3. CONSTRUCTION

3.1 Construction Strategy

Enterprise has awarded a number of contracts for the detailed engineering, procurement, installation and commissioning (EPIC) of the Field facilities, pipeline, umbilical and discharge pipeline. The exact construction and installation methods will be determined by the contractor in consultation with Enterprise. This section provides information on the anticipated methods of installation of the above facilities, based on the equipment and system options identified by the preliminary engineering studies and the constraints present in the Corrib Field and along the pipeline route.

3.2 Project Management and Control

Project management and control over the construction contractors' works (design and construction) are set out in the Construction Specifications and the Contracts. Enterprise will oversee and supervise the various sections of the work and will audit and verify the programme.

An Environmental Management Plan (EMP) will be prepared to ensure that all project activities comply with the commitments made in this EIS and with Enterprise's Environmental Policy. The EMP will encompass any restrictions on working methods and timing enforced by the authorities who regulate the environment in which the project will be constructed. The contractor's operations will be audited regularly by Enterprise to ensure that the environmental requirements of the contract are being met.

3.3 Drilling

For the purpose of this EIS, the drilling of wells in the Corrib Field is considered to be a construction activity.

Drilling in the Corrib Field is carried out by a semi-submersible drilling rig, also called a MODU (mobile offshore drilling unit), which is anchored on location during the drilling operations.

The discovery well (18/20-1) was drilled in 1996 as a five section well. This well was plugged and abandoned.

Five appraisal wells have been drilled between 1998 and 2001 and it is intended that each of these will be used as a future production well. These are:

- 18/20-2z, (P1) drilled to a measured depth of 3731m in 1998;
- 18/25-1, (P2) drilled to a measured depth of 3770 m in 1999;
- 18/20-3, (P3) drilled to a measured depth of 3790m in 2000;

- 18/20-4, (P4) drilled to a measured depth of 4062 m in 2000; and
- 18/25-3, (P5) drilled to a measured depth of 3763 m in 2001.

The principal objectives for these operations included: a) safe and efficient drilling operations; b) effective appraisal of the Corrib Field; c) effective drainage of the Corrib Field if the wells concerned were re-used as production wells; and d) waste minimisation. The first and last of these affect both drilling fluid selection and the handling and disposal of drilled cuttings. The regulatory background has changed since the initial exploration well was drilled, and Enterprise have adopted measures to reduce the discharge of mud and cuttings.

For wells 18/20-1, 18/20-2z and 18/25-1, drilled in 1996, 1998 and 1999 respectively, all the drilled cuttings were discharged to sea, with a synthetic-based mud (SBM) used for the 12¼" and 8½" sections. This measure reflected best international oil industry practice at the time. An organic-phase fluid was required to drill the lower well sections efficiently. The use of SBM minimised the toxicity of the cuttings discharged, and was thought to shorten seabed recovery time compared to mineral oil-based fluids. Efforts were made to reduce the organic base fluid content of the wet cuttings discharge from 10% by weight, relative to the weight of rock, to 8%.

The acceptability of discharging SBM wet cuttings into the sea has been challenged, and alternative processes, including the onshore re-cycling of this type of cuttings has become available at various sites in the UK. Enterprise adopted onshore re-cycling of SBM wet centrifuge solids for wells 18/20-3 and 18/20-4. Wet centrifuge solids comprise the smallest particles of drilled solids, together with particles of barite, coated with SBM.

The well design for wells 18/20-2z and 18/25-1 used the five section casing design as used in the discovery well. This design was altered for subsequent wells to a four section model, omitting the whole 26" section. One consequence of this is that all the cuttings coated with environmentally benign water-based mud (WBM) are expelled from the well at the seabed. The marine riser is then connected to a wellhead on the 13.375" casing. The volume of WBM cuttings discharged from 18/20-3 was 60% less than the volume of WBM cuttings discharged from the 1996 exploration well.

On future wells[1], all the cuttings from sections drilled with organic-phase mud will be collected on the MODU and brought ashore for re-cycling (see **Section 15**). This process was also undertaken for well 18/25-3 drilled in 2001. Minimising the quantity of cuttings that require transportation is a significant issue, as cuttings handling has health and safety implications. The policy of minimising cuttings by well design will be continued.

It is currently planned that up to three further will be drilled. It is expected that future wells will each involve the discharge of about 700 m^3 of WBM to the sea and 150-170 m^3 of rock cuttings at the seabed. They are expected to involve the transport of some 400 m^3 of wet cuttings, together with around 40 m^3 of centrifuge solids to shore.

[1] For simplicity, future production wells that may be required, (which currently have no official name) are referred to as P6, P7 and P8 in this document.

3.3.1 MODU and Support Vessel

Drilling a typical appraisal well in the Corrib Field takes around 60 days, and well completion and well testing activities typically takes a further 25 days. During this time a MODU will be present on location, with a stand-by vessel for safety and rescue purposes. In addition, supply vessels will shuttle between the location and onshore supply depots with drilling materials, cuttings containers and other supplies. Helicopter flights between Donegal and the MODU are used for crew changes.

3.3.2 Completion of Suspended Wells

It is intended that the appraisal wells that have already been drilled and suspended will be used to produce gas from the Corrib Field. These wells will be re-entered and completed during 2002 or 2003, more probably the latter. The duration of such completion work is expected to be about 25 days per well.

Completion work involves drilling out the cement plugs set in the wellbore, running a completion tubing string into the well, setting a christmas tree on the wellhead, re-perforating the well, flowing it and shutting in the well as a 'live producer'.

The well is then ready for connection to the manifold by jumpers or by flowlines.

3.4 Offshore Installation General

3.4.1 Schedule of Operations

The overall schedule for the installation operations is outlined in **Figure 3.1**.

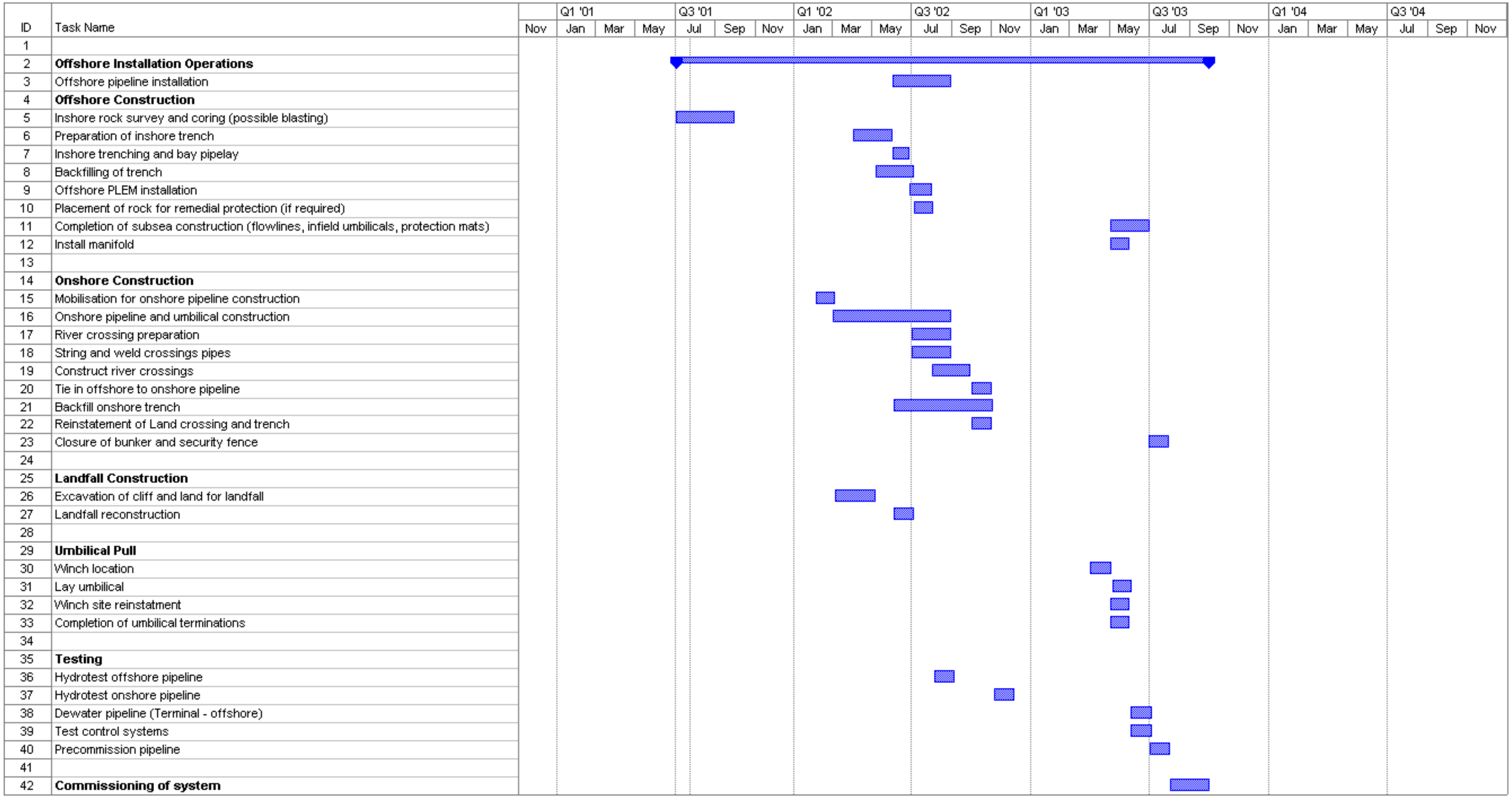

Figure 3.1: Schedule of operations

3.4.2 Safety and Environment Management

All activities and equipment which have a direct influence on the safety of personnel, the environment or the resources deployed, will be the subject of controls during the activities.

These controls would include:

- safety planning;
- safe systems of work, including risk assessments;
- vessel safety and survival equipment;
- emergency response procedures;
- protective clothing;
- discharges to the environment;
- lifting and lifting equipment, including cranes, hoists, conveyors, slings, etc;
- personnel transport; and
- safety and environmental audits.

Safety goals and performance standards will be set for the project. All contractors will be required to conform to these.

3.4.3 Subsea Construction

An installation plan has been prepared in order to optimise the sequence of installation activities, thereby avoiding the potential for interference between vessels. The installation processes will be undertaken using the following methods:

- pre and post-lay surveys will be undertaken to ascertain the seabed condition before and after construction;
- subsea manifold(s) will be installed by a diving support vessel (DSV) (Seaway Eagle);
- subsea trees will be installed by a drilling rig. Hook-up of the wells to the pipeline and control system will be by marine construction vessel and diverless methods. Remotely operated vehicles (ROVs) will therefore be used and their interface with other activities will conform to industry standards;
- the pipeline(s) will be installed using a dynamically positioned (DP) pipelay vessel, the Solitaire, capable of laying the 20” line in 360 m water depth. This vessel will lay in to Broadhaven Bay to the 20 m LAT contour area. A smaller anchored barge, the TogMor will then lay the inshore section to the landfall;

- trenching of the pipeline, where applicable, will be post-lay using a specialised trenching/jetting vehicle the 'Digging Donald' supported from a DP vessel, the Trenchsetter; and
- a specialised cable-laying vessel, the Seaway Falcon, will install the control umbilical. Trenching will be undertaken post-lay by a cable plough towed from a DP vessel called Seaway Explorer.

Other support vessels that may be used in order to complete the installation include:

- 2 x Anchor handling tugs, for MODU;
- 2 x Support vessels;
- 4 x Pipe haul vessels;
- survey vessel;
- rock placement vessel;
- dredger; and
- work barges.

During installation there may be the need to 'wet park' (lay on the seabed temporarily) the pipelines or equipment prior to tie-in and commissioning.

3.4.4 Seabed Preparation

In certain deepwater locations, such as the area that has been 'scoured' by ancient icebergs, it may be necessary to profile the seabed. This will be carried out using pressurised water jets installed in the Digging Donald which will remove the steep sided 'shoulders' that typify an iceberg scour. It is not anticipated that rock placement will be required to enhance the pre-lay profiling work. However, it is expected to take place to correct unavoidable spans of the pipeline after it has been laid. This is discussed further in **Section 3.6.4**

At some inshore locations the need for blasting to weaken the rock prior to excavation by a dredger has been considered. This is discussed further in **Section 3.6.2**.

3.5 Installation of Field Facilities

This section describes the installation procedures for the wellheads and manifolds including how the design will cater for the connections of jumpers and control umbilicals.

3.5.1 Wellheads

The Xmas trees will be installed from the MODU rig during well completion and the protection structures will be installed by a construction vessel such as that presented in **Plate 3.6**.

3.5.2 Production and Pipeline End Manifolds

The units will be delivered to the Field on the deck of the vessel that is to install them. The structures will then be lowered by crane from the vessel as single units, and guided to their exact location using acoustic positioning techniques and monitored by ROVs. Their own weight in combination with suction piles, will anchor them to the seabed.

3.5.3 Infield Flowlines and Umbilicals

Flowlines and umbilicals will be laid from the 'cluster' and 'satellite' wells to the manifold. **Figure 2.2** shows the seabed locations of the central area wells. The flowlines between the single satellite (18/20-3) well and the manifold will be 8" in diameter, while that from the 'mother' well (18/25-1 or 18/25-3) to the manifold will be 10" in diameter, the line from the daughter well (18/25-3 or 18/25-1) to the mother will be 6" in diameter.

The vessel scheduled to lay these lines is the same type that lays the main umbilical (see **Section 3.6.7**).

All infield flowlines and umbilicals will be laid approximately 50 m apart and will lowered into the seabed, using a remote controlled tracked jetting vehicle, to within 20 m of the various structures in the Field. The jetting vehicle will travel along the lines once they are laid on the seabed and displace the sediment from beneath the lines using water jets. The lines will then sink into the trench. The process of natural infill will bury them, since the soils at the site are very soft and seabed currents will redistribute them. Sections of flowlines close to the facilities remaining unprotected (due to inaccessibility by the jetting vehicle) will be covered with concrete mats that will provide physical protection.

The overall width of a typical jetting vehicle is about 8 m. The seabed will be locally disturbed by its passage, but the imprints will be filled and covered by natural sediment transport.

3.6 Installation of Pipeline and Umbilicals

3.6.1 Introduction

The pipeline and umbilical installation section is presented in the sequence in which facilities will be constructed, i.e., from the landfall to offshore. This section firstly describes the preparatory works that are required, prior to the actual installation of the pipeline.

3.6.2 Nearshore Pipeline and Landfall Preparation

3.6.2.1 Onshore

Preparatory work will be carried out during early spring of the pipelay year to establish bases for two linear winches, which will be used to pull the pipeline ashore. The winches (typically with a 250 tonne pulling capacity) will be mounted on concrete pads. The winches, which are approximately 8 m x 3 m, will be anchored by wire ropes on their landward side to drilled rock anchors, or a sheet piled anchorage, to counteract the pulling load. The type of anchorage will depend on the results of site surveys carried out prior to installation.

3.6.2.2 Landfall

The pipeline approach through the low, clay cliff and beach at Dooncarton will be excavated by conventional land-based earthmovers. All excavated material will be stored within the pipeline working area. The winches and other equipment required will then be brought to the site via local roads. Behind the winches, two hydraulically operated wire rope reel winders will be positioned to receive the pulling wire from the winches. Public access to the site will be restricted by the use of barriers and signs erected to indicate alternative paths around the work area. Given the relatively shallow depth of the bedrock, it is unlikely that a cofferdam would be needed to keep the trench clear of excavated sediment.

Below the high water mark the trench excavation will be carried out by tracked vehicles with hydraulic rock breaking tools. These will progressively work away from the landfall during low water creating the deep trench. Other specialised vehicles will remove the rock and sand materials to storage. It may be necessary to construct a temporary causeway in the shallow water in order to provide access to the area below low tide, referred to here as the surf zone.

Construction of the trench in the surf zone (i.e. below low water) will be by a powerful backhoe dredger/excavator operated from a self-elevating platform. A multi-point mooring system may be used to help position the platform prior to it being jacked up to operating level.

The trench spoil will either be placed into a split hopper barge or side cast for subsequent reuse.

A similar platform will also carry out any required rock blasting as described below.

3.6.2.3 *Inshore*

The construction of the pipeline, from a position within Broadhaven Bay to the landfall at Dooncarton, will be carried out in a different manner to the remainder of the offshore pipeline. This is because the draught of the main pipelay vessel excludes it from the shallower water, but also because of the need to realign the pipeline inshore to avoid areas of rock at or very close to the seabed. Where such ground conditions cannot be avoided, a trench will have to be cut in rock. This preparatory work is discussed below.

Surveys have already taken place along the route of the pipeline within Broadhaven Bay, from approximately 1 km offshore to the high water mark (HWM). These surveys have determined the depth and type of bedrock, and the properties of the overlying sediments, enabling an accurate estimate to be made of the task for preparing a trench for the pipeline in this area. The survey has identified the requirement for blasting at some inshore locations. Fine tuning of the exact route is ongoing in order to minimise the extent of rock blasting. However, it is almost certain that some blasting operations will be required for approximately 500 m from the low water mark outward.

Underwater blasting has the potential to create significant impacts on the environment if the work is not properly planned and executed.

In air, noise is well recognised as a pollutant. This is a view which is increasingly being applied to underwater noise. The impacts are discussed in detail in **Sections 7 and 11** of this EIS. In summary here, for the purposes of explaining the proposed construction methods and associated mitigations, the three most significant effects of underwater sound on fish and other marine mammals are listed:

- direct harm to marine mammals, fish and other aquatic fauna, either physically or by causing changes in their normal behaviour;
- indirect harm via effects on food species (e.g. on marine mammals when fish are driven away); and
- the commercial effect of localised depletion of exploited fish stocks.

The underwater blasting will be carried out from the deck of a self-elevating platform (**Plate 3.1**) that will be towed into the bay and positioned, possibly with the aid of anchors.

The platform will be equipped with a percussion hammer drill rig, stores containers, emergency accommodation, and power generators. The drill rig is on skids and can be moved around on the deck of the platform so that it can prepare a grid-like pattern of shot holes. Hole spacing is selected to achieve a number of objectives:

- effective fracturing of the rock to the required depth of trench in a single blast;
- the need to ensure that all charges are detonated (if a charge is not detonated by way of the detonator it will be detonated by the charges adjacent to it); and
- minimising the time spent on site preparing the blasting pattern.

From experience it is expected that the shot holes would be laid out with a grid spacing of about 3 m. The depth of hole is likely to be between 3 and 6 m deep below the seabed.

Plate 3.1: Self-elevating platform to support underwater blasting operations

Immediately after drilling the shot holes are loaded with explosive charges, typically of 25 kg weight. Once the pattern of holes along the section of trench to be excavated are complete, the drill platform would be moved off and the charges detonated in sequence, this is known as delay blasting. The platform will then set-up over the next location and repeat the sequence.

When an explosive charge is detonated underwater the water shock wave travels at 1,500 m/sec. In shallow water the wave travels along three paths (see **Section 11**).

The surface relief wave and the direct wave can, if the direct wave is slowed down, destructively interfere with each other and reduce the impact on the underwater environment.

The key elements of the underwater blasting operation that will be taken into account in the design to reduce the environmental impact are:

- placing of charges below the seabed in shot holes and not directly on the seabed or in the water column (see **Figure 3.2);**
- establishment of both onshore and underwater monitoring instruments in order to measure ground movement and water borne pressure waves respectively;
- a small explosive charges will be detonated underwater in order to scare fish away from the blast site in advance of blasting;
- a blast design to minimise the shock wave whilst still achieving acceptable productivity essential to keeping the time span of this activity as short as possible;
- use of air curtain to attenuate the water borne pressure pulse[1];
- careful shot hole loading to ensure all explosive is below seabed level in the hole;
- use of delay blasting to reduce the maximum instantaneous charge;
- use of down hole initiation, i.e. no detonating cord outside of the shot hole;
- blasting is only carried out in day-light hours and only after audible signals have been given; and
- underwater blasting does not create an audible noise above the surface apart from the commotion of the water.

[1] Water shock levels can be significantly reduced by the use of bubble screens between the area to be protected and the explosion source. This mechanism has been shown to prevent fish kills and structural damage to marine structures (Strange, 1963; Abrahams, 1974; Keevin *et al.*, 1991). Reductions of peak pressures by a factor of 5 have been observed. The reduction mechanism is two-fold: the initial part of the direct wave is strongly attenuated by the bubble screen, and the remaining portion of the direct wave is slowed down so that the surface relief wave can catch up and reduce the effect of the direct wave.

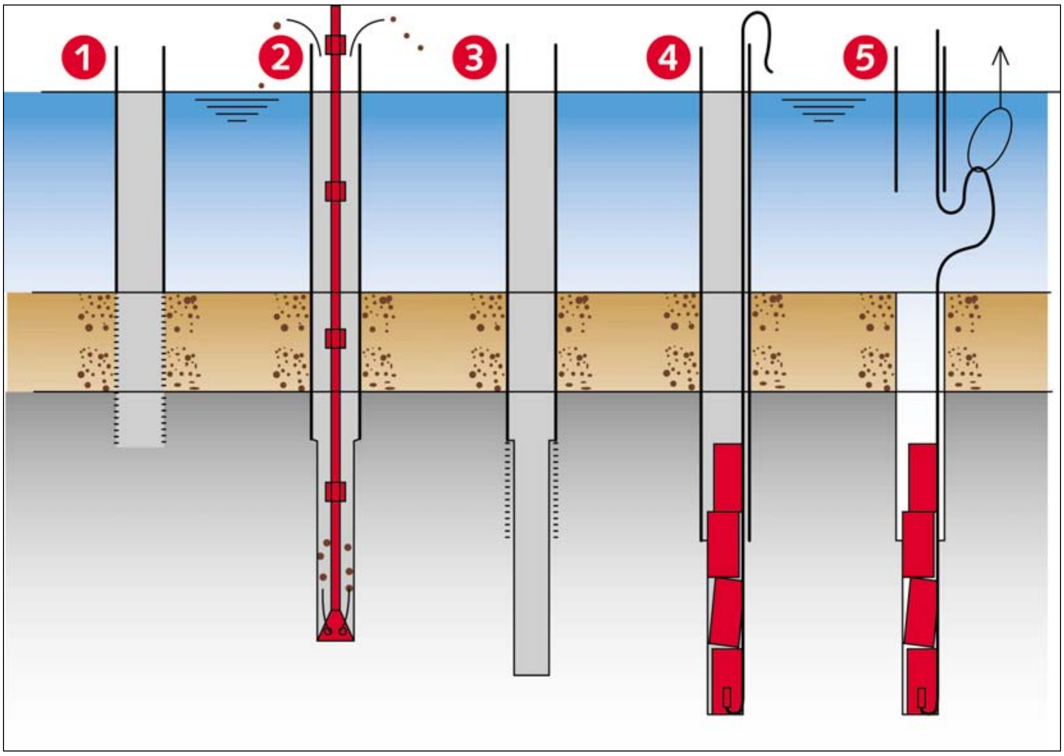

Figure 3.2: Schematic of charge setting operations

Following a blast the platform would move onto the next pattern location and commence drilling new shot holes. A supporting backhoe dredger would accompany the jack-up and clear the trench of rock after blasting. The fragmented material collected by the backhoe would be loaded to a hopper barge and side cast onto the seabed along the licensed route of the pipeline for storage until it is used to backfill the trench once the pipeline has been laid. It is not expected that there will be a significant amount of surplus material due to the winnowing action of the waves and currents.

The nominal depth of excavation of the trench would be 3 m. A post excavation survey will be carried out to demonstrate that the trench profile is acceptable for subsequent pipe installation.

When all blasting is complete the backhoe dredger will then complete the trenching work.

Once the trench has been established onshore and offshore, the pulling wires would be laid in accordance with the contractor's wire laying procedure. The wires will be laid to a location in the Bay (approximately 1-1.5 km offshore) where the inshore laybarge will anchor. The wires will then be marked using a pennant and buoy to enable the laybarge to retrieve them.

3.6.3 Inshore Pipeline Construction

The inshore laybarge will then arrive on location at about 10 m water depth and pick up the pulling wire mentioned in **Section 3.6.2.3**. The wire will be connected to the end of the pipe section on the barge, which will be closed off with a pulling head designed for the pulling loads and to ensure that the landfall section of pipe remains dry.

The controlled pull will then take place between the barge and the shore. New sections of pipe will be welded on the barge as the pulling operation progresses. The pulling operation will cease when the pulling head has been pulled along the prepared trench to a location some 10 m behind the line of the cliffs. This operation is expected to take between 24 and 48 hours. Diving support will be present throughout the pull to ensure that the pipeline is traversing through the trench.

The pipe, which is welded together and pulled from the vessel to the shore, will have another two pipes "piggy–backed" just before it passes over its stern. These will be a 10" conduit for the umbilical and the 10" produced water discharge pipe from the Terminal. The pipes will be secured using a robust system of spacers and straps so that the composite bundle behaves as one unit. The method to be employed is in common use and will ensure all 3 pipes end up in the bottom of the trench. It is possible that some additional temporary buoyancy will be added to the bundle to reduce the pulling weight as it is pulled into the trench. Once the pulling head has arrived at its chosen position, the buoyancy will be removed.

The 10" conduit for the umbilical will extend from the landfall to approximately 1000 m from shore.

Once the pipe end is secure on shore the barge will lay pipe until it overlaps the pipe end buoyed off by the offshore laybarge Solitaire. The inshore barge will then weld the two pipe ends together. Once welding is complete the joint will be tested and the pipeline lowered to the seabed.

It is anticipated that the landfall pull will begin in early summer.

The outfall pipe that is to be laid with the pipeline in the inshore section will be terminated with a simple diffuser structure. The structure will be attached to the line and be lowered with it. Protection materials such as rock and an overtrawlable cover will then be placed around and over the structure to give it anti snagging capability.

The burial of the pipeline in the nearshore area will take place over the following few weeks and the backhoe will recover stored material and relay it on top of the pipeline in the trench. The trenching machine (Digging Donald) deployed from its mother ship the Trenchsetter will construct the trench from the end of the rock section. It will also take over from the backhoe at approximately 20 m depth and bury the pipeline to the limit of Broadhaven Bay.

The landfall section will then be reinstated by replacing, when possible, any rock, subsoil and sand into the trench in the order it was removed. The winches will remain on the site to carry out the pipeline pull across the Sruwaddacon as described in **Section 3.7.3**.

3.6.4 Offshore Pipeline Construction

A dynamically positioned (DP) pipelay vessel **(see Plate 3.2**) will lay the pipeline from about 20 m LAT water depth in Broadhaven Bay out to the field. DP vessels maintain position by means of a series of thrusters, which are controlled by the vessels management system linked to the electronic positioning system. This allows the vessel to hold station at a location without anchors, reducing disturbance to the seabed.

It will arrive on location and install a temporary 'start up pile' and pulling block. The pipeline sections will be welded up and laid onto the seabed, secured to the start up pile. The barge will then lay away and continue offshore to the field.

It is expected that the pipelay vessel will take approximately 25 days to lay the pipeline including the offshore section that is fitted with the PLEM.

The pipeline is delivered to the pipelay vessel in lengths of approximately 12 m by support vessels. The lengths of pipe are welded together on the pipelay vessel. The welds are inspected using a radiographic technique and the weld area is then coated with an epoxy resin for protection and continuity of the corrosion coat. A mastic filler is then used to fill the gap in the concrete coat. The pipeline is lowered over the stern of the vessel as the vessel moves along. The natural flexibility of the pipeline allows it to be lowered to the seabed in an arc shape, generally described as 'S' lay, controlled by tensioners linked to the vessel management system.

The contractor will be following a route which has been determined on the basis of detailed surveys, and which will traverse areas of least seabed undulation. Ancient iceberg scours 5–35 km away from the Field and within 19 km of the Field, are particular problems in this respect. The scours have defined 'shoulders', which make the seabed stand proud in some places. By routing the pipeline to avoid these, it has been possible to greatly minimise the potential for spanning (see **Section 2.5.3.1**).

Even so, there may still be the need to profile the seabed in areas to reduce the potential of the pipeline to span between high spots. Such seabed work will be achieved using a twin-tracked trencher that removes material from under the pipe, and by rock placement at the significant remaining spans once the pipeline is laid. Rock placement will be achieved by the use of a fall or 'tremie' pipe which allows the rock to be delivered directly to the seabed at the location where it is required, thus minimising the impacts often associated with the free fall method where rock is dropped from the sea surface. It is anticipated that a maximum of 16,000 tonnes of rock may be required for the correction of spans and for other remedial burial needs.

The pipeline will be coated with a polypropylene layer in the factory. The primary function of this material is cathodic protection. It is however a very hard material and will also be capable of withstanding impacts from fishing gear. Where additional weight is required, such as in the shallow waters of Broadhaven Bay and also where the pipeline is not buried in trench, a concrete weight coat is applied over the polypropylene layer.

The pipeline will be concrete coated and buried within a trench out to the limit of the Broadhaven Bay SAC. Thereafter it will be concrete coated and laid on the seabed until about 19 km from the field itself. At that point, because the water is over 200m deep, the hydrodynamic forces are no longer expected to be significant and so there is no need for the concrete weight coat.

Where the pipeline sections are welded together a heat shrink wrap is applied over the welded area to provide continuity of the cathodic protection layer. Where the pipe has the additional concrete coat, the weld zone is then filled out with mastic in order to give an even profile along the pipeline.

Plate 3.2: Typical pipelaying barge, Solitaire

3.6.4.1 Pipeline Hydrotesting

Once the pipeline has been laid, it will be flooded with seawater for pressure testing. The water will be introduced at the offshore end with a series of gauging PIGs ahead of it. Four different types of chemical will be added to the seawater, namely biocide, oxygen scavenger, corrosion inhibitor, and dye. The biocide, oxygen scavenger and corrosion inhibitor are to inhibit any damage to the pipeline material during the time the pipeline lays dormant, while the dye would indicate the precise location of any leak from the pipeline. The exact type and quantity of chemicals used for this test will be agreed in advance with the DOMNR.

Once the PIGs have arrived at the landfall, the pressure in the pipeline will be increased, using pumps located on the offshore construction vessel, to the applicable code test pressure which is above the normal operational pressure to test the integrity of the line. An electronic pressure monitoring system will record the pressure and temperature of the water within the pipeline for the test duration.

The pipeline will be left flooded until the onshore pipeline connecting it to the Terminal has been completed, flooded and hydrotested, after which the entire line will be de-watered. This will be carried out from the Terminal by pumping a 'train' of PIGs, each separated by quantities of drying agents, such as methanol, using compressed air or nitrogen as a driver. The inhibited water and the methanol will vent through the subsea manifold offshore, where the mixing and dilution of the chemicals will take place rapidly. This operation is standard practice for testing subsea pipelines, and is subject to specific approval by DOMNR.

3.6.5 Pipe Burial

Where it is necessary to bury the pipeline in a trench, it is common practice to lay the pipeline on the seabed and then return or follow behind with a trenching machine, plough or jetting machine. In some cases, usually only in shallow water where hard substrates exist, a trench could be excavated in advance of laying the pipe.

For the Corrib pipeline, it is anticipated that a trenching machine will be the method used for burial.

With the trenching method proposed spoil mounds will be created on either side of the trench. These mounds are typically unstable in the long term and fall back into the trench under the influence of bottom currents. **Plate 3.3** provides a photograph of the proposed trenching equipment.

Plate 3.3: The trenching machine," Digging Donald"

Jetting provides an alternative technique to pipe-trenching. The principle of the jetting technique is that high pressure water jets are directed on the sediment on either side of the pipeline, creating a trench. The pipeline then slides down into the trench. During jetting the spoil tends to go into suspension with the coarser fraction falling out in the vicinity of the pipe route, the remainder being dispersed to some degree by currents. **Plate 3.4** shows a typical jetting machine for use in shallow waters.

Plate 3.4: Typical inshore sediment "jetting" equipment

3.6.6 Inshore Umbilical Construction

An umbilical lay vessel **(Plate 3.5)** will install the umbilical. The umbilical, which is stored on a large reel, arrives with the lay vessel. Before the vessel arrives, the conduit for the umbilical will have been installed with the inshore section of the pipeline (see **Section 3.6.3**). The conduit will have a bell mouth fitted to its end to guide and protect the umbilical. The lay vessel will initially position itself over the capped end of the umbilical conduit, approximately 1000 m from shore. The vessel's ROV will remove the conduit cap, retrieve the 'messenger wire' inside the conduit and bring it to the surface where it will be attached to the pulling head of the umbilical.

A winch of about 50 tonnes capacity stationed near the onshore end of the conduit will exert a continuous pull force on the umbilical via the messenger wire as it is paid out from the vessel. The time required for the pull from the vessel to the shore will be much less than that for the pipeline (which stops intermittently for new sections to be welded).

Once the pulling head has arrived onshore, it will be removed and the 'tails' of the umbilical's internal cables and tubes will be attached to the Onshore Termination Unit (OTU) that provides the transition to the onshore umbilical components. Tests will be performed immediately to ensure the integrity of the umbilical after it has been pulled ashore.

3.6.7 Offshore Umbilical Installation

The umbilical lay vessel (**Plate 3.5**) will move offshore from Broadhaven Bay, laying the umbilical as it moves. Due to the length and weight of the umbilical it will be necessary to lay it in two parts. The length of umbilical from the OTU will reach approximately 42 km from shore, where it will be connected to a new length delivered by another lay vessel which lays the remaining 42 km of umbilical to the Corrib Field. The mid-point connection will be enclosed in a box on the seabed and protected by mattresses.

Plate 3.5: Umbilical lay vessel (Seaway Falcon)

It is estimated that it will take approximately 7 days to lay the umbilical from Broadhaven Bay to the underwater termination assembly (UTA) in the Corrib Field. Immediately after the umbilical is laid, it will be buried. The trenching vessel will commence work at the landward end as soon as the final section of the umbilical has been laid and tested, if not before.

Plate 3.6: Typical dynamically positioned installation vessel (Seaway Eagle)

It is estimated that approximately 30 days will be required for burial of the umbilical. The umbilical will be buried so that it is covered by at least 0.6 m of sediment.

3.7 Estuary Crossings

The onshore section of the pipeline includes two estuary crossings namely:

- downstream crossing at mouth of Sruwaddacon Bay, length 449 m; and
- upstream crossing of Sruwaddacon, at the mouth of Glenamoy River, length 228 m.

The two crossings have a main flow channel, with maximum depths of about 2 m below Chart Datum that is surrounded by shallow banks with levels up to 1.5 m (downstream) and 2 m (upstream) above Chart Datum. These banks are tidally inundated.

Two crossing techniques have been investigated, these being horizontal direction drilling (HDD) and open cut (further information on these techniques can be found in **Section 4**). The survey and site investigation information gathered during the design phase indicates that HDD will not be suitable on the basis that the permeable nature of the ground could allow drilling mud to escape into the estuary and present unacceptable environmental and technical risks to the operation of pulling the pipeline into the drilled hole. Therefore, both crossings will be executed by pulling pre-fabricated bundled pipeline strings across the water into an open-cut trench. Where the steepness of the river bank precludes the pipe bending naturally to the profile of the emergent trench, it will be necessary for the pipe string to be fitted with a pre-formed section or spool.

3.7.1 Pipeline and Umbilical

Gas Pipeline

During the operation to pull the gas pipeline through the open-cut trench, there is a risk of damaging the corrosion coating. In order to prevent that and for the purposes of providing stability, the pipeline is likely to have a concrete coat. This would be applied by a specialist facility before the pipe is delivered to site.

Outfall Pipeline

The outfall pipe will be strapped onto the 20” gas pipeline in the Sruwaddacon crossing operations to create a ‘bundle’.

Umbilical

In order to facilitate the installation of the umbilical elements (control system hydraulic lines and cables) small bore polyethylene conduits will be attached to the bundle. The individual control lines will be pulled through these conduits at a later stage of construction. It is assumed that up to 5 such conduits each with a 100 mm diameter will be used. They are joined together using an external sleeve heating process, which guarantees a smooth internal surface for unhindered passage of the control lines.

3.7.2 Pulling Loads

The downstream Sruwaddacon crossing is about 450 m, which requires a total pipe-string length in the order of 500 m. The upstream crossing is shorter. The total weight of the assembly of the 20" pipeline, 8" outfall pipeline and five 4" HDPE/umbilical conduits is estimated to be approximately 260 tonnes, slightly less for the upstream crossing. The bundle will be assembled on land and supported on rollers roughly in line with the direction of pull.

The pull-load at the beginning of the operation will be in the order of 40 tonnes. In the final stages of the pull the actual weight of the bundle will be less than half its in-air weight but the pull force will have increased to 100 tonnes.

Detailed design will address the optimisation of the operations. Pull-loads, for instance, can be reduced by adding extra buoyancy to the bundle in the river section of the crossing.

3.7.3 Installation

The downstream crossing of the Sruwaddacon can, in principle, be done in two directions. However, the land behind the west bank (Dooncarton side) is seen to offer distinct advantages over the east bank (Rossport) for the assembly of the pipe bundle. Access is more complex on the west, but since the landfall preparation activities will have to be carried out in this area, the necessary arrangements will have already been made. Therefore, the pull operation of the downstream crossing will be from west to east with the assembly area located between the sea and the Sruwaddacon.

For the upstream Sruwaddacon crossing, the land to the south of the river offers a better location for pipe assembly, being further away from the dwellings situated on the north bank. Access will have to be provided using temporary materials as required. Rollers will be laid down on the ground to assist the passage of the bundle into the river.

The following activities can be considered common for both crossings:

- preparation of the pipe assembly site: access; removal of topsoil; storage; welding station(s); locations for radiography and field weld coating; roller track; and small winch to pull the pipe string along the rollers;
- installation of pulling winch onto prepared foundations;
- route preparation: river excavation and preparation of transition trenches at either side of the river;
- pipeline assembly, bundling and pulling;
- backfilling of the trench with stored riverbed material;
- pulling of the component lines of the umbilical through the conduits;

and

- demobilization and re-instatement of the land.

3.7.3.1 *Preparation of the Pipe Assembly Area and Bundle*

Preparation of the assembly site and erection of the pipe strings are standard operations. However, the special needs of the surrounding environment in which the work will be carried out will be addressed, first in the design stage, and secondly in the mobilisation of the site. Enterprise will liase with local authorities and the local communities throughout the operation to ensure that local concerns are addressed.

During the landfall and Sruwaddacon crossing works, in order to aid the transport of personnel and light equipment across the river, it is expected that a temporary jetty will be established on the west bank of the estuary.

The landfall site has to be prepared to receive the heavy equipment that is needed for the transport and handling of the pipe joints, and assembled pipe strings. The area of land to be used will first be fenced off and public warning signs posted to notify the restricted access to the beach, the landfall and crossing areas. Topsoil will be removed and stored to one side of the wayleave, and any deeper excavated material will be stored separately. Where necessary, concrete foundations for items of equipment will be cast in-situ, but always in a manner that will enable their removal. The installation of the pulling winch will require more significant civil construction as highlighted below.

The welding station will be the same as that used for the welding of onshore pipelines, and established at the top of the assembly line. After laying out the single steel joints, each joint will be welded, tested radiographically, and then coated in accordance with the relevant specifications. After each joint has been successfully made, the pipeline is pulled over the length of one joint by the winch at the end of the assembly roller track.

The outfall pipe and the umbilical conduit will be assembled using the specialist equipment required to weld polyethylene pipe. Once assembled as completed strings, they will be lifted onto the steel pipe and secured with straps at frequent intervals.

3.7.3.2 *Installation of the Pulling Winch*

Detailed design will establish the best methods for the positioning of the winch and routing the wire. This will examine conditions such as foundation design, plant access, tidal flow, safety and mechanical support.

The winch will be set on concrete pads, and will be secured to drilled rock anchors by cables. The purpose of the cables is to restrain the winch during the pulling operation. The winch will weigh approximately 25 tonnes and will be transported in by road.

3.7.3.3 *Route Preparation*

Prior to the pulling operation, a trench has to be excavated in the estuary to the specified depth with transition curves at either side of the crossing.

In the main channel, excavation will be carried out from a small pontoon fitted out with a simple anchoring system and backhoe excavator. With the help of a small vessel, anchors are run out enabling the pontoon to keep station. The same pontoon can be used in the intertidal areas alongside the main channel where the pontoon is grounded during low water periods. The backhoe excavator can be rolled off the pontoon to continue excavation if necessary. A combination of these techniques is likely to be used until the trench has reached the depth required to achieve the specified depth of cover for that section. The excavated soil will be stored locally to one side of the trench and in the intertidal areas, depending upon the exact location and the propensity for the material to be lost through tidal erosion.

Throughout the operation the trench profile will be surveyed using vessel-mounted depth sounding equipment and bottom profilers.

3.7.3.4 *Pulling Operation*

Immediately prior to the pull operation, a messenger wire is laid across the river using a pontoon or similar small vessel. The pulling operation will be carried out during high water periods, in order that the submerged weight of the pipeline bundle is spread over the maximum length possible, thus deriving the most benefit from the bundle's own buoyancy. The buoyancy supplied by the polyethylene lines will offer sufficient resistance against rotation to keep the pipeline assembly in an upright position. The pull force is only applied to the steel pipeline.

In advance of the operations, notification will be given to the local community and authorities, in accordance with the procedures that will have been determined in advance of the work. Radio communication between the two sides of the river will be employed to provide adequate co-ordination between the two working sites.

The operation is complete when the pipe end has been pulled the designated distance and survey operations confirm that the pipe is sitting in the prepared trench. Divers will then remove any buoyancy. The pipe ends will be removed when the trench has been stabilised, and work will proceed to prepare the pipe for tie-in to the onshore portion.

3.7.3.5 *Backfilling of the Trench*

The excavated material will be returned to the trench using the pontoon mounted backhoe procedure in reverse. It is also expected that the trench surface will level off over time by natural current processes.

3.7.3.6 Pulling of the Umbilicals

The components of the umbilical will be installed inside the five HDPE conduits strapped to the pipeline bundle. Wires will have been pre-installed in each of the conduits, prior to the river pull.

Optimising the detailed method for installing the umbilical components will be the subject of special study involving the umbilical manufacturer, and the onshore construction contractor. The method for laying the component lines along the onshore route to the Terminal will also influence the final decision, since the technique could vary as a result of the trench construction design being different from one part of the route to another.

3.7.3.7 Demobilisation and Re-instatement

Once the onshore lengths of the pipelines and umbilicals have been laid into the trench and pulled through the river crossings, they can be joined and tested. The test equipment will be stationed at the Terminal and consist of electrical signal generators and small high-pressure pumps. There will be no visible sign of the tests. However, precautions will be taken to keep all personnel away from the items in accordance with standard test procedures.

Once accepted, any remedial work that has not taken place, such as infill of the trench, will be completed. Topsoil will be returned from where it was taken and the necessary replanting and seeding of ground carried out. Where rock has been excavated out of the riverbank crossings, it will be returned with the possible use of wire gabions to help stabilise it. The heavy plant will have been removed soon after the pull operations have taken place and the ground restored. Any drilled foundations that cannot be removed will be cut close to the bedrock and then covered with the original excavated subsoil material and topsoil. Paths, hedges and fences will be restored to the satisfaction of the landowners.

3.7.4 Onshore Block Valve and Termination Unit

The onshore pipeline and umbilical will join with the offshore lines in a special facility a short distance behind the landfall. This facility will be constructed in an underground box. Standard civil engineering techniques will be used to excavate the box location. The site will be covered using excavated material and the top soil and habitat reinstated to the satisfaction of the landowners.