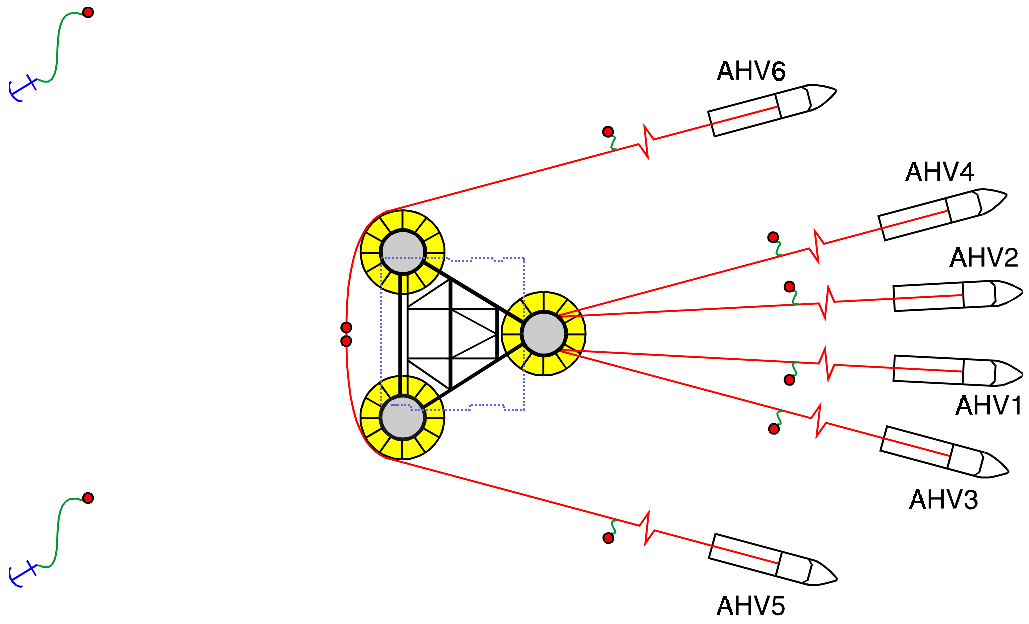
Figure 7-10 Initial Deployment of Towing Vessels



7.5.3 Towing Operations

The tow operation will begin when the towing draft of approximately 65 m is achieved. The two moored towing vessels will initially remain moored and pay out their tow wires until the Platform has moved sufficiently to no longer be vertically above the Drilling Template. The Platform will then be stopped and the two moored towing vessels will be disconnected from their moorings leaving recovery buoys in the water. The towing configuration will then be as shown in Figure 7-11.

Figure 7-11 Towing Configuration



Tow Fleet

In addition to the six towing vessels, an offshore control vessel (OCV) and a survey vessel (shown in Figure 7-10) will be included in the tow fleet:

The OCV will escort the tow to remotely monitor the operation of equipment on the Platform. It will also act as an emergency replacement tow vessel should one of the six tow vessels become unable to continue with the tow.

The survey vessel will run ahead of the tow and will use a side scan sonar to check the tow route for unexpected obstructions. A pre-tow route survey will have been performed within 6 months prior to the tow, so this survey will confirm that the route has not been obstructed during the intervening period. The survey vessel will also check the tow route behind the tow to confirm that no obstructions have been placed in the route as a result of the tow. Any pipelines crossed will be identified and inspected using an ROV before and after the tow. The survey vessel will also act as a guard vessel for the tow by passing warnings to other traffic in the area to insure a clear path is maintained.

Tow Routes

There are several possible tow routes that can be used to take the Platform from the offshore site to the potential inshore mooring sites. These vary from 165 nautical miles (nm) to 600 nm in length. The tows are anticipated to take between approximately 3 days to two weeks depending on which inshore mooring site is selected. The average tow speed is anticipated to be between two (2) and 2.5 knots (nm per hour).

Deep Water Mooring Operations

When arriving at the deep water mooring the towlines may be shortened, to maintain control of the tow, and the towing vessels will again be positioned in a "star" configuration prior to connecting to the inshore mooring system.

7.5.4 Platform Requirements for Mooring

Preliminary analysis of the mooring system requirements for the Platform, such that it remains stable under 100 year storm conditions, has been undertaken for each potential mooring site using the wind and wave conditions specific to it.

Final analysis and detailed design will be undertaken for the selected mooring site once the contract for this work has been awarded.

7.6 Disposal of the Maureen Platform

7.6.1 Option Selection Process: Reuse or Recycle

The Maureen Owners have not yet made a final decision on whether to reuse or recycle the Maureen Platform, as every reasonable effort is being made to secure a reuse opportunity for the installation in accordance with the principles of the waste hierarchy. The efforts being made to secure full or partial reuse of the Maureen Platform are described in subsection 6.4.

In the event that the Maureen Owners determine that no suitable reuse opportunity has or will be found for the Maureen Platform within a reasonable timeframe, it will be deconstructed and its materials recycled onshore. This is described in the following subsection.

7.6.2 Demating of the Topsides from the Substructure

If reuse of the topsides on another substructure is considered, or if it is finally decided that dismantling is the alternative to refurbishment and reuse of the Platform, the topsides will be demated from the substructure.

The main steps planned for demating the Platform topsides from the substructure are described below. The description comprises all marine activities involved in the proposed demating method. In overview:

- A reversal of the original mating method will be followed
- A thorough preparation of all structural components and commissioning of all equipment will be completed prior to start of the operation
- The operation will be divided into logical steps with comprehensive on-site evaluation of measurements and full control of the situation before continuing to each successive step.

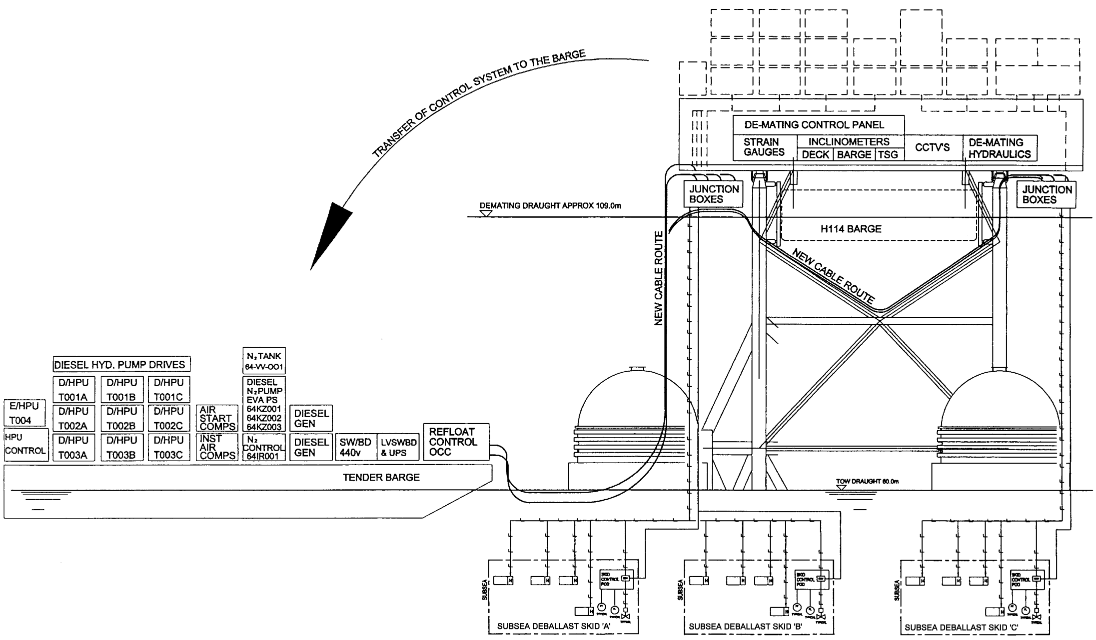
It should be noted that the optimal sequence for demating will be ascertained during detail design. This will take into account aspects such as pumping capacities of the barge and substructure, geometrical constraints, etc.

The Maureen Platform will be safely moored and ready for demating at the start of the operations described below. In particular, all ballast tank pressurising and levelling systems installed for the Platform refloat operation will be fully operable.

Demating activities

Figure 7-12 provides a view of the possible demating system.

Figure 7-12 Platform Demating System



A breakdown of the main demating activities is as follows:

a) Ballast down the Platform to a draught for receiving the demating barge

b) Tow the demating barge into position under the topsides and lower the substructure to make contact

c) Load transfer from the substructure to the barge

d) Seafasten the topsides to the barge

e) De-mate topsides and substructure

f) Manoeuvre barge away from the substructure then bring substructure up to parking draught.

A total elapsed time of about 1.5 days is anticipated.

The total operation has to be carried out within a defined weather window. Critical phases that depend on the weather are the manoeuvring of the barge in and out from the substructure. Before the start of operations a corresponding weather window has to occur and approval has to be obtained from the Marine Warranty Surveyor.

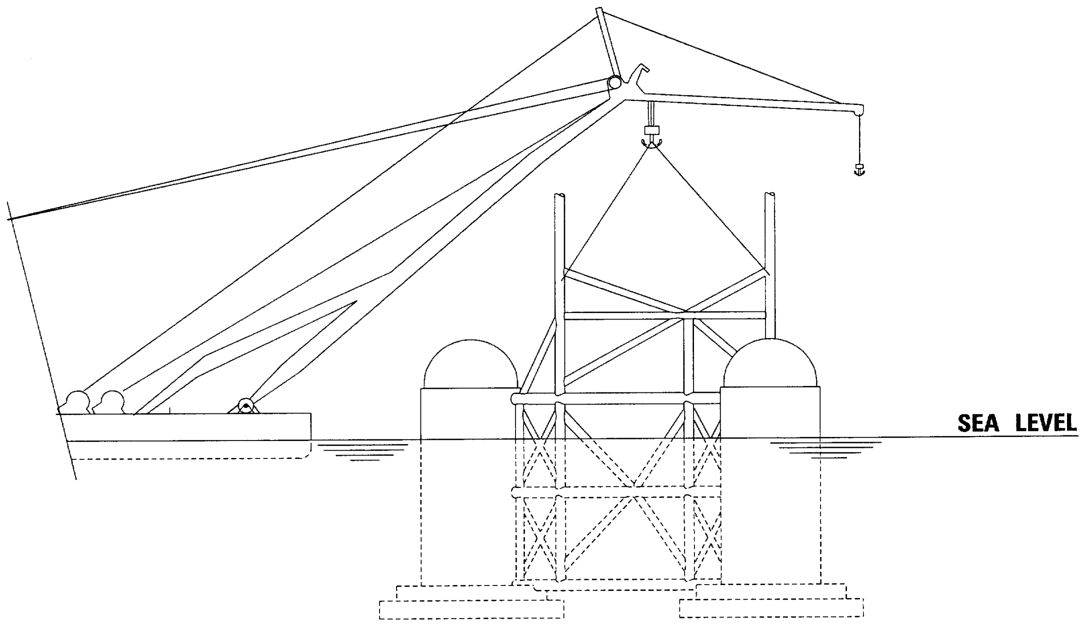
7.6.3 Substructure Deconstruction

If the substructure is to be deconstructed, the work will be carried out in a safe manner and in accordance with controlled methods. Deconstruction will be effected using a high-capacity shear-leg derrick crane (or equivalent) for lifting structural members and frames. Care will be taken to minimise subsea work during deconstruction.

The substructure will be deconstructed in the following sequence:

a) The upper jacket section of the substructure will be dismantled (down to approximately 36 m below the deck level) as shown in Figure 7-13.

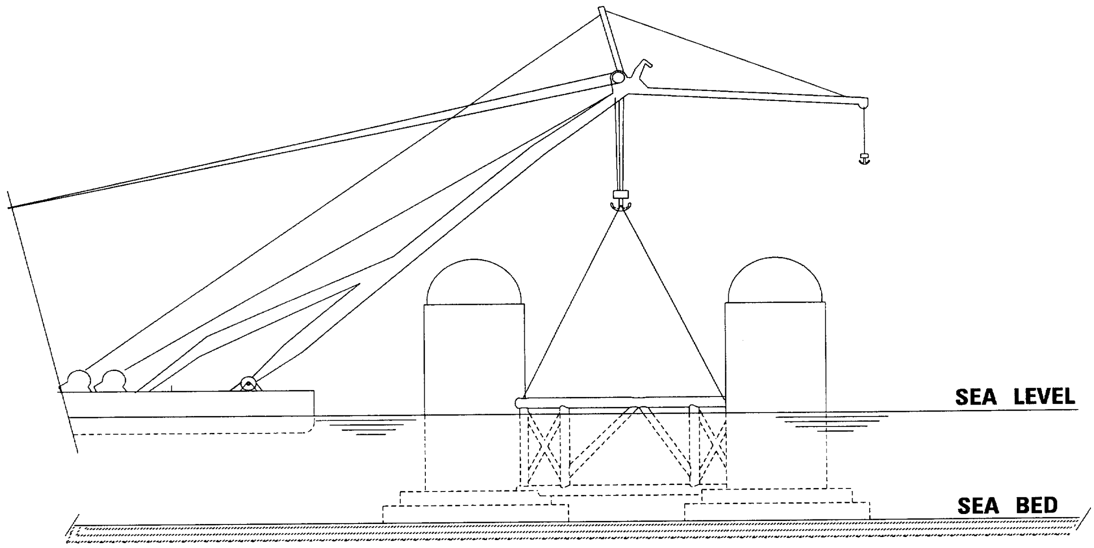
Figure 7-13 Dismantling of Upper Structure



b) The remaining part of the substructure will be transported to a suitable location with a flat seabed. Such a location would exist close to the selected demolition site.

c) The remaining lower lattice framing will be dismantled as shown in Figure 7-14.

Figure 7-14 Dismantling of Lower Lattice Frame



d) The storage tanks will be deballasted and transported to a demolition/reuse site.

e) The orecrete in the three storage tank bases will be removed and recycled in a safe and environmentally acceptable manner.

7.6.4 Topsides Deconstruction

The topsides will be transported on the demating barge to the deconstruction site where the total topsides structure will be transferred to temporary supports in a dry dock or skidded/trailered onto a deconstruction pad. The deconstruction area will contain surface drains to allow collection of any remaining liquids within the topsides and the subsequent disposal by appropriate methods.

The method of deconstruction will generally be the reverse of the original construction method as follows:

- The topsides modules will be removed using onshore/inshore craneage
- The upper deck equipment and deck panels will be removed
- The mezzanine and lower deck equipment will be removed
- The lower deck panels, access ways, staircases will be removed
- The primary steelwork will be dismantled frame by frame
- The modules and large items will be further dismantled for disposal by recycling.

Pipework and any remaining equipment containing LSA will be sealed and shipped to an approved specialist contractor for disposal. Any other hazardous wastes will be removed and stored in suitable containers prior to proper disposal by approved sub-contractors.

7.7 Removal of the Drilling Template

7.7.1 Overview

The principal activities are as follows:

1) Retrieve and dispose of the mooring piles and docking piles.

2) Plug and abandon all the wells (this activity has already been approved under the relevant legislation and has now been completed – see description in subsection 7.3.2).

3) Sever the conductors of each well approximately 3 m below the mudline and again above the wellhead.

4) Recover the conductor strings.

5) Recover the wellheads.

6) Displace debris and drill cuttings where necessary to gain diver access to the tops of the foundation piles.

7) Remove spoil from within the foundation piles and then cut them internally with a hydro-abrasive cutter and retrieve them to the surface.

8) Lift and dispose of the Wellheads and Drilling Template.

7.7.2 Cutting and Retrieving the Docking and Mooring Piles

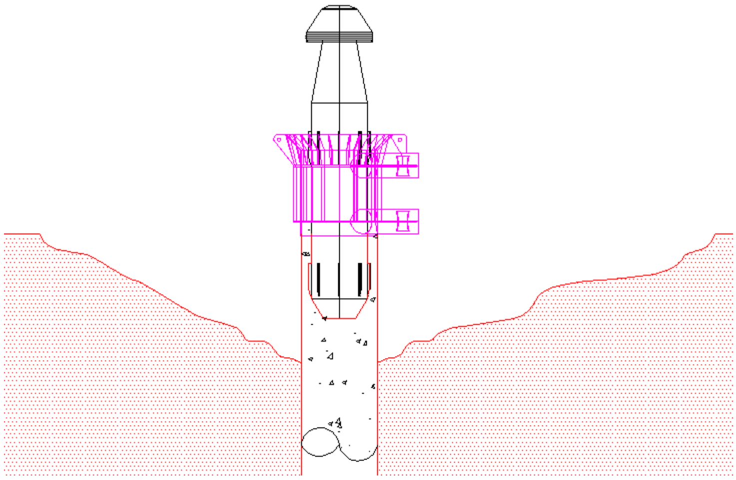
It is probable that the Template docking piles and the Platform mooring piles will be cut during the same mobilisation of an appropriately equipped vessel. The following summary therefore describes both the treatment of the two docking piles and the four mooring piles.

Docking Piles

The two concrete-filled docking piles are situated adjacent to the Drilling Template. The objective is to cut each of the two docking piles approximately 2 m below the seabed in order to ensure that the seabed will be left clear and remain so. The upper sections of the docking piles will be recovered to the surface and brought onshore for recycling.

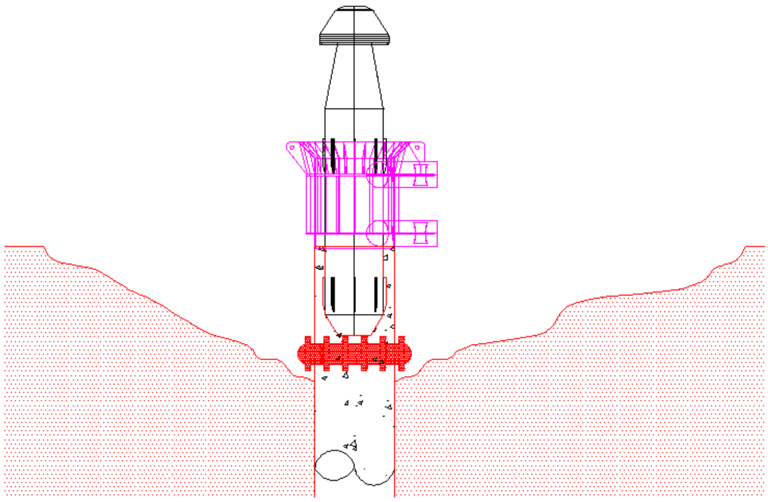
In order to gain access for cutting at the appropriate depth below the seabed, the steel docking piles must be partially exposed by removing some seabed material. A dredging system, operated either by a diver or an ROV, will be deployed from a diving support vessel to expose the piles with minimum disturbance to the surrounding seabed. A dredging system can be closely controlled in terms of material removed and spoil deposition, thereby minimising such disturbance. The displaced material from the pile excavation will be deposited adjacent to the hole. This will naturally backfill once the pile structure is removed. Figure 7-15 shows the excavation prior to cutting.

Figure 7-15 Seabed Excavated to Gain Access to Docking Pile



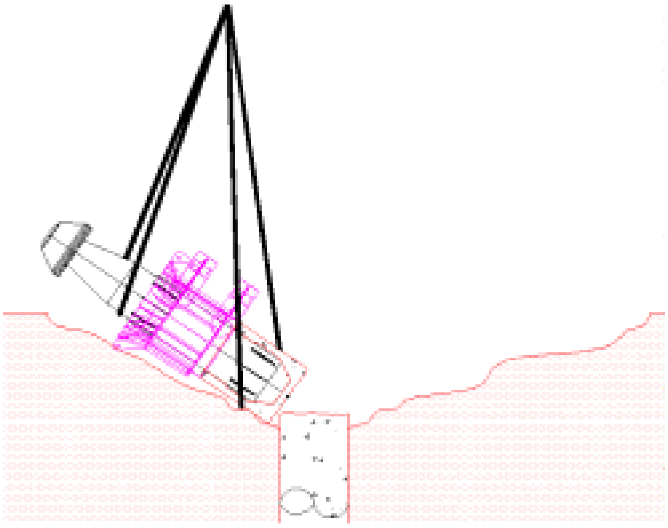
The steel docking piles will be cut using small, shaped explosive charges that will be attached as shown in red in Figure 7-16. The use of shaped charges is the safest option and standard practice for cutting large tubulars such as these and will also minimise disruption of the seabed and drill cuttings.

Figure 7-16 Cutting Charges Attached to Docking Pile



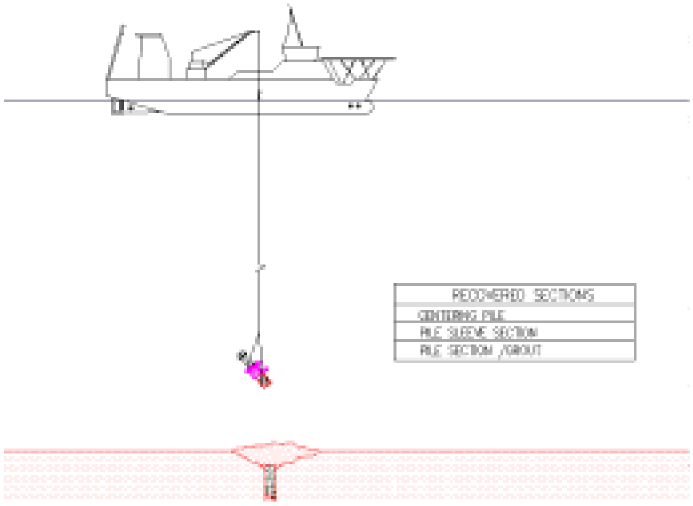
The cut docking pile will be prepared for recovery by divers, as indicated in Figure 7-17 overleaf.

Figure 7-17 Docking Pile Prepared for Recovery



The docking pile will be recovered by the Diving Support Vessel (DSV) as shown in Figure 7-18. The seabed will then be left in an overtrawlable condition with no obstruction remaining.

Figure 7-18 Docking Pile Recovered to Surface



Mooring Piles

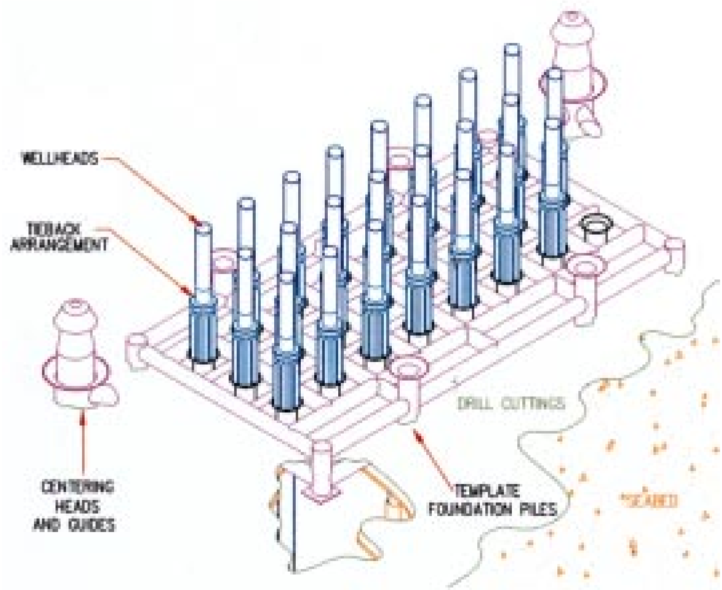
There are four steel mooring piles located approximately 1900 m from the centre of the Platform on NW, NE, SE and SW bearings. These are smaller than the docking piles and were used to assist the Platform installation. The four steel mooring piles will be treated in a similar manner to the docking piles. Each of the four piles will be cut below seabed level and the recovered section will be sent ashore for disposal.

7.7.3 Lifting the Wellheads and Drilling Template

The proposed method for removal of the Maureen Drilling Template has been revised owing to changed circumstances arising during the execution of the Maureen Decommissioning Project. The new methodology is presented in Addendum 1 of this Maureen Decommissioning Programme.

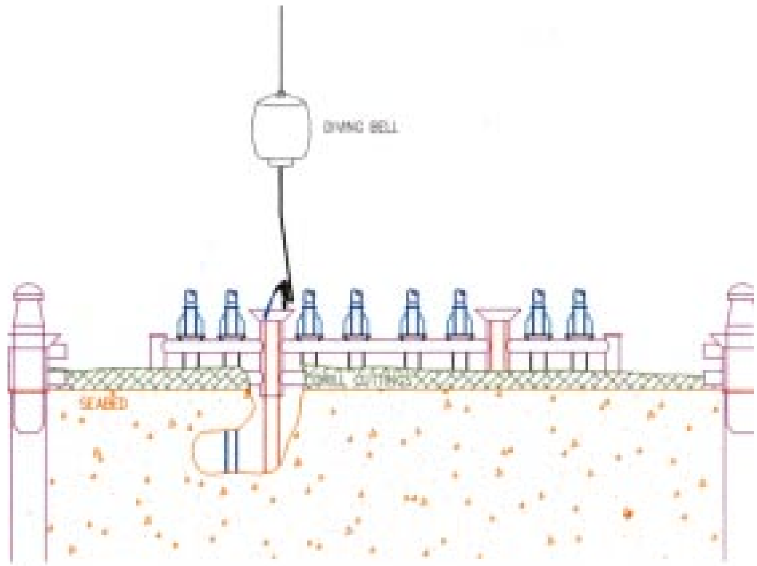
A general view of the Drilling Template is shown in Figure 7-19. The Template will be removed intact and then cut into sections at the surface before the sections are transported to shore for recycling.

Figure 7-19 Drilling Template



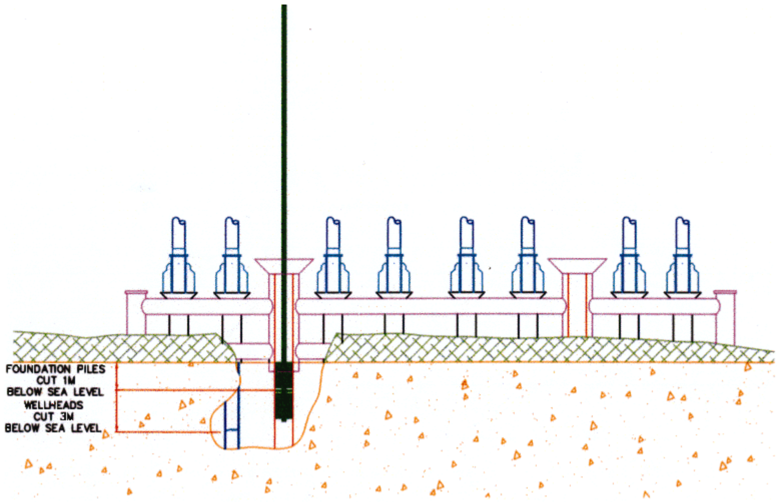
To lift the Template intact, the four 42" steel foundation piles which attach it to the seabed must be cut. The foundation piles will be cut below the seabed after the well conductors are cut. This will be achieved by first removing spoil from within the foundation piles, as shown in Figure 7-20, to allow insertion of a hydro abrasive cutter.

Figure 7-20 Jet Out Spoil from within Foundation Piles



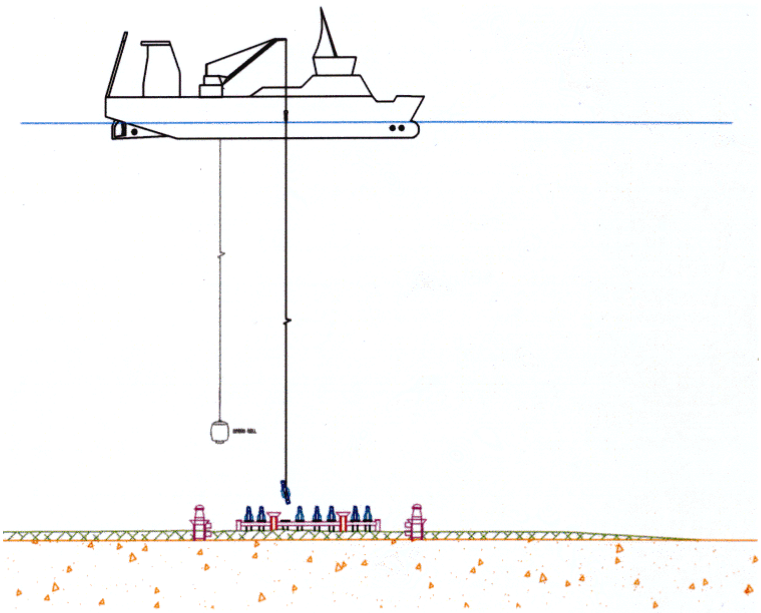
After the spoil is removed from within the foundation piles, a hydro abrasive cutter will be inserted into one of the foundation piles in order to sever it approximately 0.6 m below the seabed, as shown in Figure 7-21.

Figure 7-21 Using Hydro Abrasive Cutter, Sever Piles Below Seabed Level



Having performed all cutting activities, the wellheads will be recovered to the deck of the DSV, as shown in Figure 7-22.

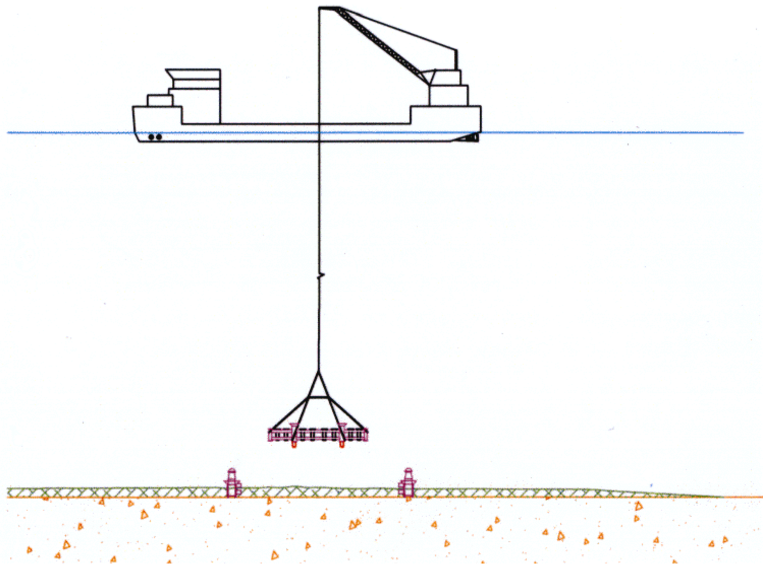
Figure 7-22 Recover Wellheads with DSV



The Drilling Template will be recovered from the seabed using a Heavy Lift Vessel (HLV), as shown in Figure 7-23. The lifting rigging will be designed to accommodate any deterioration in the original lifting points and supplementary slings may be utilised. The Template installation weight was about 490 te in air. For purposes of planning removal operations, this weight will be factored to take into account any pile remnants, grout within sleeves or drill cuttings residing upon structure members.

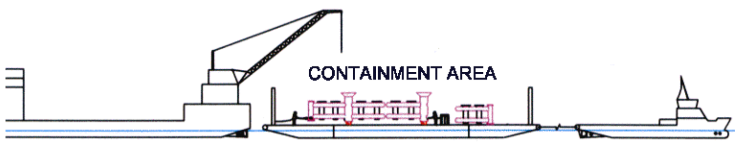
In preparation for removal, an attempt will be made to dislodge loose drill cuttings from the Template structure. This will allow the cuttings to fall back into the Template "footprint" prior to recovery through the water column to the surface. This removal of material from the template has been modelled predictively by BMT[7]. The modelling presumes an extreme case where the cuttings are blown from the structure. Even this corroborates the expectation that the cuttings will return to the seabed within the existing cuttings layer.

Figure 7-23 Recover Template Intact Using HLV



The HLV will load the Template onto a barge as shown in Figure 7-24. This barge will contain a "sealed containment area", which will safely retain (for collection and subsequent treatment and disposal) all loose material lifted with the Template and any wash water and mud residues resulting from washing activities.

Figure 7-24 Template Loaded onto Barge, Washed and Cut



7.8 Drilling Template Disposal

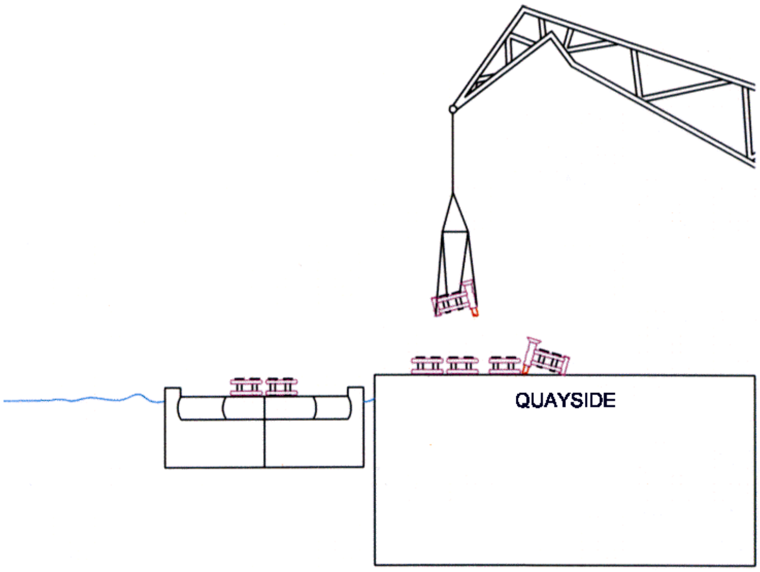
The Drilling Template, having been washed and cut into manageable sections offshore, will be brought onshore for disposal. The wash water and mud residues will be collected and transported to shore for treatment and disposal at an authorised facility.

Figure 7-25 Template Sections Towed to Port

Once they are cut, it will be possible to lift the Template sections with conventional equipment. The sections can therefore be offloaded at any one of a number of ports which have scrapping/recycling facilities nearby.

Figure 7-26 shows a typical transfer of the Template sections to shore.

Figure 7-26 Transfer Sections of Template to Quayside for Disposal



7.9 Environmental Considerations

Selection of the best decommissioning solutions for the Maureen Facilities was done through an overall analysis of a number of criteria, including environmental considerations. Thus, although an environmental impact assessment is not legally required for this Decommissioning Programme, the Maureen Owners have, nevertheless, taken due consideration of the environment when selecting the best decommissioning solutions for the Maureen Facilities. They have also determined that the selected removal and disposal options will not cause unacceptable environmental impacts.

In 1998 Cordah carried out an assessment of the environmental impacts of the operations to refloat the Maureen Platform[10]. The purpose of this study was to describe, and as far as possible, quantify the local marine environmental impacts that will arise as a direct consequence of the operations to refloat the Maureen Platform. The study assessed the impact of discharge of ballast water and the disturbance of seabed sediments during the refloat operations.

Further studies were undertaken by Cordah to determine the extent of thickness of the drill cuttings layer around Maureen and the concentrations of hydrocarbons and heavy metals in the cuttings layer. The conclusions have been subject to independent third party review[11].

A summary of the estimated environmental impacts is given below. Subsection 7.10 provides a more detailed discussion of the drill cuttings issue.

7.9.1 Discharges to Sea

To refloat Maureen, water must be discharged from all flooded spaces, e.g. ballast water from storage tanks and secondary spaces (lattice frame, double hulls). As explained below, the Maureen Owners have planned the decommissioning activities to ensure minimal discharges to sea, and have determined that any unavoidable discharges will have minimal or insignificant impacts.

Ballast Water from Storage Tanks

As the concentration of Total Organic Extractables (TOE) in the ballast water was less than 1 ppm, full discharge to sea could be considered as an option under the terms of the normal operating licence. The Maureen Owners, however, are planning to discharge all the ballast water from the oil storage tanks directly to a tanker for shipment to an onshore treatment facility. Thus, no discharges to the sea are expected to ensue from the deballasting.

The ballast water now in the storage tanks is seawater which was introduced following the flushing out of all the oil to the last tanker loading. No oil or other chemicals have been added to these tanks since that time. Consequently, as there is no active oil water interface in the tanks, the effects of the discharge of any oil that might be in this ballast water will be significantly less than the produced water and operational ballast water discharged throughout the life of the installation. During the life of the Platform, oil in water levels from this operation have been very low (1-5 ppm oil in water) even upstream of the treatment facilities. Detailed analysis by M-Scan[12] of the ballast water discharged from the subsea oil storage tanks between July and September 1999, revealed that the concentration of TOE was consistently less than 1 ppm. The small volume of water that must be discharged during introduction of the nitrogen charge into the same tanks is expected to have similarly low levels of oil-in-water concentration.

The closest analogue to the proposed discharges from the ballast tanks would be an assessment of the effects of oil in water discharges from producing Platforms. Few studies exist which have attempted this. Best evidence to date shows that the effects of such discharges are very small and limited to a very confined area around the point of discharge. In the case of Maureen, such an occurrence would be very short lived and, owing to the low volume to be discharged, will have minimal environmental impact.

Structural Fill Water

As part of the removal planning process, M-Scan undertook a detailed analysis of the structural fill water during the summer of 1999[13]. Sixteen samples were taken from the structure at different locations around the Platform. The analysis confirmed the presence of corrosion inhibitor in the water from most samples taken, but generally in low concentrations (<10 ppm TOE). Significantly higher concentrations of TOE were detected in two of the header tanks, but this was expected, as this is where the inhibitor is introduced to the system. Elevated levels of corrosion inhibitor were, however, found at three other sample points.

Treatment and disposal options for the structural fill water are still being assessed, but a third-party review of the M-Scan analysis by Rudall Blanchard Associates indicated that direct disposal to sea was not recommended without prior treatment. As no adequate treatment process offshore has currently been identified, the intent is to bring the structural fill water ashore for final treatment and disposal at a specialist disposal facility. Thus no discharges of structural fill water to the sea are anticipated from this source.

Ballast Water from Secondary Spaces

During the refloat operation the water in the secondary spaces will be displaced to sea by compressed air. This consists of approximately 9100 m^3 of water from the lattice frame and 3160 m^3 from the double hulls. These secondary spaces were flooded for stability reasons and have never contained any hydrocarbon fluids. The water in these spaces contains fluoresceine dye, at a concentration of approximately 35 ppm, which was injected into these spaces to assist with identification of leaks during pressure testing activities.

The results of ecotoxicological tests on fluoresceine indicate that the concentration used is well below the concentrations found to be lethal for the planktonic organisms used in the ecotoxicological tests. This fluoresceine-dyed water will be discharged directly into the sea and will be rapidly diluted to insignificant levels by the action of marine currents, and will have minimal impact on the surrounding environment.

Water in Storage Tanks While in Inshore Mooring

Ballast water discharged from the storage tanks while the Platform is moored inshore, will be discharged directly to a tanker for shipment to an onshore treatment facility. Thus no discharges to sea are anticipated from this source.

Conclusions Regarding Handling of Ballast Water

The possible impact from the discharge of ballast water from the Maureen Platform is judged to be minimal. This is because all the ballast water will have been removed for treatment onshore. There might be a slight impact (possibly visual owing to the non-toxic dye), from the secondary spaces and leak testing (if carried out) but it would be very localised and short-lived. It is not anticipated that elevated concentrations of pollutants in the water column would be found beyond the 500 m exclusion zone around the Platform. It is also likely that any local impacts that will occur will be short-lived and recovery would be underway within a few hours or days of the discharge.

The pelagic community comprises a range of organisms including plankton (phyto-plankton and zoo-plankton), invertebrates, fish and mammals. All may be vulnerable to various types of water-borne pollution. The most vulnerable groups are probably planktonic organisms (particularly the eggs and larvae of various species), and, to a lesser extent, fish. Strict control of discharges from Maureen during the refloat will ensure minimal impact on these species. It is likely that the marine activity in the area around Maureen will deter marine mammals from the area around the Platform during the refloat operation, so they are unlikely to be directly affected by any activities in the area.

Discharges During Retrieval of the Template

The base of the Drilling Template is located within the drill cuttings layer. The activities to access, cut and remove the Template and the Platform docking piles will disturb and cause some re-suspension of the drill cuttings. An effort will be made to dislodge any cuttings material from the Template prior to lifting it through the water column, and it is expected that most of the disturbed cuttings will quickly resettle on the existing cuttings layer. The impact of the Template removal on the drill cuttings is described in more detail in subsection 7.10.

Once the Template is retrieved to the surface, any cuttings and mud residues will be washed off the Template. The wash water and residues will be collected in a contained area and properly disposed of onshore, so no discharges to the sea are expected from this source.

7.9.2 Residual Contents of Storage Tanks

Internally the tanks are smooth-walled, as all the stiffeners are externally mounted, and other than the internal cupola, have few areas for trapping debris. For safety, refloat integrity and avoidance of accidental pollution, tank entry will not be attempted prior to refloat. However, until the storage tanks can be inspected while moored in the inshore mooring location, it is not possible to determine the exact extent of residues requiring disposal. A calculation to determine, as closely as possible, what these residues (trapped oil and oily residues) might be has been carried out. The methodology and results of this calculation are detailed in Appendix F. In any event, no discharges from this source are anticipated.

The oily residues may contain low levels of radioactivity and, consequently, their disposal will be subject to licensing under the Radioactive Substances Act 1993. In addition, should all the oily residues, as a waste stream, be disposed outside the UK they will be treated under the applicable waste shipment regulations. In particular a license would be sought under the Transfrontier Shipment of Radioactive Waste Regulations 1993. All necessary consents under the foregoing legislation will be obtained prior to carrying out the Platform removal.

7.9.3 Disturbance of the Seabed

Disturbance Caused by the Placement of the Soil Surcharge

Placement of the soil surcharge will cause disturbance of the drill cuttings. The impacts of this activity have been addressed and determined to be acceptable. This is discussed in subsection 7.10.

Disturbance Caused by Platform Refloat

Physical disruption of the seabed is only likely to significantly disturb the habitats of organisms or creatures living in and on the sediment adjacent to the tank skirts. A 5 m wide soil surcharge will be placed around the skirts in advance of the refloat to mechanically reinforce the seabed. Apart from the immediate effect of its placement the soil surcharge will prevent wider disturbance of the seabed during the refloat operation. No new areas of seabed will be affected by new depositions.

The benthic community could be affected by excessive pressure in the sediment, or smothered by sudden burial beneath sediment. They may also experience non-lethal impact, for example, as a result of the destruction of dwelling tubes, of anchor points, or of the local ecosystem on which they depend for their food. Predictive work on the Platform removal indicates that these effects will not be significant, even if present.

The benthic community around Maureen comprises typical North Sea Polychaete worm species such as *Paramphinome jeffreysii* and *Chaetozone setosa*. The AUMS survey in 1988[14] did not reveal any evidence of the presence of an unusual or rare community, or one that was particularly vulnerable or sensitive to disturbance.

In areas where there is a substantial covering of drill cuttings, there may already be an impoverished or absent benthic community. As the cuttings are not going to spread over and cover any clean sediments (Reference BMT[7]) then the disruption of the cuttings will not lead to any environmental impact. Drill cuttings are considered in further detail in subsection 7.10.

Conclusions

The disturbance of sediments around the skirts generated by the slow movement of the Platform during refloat is likely to cause only limited impact to the local benthic community. This impact is categorised as being minimal, because the community disturbed would represent only a tiny fraction of the community in the area. The area disrupted would begin to be re-colonised within months of the disruption ceasing; and the extent of the impact would be confined to a much smaller area than the 500 m safety zone around the Platform.

7.10 Management of the Maureen Drill Cuttings

7.10.1 Overview

An oval shaped layer of drill cuttings approximately 150 m long and 100 m wide lies underneath the Maureen Platform and around the Drilling Template. The layer has an average height of 60 cm within the footprint area of the Platform and a single peak of 1.3 m. Based on recently collected data, Cordah[15] estimates that of the 21,000 te of drill cuttings originally discharged, approximately 6000 te of drill cuttings remain under the footprint of the Maureen Platform today (see also Description in Section 4).

The Maureen Owners have considered short-term and long-term actions, as well as overall impacts, of several alternatives that address the ultimate disposition of the Maureen cuttings layer. The Maureen Owners evaluated several options to implement active remediation efforts, but discarded these options because evaluations concluded that, based on existing data, leaving the cuttings layer in place is the best overall solution.

The Maureen Owners have concluded that the Platform and Drilling Template removal operations will result in disturbances to the cuttings layer, but these will have localised and short-lived effects. Procedures are being developed to assure disturbance is minimised (see subsections 7.3 to 7.9).

7.10.2 Evaluation to Determine Best Solution for Maureen Cuttings Layer

Drill cuttings piles beneath platforms in the North Sea vary significantly in their content and distribution. This means that each cuttings accumulation requires evaluation on a case by case basis. Piles may vary considerably, depending on history of operations, types of drilling fluids used and local conditions such as outfall height, bottom currents, and depth. The Maureen accumulation, which consists of 75% water based drilling mud, is, consequently, different from all other cutting piles.

To accurately evaluate that impact, it is essential first to determine the extent and content of the pile. Maureen is unique in that extensive studies have been conducted, documenting conditions, from pre-drilling surveys throughout the life of operations, to post drilling conditions. Of course, the intent of earlier studies was different from recent studies, and different components, or different method analyses often prevents direct comparisons through time. However, generally, information on metals and hydrocarbon has been obtained, and where comparisons can be made, has proved very useful in spotting trends and identifying chemical or physical processes taking place.

The Maureen cuttings layer is a relatively small quantity/thin layer which, through weathering, has been, and appears to continue to be diminishing with time.

Three separate evaluations (described below) contributed to the overall assessment, which identified the "leave in place" option as the best solution for the cuttings layer at Maureen, based on the current state of knowledge. These are the:

- cuttings layer impact evaluation
- evaluation of disposal alternatives (comparative assessment)
- evaluation of removal impacts.

An assessment of overall impacts and the combined affects of those impacts followed this. The evaluations are described below.

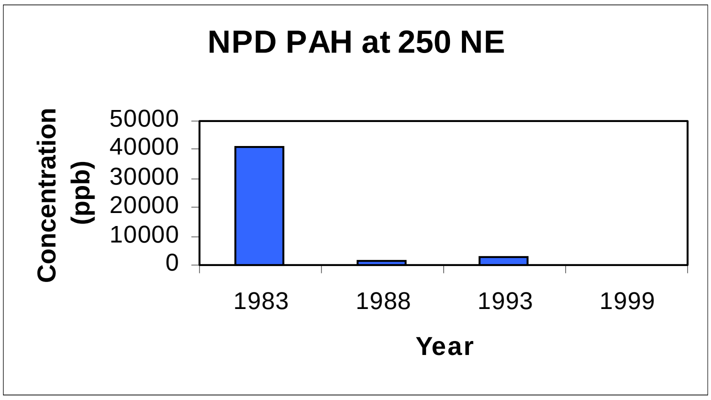
7.10.3 Cuttings Layer Impact Evaluation

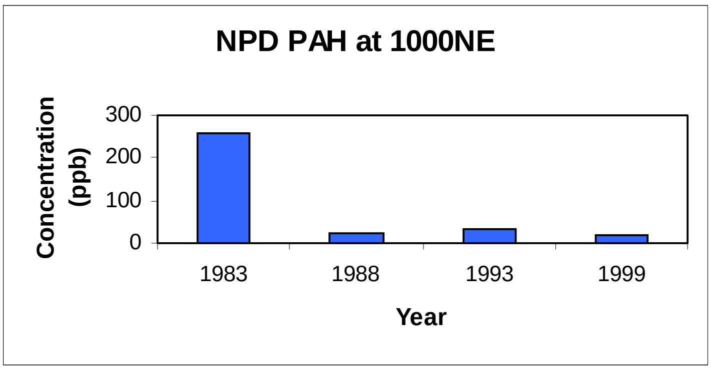
As mentioned, the first step in considering the necessity of implementing remedial measures with respect to Maureen cuttings, is to determine the extent and content of the cuttings layer and the overall impact the layer might have, over time, if left in place.

In general, the primary concerns with drill cuttings accumulations, especially those containing oil based muds, are the presence of hydrocarbons and heavy metals. Based on previous surveys and ongoing research it was anticipated that the small quantity of cuttings spread in a thin layer (average of 60 cm high within Platform footprint) at Maureen existed in a condition which allowed the surface layer (a significant portion of a thin pile) to remain aerobic and conducive to natural degradation. Extensive surveys have been conducted (as described in Section 4) at Maureen which do indicate that through a natural weathering process, the Maureen drill cuttings accumulation is diminishing, hydrocarbons are biodegrading, and the area is gradually recovering to pre-drilling conditions.

This hydrocarbon degradation process is depicted in the graphs in Figure 7-27. These show a significant decrease in NPD PAH concentrations from 1983 to 1988 when initial drilling activity had ceased and no discharges to the pile were made. This decreasing trend continued from 1988 to 1999 and will most likely continue with time owing to the low volume and large surface area of the Maureen cuttings layer.

Figure 7-27 NPD PAH concentrations and THF (Cordah Graphs)





The degradation process is supported by preliminary conclusions of the Phase I UKOOA drill cuttings JIP studies that determined that hydrocarbons in the surface sediments decompose rapidly. The JIP *in situ* environmental study 2.3 (Natural Degradation and Estimated Recovery) found evidence of a variable range of contaminants with potential for natural biodegradation in a pile, and concluded that seafloor transport and erosion, in general, is likely to be of greater significance at a pile than natural sedimentation rates. Biodegradation rates vary between piles and within piles, and it is primarily the larger piles with low surface area that limit the oxygen penetration deeper within the pile and inhibit, or slow, natural degradation.

The second primary concern presented by drill cuttings is the presence of heavy metals. The Maureen studies show that in most cases, the concentrations of metals recorded during the 1993 survey were higher than in previous surveys (see Section 4 for more detail). In addition, the concentrations determined in 1993 were almost exclusively higher than those recorded in 1999. In 1999, concentrations had reduced to levels comparable with the pre-drilling surveys. There is evidence to suggest that metals have been removed from the survey area through winnowing or some other mechanism with the result that the area of the field is being remediated.

The concern then arises that metals, dispersed as cuttings piles weather, are merely spread throughout a greater area increasing the potential impact of a pile. This concern is addressed in the conclusions of the Phase I UKOOA drill cuttings JIP study 2.2 (*In situ* Environmental Impacts - Contaminant Leaching). This study observed that metals are precipitating as mono and disulphides within drill cuttings piles. It was also determined that there are low exchange rates of metals with overlying seawater. These conclusions mean that metals are immobilised and not bioavailable.

In addition to reviewing the Maureen drill cuttings impact with regard to hydrocarbon and metal content, macrobenthic infaunal condition was considered. Earlier studies have indicated a pattern of effect, shown by infaunal communities, in relation to organic enrichment (Pearson & Rosenberg, 1978[16]). This is apparent in reviewing results at Maureen. Generally, throughout the area, as diversity of the macrobenthic infauna increases in an area over time, hydrocarbon concentrations are generally decreasing in that area.

Figure 7-28 depicts areas of relative faunal disturbance in sediments around the Maureen Platform, and areas where faunal communities have begun to recover. The faunal communities within 200 m NW/SE of Maureen were clearly impacted with no evidence of recovery to date. These sites had low diversity values and low numbers of species. It is highly likely, however, that these sites will begin to recover in the future (Cordah[17], April 2000).

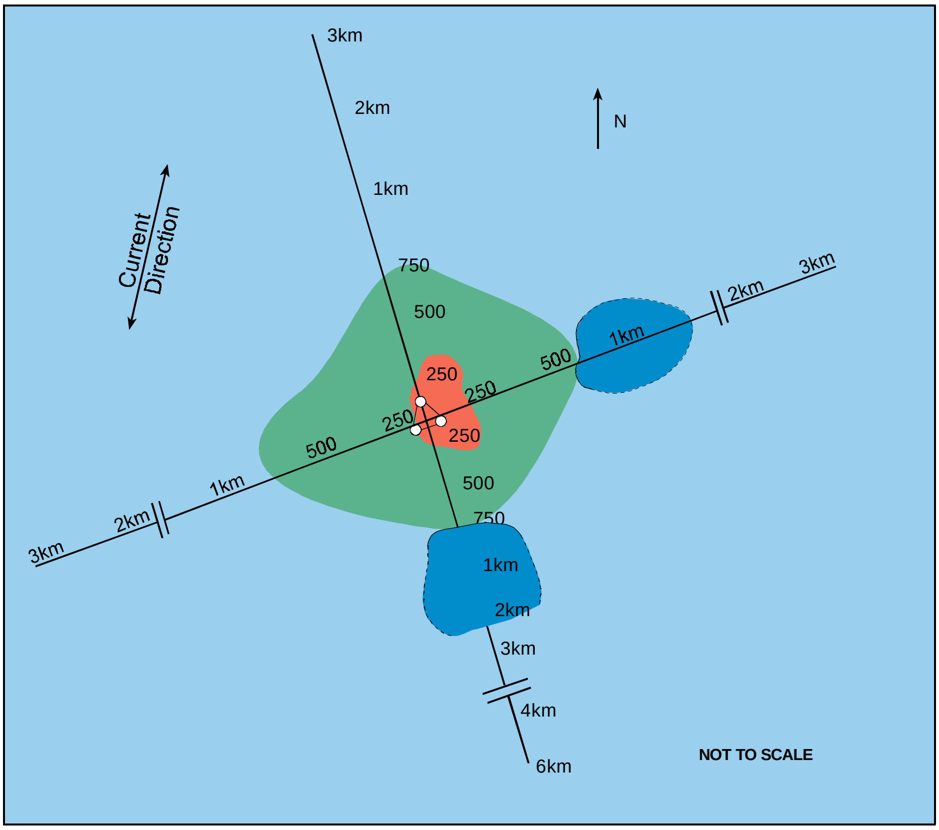
Surrounding this area was another, extending to 500-750m from the Platform, which was characterised by fauna with a different disturbance pattern. There is evidence that the fauna within this area had begun to recover from previously disturbed levels, but which were not yet of the same structure as the non-impacted sites further out. Sites that were considered to be non-impacted were those that had no alteration of faunal structure (Cordah)[17].

On the NE and SE transect legs, however, in areas extending from about 750m to 2 km from the Platform, were areas where the condition of the faunal communities (as exemplified by diversity indices and species richness) had begun to decrease. This pattern of increasing disturbance might be due in part to the transport of contaminants from the area surrounding the installation (Cordah)[17]. Similar patterns have previously been reported (Davies *et al*, 1989[18]). Further studies might allow more definite conclusions to be made.

Overall, the pattern of disturbance was one of dynamic change, where the impacted zone centred on the Platform has reduced in area with time, and is surrounded by sediments that have begun to increase in diversity and species richness with time.

Figure 7-28 Cordah Map of Fauna Areas

Relative faunal disturbance in sediments around the Maureen platform.
Distances in metres from platform



KEY

Area with most disturbed fauna around Maureen

Area where a slight and gradual decrease in quality of faunal communities has been observed

Area where faunal communities have begun to recover

Area where no faunal impact has been detected

Lastly, further studies at Maureen have shown that the impact of hydrocarbon on fish and macrofauna is minimal (see Section 4). The Maureen Owners will, however, take into consideration results of ongoing or future research and studies relevant to the Maureen cuttings layer.

The assessment of the Maureen drill cuttings thus concludes that the accumulation is gradually eroding, hydrocarbons are naturally biodegrading in favourable conditions for this process (shallow pile, weathering), any heavy metals present are not bioavailable, and fauna in the area show continual signs of recovery. In review of these results and conditions, it appears that the existing, somewhat systematic, natural remediation process will continue to remediate the layer if it is left in place. The question then becomes whether, based on the overall evaluation of all the relevant circumstances, there are any active remediation measures which would result in a better overall solution.

7.10.4 Comparative Evaluation of Alternatives

The Maureen Decommissioning Project considered the overall impacts and consequences of three disposal alternatives to assist in determining which was the best solution for the cuttings layer at Maureen. These three alternatives were "short-listed" and selected based on preliminary results of industry studies and recent experience from similar cuttings pile impact assessments.

In situ treatment alternatives such as enhanced bioremediation were discarded after studies concluded this method was not appropriate for smaller, large surface area, low volume piles such as Maureen (UKOOA Drill cuttings JIP Phase I research area report 4.1). In addition, the retrieval option assessment is limited to retrieve and transport cuttings to shore, since no well is available at Maureen for reinjection/offshore disposal of cuttings retrieved from the sea floor.

Alternatives considered are as follows:

- Leave in place
- Cover with gravel and leave in place
- Retrieve and transport to shore for processing/disposal

Criteria used to assess impacts of these alternatives included safety, cost, impact to fisheries and other users of the sea as well as environmental impacts. The environment evaluation considered impacts through discharge/dispersion, energy use, emissions, impacts to the ecosystem, littering, waste management/resources, and aesthetics.

Environmental studies and industry research assist in assuring evaluations are accurate, however for some criteria (energy use/consumption, emissions, safety, cost) in depth studies/calculations were not conducted since "leave in place" often had zero impact in those categories, and an assessment of "impact" verses "no impact" could be made. All alternatives were compared by means of a qualitative assessment across the five selection criteria. These qualitative evaluations also considered knowledge and experience from similar impact assessments. In conclusion, a recommended disposal alternative of "leave in place" was identified for the cuttings layer at Maureen.

Table 7-1 shows a comparison of the three alternatives, with regard to the environment criteria, in a table where "**X**" means impact, and the absence of an "**X**" means zero to insignificant impact. Discussion concerning each evaluation follows.

Table 7-1 Comparison of Alternatives - Environmental Criteria

"**X**" Identifies Impacts

Cuttings Alternative	Retrieve	Leave in Place	Cover With Gravel
Energy consumption	**X**		**X**
Atmospheric Emissions	**X**		**X**
Discharges to Sea	**X**	**X**	**X**
Other Impacts on Ecosystems	**X**		
"Aesthetics"	**X**		
Waste/Resources	**X**		**X**
Littering		**X**	**X**

7.10.5 Environment Criteria Evaluation

7.10.5.1 Cover with Gravel

Covering the cuttings layer at Maureen would require gravel or sand to be placed onto the layer to "protect" it from outer forces. Gravel placement is a technique in the offshore industry used for such applications as adding protective covering to exposed pipelines or other structures on the seabed. The method involves placing material, such as small gravel, from surface vessels, normally through a fallpipe. Gravel is preferable to boulders because of the reduced risk of damage to the layer and consequent re-suspension; however some re-suspension should still be expected even if gravel is used.

<u>Energy Consumption/Emissions</u> – Impact. No calculations have been attempted of energy consumption or emissions associated with the three disposal alternatives. However, it is evident that energy consumption and emissions would be highest for solutions requiring intensive use of marine vessels. Gravel placement is assumed to require limited energy consumption, but enough to show an impact. This is true for emissions as well.

<u>Discharges to Sea</u> – Impact. The most relevant environmental issue is identified as discharges to the sea, which can be described as swirling/re-suspension of fine particulate matter and contaminants, leaching of pollutants (by natural means) and discharges/environmental detriments during treatment/disposal on shore.

It is expected and confirmed by predictive modelling studies (Reference BMT[7]) that placing stone or gravel on the cuttings could cause some re-suspension of contaminated sediments from the cuttings layer, therefore this alternative was shown to have an impact in the "discharges to sea" category.

Other Impacts on Ecosystem – No Impact. The cover with gravel option causes insignificant to no impact/physical damage to the ecosystem. Despite the fact that the cover materials would cause changes in the local fauna, the cover itself will constitute a new, clean substrate, which can be positive, therefore leaving an overall insignificant impact.

Aesthetics – This option has no impact on aesthetics.

Waste/Resources – Impact. No waste material would be generated by this option. However, the option would utilise some resources (i.e. gravel), therefore this option shows "impact" on the table above.

Littering – Impact. Cuttings are not "litter" in a normal context. Nevertheless, cuttings are a waste product resulting from the offshore operations, which are discharged in accordance with permits. According to this option, these cuttings would be left when the Platform is refloated, thus it was determined to have an impact in this category.

7.10.5.2 Remove Cuttings from Seabed and Dispose Onshore

It is important to emphasise that, at present, no retrieval technology exists for removing drill cuttings piles in an environmentally acceptable manner. To date, this is supported by findings of the UKOOA drill cuttings JIP study 6.1/6.2 (Removal solutions). This has identified only one proposed technique, not yet proven, which appears able to address cuttings within a template.

The concept involves excavating and "pumping" the cuttings layer from the seabed to the installation. According to UKOOA drill cuttings JIP studies on removal solutions (studies 6.1/6.2), substantial dilution with seawater is likely in most techniques which means the volume retrieved would contain a substantial degree of water which would need to be separated (either offshore or onshore). The retrieved cuttings material would be shipped to shore in containers on a barge or as bulk.

There are several technologies and facilities for treatment of fresh cuttings onshore. Cuttings removed from the seabed, however, would contain chlorides, seawater and mixture of different mud additives. This would represent a greater challenge to the processing facility. This is supported by the UKOOA drill cuttings JIP Phase I study 7.1 which reviews the practicalities of managing recovered cuttings, and the possibilities, limitations, and impacts associated with processing old drill cuttings onshore. When processed, the cuttings volume would still be significant and the waste would have to be disposed of onshore in a suitable landfill.

Energy Consumption/Emissions – Impact. As indicated above, no calculations have been attempted of energy consumption or emissions associated with this disposal alternative. However, it is apparent that energy consumption would be highest for solutions such as removal, requiring intensive use of marine vessels. In addition, onshore treatment would require some energy. This level of impact for this option is true for emissions as well.

Discharges to Sea - Impact. As mentioned above, there are no methods available for retrieving/removing drill cuttings from beneath an offshore Platform that adequately addresses environmental concerns. The biggest concern is re-suspension or dispersion of contaminated material during retrieval operations. A significant portion of the contaminants may not be recovered by the dredging mechanism and could be rapidly spread into the surrounding environment. This is considered when evaluating the overall environmental impact of this option.

Evaluations by Rogaland Research[19] carried out for OLF determined that different methods of removal could cause anything from large to small environmental impacts. Removal by mechanical means was considered to have large negative consequences, as it potentially could cause extensive re-suspension and dispersion of the sediments. Suction-dredging methods were assessed to result in somewhat less negative environmental impacts, though it is still not quantified. It is anticipated that the UKOOA drill cuttings JIP Phase II will conduct removal trials at the end of 2000 to assess the level of impact and dispersion removal may cause.

Other Impacts on Ecosystem – Impact. Removal of the cuttings will significantly change the local habitat at the site as the organisms, fauna, etc., colonising the area would be sucked up with the cuttings. As described for discharges above, re-suspension may occur, resulting in fine particles settling on the seabed, covering immobile marine organisms over a wider area and changing the local seabed condition. This results in an impact to local habitat.

Aesthetics – Impact. This option was found to have an impact on "Aesthetics". As cuttings are retrieved from the seabed any oil/diesel residues trapped in the cuttings layer would be released into the water column, resulting in the sheen on the sea surface. Cuttings would then be brought onshore in bulk or in containers on ships, and would be temporarily stored at the quayside or at a similar location. Such storage can have a visual impact, though its impact is assessed as insignificant. Processing the cuttings and further handling the various waste streams could also result in some negative aesthetic impacts to the local environment.

Waste/Resources – Impact. The total volume of cuttings, and amount of water generated with recovering the sediments, must be delivered for treatment at the existing treatment facilities that have plant capacity. The cuttings, whether treated or untreated could also possibly be deposited in a landfill. Once deposited, these cuttings have the potential to release substances into the run-off water, though current requirements governing operation of landfills should counteract this potential.

Littering – No Impact. Removal of the cuttings layer would not result in any littering impacts.

7.10.5.3 Leave in Place

Energy Consumption, emissions, impacts on ecosystem, aesthetics, and waste/resources – No impact. When considering the option to leave in place, then each of these criteria shows no impact.

Discharges to Sea – Impact. The most relevant environmental issue is identified as discharges to the sea, which as above, can be described as swirling/re-suspension of fine particulate matter and contaminants, leaching of pollutants (by natural means) and discharges/environmental detriments during treatment/disposal on shore.

This was shown as an impact under the leave in place option owing to the natural disturbance caused by the weathering process. For Maureen, it was determined this impact was minimal (see above - Cuttings Layer Impact Evaluation) owing to the condition of the cuttings layer which allows the natural erosion process to enhance degradation.

Littering – Impact. Cuttings are not "litter" in a normal context, as mentioned above. Nevertheless, cuttings are a waste product resulting from the offshore operations, which are discharged in accordance with permits. According to this option, these cuttings would be left when the Platform is refloated, thus it was determined to have an impact in this category.

7.10.6 Other Evaluation Criteria

In addition to environment, other considerations were assessed and are shown similarly in Table 7-2 below, where "**X**" means impact, and the absence of an "**X**" means zero to insignificant impact. Discussion concerning each evaluation follows.

Table 7-2 Comparison of Alternatives - Other Criteria

"**X**" Identifies Impacts

Cuttings Alternative	Retrieve	Leave in Place	Cover With Gravel
Safety	**X**		**X**
Cost	**X**		**X**
Fisheries		**X**	**X**
Other users of the Sea/Shipping			

Below, each of the criteria is discussed along with the impacts each option has on those criteria.

7.10.6.1 Cost and Safety

The impacts the 3 options have on personnel safety, and the costs each option would entail, was not assessed in detail. However since leaving in-place does not require any operations, this option would have no impacts on safety, and likewise no cost. For the other options (removal, cover with gravel) the safety risks and costs will generally increase with increasing man-hours. This means that the options requiring removal for onshore disposal have the highest risk levels.

7.10.6.2 Fisheries

The fisheries issues considered relevant in connection with the cuttings layer at Maureen are as follows:

- contamination of fish - short and long term
- pollution (soiling) of fishing gear

<u>Removal</u> – No impact. No retrieval technology currently exists for removing drill cuttings from the seabed in an environmentally acceptable manner and it is possible that removal operations might release contaminants present within the cuttings layer, which in turn means this option could lead to an impact on local fish populations. However, this is not expected to attain such a proportion that it would affect fish populations, and by extension, the fisheries in the area.

Adult fish and prey animals living in the area could also assimilate some substances that spoil ("taint") the taste owing to a potential release when the drill cuttings are disturbed. However it is expected that adult fish would be scared away during a removal operation, and thus they would largely avoid exposure to re-suspended components. The short duration and local area affected by this would also limit the probability that large quantities of fish would be affected.

Generally speaking, removal of cuttings from the seabed would ultimately help eliminate any risk, long and short term, of contamination of fishing gear and contamination of catches during trawling operations. Cuttings associated with Maureen (low volume of cuttings) do not represent a major obstacle to fishing, however, therefore the area that would be released for fishing by removal would not have any noticeable effects on fisheries. This evaluation concluded that removal of the cuttings layer would have no impact on fisheries.

<u>Leave in Place</u> – Impact. If the cuttings layer at Maureen is left in-place, then when the Platform is removed it might come into conflict with bottom-deployed fishing gear in various ways. However, cuttings usually consist of broken rock of variable size, ranging from dust to sand to small stones (1-2 cm in diameter) (McFarlane & Nguyen 1991[20]). Therefore, direct tear damage or snagging of fishing gear on the "left in place" cuttings layer is not considered likely since the bits of rock are so small.

In addition, as described in Section 3, the mean annual fishing hours (1994-1998) in the area which includes Maureen (ICES Rectangle 45 F1), is reported to be 9292 for all types of fishing gear. The fishing effort of course varies from year to year, but for 1998 alone, the fishing effort (hours fished) for this rectangle, to include all fishing techniques, was 12,360 hours. The majority of that fishing effort was made using light trawl. The type of trawl most likely to encounter and impact the Maureen cuttings layer is, however, beam trawl, and heavy trawl gear.

These methods involve dragging heavy gear over the seabed, increasing the possibility of encountering the cuttings layer. In view of the fishing effort for this trawl type (72 hours in 1998), it appears the Maureen area can be considered as a low intensity bottom fishing area. Therefore, leaving the cuttings layer in place has only slight potential to affect, and damage fishing gear.

What could represent a concern, however, is that hydrocarbon residues and other components in the cuttings could taint the catch and perhaps soil the gear if they drag over the cuttings piles left on the seabed. This might ultimately mean that areas where cuttings remain on the seabed are avoided by fishing vessels that operate with bottom-deployed gear. The option to leave in place could then result in a small reduction in the area available to bottom fishing trawlers.

In addition, one possible negative impact of the option to leave cuttings in place might be that fish congregating there would be unsuitable for human consumption owing to bad taste (tainting). However, recent analyses at Maureen (Cordah[17]) concluded that there was no evidence of taint in fish caught over the area of the cuttings layer. The fish sampled were Sole which are bottom feeding flatfish.

The option to leave cuttings in place on the seabed has been assessed overall to result in an impact to fisheries. The impacts of this option are linked to the risk of contamination (soiling) of fishing gear and the fish catch during trawling, which in practice might cause fishermen to avoid this locality, thus effectively reduce grounds available to them.

<u>Cover with Gravel</u> - Impact. Covering the cuttings layer will further raise the height of the layer over the surrounding seabed. Depending on the size of the rock, gravel or sand used, the cover might, potentially, cause damage to trawling gear and catches if the trawl door snags or stones enter the net. Fishermen using bottom-deployed gear might prefer to avoid fishing over covered cuttings layer. The layer would be shaped to be "over-trawl-able" and gravel would be preferred to rock to avoid potential damage to gear and catches. The probability that a trawl would contact the cuttings is statistically small. This option was still determined to have an impact to fisheries, though covering the cuttings layer is considered a very limited obstacle to fisheries.

7.10.6.3 Impact on Free Passage

No impact. The various solutions for removing or leaving the cuttings layer will only affect free passage of shipping during the operational phase. The option to leave the cuttings in-place requires no operational activities and therefore there are no impacts on shipping. Other solutions would require the use of some vessels, but both the scope and consequences of the operations to shipping would be small. Therefore, all options were determined to have no impact on free passage.

7.10.6.4 Conclusion of Alternatives Evaluation

In review of the criteria assessed above, the "leave in place" option had the fewest impacts and was selected as the best solution for the Maureen cuttings layer.

The option to cover with gravel was not optimal for the Maureen cuttings layer since, in addition to other environmental impacts, there were impacts to safety, cost, and fisheries. It is also evident that the cuttings layer at Maureen is biodegrading, and covering it would interfere and essentially stop this natural process, with no significant benefit.

The option to recover cuttings from the seafloor was not selected, owing primarily to the number of impacts this action has on various criteria, for such a low volume of cuttings at Maureen. In addition, there is an added risk because the technology is not yet proven to be environmentally acceptable.

The leave in place option showed minimal impacts with the most relevant impact being discharges to the sea, and the impact of this was determined to be minimal as well.

7.10.7 Evaluation of Removal Impacts (Template/Cuttings)

One additional consideration for the cuttings layer at Maureen is the level of disturbance and dispersion the Template removal might cause to the cuttings layer, and if that level of disturbance is acceptable. That level of disturbance must also be compared with the disturbance and overall impact a complete cuttings removal technique may cause. The level of disturbance will also be investigated using a mathematical model of pile dispersal. BMT have done studies for the UKOOA JIP on drill cuttings in Study Item 3.2. BMT has likewise carried out work for the Maureen Owners[7].

The proposed method for removal of the Maureen Drilling Template has been revised owing to changed circumstances arising during the execution of the Maureen Decommissioning Project. The new methodology is presented in Addendum 1 of this Maureen Decommissioning Programme.

It is first essential to review the proposed method to remove the Template, the base of which lies within the cuttings layer. Initially, Template foundation piles will be accessed and cut from the inside. It is anticipated that any contact with cuttings during this activity will be minimal, and any disturbance very localised.

Divers will then attach slings to the Template in order for it to be lifted by a heavy lift vessel (HLV). It is anticipated that 2 to 4 slings will be attached to the upper frame of the Template, which stands above the cuttings layer.

The Template is a tubular lattice framework structure, which should allow the majority of cuttings to fall back down through onto the cuttings layer as the framework begins to be slowly lifted. (The main members of the lattice structure are 20" and 30" diameter tubes.)

Some cuttings will unavoidably be lifted with the Template, however with the localised current activity generated from the lifting process; cuttings will immediately begin to be "washed" off the template framework while the template is still close to the seafloor. If this does not happen the cuttings will be physically washed off before lifting too far above the seabed. The BMT modelling results[7] predict the heavier particles falling and re-settling on the existing cuttings surface, and the lighter particles drifting and settling locally.

The short duration and localised area affected by this will limit any potential impacts on fish and the surrounding environment. In looking at disturbance caused by Template removal, and comparing it with disturbance caused by removal of the entire cuttings layer, it is apparent the template removal will have less of an impact on the surroundings than cuttings layer removal simply because of the actual area removed and disturbed.

It was determined that disturbance caused by removal of the cuttings layer could potentially impact an area of 50,000m^2, which is greater than the area anticipated to be disturbed by removing the template (around 1300m^2). It is also believed the potential for disturbance is greater for removal when considering actual procedures and proven technologies.

Procedures for Template removal will be implemented and monitored to assure disturbance of the cuttings layer is minimal when the Template is removed.

7.10.8 Impact of Pipeline Removal on the Maureen Drill Cuttings

As for the Template, removal of the short section of Oil Loading Pipeline, ends of the 6" and 2" Moira pipelines and umbilical will locally disturb the sediments and a small portion of the drill cuttings layer. This removal procedure, as with the Template, will be implemented and monitored to assure disturbance of the cuttings layer is minimised.

7.10.9 Impact of Platform Removal on the Maureen Drill Cuttings

As mentioned in previous sections, the placement of the "soil surcharge" on the seabed around the outer sections of the tanks of the Maureen Platform is essential for Platform removal and as it assists in the operation to jack the tanks out of the seabed.

- To assist in tank removal and actual separation from the seabed surface,
- To assure minimal impact and limit disturbance to the sediment and cuttings in the area when the low pressure water release takes place in the "break out" operation.

It is also necessary to evaluate how the placement of soil surcharge will affect the cuttings layer short and long term. Short term, to assure minimal disturbance when placing the soil surcharge, and long term, to assure the remaining soil surcharge "cover" does not inhibit natural means of pile recovery (such as weathering and degradation).

To address short term impacts; procedures will be implemented to mitigate and assure minimal disturbance of cuttings when the "soil surcharge" is placed on the seabed around the outer sections of the tanks of the Maureen Platform.

Mitigating measures and factors include using a small grain size of rock (2 mm to 100 mm) to reduce the disturbance to the seabed on landing, and assuring a controlled placement with the use of a fall-pipe which will be accurately positioned to place the rock material only in the required area.

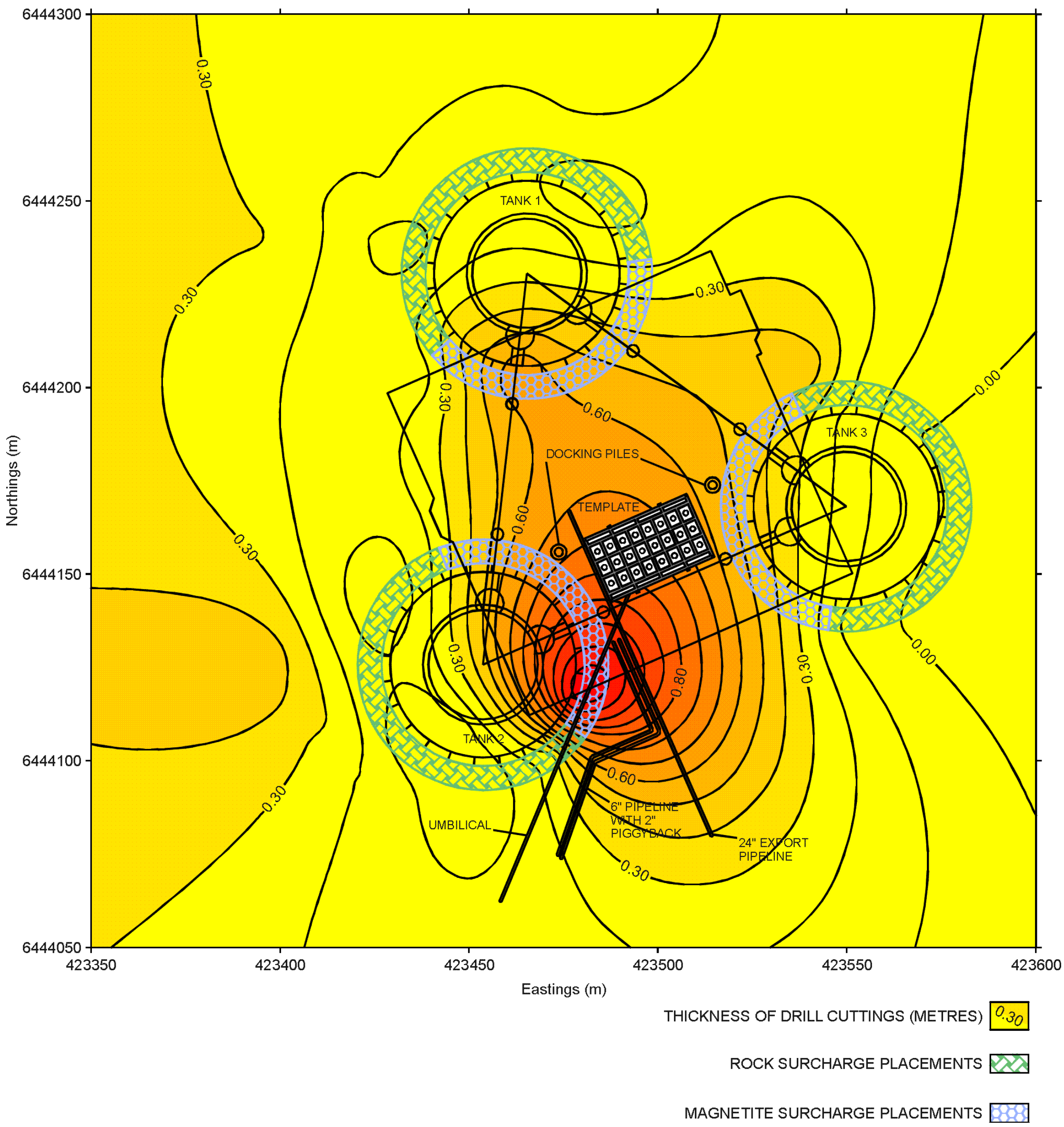
In addition, the divers carrying out the magnetite placement operation will ensure precise placement of the magnetite, and small particle sizes (3 mm to 20 mm) will be used, having minimal impact on landing as well.

Despite implementation of mitigating measures, placement of the soil surcharge will cause disturbance and some re-suspension of the drill cuttings.

Any sediments re-suspended as a result of rock material placement are predicted (Reference BMT[7]) to be of relatively low volume and localised, eventually re-settling in the same area. This behaviour has been noted from video film taken during inspection and testing activities.

Figure 7-29 shows the area around each tank that it is intended to be "covered" by soil surcharge.

Figure 7-29 Maureen Platform Thickness of Drill Cuttings and Rock and Magnetite Surcharge Placements



Overall, it is estimated that the soil surcharge operation might cover approximately 5% of the estimated surface area of drill cuttings greater than 0.1 m around the Maureen Platform.

The main impact resulting from this operation will be the loss of habitat to benthic species, such as the Polychaete worm *Capitella capitata,* which are tolerant of drill cuttings in the immediate area around the tank bases. The AUMS survey[10] in 1988 did not reveal any evidence of the presence of an unusual or rare community, or one that was particularly vulnerable or sensitive to disturbance. Regarding the long term/chemical affect of the soil surcharge, and the potential to inhibit natural means of "pile" recovery (such as weathering and degradation), it is anticipated that this will have a minimal affect as well. The actual area affected by the "cover" will be limited.

After the tanks are removed (Platform refloated), the soil surcharge will look like a small ring (o-shape), with natural seabed sediments within. The area within will immediately be available for re-colonisation by infaunal organisms and will most likely culminate in a community similar to that on other portions of the cuttings layer (low diversity, and high densities of a small number of species). This bioactivity on either side of the "ring" will continue to enhance degradation of the cuttings accumulation.

In summary, the impact of the soil surcharge on the cuttings layer, physically and chemically, short and long term, is anticipated to be minimal, on a small scale, of short duration, and have short-lived effects on the surrounding environment.

7.10.10 Selection of the Best Solution for Maureen

The best overall solution, based on current knowledge, for the Maureen cuttings layer is to leave it in place. This is evident when considering the conclusions of the three separate evaluations contributing to the overall assessment of the Maureen cuttings layer.

The layer is gradually eroding, hydrocarbons are naturally biodegrading in favourable conditions for this process (shallow accumulation, weathering), any heavy metals present are not bioavailable, and fauna in the area show signs of continual recovery. In review of these results and conditions, it appears that the existing, somewhat systematic, natural remediation process will continually remediate the layer, if it is left in place.

In review of disposal alternatives, the leave in place option had the fewest impacts and was selected as the best solution for Maureen.

Refloating the Platform and removing the Template will have minimal, localised impacts which when evaluated, are of less consequence than impacts resulting from other alternatives.

Characteristics of the Maureen cuttings layer are well documented with fairly comparable data available throughout most of the operating life, something unique in the field of cuttings piles research. The Maureen Owners plan to contribute data from this study, and future monitoring efforts at Maureen, to the overall industry and research efforts with the intention to increase knowledge and to assist in determining the best practicable solution for cuttings piles in the North Sea. Maureen Owners will continue to participate in the UKOOA drill cuttings JIP and will take into consideration the results of ongoing and future studies as they affect the Maureen cuttings layer.

7.11 Notes and References

The notes below, provide additional reference information relevant to this section. A Glossary of terms and abbreviations is also included within Appendix A, and a complete list of supporting studies is contained within Section 17.

1 The Report for the Maureen Alpha Application for Consent to Plug and Abandon the Maureen Platform Wells may be viewed at the offices of Phillips Petroleum Company United Kingdom Limited.

2 Maureen Decommissioning; Disposal of Naturally Occurring and Man Made Radioactive Waste, internal Phillips Petroleum Company United Kingdom Limited Report No. dmr\mau\cop\99, dated 10 February 1999.

3 Maureen Refloating Study Block 16/29a, UK Sector North Sea, Report No 73573-1, Issue 04, 5 February 1999, Fugro Limited.

4 Maureen Refloating Study as per Note [3].

Geotechnical Interpretation Report, Maureen Underbase Pumping Tests Block 16/29a, UK Sector, North Sea, Report No 73573-2, Rev 02, 17 April 1998, Fugro Limited.

5 Maureen Refloat Project Phase II Model Testing Results, Report No 93809-1, Issue 01, 26 June 1999, Fugro Limited.

Maureen Refloat Project Interim Report Phase III Model Testing Report No 93814-1, Issue 02, 2 December 1999, Fugro Limited.

Maureen Refloat Project Interim Report Phase IV Model Testing Report No 93817-1, Issue 02, 10 February 2000, Fugro Limited.

6 Maureen Refloat Project Geotechnical Verification, Report 990524-1, 1 March 2000, Norwegian Geotechnical Institute.

Technical Audit of Maureen Refloat Operation, Technical Report No. 99-3562 Rev. 03, 13 March 2000, Det Norske Veritas.

7 Environmental Modelling of Cutting Disturbance: BMT Marine Information Systems Limited Report No 13800/00, April 2000.

8 Offshore Design Engineering Limited.

9 Phillips Petroleum Company United Kingdom Limited, Maureen Operations Manual, Document No. UK/SE-011.

10 Assessment of the Environmental Impacts of the Operations to Refloat the Maureen Platform: Cordah Report 0572-33-492, Oct. 1999.

11 Prof John Shepherd (Southampton Oceanographic Centre, University of Southampton) *et al* (see Section 14).

[12] Analysis of Ballast Water Samples from the Maureen Platform July – September 1999: M-Scan Report 0572/33/503 Rev 1.

[13] Analysis of Structural Water Samples from the Maureen Platform July – September 1999: M-Scan Report 0572/33/502 Rev 1.

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[17] Pre-decommissioning Baseline Seabed Survey of the Maureen Alpha Platform and Associated Infrastructure: Cordah Report 0572-33-506, (Draft) March 2000.

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[20] McFarlane K. & Nguyen, V.T. 1991. The Deposition of Drill Cuttings on the Seabed. Society of Petroleum Engineers. SPE Paper 23372. In: Proceedings of 1st International Conference on Health, Safety, and Environment, Hague 1991.