Appendix M5

Hydrological Impact Assessment

Hydrological Impact Assessment and Stormwater Management during Construction

May 2010

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APPENDICES

1.0 INTRODUCTION

This report examines the existing hydrology along the proposed Corrib Onshore Pipeline route. The report also assesses the potential impacts that the proposed pipeline construction might have on the existing hydrological regime of the area. Chapter 15 of the Corrib Onshore Pipeline EIS provides a summary of the information contained in this report.

The principal objectives of this assessment are to:

- Identify and compile all available hydrological data associated with the construction of the proposed pipeline;
- Identify, describe and evaluate sites of known or potential hydrological interest;
- Assess the significance of the likely impacts of the proposed scheme on the existing hydrological environment along the proposed route including the residual impact; and
- Identify the mitigation measures required to minimise the likely impacts identified.

The location of the proposed pipeline route is illustrated in the Alignment Sheets contained in Appendix A1 of the Corrib Onshore Pipeline EIS.

1.1 METHODOLOGY

This hydrological impact assessment was carried out by RPS. The assessment was based on available information and site visits carried out along the proposed route in August 2008 and March 2010.

This report is prepared having regards to:

- *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (Draft)* (NRA 2007);
- *Environmental Impact Assessment Guidelines of National Road Schemes – A Practical Guide* (NRA 2004);
- *Advice Notes on Current Practice in the preparation of Environmental Impact Statements* (EPA 2003);
- *Guidelines on the information to be contained in Environmental Impact Statements* (EPA 2002),
- *Guidelines for the Crossing of Watercourses during the construction of National Road Schemes* (NRA);
- *Control of water pollution from linear construction projects* (CIRIA Report No. C648, 2006); and
- *Fisheries Protection Guidelines – Requirements for the protection of Fisheries Habitats during construction and development works at river sites* (Eastern Regional Fisheries Board).

The following sources of information were used in order to complete the assessment:

- Corrib Onshore Pipeline Environmental Impact Statement (EIS), April 2008;
- Flood data obtained from the website maintained by the Office of Public Works (www.opw.ie);
- Western River Basin District (WRBD) Reports – water quality risk assessment results;

- Other relevant websites, i.e. Environmental Protection Agency (EPA) (www.epa.ie) and Met Éireann (www.meteireann.ie); and
- Ordnance Survey 1:50,000 Discovery Series Maps.

Relevant information, including catchment soil type, topography and morphology of the lands along the proposed route corridor and construction compounds, as well as the nature of the stream crossings were collected through walkover surveys and site/ground investigations.

2.0 PROPOSED DEVELOPMENT

Details on the design of the proposed onshore pipeline development and the overall approach to construction are provided in Chapters 4 & 5 of the Corrib Onshore Pipeline EIS.

The proposed onshore pipeline has a total length of approximately 8.3km between the LVI at Glengad and the Gas Terminal at Bellanaboy Bridge. Over half of the pipeline will run in a tunnel beneath Sruwaddacon Bay between Glengad and Aghoos. The pipeline route crosses one estuarine river (Leenamore River) and three small streams (see table 3.5). Drawing No. Mi2188 in Appendix A of this report illustrates the proposed route of the onshore pipeline. A section of the pipeline will run through a peatland area located south of Sruwaddacon Bay, as highlighted in green in Drawing No. MI2188.

In peatland areas it is proposed to install the pipeline in a stone road. The detail of this construction method is provided in Chapter 5 of the Corrib Onshore Pipeline EIS. It is proposed to use open-cut techniques for the river/stream crossings.

3.0 EXISTING ENVIRONMENT OF THE PROPOSED PIPELINE

3.1 REGIONAL HYDROLOGY

The regional hydrological environment within which the proposed development site is located is discussed below in the context of the following attributes:

- Topography;
- Flood Hydrology;
- Drainage;
- Water Quality;
- Water Quantity; and
- Amenity Value.

River Catchments and Hydrology

The proposed pipeline route lies mainly within the catchment area of Sruwaddacon Bay. The two largest rivers draining into Sruwaddacon Bay are the Glenamoy and Muingnabo Rivers. The Sruwaddacon Bay catchment area forms part of the National Hydrometric Area – 33 and falls within the Western River Basin District (WRBD). **Figure 3.1** shows the extent of the associated river catchment areas, which drain into Sruwaddacon Bay, together with a layout of the proposed pipeline route. A short section of the onshore pipeline route within the Terminal is not shown within any catchment as it is understood to be facilitated by the surface water drainage in the Terminal site, which discharges to the Carrowmore Lake catchment.

The Glenamoy River rises in a mountain located at Glenagh, Co. Mayo (land elevation 304mOD Malin Head), approximately 20km northeast of its confluence with Sruwaddacon Bay. The Glenamoy River has an approximate catchment area of 87km^2 upstream of Sruwaddacon Bay. The Muingnabo River rises in high ground at Glenagh (land elevation of 265mOD Malin Head), approximately 15km upstream of its confluence with Sruwaddacon Bay. This river has an approximate catchment area of 40.14 km^2 upstream of Sruwaddacon Bay. Both the river catchments are steeply sloped towards Sruwaddacon Bay with an approximate main channel slope of 1 in 85. The soil types within both of the catchments areas vary between the FSR (The UK Flood Studies Report, NERC 1975) soil types 3 and 5, suggesting moderate to very low winter rain acceptance potential.

In addition to the Glenamoy and Muingnabo Rivers, a number of other local rivers/streams and land-drains also discharge directly into Sruwaddacon Bay (see **Figure 3.1**). One of these estuarine rivers, locally known as the Leenamore River, will be crossed by the proposed pipeline at chainage 89.250km. The Leenamore River rises in high ground at Bellanaboy and discharges into Sruwaddacon Bay approximately 2km downstream. The river has an approximate catchment area of 2.53km^2 upstream of its confluence with Sruwaddacon Bay. The topography of the catchment is steeply sloped (1 in 90) and the FSR soil type varies between type 3 and 5 suggesting moderate to very low winter rain acceptance potential (i.e. moderate to very high runoff potential).

The observed long term average annual rainfall at Bangor, Glenamoy, Rossport and Belmullet are 1352mm, 1416mm, 1339mm and 1173mm, respectively (source: Met Éireann). The estimated 100 year return period hourly rainfall at Belmullet is 34.6mm, while the maximum observed hourly rainfall at Pollatomish is approximately 40mm, recorded in September 2003, which had an approximate return period of 190 years (source: EIS prepared for Bellanaboy Bridge Terminal, EPA data, October 2003).

The west of Ireland experienced notably high rainfalls in November 2009 along with many other parts in Ireland. The most extreme rainfall occurred over the period from 16th to 18th November 2009. The observed daily total rainfall at Belmullet on 16th November 2009 was 23.20mm. This prolonged rainfall led to flooding in many areas. A study carried out by Met Éireann on the November 2009 rainfall concluded that, "*The maximum 24hr rainfall totals have a return period of less than 100 years and higher return periods occurred for longer duration* *rainfall totals (>4 days),"* (Climatological Note No. 12, Met Éireann, February 2010). The estimated return periods of the November 2009 rainfall totals for the 4, 8 and 16-day periods at Belmullet are 2, 3 and 5 years respectively (see **Table 3.1**). This suggests that the observed rainfall at Belmullet in November 2009 was not as severe as that experienced at Pollatomish in September 2003.

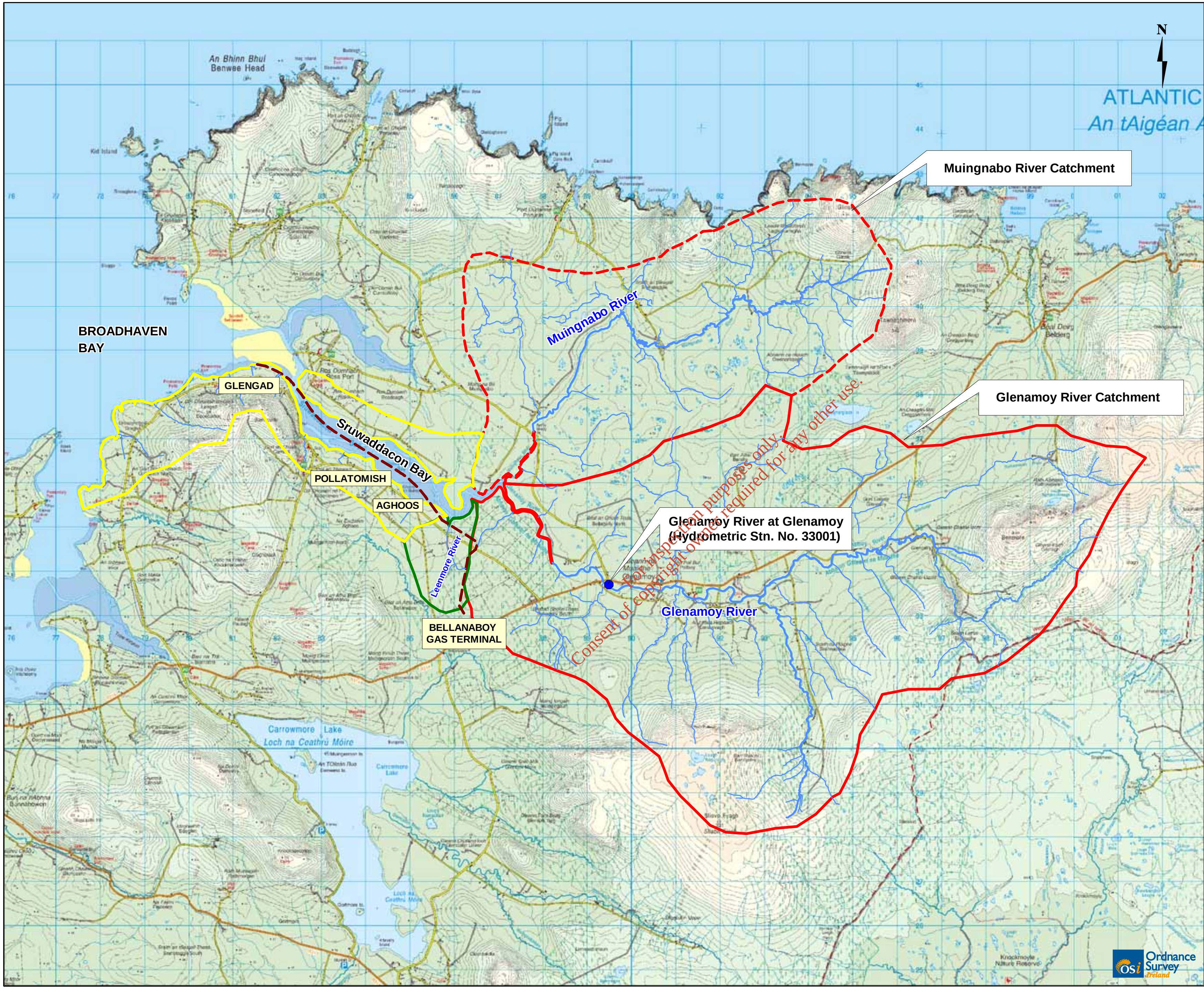
Table 3.1: Frequency of observed rainfall totals in November 2009 at Belmullet

Sliding durations (day)	Maximum Rainfall totals (mm)	Estimated Return Period (years)
1	21	1.1
2	32	1
4	51	2
8	89	3
16	143	5
25	198	7

Flow records for the Glenamoy River at Glenamoy (Hydrometric Station No.33001, **Figure 3.1**) have been obtained from the EPA Hydro-data website. Mean daily flow records for a period from 1977 to 2007 are available for this station (see Appendix B of this report), a summary of which are presented in **Table 3.2**. The recorded mean annual maximum and 95 percentile flows at this location are 27.87m^3/s and 0.24m^3/s, respectively. The relatively high mean annual maximum flow rate (0.366$m^3/s/km^2$) can be attributed to its steep catchment slope and the catchment soil types with moderate to very high runoff potential.

Table 3.2: Summary of Flow Records for the Glenamoy River at Glenamoy (Hydrometric Station No. 33001)

Upstream Catchment Area (km^2)	Mean Annual Flow (m^3/s)	95 Percentile Flow (m^3/s)	Annual Maximum Flow	
			Mean (m^3/s)	Median (m^3/s)
76.1	2.91	0.24	27.87	27.50



Legend

- Proposed Pipeline Route
- Muingnabo River Catchment
- Glenamoy River Catchment
- Leenmore River Catchment
- Additional Catchment Areas
- River Station
- River

Client

Corrib natural gas

Project

Corrib Onshore Pipeline

Title

River Catchments

Figure 3.1

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Date: May 2010	

Notes
1. This drawing is the property of RPS Group Ltd. It is a confidential document and must not be copied, used, or its contents divulged without prior written consent.
2. All levels are referred to Ordnance Datum, Malin Head.
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Ordnance Survey Ireland

No flow records for the Muingnabo and the Leenamore Rivers in the vicinity of the study area were available. Flood flows for the Leenamore River at the proposed pipeline crossing have been estimated in accordance with the methodology set out in the UK Institute of Hydrology, Report No. 124 *"Flood estimation for small catchments"* (1994). The details of flow estimates for the Leenamore River catchment are presented in **Table 3.3** below.

Table 3.3: Leenamore River catchment details and flood flow estimates

Parameters	Flow estimates
AREA:	2.53 km^2
SAAR:	1416 mm
SOIL:	0.40
Q_{BAR}	1.642 m^3/s
FSE	1.65
Q_{BAR}	2.709 m^3/s
Growth Factors –return periods of 100 year and 200 year	1.96 & 2.14
Q_{100}	**5.309m^3/s (2.10cumec/km^2)**
Q_{200}	**5.796m^3/s (2.29cumec/km^2)**

The estimated 100 year and 200 year return period flood flows for the Leenamore river catchment are **5.309m^3/s and 5.796m^3/s**, respectively. In terms of specific flows, these are **2.10$m^3/s/km^2$ and 2.29$m^3/s/km^2$**, respectively. These estimates give an idea of the extent of surface water runoff likely to be generated following an extreme rainfall event at the Leenamore River catchment.

The Glenamoy and Muingnabo Rivers generally flood every winter after heavy prolonged rainfall. These catchments have experienced a number of high floods in the past. The worst flooding in these catchments occurred in 1984 (21st September), 1989 (27th October) and in September 2003 (19-20th September). Much of the low lying floodplain of the river catchments flooded during these flood events. The OPW flood hazard maps show a flood point at the Glengad Area (**Figure 3.2**).

Flooding in September 2003 occurred at the Glengad, Barnachuille and Dooncarton areas following an intense localised rainfall event. A total 80mm of rainfall fell over an approximately two-hour period shortly before midnight of the 19th September 2003 (Mayo County Council, October 2003). The rainfall was described as 'unreal' by Met Éireann and was accompanied by a heavy thunderstorm and large hailstones. This rainfall event caused multiple landslides on the slopes of the Dooncarton and Barnachuille mountains. There were approximately 40 individual slides of peat and weathered rock, varying from 15m^3 to 20,000m^3, which resulted in considerable damage to roads, bridges, property and the environment. Approximately 40 families were evacuated from their homes (Geological Survey of Ireland, 2006). Immense volumes of peat, soil and stone were washed from the mountain into Sruwaddacon Bay. The bridge at Glengad was washed away. The primary cause of the landslides in the Pollatomish area was exceptional rainfall following a dry summer period, of such intensity as to overwhelm natural drainage systems in the relatively thin overburden layers of peat and weathered rock.

The Bellanaboy River, one of the principal tributaries of Carrowmore Lake, also experienced unprecedented flooding during the September 2003 rainfall event. The Bellanaboy River catchment is located south of the subject study area and comprises the southern sloping areas of the Dooncarton, Barnachuille, Glengad and Pollatomish mountains. The observed peak flow for the Bellanaboy River catchment at Bellanaboy Bridge (Hydrometric Station No. 33011) on 20th September 2003 was 45m^3/s (EPA, October 2003). Based on an upstream associated catchment area of 20.5km^2, the estimated specific flow rate for the Bellanaboy River catchment is 2.20$m^3/s/km^2$. This is equivalent to a 180 year return period flood flow in the Leenamore River catchment as can be seen in **Table 3.3**.

Flooding of low lying lands in the vicinity of Sruwaddacon Bay can be caused by joint occurrences of high fluvial flows from the upstream river catchments and high tidal levels in

Broadhaven/Sruwaddacon Bay. No long-term tidal records are available for Sruwaddacon Bay, but a tidal survey carried out in July 2007 (from 25th July through to 8th August, 2007) showed that the highest observed tide level in Broadhaven Bay during this period was in the order of 3.8m above chart datum (2.622mOD Malin Head). The data shows a semi-diurnal tide with a tidal range varying from approximately 1.4m during neap tides up to about 3.8m during spring tides. Furthermore, the tidal range within the estuary also falls from 3.7m at the Bay mouth, to 2.9m at the upstream section (in the vicinity of the Leenamore River confluence), a difference of over 0.8m. The observed average durations of high and ebb tides in Broadhaven Bay during this recording period were 5.65 and 6.36 hours, respectively. The maximum channel water depths in the lower and upper section of the Bay were 5m and 3m respectively at the highest astronomical tide (HAT). Further details of the tidal records can be found in Chapter 14 of the Corrib Onshore Pipeline EIS. The predicted highest tide level in Broadhaven Bay shown in the 2008 tide table for Broadhaven Bay (Proudman Oceanographic Laboratory) is in the order of 3.9m above chart datum (2.69mOD Malin Head, March, April and October).

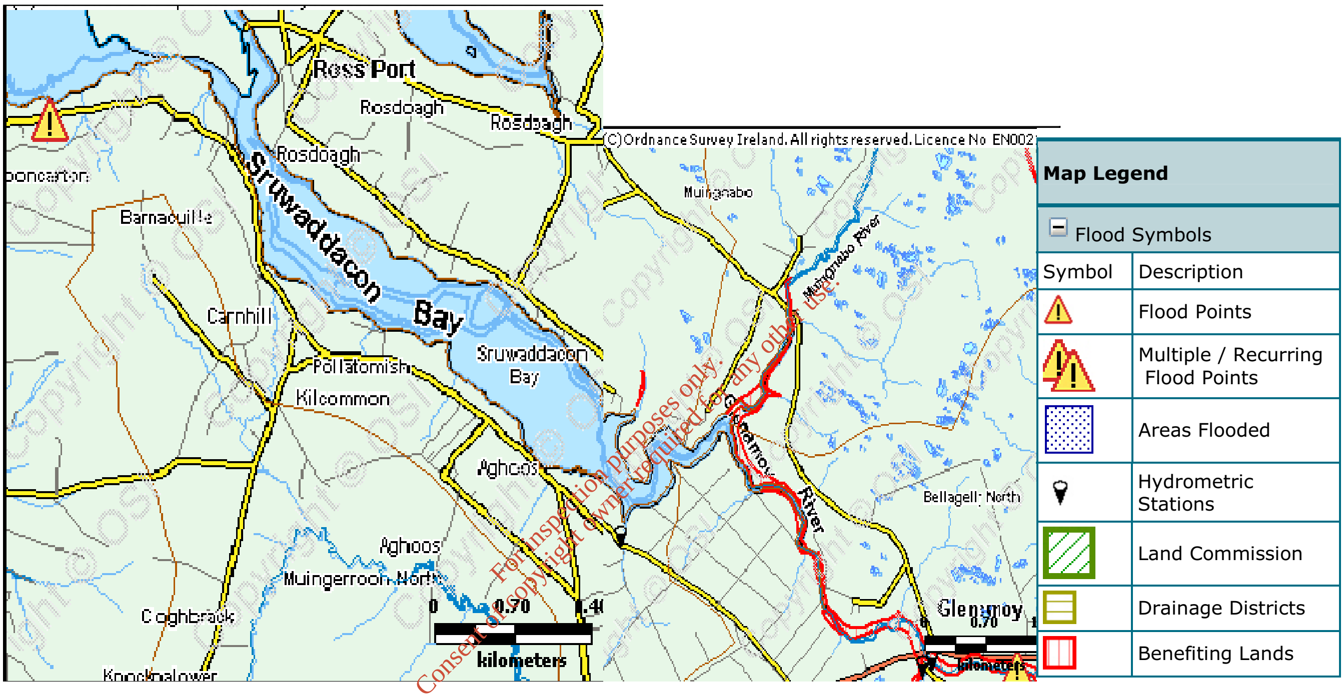


Figure 3.2 An extract of the OPW Flood Hazard Maps showing the subject Study Area (Source: www.opw.ie).

Drainage

The lands along the proposed pipeline route drain via the Leenamore River and via other land-drains located within the Sruwaddacon Bay catchments areas (**Figures 3.1 & 3.2**). The soil types within the main river catchments areas vary between the FSR (The UK Flood Studies Report, NERC 1975) soil types 3 and 5, suggesting moderate to very low winter rain acceptance potential (i.e. moderate to very high runoff potential).

Water Quality

Water quality records for the watercourses in the vicinity of the proposed pipeline route were sourced from the EPA. An assessment carried out by the EPA on these water quality records showed that the Glenamoy River has a Biotic Index (Q-value) of Q4 at Glenamoy (located approximately 5km upstream of the confluence with Sruwaddacon Bay), suggesting the river has "good status" water quality [*Water Quality in Ireland 2001-2003, EPA 2005*] (**Figure 3.3**). Bathing water quality in Glengad in the vicinity of the proposed LVI has been assessed as "*good"* and complies with EU Guide Values under the EU Bathing Water Directive.

A recent assessment of the water quality status for the watercourses within the Sruwaddacon Bay catchment areas has also been carried out under the WRBD project (**Figure 3.3**). **Table 3.4** gives an overview of the risks assessed for these watercourses.

Both the Glenamoy and Muingnabo Rivers in the immediate upstream vicinity of the confluences with Sruwaddacon Bay were assessed as "*1b- Probably at Significant Risk*". The study also found that Sruwaddacon Bay, which is classed as a transitional water, is "*probably at risk of not achieving good status by 2015*". The source of the water pollution at the upper section of these watercourses was mainly identified as siltation resulting from land clearing practices and agricultural practices within the catchment areas.

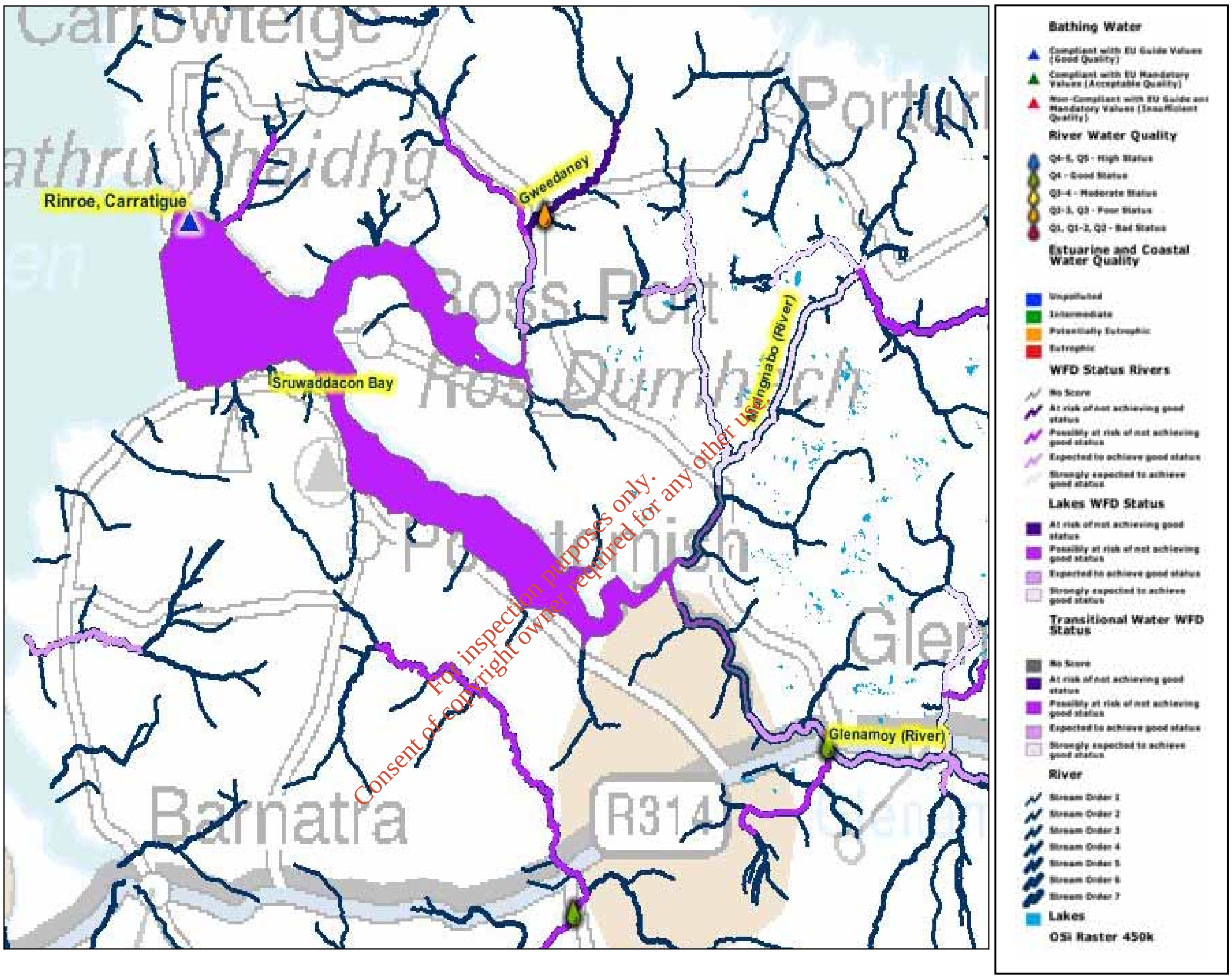


Figure 3.3 Water Quality Map and Risk Assessment for the surface water bodies located within the study area (Source: www.epa.ie).

Table 3.4 WRBD – Water Quality Risk Assessment

Risk Factors	Risk			
	Glenamoy River	Muingnabo River	Transitional Water (Sruwaddacon Bay)	Coastal Water (Broadhaven) EPA
Risk Assessment Summary	1b- Probably at significant risk	1b–Probably at significant risk	1b– Probably at significant risk	Unpolluted

Further information on the water quality in the rivers and streams traversed by the proposed pipeline route is provided in Chapter 13 of the Corrib Onshore Pipeline EIS, while issues regarding the water quality of Sruwaddacon Bay are discussed in Chapter 14 of the EIS.

3.2 DETAILS OF THE EXISTING ENVIRONMENT OF THE PROPOSED PIPELINE

A description of the proposed pipeline route is provided in Chapter 4 of the Corrib Onshore Pipeline EIS and Table 13.1 in Chapter 13, which outlines the locations and description of streams and river crossings along the proposed route.

As mentioned in Section 2 of this report, the majority of the proposed pipeline will run beneath Sruwaddacon Bay between the townlands of Glengad and Aghoos. The route will cross three small streams and one estuarine river. **Drawing No. MI2188** in Appendix A illustrates the proposed route of the pipeline. **Table 3.5** lists the approximate chainages of these crossings and provides a brief description of each crossing. Refer to **Drawing No. MI2188** in Appendix A for the locations of these crossings.

Table 3.5: List of Watercourses to be crossed by the Proposed Pipeline

Approximate Chainage (km)	Location/Townland	Brief Description
84.100	East of the LVI at Glengad	A small first order stream close to outer Sruwaddacon Bay.
84.000-88.600	Sruwaddacon Bay	The proposed pipeline will run beneath Sruwaddacon Bay under the main low-tide channel in and out of the Bay.
89.250	Leenamore River	A small, second order[1] stream draining to the southeast corner of Sruwaddacon Bay, known locally as the Leenamore River.
90.134	Aghoos	A first order stream close to the roadside about 0.5km east of the Leenamore River crossing.
90.688	Aghoos	A small first order stream/drain approximately 0.7km north of the Bellanaboy Bridge Gas Terminal site.

At the proposed river crossing, the Leenamore River Inlet is approximately 40m wide and 1.5m deep below its banks.

It was reported locally that the above mentioned rivers/streams generally overflow banks every winter after periods of heavy prolonged rainfall. However, OPW flood hazard maps do not show any flood prone areas along the proposed pipeline route or in the vicinity of the proposed crossings.

Drainage

Surface runoff from lands along the proposed pipeline route drains directly into Sruwaddacon Bay as overland flow and also via a number of local streams and drainage ditches (**Figure 3.1 & Drawing MI2188**). Based on the topography of the lands along the proposed pipeline route, the existing flow paths of surface water drainage systems and their associated catchment areas have been identified. The details of these sub-catchments are presented in **Table 3.6**.

[1] A second order stream is formed by the joining of two first-order streams

Table 3.6: Stormwater sub-catchments – existing environment

Sub-Catchment	Approximate Chainage (km) & Location	Brief Description
CA-01	Between Ch. 83,400 and 83,800	Approximate catchment area of 0.86ha. Soils are improved agricultural grassland. Surface water drains directly into the sea as overland flows. The soils in this catchment are free draining and during a rainfall event, water percolates to ground and the remaining water is conveyed via a series of surface water drains to the foreshore (**Drawing No. MI2188**).
CA-02	Between Ch. 83,800 and 84,100	Approximate catchment area of 1.04ha. Soils in this catchment comprise a mosaic of improved grassland and marshy lands. The marshy lands indicate impeded drainage; therefore, overland flow during a rainfall event may be increased. Excess surface runoff is conveyed as overland flows and also via a series of surface water drains into Sruwaddacon Bay.
Sruwaddacon Bay	Between Ch. 84.000-88.600	The proposed pipeline will be in a tunnel under Sruwaddacon Bay.
CA-03	Between 88,600 and Ch 89,008	Approximate catchment area of 1.11ha. Soils comprise of cutover bog, recovering eroded/cutover blanket bog, eroding blanket bog with wet acid grassland (Nardus-dominated (ref. Chapter 12 of EIS 2009). Excess runoff drains as overland flow and also via a number of land-drains into the Bay.
CA-04	Between Ch. 89,008 and 89,557	CA-04 forms part of the Leenamore River catchment and has a catchment area of 1.02ha. Soils comprise wet grassland and eroding blanket bog (ref. Chapter 12 of the 2008 EIS). Surface runoff drains as overland flow to Sruwaddacon Bay via the Leenamore River. This catchment is located on either sides of the Leenamore River crossing.
CA-05	Between Ch. 89,557 and Ch. 90,127	Approximate catchment area of 1.27ha. The habitats comprise conifer plantation and recently felled woodland. Numerous drainage channels exist within the conifer plantation. These drain into the Glenamoy River via a small first order stream/drain close to the roadside about 0.5km east of the most downstream crossing of the Leenamore River, which is culverted under the road.
CA-06	Between Ch. 90,127 and Ch. 91,174	Approximate catchment area of 1.76ha. The habitats comprise conifer plantation and recently felled woodland. Numerous drainage channels exist within the conifer plantation. These drain into the Glenamoy River via a local stream located 0.7km north of the Bellanaboy Bridge Gas Terminal.

Water Quality
The existing water quality status for all watercourses in the vicinity of the proposed pipeline route is discussed in the Section 3.1 of this report and further in Chapter 13 of the Corrib Onshore Pipeline EIS.

Water Quantity and Abstraction
Water supply in the area is primarily provided through group water schemes supplied from the Carrowmore Lake. Both the Glenamoy and Muingnabo Rivers are perennial (year round) flow rivers.

4 IMPACT ASSESSMENT AND MITIGATION MEASURES

4.1 GENERAL

The proposed development has the potential to affect only a very small proportion of the Glenamoy River catchment (as can be seen in figure 3.1).

Sruwaddacon Bay, and its associated tributaries located in the vicinity of the proposed pipeline route, may be impacted during the construction phase of the proposed pipeline. The hydrology of the associated peatland areas may also be temporarily affected by the construction of the proposed pipeline.

The potential impact on various hydrological aspects such as flooding, drainage and water quality likely to be caused by construction of the proposed pipeline have been examined and appropriate mitigation measures have been proposed in accordance with the '*Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (Draft)* (NRA, 2007) and the CIRIA (Construction Industry Research and Information Association) guidance on *'Control of Water Pollution from Linear Construction Projects'* (Report No. C648, 2006).

All relevant authorities including the OPW, the North Western Regional Fisheries Board (NWRFB) and the WRBD were contacted in order to get feedback on any likely adverse impacts that the proposed pipeline might have on the environment. This information along with the EPA and WRBD water quality status information for the associated watercourses was taken into account in carrying out this hydrological impact assessment for the proposed pipeline.

4.2 IMPACT ASSESSMENT

Flooding (Tidal and Fluvial)

During Construction

During the construction phase of the works, temporary localised flooding of lands in the vicinity of the proposed river/stream crossings might occur. Potential causes of flooding could include:

- Obstruction of upstream surface water runoff flow paths caused by the pipeline alignment and the stone road construction works;
- Obstruction of flow paths to the natural drainage system and river channels at the location where the open-cut technique will be used for laying pipe in the river bed;
- Blockage of surface water runoff flow paths due to collapse of unstable river/stream/trench banks, particularly in peatland areas;
- Flooding in the vicinity of the proposed river crossings, particularly at the Leenamore River crossing, could occur from a joint effect of high fluvial and tidal flood levels in Sruwaddacon Bay; and
- Flooding of the temporary construction compounds, the stone road or pipeline route, or the start and reception pits from the joint occurrences of extreme rainfall and a high tidal event. The impact of tunnel construction pits on the marine environment of Sruwaddacon Bay is discussed in Chapter 14 of the EIS.

The lowest ground levels are at LVI dished area and the construction compounds located at the reception pit at Glengad (SC2), and the start pit at Aghoos (SC3). Ground levels at these locations are approximately 6.5mOD, 10mOD and 6mOD (Malin Head), respectively. The observed highest tide level in Broadhaven Bay is in the order of 2.622mOD (Malin Head). Adding an allowance of 2m for a large wave surge, the tidal water level at Broadhaven Bay could rise as high as 4.622mOD (Malin Head). This suggests that the proposed compounds will not be at a risk of tidal flooding.

As the portion of the pipeline route beneath Sruwaddacon Bay will be installed via tunnelling, there will be no impact on the current flooding scenario in the Bay.

During Operation
As the pipeline will be laid beneath the beds of the watercourses located along the route (minimum depth of cover is 1.6m), the crossings will not cause any constriction to the existing flood flow path during the operational phase. No adverse impact on flood levels in the associated rivers/streams or in their flood plains is predicted during the operational phase of the works. Any potential increase in runoff volume caused by changes in the soil permeability along the pipeline route and also from clearing of forest is expected to be minimal.

Drainage

During Construction
The existing land drainage system in the vicinity of the proposed pipeline route may be affected during the construction period. Potential impacts on the existing drainage system may include:

- Pattern of runoff could change with some existing drains and ditches receiving significantly more or less flow than they receive currently;
- Rainfall on elevated areas, could wash peat and silt into the surrounding watercourses. Localised erosion and scouring could occur, while reduced flow may result in stagnation in some drains and ditches;
- Obstruction of up-gradient flow paths could cause localised water logging in the upstream vicinity of the pipeline route; and
- Existing surface and subsurface drainage flow paths in peatland areas may be altered slightly during the construction phase of the works. The proposed stone road could act as a preferential drainage path. The impact of the stone road construction method on the peatland hydrology is addressed in a separate report contained in Appendix M6 of the Corrib Onshore Pipeline EIS.

During Operation
The impact on the existing land drainage regime during the operational phase is expected to be minimal. Where river and stream crossings occur the pipeline will be constructed with a minimum of 1.6m cover between the top of the pipe and the true bottom of the stream/river. The clearance of the forest lands along the proposed pipeline route and the construction of a stone road in the peatland areas (south of Sruwaddacon Bay) may have some impact on the current drainage pattern (e.g. a slight increase in runoff volume and response time). This could cause erosion to the land surface and give rise to an increased level of sediments in the receiving waters. The impact of construction on the hydrology of the peatland areas has been addressed in a separate report (see Appendix M6 of Corrib Onshore Pipeline EIS). However, the predicted impact on the regional hydrology in this regard will be minimal.

Water Quality

During Construction
There is a potential for adverse impacts to water quality and aquatic life in adjacent watercourses during the construction phase. These could arise from the following sources:

- Mobilisation of sediments and harmful substances during the construction phase due to exposed soil and earth movement, particularly from the construction of the stone road in the peatland areas, which may block local streams and drains and which could be flushed into the adjacent watercourses during heavy rainfall events;
- Accidental spills of harmful substances, such as petrol or diesel, oil and liquid cement, during delivery and storage or by leakages from construction machinery;

- Increased pollutant and nutrient inputs due to an increase in surface water runoff and removal of existing vegetation; and
- Increased litter from construction materials.

Impacts on freshwater ecology are addressed separately in Chapter 13 of the Corrib Onshore Pipeline.

During Operation
The potential for adverse impact on water quality during the operational phase of the development is expected to be minimal. Any machinery, vehicles or fuel storage tanks associated with the operational phase of the development have the potential to cause a hydrocarbon spill or leak.

Water quantity and water abstraction
A very small area of the pipeline route is located within the catchment area of Carrowmore Lake. However based on existing and proposed surface water management controls, it is predicted that the proposed pipeline construction will not pose any impact on the existing sources of raw water quantity and quality that are currently being used for the regional water supply system.

4.3 MITIGATION MEASURES

Appropriate mitigation measures will be implemented in order to minimise the potential impacts identified both during the construction and operational phases of the proposed pipeline. The following documents were referenced during the preparation of the mitigation measures:

- North Western Regional Fisheries Board, *Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites*;
- CIRIA guidance on '*Control of Water Pollution from Linear Construction Projects*' (CIRIA Report No. C648, 2006);
- EPA, *Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites* (EPA 833-R-060-04 May 2007);
- Design Manual for Roads and Bridges: Volume 4 HA 103/06, *Vegetative Treatment Systems for Highway Runoff;* and
- Corrib Onshore Pipeline EIS - February 2009.

Drainage and Flooding

During Construction
The following measures will be implemented to manage flooding and storm water drainage during the construction phase of the works:

- Surface water runoff from the lands and green areas up-gradient of the working area will be conveyed via existing drainage channels where these occur along the route. These channels will be piped under (or in the case of compounds, around) the working area through a series of pipes to connect to existing outfalls and drains. Where drainage channels do not occur, a shallow interceptor ditch or barrier will intercept overland flows and discharge to the outfalls without any further attenuation and/or treatment as this runoff will be from undisturbed areas;

- Storm water runoff from the stone road layers will be conveyed via a swale or vee drain located down slope of the working area. Flow will be intercepted and a number of attenuation features (silt traps or check dams) will be located intermittently along the swale to encourage the settlement of any potential silt. At the outfall, the discharge will be passed through a graded stone chamber encased in geotextile fabric as a final silt control mechanism;

- Where required, settlement lagoons will be constructed along the temporary ditches & drains and also at the construction compounds to remove silts from surface water runoff through settlement. The sedimentation management system will be sized for a 10 year 24 hour storm event (CIRIA Report 142, 1994; CIRIA Report 532, 2001; CIRIA C648, 2006 & CIRIA Report B14, 1993);

- Any stockpiles will be kept at a minimum reasonable distance (minimum 50m) from any stream crossing, particularly from the Leenamore River crossing, to prevent and any blockage to flood water flow path from collapse during high rainfall event. Given the steep nature of the catchment slope, a flash flood in the Leenamore River could occur. Thus, adequate flood diversion works must be designed for this and pumping of floodwaters may be considered. Refer to Chapter 5 of Corrib Onshore Pipeline EIS for the construction methodology of the river crossings.

- Flooding in the vicinity of the proposed river crossings, particularly at the Leenamore River crossing, could occur from a joint effect of high fluvial and tidal flood levels in Sruwaddacon Bay. Therefore it is recommended that the works be undertaken at an appropriate time having regard to weather and tides.

- As the proposed pipeline will be laid a minimum of 1.6m below the invert of watercourses, OPW Section 50 consents will not be required. However, the Northwestern Regional Fisheries Board will be informed before carrying out the river crossing works. All river crossing works will be carried out in accordance with the North Western Regional Fisheries Board, "*Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites*".

Further details of the surface water management measures proposed along the pipeline route during the construction phase are provided in Section 5 of this report and in Appendix M7 of the EIS.

During Operation
Due to the limited nature of proposed disturbance and the proposed reinstatement plans any impacts on the existing flooding and drainage regime during the operation phase are expected to be minimal.

Water Quality

During Construction
The following measures will be implemented during the construction phase to preserve water quality:

- A series of ditches and drains will be installed, up gradient and down gradient of the working area, during the construction phase to collect runoff. Temporary and permanent ditches will be used. Localised pumping may also be required;

- Fuels, oils, greases and hydraulic liquids will be stored within enclosed concrete/bunded areas and as far as possible away from drainage ditches, surface water drains and watercourses. These bunds will be designed in accordance with the EPA Guidance Note on Storage and Transfer of Materials for Scheduled Activities (requirement for 110% storage volume for all tanks storing petroleum products). Where required at the construction compounds appropriately sized hydrocarbon interceptors will also be used on the surface water drainage system;

- Runoff from construction areas will be will be collected and managed so that no direct discharges to watercourses occur;

- Stockpile areas for sands, gravels, excavated mineral soil and peat will be kept well away from watercourses;
- Run off will only be routed to the watercourse via suitably designed and sited settlement lagoons, swales and channels;
- Settlement lagoons will be inspected daily and maintained regularly;
- Watercourse banks will be left intact, where possible. If they have to be disturbed, all practicable measures will be taken to prevent soils from entering the watercourse;
- A pollution prevention plan will be implemented at the commencement of the construction phase;
- Weekly, and where necessary, daily inspections and maintenance of the above measures will be carried out to ensure that they are maintained in a satisfactory condition, and discharges will be monitored prior to discharge; and
- Strict control of erosion, sediment generation and other pollutants associated with the construction process will be implemented, including silt barriers and ditches, downslope from the construction works in order to intercept waters with high sediment loads and accidental leakages/ spillages of harmful substances.

Further details of the storm water management measures proposed for use during the construction phase of the works are provided in Section 5 of the EIS.

During Operation
Due to the limited nature of proposed disturbance and the proposed reinstatement plans any impacts on water quality during the operation phase is expected to be minimal.

Water Quantity and Water Abstraction
Construction and operation of the proposed pipeline will not pose any risk to either the quantity or quality of existing sources of raw water that are currently being used for the regional water supply system. Therefore, no remedial measures are considered necessary.

Amenity Value:
From a hydrological perspective there will be negligible impact on the amenity value of local water environment during the construction and operation phase of the development. Therefore no mitigation measures are considered necessary.

4.3 RESIDUAL IMPACTS

Following implementation of the proposed mitigation measures, minimal to no residual impacts on the existing hydrological/drainage regime are expected as a result of construction and operation of the proposed project.

5. STORMWATER MANAGEMENT DURING THE CONSTRUCTION PERIOD

5.1 INTRODUCTION

There is potential for the water quality of Sruwaddacon Bay and its tributaries to be affected by the construction of the proposed pipeline. The main activities with potential for impacts on the hydrology as a result of construction include:

(i) Surface water discharge from the temporary working areas to existing watercourses during the construction phase;
(ii) Construction of the Landfall Valve Installation;
(iii) Construction of the river & stream crossings.

This section of the report has been prepared to address the potential impacts associated with above items. Appropriate mitigation measures are proposed to mitigate these impacts.

Summary of Impacts and Mitigation Measures

Suspended solids arising from excavation works have the potential to cause adverse impact on water quality as fines may be mobilised during rainfall events and enter watercourses.

In addition, changes to the volume and/or characteristics of the surface water runoff from the surrounding area during the construction period could have a negative impact on adjacent watercourses. The pattern of runoff could change with some existing drains and ditches receiving significantly more or less flow than they receive currently. Also, rainfall on elevated areas has the potential to wash peat and silt into the surrounding watercourses. Localised erosion and scouring could occur while reduced flow may result in stagnation in some drains and ditches.

To address these potential adverse impacts a series of ditches and drains will be installed during the construction phase, to collect runoff. Temporary and permanent ditches will also be used. Localised pumping may also be required. The following measures will also be implemented to preserve water quality:

- Fuels, oils, greases and hydraulic liquids will be stored in bunded compounds well away from the watercourse. Refuelling of machinery, etc., will be carried out in bunded areas;
- Run off from machine service and concrete mixing areas will not enter the watercourses;
- Stockpile areas for sands, gravels, excavated mineral soil and peat, will be kept to minimum size and well away from watercourses;
- Run off will only be routed to the watercourse via suitably designed and sited settlement lagoons, swales and channels;
- Settlement lagoons will be inspected daily and maintained regularly;
- Temporary crossings will be designed to the criteria laid down in CIRIA for temporary works;
- Watercourse banks will be left intact, if possible. If they have to be disturbed, all practicable measures will be taken to prevent soils from entering the watercourse; and
- A programme of surface water inspection and monitoring will be established and form part of the Environmental Management Plan for the works. After construction, reinstatement monitoring will take place to ensure that existing drainage systems are fully reinstated.

The most appropriate surface water management controls will be implemented within and around each of the catchment outfalls to prevent pollution from entering nearby water courses. The maintenance of these controls will be detailed in the Environmental Management Plan for the works. The controls (including preventative measures) are outlined in the following sections.

Appendix M6 of the Corrib Onshore Pipeline EIS provides details regarding the measures that will be put in place during construction of the stone road.

5.2 METHODOLOGY

The following documents were referenced during the design of the stormwater management system to be used during the construction phase of the works:

- North Western Regional Fisheries Board, *Requirements for the Protection of Fisheries Habitat during Construction and Development Works at River Sites*;
- CIRIA guidance on '*Control of Water Pollution from Linear Construction Projects*' (CIRIA Report No. C648, 2006);
- EPA, *Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites* (EPA 833-R-060-04 May 2007);
- Design Manual for Roads and Bridges: Volume 4 HA 103/06, *Vegetative Treatment Systems for Highway Runoff;* and
- Corrib Onshore Pipeline EIS - February 2009.

5.2.1 INTERCEPTOR DITCHES ANDD

An interceptor drain will be provided along the upstream edge of the working areas to convey overland flow and storm runoff to local watercourses via the proposed outfalls. The velocity of flow will be limited to 1.5m/s and timber planking or stone check dams will be provided at regular intervals with maximum drops of 0.5m to 1m to prevent excessive flow velocities. Instream erosion prevention measures will be put in place at check dams. The design basis for the interceptor ditches is set out in Section 5.3 of this report.

Where space is limited, a timber planking or similar barrier placed on top of the ground may be used to exclude and divert surface water away from the working area and along the perimeter of the wayleave to existing outfalls.

5.2.3 SWALES

Storm water runoff from the stone road and compounds in excess of the available storage in the stone road layers will be conveyed via a swale located on the down slope of the working area. Swales are wide, shallow, gently sloping depressions used to convey water. Swales are most effective on gentle slopes with the incorporation of attenuation features such as silt traps, which attenuate flow and encourage the settlement of any potential silt. At the outfall the discharge will be passed through a graded stone chamber encased in a geotextile as a final silt control mechanism. Other forms of water treatment may be implemented as required to ensure water quality of discharges will cause minimal impact to receiving waters.

5.2.4 VEE DRAINS

In areas where gradients are steeper, storm water runoff will be conveyed via a shallow vee drain located on the down slope of the working area. This vee drain will be lined and filled with stone, where required. To prohibit the migration of sediment from the peat stockpiles into the drain, a silt fence (as described in section 5.2.5) will be erected around them and the vee drain will be surrounded in a geotextile.

In the peatland areas of the route, the top of the stone road will be up to 0.6m below ground level. The ground water level will be controlled by the invert level of the vee drain. Peat plugs will be provided at minimum 50m intervals in peatland areas to prevent longitudinal flows within the stone road and also to maintain the moisture saturation levels in the adjacent peatland.

5.2.5 SETTLEMENT LAGOONS

Settlement lagoons may be required in certain locations to detain sediment-laden runoff, allowing sediment to settle before the runoff is discharged. Proper design and maintenance are essential to ensure that these practices are effective[2]. All elements of the Settlement lagoon will be designed in accordance with the design criteria set out in the CIRIA guidance on '*Control of Water Pollution from Linear Construction Projects*' (CIRIA Report No. C648, 2006). Settlement lagoons will be lined and will be located sufficiently away from the proposed outfalls. The settlement lagoons will be designed to provide detention time of 24 to 48 hours for the 10 year 24 hour storm. In addition, a contingency measure will be in place to release water via a spillway or similar should a more serious rainfall event occur.

5.2.6 SILT FENCES

Silt fences are most effective on the down slope of exposed and erodible slopes, along watercourses and around temporary spoil storage areas and stockpiles. Silt fences should not be used in streams, channels, drain inlets, or anywhere flow is concentrated. The silt fences at outfalls must be installed at the same elevation throughout, if not erosion may be caused. Silt fencing will be erected on either side of the temporary storage areas to confine the material and prevent runoff to the interceptor ditch, excavated trench or vee drain. Where steep gradients occur on the downslope of the swales, an additional silt fence may be erected in the event of overland flows from the swales. Examples of silt fences and their applications are provided in **Images 5.1** and **5.2**.

Image 5.1: Example of silt fencing on banks of watercourse
(source CIRIA Report No. C648, 2006)

2 Developing Your Stormwater Pollution Prevention Plan: A Guide for Construction Sites. EPA 833-R-060-04 May 2007

Image 5.2: Example of silt fence at toe of stockpile
(source CIRIA Report No. C648, 2006)

5.3 PROPOSED STORMWATER MANAGEMENT MEASURES

The following measures will be used to manage surface water discharges:

- Where required surface water runoff from the lands and areas up-gradient of the working area will be conveyed via existing drainage channels where they occur along the route. These channels will be piped under the working area through a series of pipes to connect to existing outfalls and drains. Where drainage channels do not occur, a shallow interceptor ditch or barrier will intercept overland flows and discharge to the outfalls without any further attenuation and/or treatment as this runoff will be from undisturbed areas;

- Storm water runoff will be conveyed via a swale or vee drain located on the down slope of the working area. Flow will be intercepted and a number of attenuation features (silt traps or check dams) will be located intermittently along the swale to encourage the settlement of any potential silt. At the outfall the discharge will be passed through a stone chamber encased in a geotextile as a final silt control mechanism. Other forms of water treatment may also be implemented if required;

- Where required settlement lagoons will be provided upstream of the surface water outfalls and will receive surface water run-off from the site, from the vee drains and swales, before it is discharged at the outfall. The settlement lagoons will provide additional detention time to allow any potential suspended solids to settle. The settlement lagoon, if required, will be sized for a 10 year 24 hour storm event (CIRIA Report 142, 1994; CIRIA Report 532, 2001; CIRIA C648, 2006 & CIRIA Report B14, 1993);

- A pollution prevention plan will be prepared before the construction works begin, and will form part of the Environmental Management Plan for the Works; and

- Weekly, and where necessary, daily inspections and maintenance of the above measures will be carried out to ensure that they are maintained in a satisfactory condition and that discharges are monitored prior to discharge.

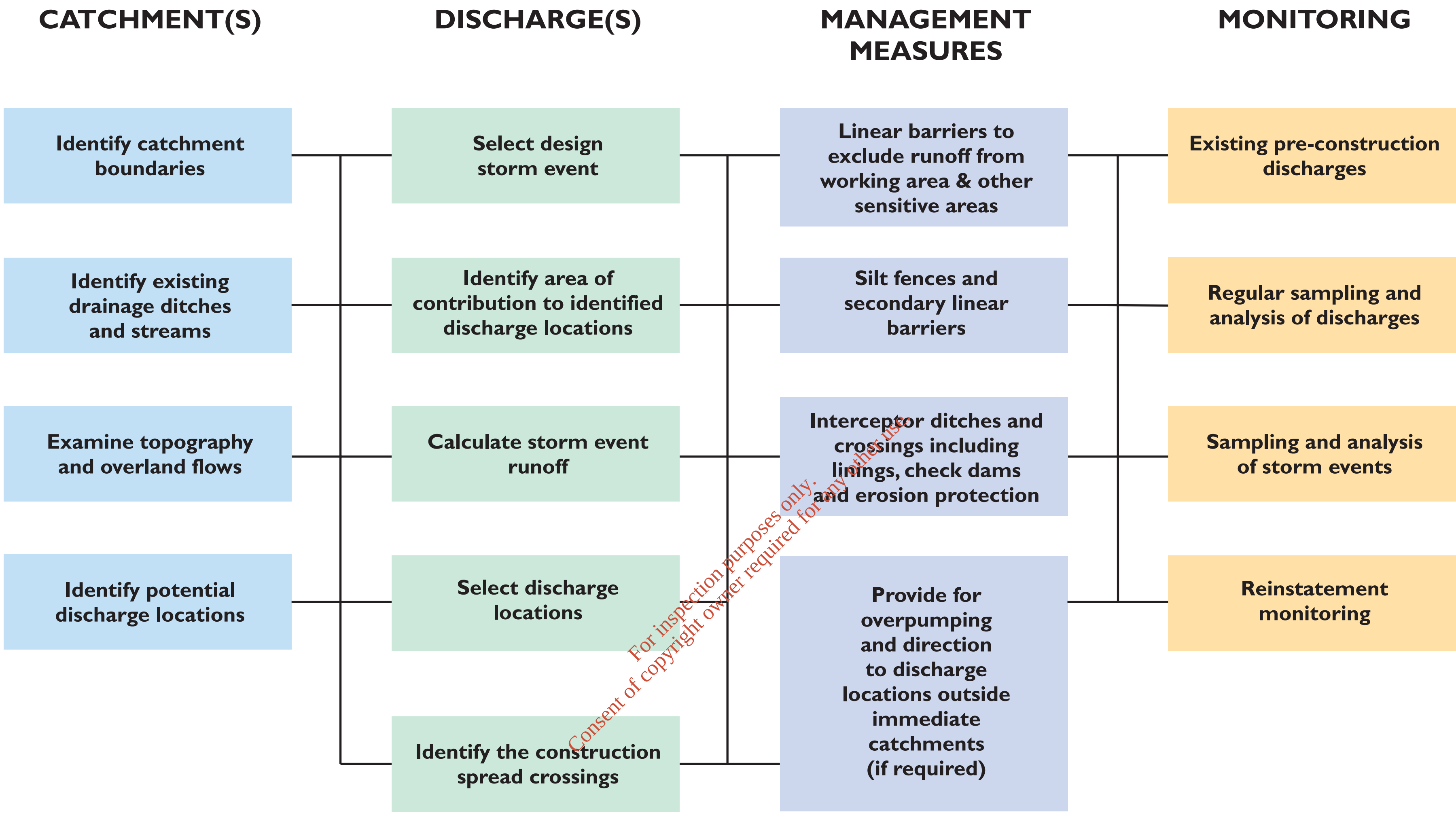


Figure 5.1 **SURFACE WATER MANAGEMENT PRINCIPLES FOR UP-GRADIENT CATCHMENT AREAS**

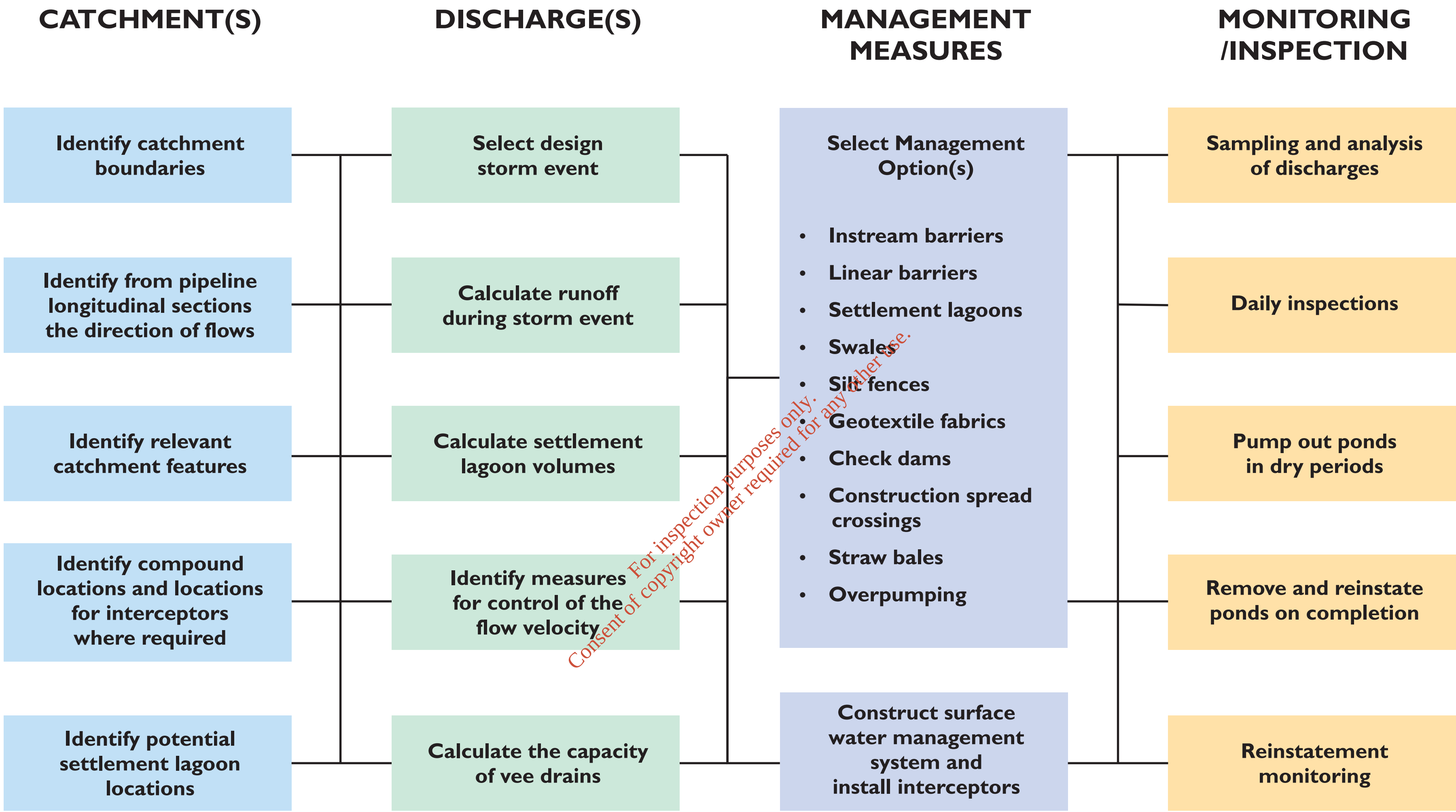


Figure 5.2 PRINCIPLES OF SURFACE WATER MANAGEMENT FOR CONSTRUCTION SPREAD AND COMPOUNDS

RPS

5.4 MONITORING

A programme of surface water inspection and monitoring will be established and form part of the Environmental Management Plan for the works. After construction, reinstatement monitoring will take place to ensure that existing drainage systems are fully reinstated.

5.5 SPECIFIC PROPOSALS FOR EACH SUB CATCHMENT

Only catchments at Glengad are dealt with here as the remainder of the site is covered in Appendix M6 and Appendix M7 of the EIS.

CATCHMENT CA1: GLENGAD – WEST OF ACCESS ROAD
Location: Between Ch. 83,400 to Ch. 83,800, Catchment Area 0.86 ha

Habitat: Improved agricultural grassland (ref. Chapter 12 of the EIS).

The sandy soils in this catchment are free draining and during a rainfall event, water percolates into ground and the remaining water is conveyed via a series of surface water drains to the foreshore. Where the pipeline route crosses these drains they will be piped under the road. Any overland flow occurring within the working area will be conveyed via a shallow interceptor drain located up gradient of the working area to an existing outfall at the foreshore.

Any stockpiles of excavated materials will be surrounded by shallow shingle filled vee drains which will discharge to existing filter drains.

Surface water occurring within the access roads, pipeline spread and compound will discharge via shallow shingle filled vee drains, located down gradient of the working area, to existing filter drains which discharge into Broadhaven Bay.

If required, a settlement lagoon will be provided at the compound location in catchment CA1. The discharge will be via existing filter drains into Broadhaven Bay.

CATCHMENT CA2: GLENGAD – EAST OF ACCESS ROAD
Location: Between Ch. 83,800 to Ch. 84,100, Catchment Area 1.04 ha

Habitat: Improved agricultural grassland and wet, rushy grassland (ref. Chapter 12 of the EIS).

The habitats in this catchment comprise a mosaic of improved grassland and marshy lands. The marshy lands indicate impeded drainage and therefore overland flow during a rainfall event may be increased.

Surface water occurring up-gradient of the working area will be piped under the working area through a series of pipes and discharge into existing outfalls. Excess runoff will be conveyed via a shallow interceptor drain and discharged to an existing course.

Excess surface water from the access road, pipeline spread and compound will be conveyed via a swale located down slope of the working area. The swale, with integrated silt traps, will discharge into the existing surface water course.

A settlement lagoon will be provided at the compound location in catchment CA2 (see Appendix M7 for details). The discharge from the settlement lagoon will be into the existing surface water course.

Any stockpiles of excavated materials will be surrounded by shallow shingle filled vee drains which will discharge to the existing surface water course.

5.6 WATER MANAGEMENT AT LAUNCH AND RECEPTION PITS

Settlement lagoons & appropriate collection and treatment facilities are proposed at the tunnel start and reception pit compounds. Details of the surface water management at these locations are included in Appendix M7 of this EIS.

6.0 CONCLUSIONS

The pipeline construction has the potential to cause a medium flood risk in the vicinity of the watercourses during the construction phase of the works. Temporary localised flooding of lands in the vicinity of the proposed river/stream crossings might occur from the following sources:

- Obstruction to upstream surface water runoff flow paths caused by the pipeline alignment and construction works;
- Obstruction to flow paths to the natural drainage and river/stream channels at the location where open-cut technique will be used for laying pipe in the river bed;
- Blockage to the surface water runoff flow paths due to collapsing of unstable river/stream/trench banks, specially in the peatland areas;
- Increase in runoff volume from the increased impermeable areas within the temporary working compounds and
- Flooding in the vicinity of the proposed river crossings, particularly, at the Leenamore River crossing could occur from a joint effect of high fluvial and tidal flood levels in Sruwaddacon Bay.

The proposed river/stream crossings will be carried out with due regard to weather and tides. All associated rivers/streams will be flumed during the construction of these crossing.

A separate assessment of the hydrology of the peatland areas traversed by the proposed route is provided in Appendix M6 of the EIS. Overall, the predicted impact on the peatland hydrology will be minimal.

An assessment of surface water management at the start and reception pit compounds is provided in Appendix M7 of the EIS.

The main activities with potential for adverse impacts on hydrology as a result of proposed construction include:

(i) River and stream crossings;
(ii) Construction of the Landfall Valve Installation; and
(iii) Surface water discharge from the temporary working areas to the existing watercourses during the construction phase of the scheme.

A number of mitigation measures have been proposed to protect water quality in receiving waters during the construction period of the works.

REFERENCES:

Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (Draft) (NRA 2007).

Environmental Impact Assessment Guidelines of National Road Schemes – A Practical Guide (National Roads Authority (NRA) 2004.

Advice Notes on Current Practice in the preparation of Environmental Impact Statements (EPA 2003).

Guidelines on the information to be contained in Environmental Impact Statements (Environmental Protection Agency (EPA) 2002).

Guidelines for the Crossing of Watercourses during the construction of national Road Schemes (NRA).

Control of water pollution from linear construction projects (CIRIA Report No. C648, 2006);

Natural Environmental Research Council (NERC), 1975: Flood Studies Report" Vols 1 to 5, London.

Geological Survey of Ireland, 2006. A report of the Irish Landslides Working Group, Editor Ronnie Creighton.

Greater Dublin Strategic Drainage Study (GDSDS) policy,

Report on the Landslides at Dooncarton, Glengad, Barnachuille and Pollathomais, County Mayo on September 19th, 2003 (Tobin Consulting Engineers, October 29th 2003).

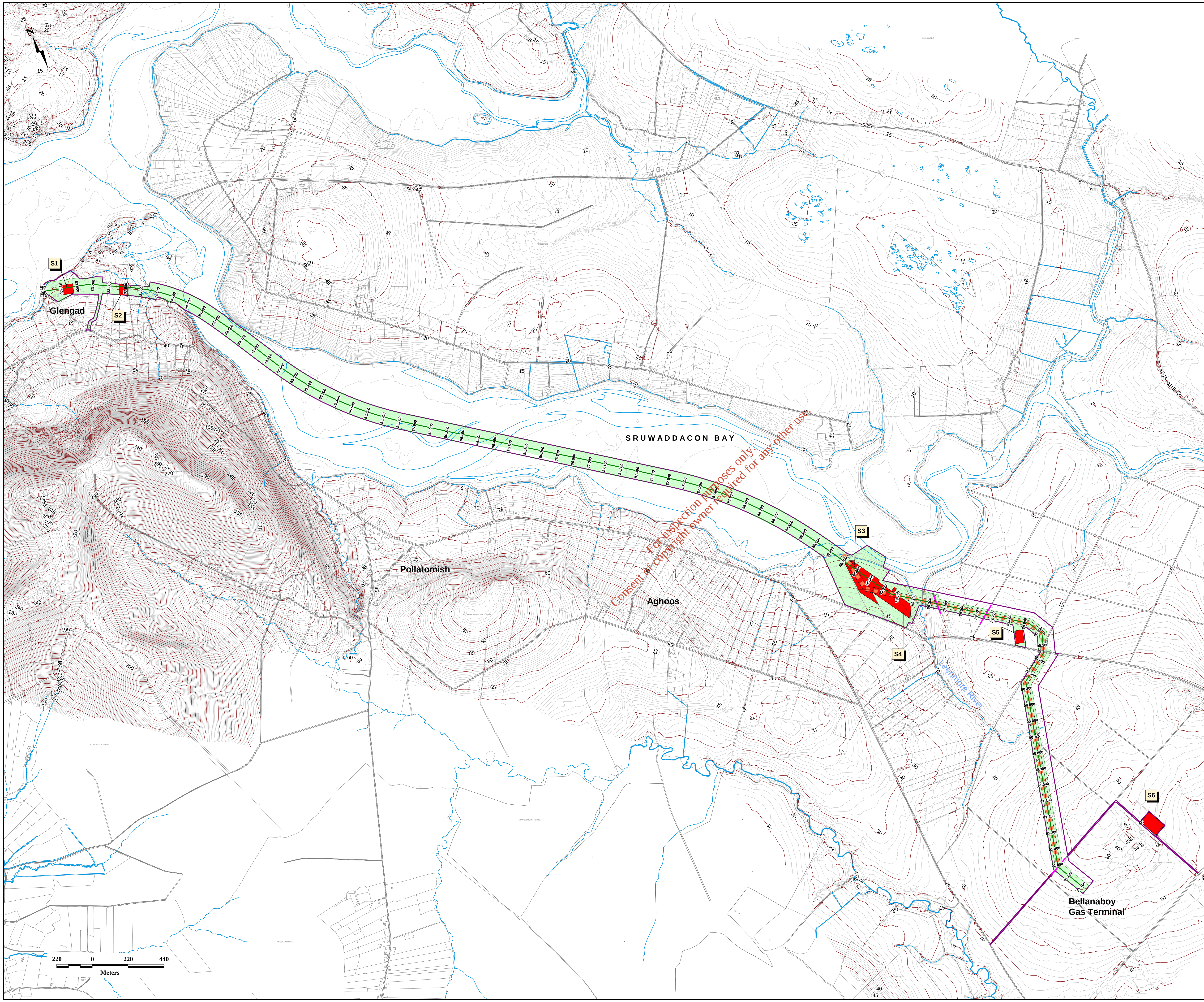
Flooding in the Glengad Region of County Mayo, 19-20 September 2003, (EPA, 21st October 2003).

Control of water pollution from linear construction projects (CIRIA Report No. C648, 2006); and

Fisheries Protection Guidelines – Requirements for the protection of Fisheries Habitats during construction and development works at river sites (Eastern Regional Fisheries Board).

Appendix A

Drawing



Legend

- Streams
- Proposed Route
- Temporary Working Area
- Wayleave Boundary
- Drainage Ditch
- Blanket Bog Area/Stone Road
- Site Compound (S1)

CORRIB natural gas

Project

CORRIB ONSHORE PIPELINE

Title

Proposed Pipeline Route and River Crossings

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Date:	May 2010	Mi2188	A03

Notes

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Appendix B

Flow Records for the Glenamoy River

Annual Maximum (AM) Flow Records
Glenamoy River at Glenamoy (Hydrometric Station No.33001)

Year	AM Flow m3/s	Date
1977	32.7	28/09/1978
1978	30.7	15/11/1978
1979	35.9	25/11/1979
1980	28.2	15/09/1981
1981	22.3	01/11/1981
1982	26.1	19/12/1982
1983	31.6	12/10/1983
1984	40.8	21/09/1985
1985	26.4	06/08/1986
1986	21.1	05/12/1986
1987	27.5	06/09/1988
1988	19.4	20/09/1989
1989	38.9	27/10/1989
1990	30.6	06/10/1990
1991	30.3	07/01/1992
1992	28.3	15/12/1992
1993	26.1	03/12/1993
1994	26.0	11/12/1994
1995	23.4	26/10/1995
1996	29.1	16/09/1997
1997	24.5	06/12/1997
1998	19.3	08/09/1999
1999	31.8	28/11/1999
2000	27.3	03/10/2000
2001	24.7	03/12/2001
2002	26.9	27/10/2002
2003	N/A	Sept
2004	25.6	15/01/2005
2005	27.7	10/10/2005
2006	29.5	03/12/2006
2007	31.1	03/02/2008