APPENDIX C – Moira Pipelines and Umbilical - Options

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C.1 Summary of Decommissioning Options Considered

Two main options were considered for decommissioning the Moira Pipelines:

Option 1 – Leave the pipelines *in situ* buried in the seabed;

Option 2 – Recover to surface intact, cut into sections and bring sections to shore for recycling.

The same options could have been evaluated for decommissioning the Moira Umbilical, but an early decision was made to reject Option 1 and choose Option 2 for the following reasons:

- Low cost for removal
- The shallow trench and covering
- Negligible safety risk of removal
- Some materials contained in the umbilical are not degradable and leaving these *in situ* would not be advisable
- Monitoring surveys, to identify potential snagging risks, would be of particular importance.

C.1.1 Option 1 – Leave the Pipelines in situ Buried in the Seabed

To decommission a pipeline *in situ*, there must be a minimum depth of cover along the pipeline in order to avoid a fishing vessel snagging its gear. A review of the available survey data for the pipelines showed that, with the given average depth of cover for the Moira pipelines, it would be unlikely that a case could be made to decommission the lines *in situ*. Therefore, remedial action would be required to increase burial depth. This could be achieved in one of two ways:

Option 1 – Method 1.1 Gravel placement

Option 1 – Method 1.2 Trench (Rebury)

The two methods for Option 1 are discussed below and are based on achieving a minimum depth of cover of 0.6 m to top of pipe.

Option 1 attracts two further activities, pigging of the oil production pipeline to ensure it is clean and periodic survey of the seabed to confirm that the pipelines remain buried.

C.1.1.1 Method 1.1 - Gravel Placement

From a review of the survey data, the shallow areas are mainly limited to KP0.0 (Maureen) to 5.0 and KP6.2 to 7.2. Therefore the gravel placement can be tailored to four zones as shown in Table C-1. The safety and environmental impact, technical challenges and the costs are summarised in subsection C.2.

Table C-1 Gravel Placement Quantities

Kilometre Points (KP)	Depth of Gravel (m)	Volume of Gravel (m^3/m)
0.0 to 5.0	0.8	4
5.0 to 6.2	0.6	3
6.2 to 7.2	0.8	4
7.2 to 10.0	0.6	3

The total amount of gravel required is therefore 36,000 m^3 with a total weight of around 108,000 te. The cost of the gravel placement has been determined as £1.65 million on the data in the table below.

Table C-2 Gravel Placement Costs

Task	Cost
Gravel placement vessel mobilisation	£70,000
Gravel placement vessel demobilisation	£50,000
Gravel placement vessel day rate (16 days @ £55,000 per day)	£880,000
Gravel placement duration (including reload x 4)	16 days
Gravel cost (108,000 tonne @ £5 per tonne)	£540,000
Survey (2 x days @ £55,000 per day)	£110,000
Total Gravel Placement Cost	**£1,650,000**

Note: Cost based on utilising a 20,000 tonne gravel placement vessel.

C.1.1.2 Method 1.2 – Trenching (Reburial)

The other method of achieving the required burial depth is to trench (rebury) the pipelines. The safety and environmental impact, technical challenges and the costs are summarised in subsection C.1.3.

Table C-3 Trenching and Diving

Task		Cost
Trenching vessel mobilisation		£300,000
Trenching vessel demobilisation		£100,000
Trenching vessel day-rate	£70,000	£350,000
Trenching duration (recovery/re-deploy etc.)	5 days	
Diving operations day-rate NOTE 1	£80,000	£400,000
Diving operations duration NOTE 1	5 days	
Total Trenching Cost		**£1,150,000**

Note 1: Diving support would also be required for any pigging operations. DSV mobilisation and demobilisation costs are therefore shown in Pigging Cost Schedule, Table C-4.

C.1.1.3 Pigging Operations

If Option 1 were to be pursued, then a final pigging operation would be required to ensure the cleanliness of the 6" pipeline. Owing to its small size, the 2" gas lift pipeline would not need to be pigged, and the prior flushing operation would be sufficient.

A mechanical subsea pigging operation would be performed on the 6" pipeline utilising temporary launching and receiving facilities.

The pigging costs are shown in Table C-4. There may also be an additional cost if the fluids from the pigging operation cannot be treated or stored on the support vessel.

Table C-4 Pigging Costs

Task		Cost
DSV mobilisation		£300,000
Support vessel mobilisation		£50,000
DSV demobilisation		£200,000
Support vessel demobilisation		£50,000
DSV day-rate	£80,000	£320,000
DSV duration of requirement	4 days	
Support vessel day-rate	£25,000	£100,000
Pigging operations duration	4 days	
Pigging spread cost		£66,000
Subsea pig launcher/receiver & pigging		£300,000
Total Pigging Cost		**£1,386,000**

Note 1: If the trenching method is selected, then DSV mobilisation/demobilisation would be covered within the pigging costs.

C.1.1.4 Periodic Survey

For Option 1, an inspection regime would need to be implemented to monitor the status of the pipeline, post decommissioning. The interval between inspections would be subject to future review and the frequency might be revised based upon the stability of the decommissioned pipelines. In the event that the pipelines become exposed then remedial action would be taken. Costs for the survey are estimated to be approximately £25,000 per visit.

For Option 1, prior to the Decommissioning Contractor departing the field an 'as-left' survey would be completed to provide base line data on the decommissioned pipeline. The survey would use sub-bottom inspection techniques to determine the depth of cover on the pipeline.

C.1.2 Option 2 – Complete Removal of the Pipelines for Onshore Recycling or Reuse

Option 2 involves complete removal of both pipelines from the seabed for recycling onshore or potential reuse. The refloat Contractor has submitted proposals and costs for this work.

The pipelines will be recovered from the seabed by a reverse reeled lay operation as described in Section 9.

There is a potential, although unlikely, for the presence of LSA scale within the 6-inch production pipeline. The pipeline will be tested for LSA contamination and if necessary LSA cleaning will be performed. Appropriate onshore handling and disposal procedures would then be adopted to address potential handling and disposal issues.

Post recovery surveys will be conducted to confirm the route has been cleared of all debris. This philosophy ensures that the pipelines pose no future risk to the environment or other users of the sea.

The safety and environmental impact, technical challenges and the costs are summarised in the subsection C.1.3.

The costs for this option are given in Table C-5.

Table C-5 Option 2 Costs

Task	Costs
Removal of Moira pipelines, transport to shore and test for LSA, and disposal of pipelines	£1,150,000
Removal & Disposal of LSA material (if found)	£600,000
Total Option 2 Cost	**£1,750,000**

C.1.3 Cost Summary for Options

Table C-6 summarises the costs for both decommissioning options.

Table C-6 Decommissioning Options Cost Summary

	Option 1 Method 1.1 Decommission *in situ* gravel placement	Option 1 Method 1.2 Decommission *in situ* rebury	Option 2 Recovery and transport to shore for disposal
Remedial Works Cost	£1,650,000	£1,150,000	N/A
Pigging Cost	£1,386,000	£1,386,000	None
Total Capital Cost	***£3,036,000***	***£2,536,000***	***£1,750,000***[NOTE]
Ongoing Costs (Survey)	£25,000/visit	£25,000/visit	None

Note: Possible LSA cleaning and material disposal cost (£600,000) is included.

C.2 Comparative Assessment of Options

This subsection identifies the risk assessments already conducted and those to be conducted. It also documents the qualitative assessment conducted to rank each option with respect to safety, environmental, technical challenges and costs. The results are summarised in Table C-7, Table C-8, Table C-9 and Table C-10.

The evaluation methodology applied, was to compare each option relative to each other and rank them in order of 1 to 3 on each of the relevant selection criteria (1 being most and 3 being least desirable).

The overall scores and rankings are considered in subsection C.3.

The following hazards are common to both options and methods above:

- Process hazards (including potential LSA concerns) associated with water flushing have been addressed in a structured safety review

- General Diving hazards and those associated with breaking the pipelines, handling of disconnected flexibles, removal of any material in the vicinity of the pipeline. These hazards have been addressed in specific Diving Hazid(s)

- Marine hazards caused by more than one vessel being involved during various stages of the field decommissioning. These will be subject to specific assessment and activities scheduled to minimise risks

- General manual handling, COSHH and other hazards will be assessed prior to carrying out the activities.

The management systems within the Maureen Decommissioning Safety Case and operating procedures will ensure these assessments are performed.

C.2.1 Option 1 – Leave the Pipelines in situ Buried in the Seabed

Complexity and associated technical risk

The most complex activity connected with this option would be to ensure that the pipelines are adequately buried. Method 1.2, the trenching method, which is cheaper than gravel placement (Method 1.1), is more complex and thus poses greater risk.

Risks to personnel

The requirement for divers operating at 96 m depth for disconnecting pipelines and providing support during pigging operations (and trenching), presents a risk to their safety. This option would require the same number of divers as option 2 but the exposure duration will be longer.

Environmental impacts

The environmental impact from this option is not totally insignificant. Trenching (re-burial) will cause significant disturbance to the seabed. Gravel placement will not have such a detrimental effect on the seabed, but over 100,000 te of gravel will be deposited (requiring a FEPA licence).

Figures for emissions to air from vessel movements during the proposed operations are, by qualitative assessment, likely to be the highest.

To leave the pipelines *in situ*, the 6-inch oil production pipeline will have to be cleaned by pigging. Temporary subsea pigging facilities will have to be installed leading to local seabed disturbance. There is a potential for LSA scale in the pigging waste, which will have to be retrieved and taken onshore for disposal.

Pipeline degradation would occur through time. As the pipeline will be at ambient temperature after decommissioning, it is likely that the corrosion rate will be lower than during the operational phase. Corrosion is likely to be limited for the first few years owing to the cathodic protection system providing some degree of protection.

In conclusion it is likely that if left *in situ*, the pipelines would take a very long time to degrade. As the pipelines are buried it is likely that over a period of time they would collapse in on themselves, posing little or no threat to other users of the sea.

Regular surveys would continue to be carried out to ensure that the pipelines remain buried (see Section 8).

There would be minimal impact on land-based disposal sites with this option.

Effect on safety of navigation and other sea users

Once the pipelines have been buried under gravel or reburied, there would be a debris sweep carried out to ensure that no snagging hazards are left and to confirm overtrawlability. There would be minimal impact on the safety of navigation and other sea users resulting from leaving the pipelines *in situ*.

Costs

Estimated costs for leaving the pipeline *in situ* buried in the seabed are given in Table C-1, Table C-2 and Table C-3 and summarised in Table C-6. This method of decommissioning is more expensive than Option 2. The gravel placement method of providing the required burial is the most expensive, followed by trenching. (See Table C-10.)

C.2.2 Option 2 – Complete Removal of the Pipelines for Onshore Recycling or Reuse

Complexity and associated technical risks

The technical complexities of retrieving the pipelines are not great or insurmountable. The retrieval process is essentially the reverse of the laying process and no technical difficulties are foreseen. Potential for damage to the pipelines is low and not critical.

Risks to personnel

The requirement for divers operating at 96 m depth to disconnect the pipeline ends and attach pulling heads and winch wires presents a risk to their safety.

Environmental impacts

Unlike a jetting operation to uncover the pipelines, which has a greater impact on the environment resulting in displacement and resuspension of material affecting a wider area, the reeling retrieval method to be used has very little disturbance effect and only a temporary impact on the environment.

There is a potential for the presence of LSA scale contamination within the 6" oil production pipeline. There could therefore be a potential handling issue during cleaning operations prior to disposal/recycling.

During recovery, the pipeline contents will be discharged to the sea.

Based on results of analysis of pipeline flushing water already retrieved, Andrew Palmer and Associates have carried out an independent assessment and conclude that there is not likely to be a significant volume of oil in water. Accordingly, application for Prevention of Pollution Act exemption and PWA DISCON for discharge of flushing water will be made.

Other environmental impacts would be emissions to air from the combustion of diesel from vessels used during the refloat operation and subsequent transport of the pipelines to shore. Figures for these emissions are likely to be significantly lower than those associated with leaving the pipeline *in situ* (Option 1), owing to the reduced number of vessels and activities involved in the shorter duration of operations (see Option Selection Summary).

Costs

Costs for the recovery of the pipelines and their disposal onshore are given in Table C-5 and summarised in Table C-6. This method of decommissioning is the most economic option.

Recommendation

The Option Ranking Summary in Table C-11 concludes that Option 2 – to retrieve the pipelines for onshore recycling is the most favourable option.

Table C-7 Option Selection Summary Table – Technical Considerations

(Rankings as well as comments on particular issues considered)

Option/Method	Technical considerations			
	Lifting/ Reeling	**Cutting**	**Burial**	**Disposal**
Option 1 Method 1.1 Leave *in situ*, Pig & Gravel placement	Flexibles & pipeline ends *Gravel placement equipt*		*Gravel placement +* pigging	Flexibles & pipeline ends *Pigging Waste*
Ranking	**2**	**1**	**2**	**1**
Option 1 Method 1.2 Leave *in situ*, Pig & Trench	Flexibles & pipeline ends *Trenching equipt*		*Trenching +* pigging	As per 1.1
Ranking	**3**	**1**	**3**	**1**
Option 2.0 Remove from seabed, reel onto vessel & return to shore for recycling	Flexibles & pipeline ends *Lifting head attached to pipelines Reeling 10 km each of 6" +2".*	500 x onshore cuts (manage-able lengths*)*		Flexibles & pipeline ends + *Pipe sections (steel x 660 te) + Poss. LSA + Oily residue + 150 m^3 water*
Ranking	**1**	**3**	**1**	**3**

Table C-8 Option Selection Summary Table – Safety Considerations

(Rankings as well as comments on particular issues considered)

Option/Method	Safety considerations			
	Divers	**Surface work**	**Marine**	**Onshore**
Option 1 Method 1.1 Leave *in situ*, Pig & Gravel placement	*12 @ 4 Days* Disconnect & remove both pipeline ends & flexibles *Pigging Ops ROV of Gravel Placement*	Recovery of flexibles & pipeline ends *Bulk handling Gravel Placement Handling Pigging Waste*	DSV – 1 @3 days Gravel Placement vessel –1 @ 4 days Trawler –1 @ 1 day Survey vessel – 1 @20 days (over 60 years) *= 28 vessel days*	Handling of flexibles & pipeline ends *Bulk handling Gravel Placement* *Handling Pigging Waste*
Ranking	**3**	**2**	**2**	**1**
Option 1 Method 1.2 Leave *in situ*, Pig & Trench	*12@ 4Days* Disconnect & remove both pipeline ends & flexibles *Pigging Ops*	Recovery of flexibles & pipeline ends *Handling Trench equipt Handling Pigging Waste*	DSV – 1 @ 8 days Trenching vessel – 1 @ 5 days Trawler – 1 @ 1 day Survey vessel –1 @ 20 days (over 60 years) *= 34 vessel days*	Handling of flexibles & pipeline ends *Handling Trenching equipt* *Handling Pigging Waste*
Ranking	**2**	**3**	**3**	**2**
Option 2.0 Remove from seabed, reel onto vessel & return to shore for recycling	*12@ 2 days* Disconnect & remove both pipeline ends & flexibles *Attach pulling heads & winch wires.*	Recovery of flexibles & pipeline ends *Pulling/reeling 6" +2"*	DSV – 1 @ 1 day Pipelay vessel –1 @ 2 days *= 10 vessel days*	Handling of flexibles & pipeline ends Handling pipelines off reels Cuts x 500 (manageable lengths) Handling cut sections Possible LSA Road transport Oily residue
Ranking	**1**	**1**	**1**	**3**

Table C-9 Option Selection Summary Table – Environmental Considerations

(Rankings as well as comments on particular issues considered)

Option/Method	Environmental considerations		
	Marine	**Atmospheric**	**Onshore**
Option 1 Method 1.1 Leave *in situ*, Pig & Gravel placement	Disturbance to 10km x 10m area of seabed to 1m depth *Gravel placement* Pigging fluids Disconnection fluids *Vessel effluent x 28 vessel .days*	Exhaust emissions x 28 vessel days. Gravel placement dust	Recycling of flexibles & pipeline ends *Pigging Waste Gravel placement residue*
Ranking	**3**	**2**	**2**
Option 1 Method 1.2 Leave *in situ*, Pig & Trench	Disturbance to 10km x 10m area of seabed to 1m depth Pigging fluids Disconnection fluids *Vessel effluent x 34 vessel .days*	Exhaust emissions x 34 vessel days.	Recycling of flexibles & pipeline ends *Pigging Waste*
Ranking	**2**	**3**	**1**
Option 2.0 Remove from seabed, reel onto vessel & return to shore for recycling	Disturbance to 10km x 2m area of seabed to 1m depth Drainage to sea Disconnection fluids *Vessel effluent x 11 vessel .days*	Exhaust emissions x 11 vessel days. Road transport	Recycling of flexibles & pipeline ends + *Pipeline sections (steel x 660 te)+ Poss. LSA + Oily residue + 150m^3 water*
Ranking	**1**	**1**	**3**

Table C-10 Option Selection Summary Table – Cost Considerations

Option/Method	Costs (£)
Option 1 Method 1.1 Leave *in situ*, Pig & Gravel placement	£3.036 million (+ £25,000 per annum)
Ranking	**3**
Option 1 Method 1.2 Leave *in situ*, Pig & Trench	£2.536 million (+ £25,000 per annum)
Ranking	**2**
Option 2.0 Remove from seabed, reel onto vessel & return to shore for recycling	£1.750 million
Ranking	**1**

C.3 Selection of Preferred Option

On the basis of the comparative assessment presented in subsection C.2 and the cost evaluations presented in subsections C.1.1, C.1.2 and C.1.3, Option 2 – recovery and removal to shore, has been selected as the preferred option. This is also supported by Andrew Palmer & Associates in their "Decommissioning Philosophy Review. A report for Phillips Petroleum Company United Kingdom Limited", 1999.

A qualitative assessment of the safety and environmental hazards, technical challenges and costs for all options and methods is contained in subsections C.2.1 and C.2.2.

The evaluation methodology applied, was to compare each option relative to each other and rank them in order of 1 to 3 on each of the relevant selection criteria (1 being most and 3 being least desirable).

The overall score and ranking was generated by summation – applying a general weighting of 2 to the safety and environmental rankings to account for their greater importance. These rankings are presented in Table C-11 and they lead to the preferred option being Option 2.

The overall ranking shows that the safety and environmental impact through gravel placement/trenching activities and the associated costs for Option 1 are greater than Option 2. Hazards specific to Option 1 include diving and other hazards associated with pigging and gravel placement/trenching activities. They would be addressed in specific Diving Hazid(s) and would add to the overall diving risk. Marine hazards for Option 1 are greater than for Option 2 owing to the extent and nature of the activities, whilst onshore handling risks (including potential LSA issues) are greater for Option 2.

A sensitivity analysis on the model has been conducted by applying different weightings, but it still draws to the same recommendation, i.e. Option 2.

Accordingly, further detailed and/or quantitative assessment is not deemed necessary for justification of option selection.

All systems and procedures associated with Option 2, including disconnection, recovery and onshore handling, will be addressed in structured safety reviews prior to any work being carried out.

Table C-11 Option Ranking Table

Option/Method	Safety				Environmental			Technical				Cost	Overall	
	Divers	Surface work	Marine	Onshore	Marine	Atmospheric	Onshore	Lifting/ Ree;omg	Cutting	Burial	Disposal		Score	Ranking
1.1 Leave *in situ*, Pig & Gravel placement	3	2	2	1	3	2	2	2	1	2	1	3	39	2
1.1 Leave *in situ*, Pig & Trench	2	3	3	2	2	3	1	3	1	3	1	2	42	3
2.0 Remove from seabed, reel onto vessel & return to shore for recycling.	1	1	1	3	1	1	3	1	3	1	3	1	31	1