# Appendix 3F
# Hydrology and Hydrogeology

# N5 SCRAMOGE TO BALLAGHADERREEN

# ROUTE CORRIDOR SELECTION

# HYDROGEOLOGY

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# 1 Introduction

## 1.1 Work brief

Hydro Environmental Ltd was commissioned by the Roscommon National Roads Design Office (NRDO) on behalf of Roscommon County Council to carry out a hydrogeological assessment for the N5 Scramoge to Ballaghaderreen Route Corridor Selection Study.

This report section was prepared in accordance with the National Roads Authority (NRA) publication '*Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes*'.

The proposed scheme relates to upgrading 35.7km of the existing N5 National Primary Road between Teevnacreeva (6.2km east of Ballaghaderreen) and Scramoge (4.7km east of Strokestown).

## 1.2 Route corridor options

Based on information obtained during the Constraints Study Report (Roscommon County Council, 2006) a total of seven feasible route corridors were developed taking into account all physical, planning and environmental constraints that were identified.

The following sections provide a general route description, subdivided into discrete sections based on recognisable features in the landscape. For each section an existing environment summary of the topography, surface water features, subsoil geology, bedrock geology, aquifers, karst features and groundwater vulnerability is given.

### 1.2.1 Corridor 1

This corridor option is approximately 33.7 km long. It is located north of the existing N5 along its entire length. The option passes just north of Frenchpark where it crosses the R361 (Boyle) Regional Road. It remains north of Bellanagare and Tulsk, crossing the N61 (Athlone to Boyle) road near Shankill Cross Roads. It then continues north of the existing N5 and north of Clooncullaan Lough before crossing the R368 (Elphin to Strokestown) at Lugboy Townland and veering south to bypass Strokestown on the north and east.

#### 1.2.1.1 Western Tie-in to R361 (Boyle) Road (approximately 6.3 km)

Topography is relatively flat with a slight overall fall from west (90 maOD) to east (80 maOD). No main surface water features are present. The subsoil is classified predominantly as sandstone and shale till. The underlying bedrock is classified as Undifferentiated Visean Limestone. This bedrock is a Regionally Important Karstified Aquifer, with conduit permeability. Two springs are located at the eastern tie-in in Keelbanada, one (Luggadill Spring Well) begin approximately 60 m to the west of the corridor. The only other mapped karst feature is an enclosed depression on the southern corridor boundary at Portaghard. Groundwater has an extreme vulnerability rating for most of this section apart from small areas with a high rating at both ends and a small pocket rated as medium at the western tie-in.

#### 1.2.1.2 R361 (Boyle) Road to Owennaforeesha River (approximately 3.2 km)

The corridor runs along the southern edge of Cloonshanville Bog a NHA and SAC designated site. It crosses the Carricknabraher and Owennaforeesha Rivers in Ballynahowna Townland. EPA water quality monitoring data is available immediately down stream towards Loughbally Bridge. A small tributary of the Owennaforeesha River flows from Mantua through the middle of the corridor for approximately 3 km. Most of

the section is characterised by flat boggy / peaty ground with a slight fall towards the rivers. The subsoil is predominantly classified as fen peat. The western half of the section is underlain by Undifferentiated Visean Limestone. These rocks are classified as a Regionally Important Karstified Aquifer, with conduit permeability. The eastern half is underlain by the Boyle Sandstone Formation that is classified as a Locally Important Aquifer where the bedrock is generally productive only in local zones. No known karst features are mapped in the section. The groundwater vulnerability in the western half of the section is predominantly rated as extreme to the south and high to the north, and the eastern half is predominantly low rated corresponding to the boggy ground, with small areas of medium, and a finger of extreme vulnerability on higher ground at Ballynahowna.

#### 1.2.1.3 Owennaforeesha River to Brackloon Road (approximately 3.0 km)

The corridor passes through a section of forestry and bog followed by marginal / peaty land before rising slightly, from 70 maOD at the River to 80 maOD at Brackloon Road. Subsoil is predominantly classified as fen peat with a small section of sandstone and shale near the LP1215road. Apart from the western edge of the section next to the river that is still within the Boyle Sandstone, the remaining section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features are mapped in the section. Groundwater vulnerability mapping along this section is predominantly rated as low with a small area of medium vulnerability just before the Brackloon Road in the east.

#### 1.2.1.4 Brackloon Road to R369 (Bellanagare to Elphin) Road (approximately 4.5 km)

A small tributary of the Owenur River flows eastwards through the corridor from Cloonyeffer. The landscape is mainly pasturelands interspersed with small pockets of forestry. Topography is relatively flat (approximately 80 maOD). Subsoils are predominantly classified as sandstone and shale till with small areas of fen peat near the R369 to the east. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features are mapped in the section, although a swallow hole is located approximately 20m from the southern corridor boundary at Clogher More. Groundwater vulnerability for this section has a medium rating apart from the eastern fifth that has a high vulnerability and a very small pocket of extreme rating at the R369 at Cartronagor.

#### 1.2.1.5 R369 (Bellanagare to Elphin) Road to N61 National Secondary Road (approximately 2.3 km)

The Owenur tributary flows along the southern edge of the corridor for 1.2 km. Continuing to run through primarily pastureland interspersed with occasional small pockets of forestry the topography is relatively flat but includes a number of small drumlins. Subsoil is classified as sandstone and shale till in the western part and limestone till along the eastern part of this section. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features are mapped in the section. Groundwater in this section has a high vulnerability rating.

#### 1.2.1.6 N61 National Secondary Road to R368 (Elphin to Strokestown) Road (approximately 5.0 km)

The corridor crosses the Owenur River near Ballyoughter Bridge on the LP1412 road the location being monitored for water quality by the EPA. It also crosses as a small tributary to the west of this road. Ballyoughter Lough, a small lake is located within the corridor west of the LP1412. The corridor passes 100 m south of Lough O'Moran and just north of the 'Clooncullaan Loughs' system trimming the northern periphery of Clooncullaan Lough. The ground is relatively flat at around 60 maOD, apart from near the lake where it drops to approximately 50 maOD. Subsoils are predominantly limestone till with interspersed fingers of fen peat associated with the lakes. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features are mapped in the section. The western and eastern thirds of the section are mapped as having a high vulnerability rating with the central third just north of Clooncullaan Loughs predominantly low rated. A small pocket of extreme vulnerability with rock outcrop at or close to ground surface as located on the southern side of the corridor at Killeen East.

#### 1.2.1.7 R368 (Elphin to Strokestown) Road to LP1405 (Kilmore) Road (approximately 5.4 km)

The corridor runs along the sides of Cregga, Cuilrevagh (Greywood Hill) and Kiltrustan hills which rise to the east of the section. The topography undulates between approximately 60 and 130 maOD with a fall off to the west and the SAC / NHA designated Lough Annaghmore located approximately 0.8 km west of the corridor. The land is predominantly pastureland. Subsoil is predominantly limestone till with significant areas of rock outcrop and several karstic features mapped in the area. A large quarry operation (Largan Quarries) is located on the eastern side of Cuilrevagh Hill. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features are mapped in the section. A spring (Lettreen Well) is located approximately 100 m upgradient of the corridor in Lettreen. Groundwater vulnerability along the whole section length has an extreme rating with widespread pockets of rock outcrop or subcrop close to surface.

#### 1.2.1.8 LP1405 (Kilmore) Road to Eastern Tie-in (approximately 4.0 km)

Topography falls gradually from 70 maOD at the LP1405 to 50 maOD at a small tributary of the Mountain River that cuts across the corridor section, remaining relatively flat through pastureland and then into low-lying marshy ground with pockets of bog and forestry particularly in the vicinity of tributary, and on to the Scramoge River and existing N5. EPA water quality monitoring is carried out east of Strokestown on the Mountain River tributary within the corridor, and at Scramoge Bridge on the N5 for the Scramoge River. The Mountain River tributary source located at Cloonslanor is identified next to the Strokestown Group Water Supply. Subsoils are predominantly limestone till interspersed with fingers of fen peat and lacustrine deposits associated with the Scramoge River. Some sandstone and shale till is present at the tie-in. The section is predominantly underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. A fault line runs southwest – northeast passing through Treanaceeve and Scramoge approximately 500 m east of the Scramoge Bridge. The bedrock to the east of this is identified as Dinantian Sandstones (Fearnaght Formation) and classified as a Locally Important Aquifer where the bedrock is generally moderately productive. No known karst features are mapped in the section, although Bumlin Spring is approximately 40 m southwest of the corridor boundary. Overall the groundwater vulnerability along this section has an extreme rating with some pockets of rock outcrop or close to surface apart from a section of high vulnerability on higher ground east of Vesnoy, a pocket north of Bumlin and an area south of Scramoge Bridge.

### 1.2.2 Corridor 1A

This corridor option is approximately 34.2 km long. It commences south of the existing N5 but, just west of Bellanagare, crossing to the northern side of the N5 and follows the same route as Option 1. The option passes just south of Frenchpark where it crosses the R361 (Boyle) Regional Road. It crosses the N5 at Cashel Townland west of Bellanagare. It proceeds north of Bellanagare where it follows the same route as Option 1 from Corry West Townland eastwards.

#### 1.2.2.1 Western Tie-in to R361 (Castlerea) Road (approximately 5.8 km)

Topography is relatively flat with an overall slight fall in gradient from 90 to 80 maOD across the section, apart from a gradual rise from the south-western boundary of the corridor towards Fairymount Hill. No main surface water features are present. West of Turlaghnamaddy Townland the subsoil is predominantly sandstone and shale till with fen peat to the east. The land is mainly pastureland west of Turlaghnamaddy Townland and a mixture of peat and forestry to the east. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. Two springs are located at the eastern tie-in in Keelbanada, one (Luggadill Spring Well) begin approximately 60 m to the west of the corridor. The only other mapped karst feature is an enclosed depression in Portaghard. Groundwater has an extreme vulnerability rating for most of this section apart from small areas with a high and medium rating at the tie-in.

#### 1.2.2.2 R361 (Castlerea) Road to Existing N5 Road (approximately 2.6 km)

The corridor crosses the Carricknabraher River at the western end of this section and a small tributary of it near the N5 road that drains from the Leitrim area on the northern part of the SAC, SPA and NHA designated Bellanagare Bog. Numerous small drainage channels flow off the northern part of the bog across the corridor discharging into a number of karst swallow holes (including Pollnagran Cave) in Leggatinty. Other karst features in the area include enclosed depressions and a second cave 40 m north of the corridor boundary. Topography rises slightly towards the east away from the river. The ground is mainly boggy with some forestry at the western end of the section. Bellanagare Bog is located approximately 400 m to the south. Subsoil is classified as predominantly peat. The western two thirds of the section is underlain by Undifferentiated Visean Limestone. These rocks are classified as a Regionally Important Karstified Aquifer, with conduit permeability. Underground flow through the limestone has been traced between Pollnagran Caven and Cloonshanville Spirng to the northeast. The eastern third is underlain by the Boyle Sandstone Formation that is classified as a Locally Important Aquifer where the bedrock is generally productive only in local zones. The north western half of this section is predominantly mapped as having an extreme groundwater vulnerability rating, bordered by thin strips of high and medium in the central part. The south eastern half is predominantly low rated relating to soft boggy ground with some areas of medium, high and extreme towards the north of this portion.

#### 1.2.2.3 Existing N5 Road to Owennaforeesha River (approximately 1.7 km)

The Owennaforeesha River is traversed in this section of corridor at the Cashel and Drummin Townland boundary. The landscape falls gently from west to east towards the river. Subsoil is primarily sandstone and shale till west of the Local Secondary Road LS5641 and fen peat to the east. The majority of the section is underlain by the Boyle Sandstone Formation that is classified as a Locally Important Aquifer where the bedrock is generally productive only in local zones. The eastern 200 m up to the Owennaforeesha River is underlain by Undifferentiated Visean Limestone that is classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features are mapped in the section. Groundwater vulnerability is mixed along the length of the section moving from approximately equal areas of high to extreme to low vulnerability.

#### 1.2.2.4 Owennaforeesha River to Brackloon Road (LP1215) Road (approximately 3.0 km)

Two small tributaries of the Owennaforeesha River are traversed in this section. The western 2 km of the corridor is borderline between pastureland and boggy ground, with forestry along the eastern 1 km. The topography rises slightly from the river at 70 maOD towards the LP1215 road at 80 maOD. The subsoils are classified as predominantly sandstone and shale till with some dispersed pockets of fen peat. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features are mapped in the section. The western three fifths of the section have a low groundwater vulnerability rating and the remaining two fifths being mapped as having a medium rating.

#### 1.2.2.5 Brackloon Road (LP1215) Road to R369 (Bellangare to Elphin) Road (approximately 4.4 km)

A small tributary of the Owenur River flows eastwards from Cloonyeffer through the corridor. This section is predominantly pastureland with some pockets of forestry especially along the western 0.5 km portion. Topography is relatively flat at approximately 80 maOD. The subsoils are predominantly sandstone and shale till with small areas of fen peat near the R369. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. Numerous karst features are mapped within the corridor in Kilvoy just south of the R369 comprising five swallow holes (one identified as Polloweneen Swallow Hole) and four enclosed depressions. Another swallow hole is located in Clogher More. Groundwater vulnerability for this section has a medium rating apart from the eastern fifth that has a high vulnerability and a very small pocket of extreme rating at the R369 at Cartronagor.

#### 1.2.2.6 R369 (Bellanagare to Elphin) Road to N61 National Secondary Road (approximately 2.3 km)

As per Option 1.

**1.2.2.7 N61 National Secondary Road to R368 (Elphin to Strokestown) Road (approximately 5.0 km)**

As per Option 1.

**1.2.2.8 R368 (Elphin to Strokestown) Road to LP1405 (Kilmore) Road (approximately 5.4 km)**

As per Option 1.

**1.2.2.9 LP1405 (Kilmore) Road to Eastern Tie-in (approximately 4.0 km)**

As per Option 1.

**1.2.3 Corridor 2**

This corridor option is approximately 34.6km long. It weaves north and south of the existing N5. The corridor follows substantially the same path as option 1A from the western tie-in to Tonaknick (north of Bellanagare). It crosses the R369 (Bellanagare to Elphin) Road at Kilvoy Townland, the N61 at Castleland Townland and continues along the existing N5 between Ardkeenagh (Plunkett) Townland and Ardakillin Townland from where it veers south to bypass Strokestown.

**1.2.3.1 Western Tie-in to R361 (Castlerea) Road (approximately 5.8 km)**

As per Option 1A.

**1.2.3.2 R361 (Castlerea) Road to Existing N5 Road (approximately 2.6 km)**

As per Option 1A.

**1.2.3.3 Existing N5 Road to Owennaforeesha River (approximately 1.7 km)**

As per Option 1A.

**1.2.3.4 Owennaforeesha River to R369 (Bellanagare to Elphin) Road (approximately 3.3 km)**

Two small tributaries of the Owennaforeesha River are traversed at the start of this section. Topography rises slightly from the river at 70 maOD to 80 maOD. Subsoil is classified as predominantly sandstone and shale till with some dispersed pockets of fen peat. The eastern third of the section is in forestry with the remaining section bordering between pasture and bog. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features are mapped in the section. The western half of this section has a low groundwater vulnerability rating with a medium rating in the eastern half.

**1.2.3.5 R369 (Bellanagare to Elphin) Road to Local Primary Road LP1419 (approximately 4.5 km)**

A small tributary of the Owenur River flows eastwards across the corridor at Flaskagh Beg. The landscape is predominantly pastureland apart from the initial 0.5 km which is forestry. The 'Rathcroghan Plateau' rises gently, approximately perpendicular to the line of the corridor in a south-westerly direction. Topography is relatively flat with a gentle rise from the R369 at 80 maOD to approximately 90 maOD in the Townland of Catron before falling again towards the LP1419 at Flaskagh apart from a small hillock. The subsoil is classified as sandstone and shale till in the western half, and limestone till in the eastern half. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. Numerous karst features are located within this section, in particular around the Townland of Kilvoy. A total of eight swallow holes, five springs (including Toberowen Spring), two enclosed depressions and one dry valley have been mapped. Further springs are located just south of the corridor in Grallagh. A small area of medium rated groundwater vulnerability extends east from the R369, moving into a high rating for the majority of the rest of the section, apart from fingers of extreme rating with occasional rock outcrop or subcrop running along the southern boundary of the corridor.

**1.2.3.6 Local Primary Road LP1419 to the Existing N5 at Ardkeenagh (Plunkett) (approximately 5.2 km)**

The corridor crosses a small tributary of the Ogulla River between Cammoge and Attiballa, and the main Ogulla channel on the eastern border of Castleland. It passes through part of Corbally Lough just south of the existing N5, a pNHA designated site. Topography varies between undulating pastureland at either end of the section and a significant section of low-lying boggy ground centred around the N61. The topography of the western part skirts along the eastern slopes of Camoge Hill (70 to90 maOD) before dropping to the boggy areas at the N61 (60 maOD) and then rising to approximately 65 maOD at Corbally Lough. Subsoil is predominantly limestone till at both ends of the section with the middle section classified as fen peat. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. Known karst features along this section comprise two springs, one of with has been identified as the source for the Ardkennagh and Cloonart Group Schemes, and Corbally Lough turlough. Further springs are located between 150 and 180 m towards the south near Tulsk, including the Tobernakicky Spring. Groundwater vulnerability is mapped as having a predominantly high rating with a pocket of medium vulnerability at the southern part just north of the N5. A small area along the N5 that borders Corbally Lough is mapped as an extreme rating with bedrock at or close to surface.

**1.2.3.7 Along the existing N5 at Ardkeenagh (Plunkett) to Ardakillin (approximately 3.8 km)**

A tributary of the Scramoge River is crossed in Kilcooley and again between Clooncullaan and Ardakillin, where it flows through a small lake located on the southern edge of the corridor. The eastern part of this section passes 150 m north of the pNHA designated Ardakillin Lough. Topography falls gently from approximately 65 to 60 maOD at the LP1422 and then lies relatively flat along boggy ground fro the remainder of the section. Subsoils are primarily limestone till with a finger of fen peat crossing the corridor west of the LP1422. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features have been mapped along this section. Groundwater vulnerability mapping is varied moving from a high rating in the western part of this section to medium and then a large portion from Clooncullaan to Ardakillin mapped as an extreme rating.

**1.2.3.8 Existing N5 at Ardakillin to R368 (Strokestown to Roscommon) Road (approximately 4.5 km)**

A small drainage channel flows from the centre of the corridor south westwards into Ardakillin Lough. The topography is predominantly flat apart from a small hillock in the Townland of Lisnahirka. The corridor passes along the northern slopes of this hillock before passing between Cloonfree Lough (to the north) and Fin Louth (to the south) which are linked by a small channel. The corridor cuts through the southern part of Cloonfree Lough before crossing the channel flowing out of the lake in the vicinity of Cloonfinlough Bridge, which is a tributary of the Scramoge River. The EPA monitors water quality 650 m downstream from the corridor at Cloonconny Bridge. Land use is predominantly pastureland apart from boggy ground between the lakes and around the R368. The ground between the two lakes (approximately 0.5 km) with is traversed by the corridor is subject to flooding and appears to be poorly drained. The topography is generally flat at around 60 maOD apart from 66 maOD at the hillock in Lisnahirka and the area around the R368 where it drops gently to approximately 50 maOD. The subsoils are classified as predominantly limestone till with significant areas of fen peat between the two lakes and surrounding the watercourse serving Ardakillin Lough and an area centred on the R368. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features have been mapped along this section. Groundwater vulnerability is mapped as a high rating with a small pocket of medium vulnerability located between the Cloonfee and Fin Loughs.

**1.2.3.9 R368 (Strokestown to Roscommon) Road to Eastern Tie-in (approximately 3.2 km)**

The Scramoge River tributary flowing from Cloonfree Lough is crossed again, as well as the main Scramoge channel. The topography through this section rises gently from 50 to 60 maOD at the N5 in Farnbeg. It then falls gently to 50 maOD at the junction with the LP1425 road. The remaining section is relatively flat. The subsoils are classified as ranging from limestone till in the western part to sandstone and shale till in the east, including an area of lacustrine deposits in between. The section is predominantly underlain by

Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. A fault line runs southwest – northeast passing through Treanaceeve and Scramoge approximately 500 m east of the Scramoge Bridge. The bedrock to the east of this is identified as Dinantian Sandstones (Fearnaght Formation) and classified as a Locally Important Aquifer where the bedrock is generally moderately productive. Only one karst feature, Bumlin Spring has been identified in this section. Groundwater vulnerability is mapped as high along the western third of the section, extreme along the middle part following the tributary of the Scramoge River from Carrowclogher to the N5 at Bumlin, and then high further east.

#### 1.2.4 Corridor 2A

This corridor option is approximately 35.0 km long. It is similar to Option 2 except that it veers further south between its western tie-in and the R361 crossing south of Frenchpark.

##### 1.2.4.1 Western Tie-in to R361 (Castlerea) Road (approximately 5.8 km)

The topography rises from the N5 (90 maOD) up to the lower reaches of Fairymount Hill to approximately 105 maOD before falling gradually back to 80 maOD at the R361 road. No main surface water features are present. The subsoils west of the LS5629 are classified as predominantly sandstone and shale till changing to fen peat east of this road towards the R361. Land usage is mainly pastureland in the western part overlying the till with peat and forestry in the eastern section. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. Two springs are located at the eastern tie-in in Keelbanada, one (Luggadill Spring Well) begin approximately 60 m to the west of the corridor. The only other mapped karst features are two enclosed depressions located in Portaghard. Groundwater has an extreme vulnerability rating for most of this section apart from small areas with a high and medium rating at the western tie-in.

##### 1.2.4.2 R361 (Castlerea) Road to Existing N5 Road (approximately 2.6 km)

As per Option 1A.

##### 1.2.4.3 Existing N5 Road to Owennaforeesha River (approximately 1.7 km)

As per Option 1A.

##### 1.2.4.4 Owennaforeesha River to R369 (Bellanagare to Elphin) Road (approximately 3.3 km)

As per Option 2.

##### 1.2.4.5 R369 (Bellanagare to Elphin) Road to Local Primary Road LP1419 (approximately 4.5 km)

As per Option 2.

##### 1.2.4.6 Local Primary Road LP1419 to the Existing N5 at Ardkeenagh (Plunkett) (approximately 5.2 km)

As per Option 2.

##### 1.2.4.7 Along the existing N5 at Ardkeenagh (Plunkett) to Ardakillin (approximately 3.8 km)

As per Option 2.

##### 1.2.4.8 Existing N5 at Ardakillin to R368 (Strokestown to Roscommon) Road (approximately 4.5 km)

As per Option 2.

##### 1.2.4.9 R368 (Strokestown to Roscommon) Road to Eastern Tie-in (approximately 3.2 km)

As per Option 2.

#### 1.2.5 Corridor 2B

This corridor option is approximately 34.5 km long. It is similar to Option 2 except that between the crossing point of the N61 at Castleland Townland and the crossing point of the N5 at Ardakillin, the route is north of and parallel to the existing N5 as opposed to along it.

**1.2.5.1 Western Tie-in to R361 (Castlerea) Road (approximately 5.8 km)**

As per Option 1A.

**1.2.5.2 R361 (Castlerea) Road to Existing N5 Road (approximately 2.6 km)**

As per Option 1A.

**1.2.5.3 Existing N5 Road to Owennaforeesha River (approximately 1.7 km)**

As per Option 1A.

**1.2.5.4 Owennaforeesha River to R369 (Bellanagare to Elphin) Road (approximately 3.3 km)**

As per Option 2.

**1.2.5.5 R369 (Bellanagare to Elphin) Road to Local Primary Road LP1419 (approximately 4.5 km)**

As per Option 2.

**1.2.5.6 Local Primary Road LP1419 to the Existing N61 (approximately 3.1 km)**

The corridor crosses two small tributaries of the Ogulla River between Cammoge and Attiballa. It passes through part of Corbally Lough just south of the existing N5, a pNHA designated site. Topography varies from undulating pastureland on the higher ground along the eastern slopes of Camoge Hill (70 to90 maOD) before descending to low-lying boggy land approaching the N61. Subsoil is divided along the section with limestone till on the higher north western part and fen peat on the south eastern portion. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. Only one known karst feature has been mapped in this section, a spring at Cloonyquin. Groundwater vulnerability has been mapped as having a high rating apart from a small finger of extreme with rock outcrop or subcrop in Cloonyquin.

**1.2.5.7 Existing N61 to Ardakillin (approximately 5.9 km)**

The corridor crosses the Ogulla River just east of the N61. A small tributary of this river flows along the south of the corridor westwards for approximately 2 km from Corrabeg back towards the river and N61. Lough Caudagh a small lake southeast of Carton is located in the centre of the corridor, with a channel flowing eastwards for 1.2 km through the corridor to connect with a tributary of the Scramoge River. Topography along this section is initially undulating pastureland to Steill, where it falls to low-lying peaty / boggy ground. It gradually climbs up onto more pastureland at Derryquirk Hillock (approximately 70 maOD) before falling back down to boggy land on the eastern side of the hillock (approximately 55 maOD). The ground begins to rise again to Correagh Hillock (approximately 65 maOD) and again falling on the far side of the hillock to peaty land (approximately 55 maOD). The subsoils are classified as limestone till on the higher ground and fen peat along the low ground. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features have been mapped along this section. Groundwater vulnerability is predominantly rated as high, with two large pockets of medium rating in the centre of the section. A small area of extreme rated ground is located close to the N5 in the east, with a few other very small pockets near the middle of the section.

**1.2.5.8 Existing N5 at Ardakillin to R368 (Strokestown to Roscommon) Road (approximately 4.5 km)**

As per Option 2.

**1.2.5.9 R368 (Strokestown to Roscommon) Road to Eastern Tie-in (approximately 3.2 km)**

As per Option 2.

### 1.2.6 Corridor 3

This corridor option is approximately 35.7 km long. It represents an online upgrade of the existing N5 route.

#### 1.2.6.1 Western Tie-in to Frenchpark (approximately 6.3 km)

There are no watercourses crossing this section of the existing N5. Land usage is mainly pastureland. Subsoils are classified as predominately sandstone and shale till, with a skirting area of fen pet from Turlaghnamaddy eastwards to the R361. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features have been mapped along this section. There are two springs (including Luggadill Spring Well) just northwest of the western tie-in. Pollnagolum Cave, a swallow hole and two enclosed depressions are located approximately 80 m south of the section in Frenchpark, along the R361. Groundwater is predominantly mapped as having an extreme vulnerability rating for most of this section apart from small areas with a high and medium rating at the western tie-in, and a high rating for the eastern 1.2 km up to Frenchpark.

#### 1.2.6.2 Frenchpark to Bellanagare (approximately 4.1 km)

The N5 crosses the Carricknabraher River approximately 0.9 km south of Frenchpark at Cloonshanville Bridge. The OPW maintain a staff gauge at this location and the EPA monitor water quality. The route crosses an underground channel that has been mapped by the GSI flowing from a swallow hole (Pollnagran Cave) in Leggatinty to the Cloonshanville Spring, a short distance south of the river. A further 1.5 km from the Cloonshanville Bridge the route crosses a tributary of the Carricknabraher River that drains from the Leitrim area on the northern part of the SAC, SPA and NHA designated Bellanagare Bog. The Owennaforeesha River crosses the route just east of Bellanagare, at a reach monitored by the EPA for water quality. Land usage is mainly pastureland. Subsoils are predominantly sandstone and shale till. The western third of the section is underlain by Undifferentiated Visean Limestone. These rocks are classified as a Regionally Important Karstified Aquifer, with conduit permeability. The eastern two thirds is underlain by the Boyle Sandstone Formation that is classified as a Locally Important Aquifer where the bedrock is generally productive only in local zones. Apart from the underground conduit mentioned above, the only other karst feature along the section is a dry valley at Leggatinty, just south of the N5. The initial two thirds of this section from Frenchpark has an extreme groundwater vulnerability rating, with the remaining third a mix of medium, high and extreme.

#### 1.2.6.3 Bellanagare to Tulsk (approximately 11.9 km)

The route crosses the Ogulla River in Tulsk. The land is primarily pastureland. Subsoils are classified as predominantly sandstone till along the western third of this section followed by limestone till along the eastern two thirds. A superimposed drumlin listed as a site of geological heritage (IGH7) borders the corridor to the northwest of Tulsk. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. This section passes through very karstified areas with numerous mapped features. Two swallow holes and an enclosed depression have been mapped on the corridor in Rathnallog / Carrowreagh. Approximately 3 km southeast of Tulsk in the Townland of Carrowreagh there is a large area approximately 1 km in length running parallel to the N5 and 150 m to the north that is heavily karstified with at least twenty three enclosed depressions and sixteen swallow holes mapped. A short distance further east and about 300 m south of the N5 at Moneylea another similar area comprises at least forty two enclosed depressions, thirteen swallow holes and one dry valley. Two enclosed depression are located within the corridor at Ballyconboy, and two springs, Tobar na Spunoige Spring at Carrowntoosan and another at Knockavurrea are also within the corridor. Groundwater vulnerability along the north western quarter of this section has a predominantly low rating, with the central half extreme and the south eastern quarter a high rating.

#### 1.2.6.4 Tulsk to Strokestown (approximately 10.5 km)

The route runs adjacent to the pNHA designated Corbally Lough. A tributary of the Scramoge River is crossed in Kilcooley and again 1.7 km downstream, west of Ardakillin. Another tributary of the same river is crossed between Ardakillin and Cloonfree. The main channel flowing into the Scramoge River is crossed at Cloonfree Bridge that is monitored for water quality by the EPA, and is 700 m upstream of Cloonfree Lough. Land use is mainly pastureland. Subsoils are classified as predominantly sandstone till. A superimposed drumlin listed as a site of geological heritage (IGH7) borders the corridor to the northwest of Tulsk. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. Three springs (including Tobernakicky Spring) are located just north of Tulsk. The only other karst feature mapped along the section is Corbally Lough. Groundwater vulnerability various along the section from equal portions of high and medium ratings apart from a small pocket of extreme vulnerability next to Corbally Lough and a 1.5 km stretch at Ardakillin.

#### 1.2.6.5 Strokestown to Eastern Tie-in (approximately 2.9 km)

The Mountain River tributary that flows from the near the source of Strokestown Group Water Supply located at Cloonslanor is traversed in Strokestown at Farnbeg. The EPA monitors water quality at the location. The final river crossing is Scramoge Bridge over the Scramoge River between Bumlin and Treanaceeve, also an EPA monitoring location. Land usage is a mixture of pastureland, forestry and poorly drained / boggy agricultural land. The subsoil is predominantly sandstone till. The section is predominantly underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. The only karst feature that has been mapped along the section is Bumlin Spring. A fault line runs southwest – northeast passing through Treanaceeve and Scramoge approximately 500 m east of the Scramoge Bridge. The bedrock to the east of this is identified as Dinantian Sandstones (Fearnaght Formation) and classified as a Locally Important Aquifer where the bedrock is generally moderately productive. The initial half of this section from Strokestown has a high groundwater vulnerability rating, with the remaining half mapped as an extreme rating, including a small pocket of high at the Scramoge Bridge.

### 1.2.7 Corridor 4

This corridor option is approximately 38.0 km long. It is located south of the existing N5 along its entire length. This option follows the approximate line of Options 1, 2 and 2B as far as the crossing of the R361 south of Frenchpark. From here it veers further south crossing the R367 (Ballintober to Tulsk) road at Mullygollan Townland and the N61 at Sheegeeragh Townland. The route then veers north-eastwards towards the existing N5 at Lissaphuca Townland and follows a similar route as Options 2, 2A and 2B to bypass Strokestown on the southern side.

#### 1.2.7.1 Western Tie-in to R361 (Castlerea) Road (approximately 5.8 km)

As per Option 1A.

#### 1.2.7.2 R361 (Castlerea) Road to Owennaforeesha River (approximately 4.2 km)

The corridor crosses the Carricknabraher River at the western end of this section and a small tributary of it near the N5 road that drains from the Leitrim area on the northern part of the SAC, SPA and NHA designated Bellanagare Bog. Numerous small drainage channels flow off the northern part of the bog across the corridor discharging into swallow holes (including Pollnagran Cave) in Leggatinty, 110 m north of the corridor. It crosses the Owennaforeesha River southwest of Bellanagare in Ballincool. Topography is relatively flat across the initial boggy ground, rising eastwards away from the Carricknabraher River (80 maOD) up a rise to Bellanagare Bog peaking at Knockroe hillock (110 maOD) before falling back towards the Owennaforeesha River at 80 maOD. Subsoils are predominantly fen peat apart from a finger of sandstone till between Knockroe and the LP1221 at the river. The western third of the section is underlain by Undifferentiated Visean Limestone. These rocks are classified as a Regionally Important Karstified Aquifer, with conduit permeability. Karst features have been mapped at Leggatinty, with two enclosed depressions and two swallow holes located within the corridor. Similar features are mapped at this location within 180 m of the corridor including the Pollnagran Cave and swallow hole that has been linked to the Clonnshanville Spring

further northeast. The eastern two thirds of the section is underlain by the Boyle Sandstone Formation that is classified as a Locally Important Aquifer where the bedrock is generally productive only in local zones. Groundwater vulnerability is predominantly mapped as having an extreme rating along with a low rating on the soft ground north of the bog area and approaching the Owennaforeesha River.

#### 1.2.7.3 Owennaforeesha River to LP1219 (approximately 5.8 km)

A small tributary of the Owennaforeesha River flows northwards through the corridor for approximately 1.3 km from Killaster to Kilcorkey. Two small tributaries of the Termon River rise in the centre of the corridor within forestry north of Rathmoyle, joining the main channel 670 m west of the corridor. The topography shows a general and gentle rise in elevation away from the Owennaforeesha River (80 maOD) to the peak of Rathmoyle Hill (140 maOD) and then gradually falls to approximately 130 maOD at the LP1219. Land usage varies from pastureland in the vicinity of the roads to boggy lands at the western section in Mountdruid and Killaster Townlands. There are also large areas of forestry along the slopes of Ballyglass / Rathkineely Hill. Subsoils are predominantly fen peat on the northern portion with a finger of sandstone till along the LP1220, and predominantly sandstone till along the south-eastern portion. The initial 500 m of this section next to the Owennaforeesha River is underlain by the Boyle Sandstone Formation that is classified as a Locally Important Aquifer where the bedrock is generally productive only in local zones. The remainder of the section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. A spring is located in Mountdruid within the corridor, and further southeast an area of karst features has been mapped in Ballyglass, 170 m east of the corridor that includes at least twelve enclosed depressions and fifteen swallow holes. The initial quarter of the section from the Owennaforeesha River has a low groundwater vulnerability rating with the remaining portion predominantly split between a high rating to the north and an extreme rating to the south on the higher ground.

#### 1.2.7.4 LP1219 to R367 (Tulsk to Castleplunkett) Road (approximately 4.0 km)

No main surface water channels are traversed along this section. The SAC and pNHA designated Mullygollan Turlough is located 600 m northeast and downgradient (89 maOD) of the end of the section, on the northern side of the R367. Castleplunkett Turlough listed as a pNHA site is located 800 m southwest and downgradient of the corridor, on the southern side of the R367. The topography is relatively level at between 125 and 130 maOD, with a gradual fall in the south east to approximately 110 maOD at the R367. Land usage is mainly pastureland with isolated pockets of forestry. The subsoil is classified as predominantly sandstone till throughout the section. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features have been mapped within the section, although St Elvia's Spring and another adjacent spring are located in Toberelva approximately 45 and 95 m south of the corridor. Groundwater has been tracer to flow to this location from a swallow hole in Knockalegan East, 2.8 km to the southwest. Groundwater has an extreme vulnerability rating along this section.

#### 1.2.7.5 R367 (Tulsk to Castleplunkett) Road to N61 (Boyle to Athlone) National Secondary Route (approximately 5.5 km)

The corridor runs through the pNHA designated Brierfield Lough, with the northern part of the lake and an approximately 1.8 km length of possible floodplain within the corridor. Topography is relatively flat along the first third at approximately 100 maOD, before rising slightly across the Carnfree 'Plateau' at approximately 120 maOD. It fails back then to 75 maOD at the N61 in Manor Townland. Land usage is mainly pastureland. Subsoils are classified as predominantly sandstone till throughout. St Elvia's Spring emerges at Toberelva 600 m southwest of the corridor. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. The only known karst feature present along this section is Brierlough Turlough that extends in flooding from the south across the mid-point of the section. The associated swallow hole if located 120 m south of the corridor. Approximately one third of the section, to the west and around Dooneen is mapped as having a high groundwater vulnerability rating. The remainder has an extreme rating with numerous pockets of bedrock outcrop or subcrop.

**1.2.7.6 N61 (Boyle to Athlone) National Secondary Route to existing N5 at Ardakillin (approximately 5.0 km)**

The corridor crosses a small tributary of the Scramoge River at Ballydaly that flows into the pNHA designed Ardakillin Lough 1 km to the east. Further tributaries run along the middle of the corridor between Clooncullaan and the N5, including a small lake within the corridor. Topography falls gradually from the N61 to Ballydaly and then remains relatively flat. The land is mostly pastureland becoming increasingly poorly drained and boggy on the approach to the N5 as it crosses the river channels. Apart from sandstone till near the N61 the subsoil is predominantly fen peat. The section is underlain by Undifferentiated Visean Limestone, classified as a Regionally Important Karstified Aquifer, with conduit permeability. No known karst features have been mapped along the section. Groundwater has an extreme vulnerability rating for the initial 600 m east of the N61 followed by a high rating to Clooncullaan with the remainder mapped as extreme including some bedrock outcrop or subcrop along the N5.

**1.2.7.7 Existing N5 at Ardakillin to R368 (Strokestown to Roscommon) Road (approximately 4.5 km)**

As per Route Option 2.

**1.2.7.8 R368 (Strokestown to Roscommon) Road to Eastern Tie-in (approximately 3.2 km)**

As per Route Option 2.

## 1.3 Hydrogeological objective

This section of the Route Corridor Report seeks to assess and evaluate the route corridor options in relation to hydrogeology. Considering the environmental aspects summarised in the previous section, the main criteria that have been used are:

- Risk to the groundwater – addressing the importance and characteristics (including the presence of karst features) of the underlying aquifer and groundwater usage in the form of groundwater protection schemes, group water schemes and private well sources;
- Impact on designated sites – considering the hydrogeological characteristics of each site within the study area and proximity to the individual route corridors; and
- General impact implications road schemes have on the hydrogeological environment.

The report has been prepared by expanding the desk study work carried out for the Constraints Study to look at all available data specifically relating to the selected route corridor options. It includes an assessment of aerial photography reviewing possible ground surface karst features. The desk study details have been verified on the ground by a drive-by survey along each route corridor.

Any areas that have been highlighted as being of potential hydrogeological significance were targeted for walkover surveys in order to assess the significance of any likely environmental impacts on them.

# 2 Methodology

## 2.1 Data sources

The following list of data sources were the main information sources reviewed as part of this route corridor selection report:

Roscommon National Roads Design Office (NRDO)

- N5 Strategic Corridor Constraints Report, December 2006
- Feasible Route Corridors overlaid on Ordnance Survey (OSi) background mapping
- Digital Ground Model Contours overlaid on OSi background mapping
- N5 Strategic Corridor Draft Route Corridor Selection Report, December 2007

Ordnance Survey

- Discovery Series Mapping (1:50,000)
- Six Inch Raster Maps (1:10,560)

Geological Survey of Ireland (GSI)

- Bedrock Geology Mapping
- Aquifer Mapping
- Groundwater Vulnerability Mapping
- Groundwater Source Protection Mapping
- Teagasc Subsoil Classification Mapping
- Well Database
- Karst Features and Tracer Test Database
- Groundwater Protection Schemes (1999). Department of the Environment, Heritage and Local Government (DoEHLG), Environment Protection Agency (EPA) and Geological Survey of Ireland (GSI)
- Geology of Longford and Roscommon: A geological description of Roscommon, Longford, Westmeath, and adjoining parts of Cavan, Leitrim and Galway, to accompany the bedrock geology 1:100,000 scale map series, sheet 12, Longford - Roscommon. GSI 2003
- Geology of Longford – Roscommon Sheet 12. GSI, 1999

Environmental Protection Agency (EPA)

- Teagasc Sub Cover Classification Mapping
- Teagasc Subsoil Classification Mapping
- Water Quality Monitoring Database and Reports
- Water Framework Directive Classification
- Towards Setting Guideline Values for The Protection of Groundwater in Ireland

Roscommon County Council

- Planning Register
- Roscommon County Development Plan (2002 – 2009)
- Water Services – Abstractions, Discharges & Supply Schemes

National Parks and Wildlife Service (NPWS)

- Designated Areas Mapping

- Site Synopsis Reports

## 2.2 Consultation with regulatory and other bodies

Consultation was made with various departments of Roscommon County Council as well as the GSI. The Irish Peatland Conservation Council (IPCC) was also contacted regarding Cloonshanville and Bellanagare Bogs.

## 2.3 Field surveys

A field survey was carried out to look briefly at any karst, outcrop and spring features that were identified during the desk study and review of the aerial photography. Key areas including the section of ground east of Frenchpark between Cloonshanville and Bellanagare Bogs were assessed and ground elevations surveyed in more detail to obtain a better understanding of the hydrogeological regime.

## 2.4 Impact assessment

In order to assess the relative merits of each of the identified route corridors, an assessment of the likely impact each route will have on the hydrogeological attributes along each route has been made. Consideration has been given to both the importance of the attributes and the predicted scale and duration of the likely impacts.

As only very limited engineering design details and site specific data is available at this stage, much of the preliminary impact assessment is of a qualitative rather than a quantitative nature. A significant degree of professional judgement has therefore been used in identifying and rating the likely impacts. For each route corridor a summary of these associated impacts has been presented in a tabular format.

In relation to likely significant impacts on hydrogeology, each route corridor option has been assessed and rated on the following attributes:

- Bedrock aquifer type;
- Groundwater resources – water supply sources and aquifer / source protection schemes;
- Hydrogeological features – wetland habitats, springs and holy wells;
- Karst features; and
- Aquifer vulnerability

## 2.5 Comparison of route corridors

A comparison of route corridors has been made based on the number and degree of likely impacts and along each corridor. This has established an order of preference from a hydrological perspective.

Where a similar number of likely impacts have been identified then the route corridor which affects the least number of high value attributes has been given preference.

## 2.6 Limitations and gaps in available data

Limitations for this stage of reporting exist in the lack of field and site investigation data for the various route corridors. Most of the conclusions and recommendations have been arrived at through desk study research

and basic site walkovers. Until the final alignment is known it will not be possible to make detailed appraisals regarding how any cut or fill sections will impact on the hydrogeological environs.

The presence of underground karst features will have implications for ground collapse and providing preferential pathways for contaminants to migrate into the underlying aquifer. Information on underground conduit flow is limited for the area, apart from a tracer test carried out by the GSI in Leggatinty, south of Frenchpark. Once the preferred route has been selected it is recommended that any areas within the corridor that have known karst features be surveyed in detail, including geophysical investigation. This should include the key area in Leggatinty.

The relationship between the SAC listed Bellanagare Bog and the hydrogeological regime i.e. the water balance between the northern edge of the bog, the various drainage channels leading off it and the underground flow path from Polnagran Cave to Cloonshanville Spring to the north should be investigated to obtained baseline data.

# 3 Aquifer Type & Classification

## 3.1 Introduction

The GSI has classified geological strata for hydrogeological purposes as one of three principal types:-

- Major (Regionally Important) Aquifers
- Minor (Locally Important) Aquifers
- Unproductive Rocks (Poor Aquifers) or Aquitards.

These are based on the value of the groundwater resource and the hydrogeological characteristics and are further subdivided into ten aquifer categories (DELG/EPA/GSI, 1999):-

| | | |
|---|---|---|
| **Regionally Important (R) Aquifers** | Karstified bedrock dominated by diffuse flow | (Rkd) |
| | Karstified bedrock dominated by conduit flow | (Rkc) |
| | Fissured bedrock | (Rf) |
| | Extensive sand & gravel | (Rg) |
| **Locally Important (L) Aquifers** | Sand and gravel | (Lg) |
| | Bedrock which is Generally Moderately Productive | (Lm) |
| | Bedrock which is Moderately Productive only in Local Zones | (Ll) |
| | Locally important karstified bedrock | (Lk) |
| **Poor (P) Aquifers** | Bedrock which is Generally Unproductive except for Local Zones | (Pl) |
| | Bedrock which is Generally Unproductive | (Pu) |

The Water Framework Directive (WFD) provides for the protection, improvement and sustainable use of waters, including rivers, lakes, coastal waters, estuaries and groundwater within the EU Member States. It aims to prevent deterioration of these water bodies and enhance the status of aquatic ecosystems; promote sustainable water use; reduce pollution; and contribute to the mitigation of floods and droughts. Member States must aim to achieve 'good' status in all waters by 2015, and must ensure that the status does not deteriorate in any waters.

Under the WFD large geographical areas of aquifer have been subdivided into smaller groundwater bodies (GWB) in order for them to be effectively managed. In 2005, all of the GWBs were assessed and given a score based on the likelihood of them achieving an objective of good status by 2015. The scores used were:

- 1a – at risk of failing to meet the objective of good status in 2015
- 1b – at risk of failing to meet the objective of good status in 2015 pending further investigation
- 2a – expected to meet the objective of good status in 2015 pending further investigation
- 2b – expected to meet the objective of good status in 2015

The GWB boundaries are delineated on the EPA website mapping section that also indicates the rating score. A hydrogeological summary description for each is available from the GSI website.

## 3.2 Aquifers in study area

The study area is predominantly (approximately 90.32%) underlain by Dinantian Pure Bedded Limestone comprising Undifferentiated Visean Limestone. These rocks are classified as a Regionally Important Karstified Aquifer, with conduit permeability (Rfc). For the WFD the aquifer has been identified as the Carrick-on-Shannon 4 GWB in the western area around Frenchpark. The main central part of the area comprises the Carrick-on-Shannon GWB and a small area within it to the south of Strokestown is identified as the Carrick-on-Shannon 4 GWB. All are thought to be at risk of failing to meet the WFD objective of good status in 2015 pending further investigation. The aquifer in the southwest part of the study area nearest to Castlerea has been identified as the Suck South GWB. This is expected to meet the objective of good status in 2015.

In the east around Scramoge, approximately 0.70% of the study area is underlain by Dinantian Sandstones bedrock (Fearnaght Formation) that is classified as a Locally Important Aquifer where the bedrock is generally moderately productive (Lm). This aquifer is identified as the Scramoge North GWB that is expected to meet the WFD objective of good status in 2015.

A lens averaging 2.5km wide and comprising approximately 8.98% of the study area of the Boyle Sandstone Formation runs northwards through the area in a line between Castlerea and Bellanagare. This is classified as a Locally Important Aquifer where the bedrock is generally productive only in local zones (Ll). This is the Castlerea Bellanagare 1 GWB and it is thought to be at risk of failing to meet the objective of good status in 2015 pending further investigation

The bedrock aquifer maps published on the GSI website have been used to assess the proportion of the route corridors overlying each type of aquifer. As the mapped unit boundaries need to be confirmed on the ground the calculated percentages are given as approximate.

### 3.2.1 Corridor 1

The corridor starts off on a Regionally Important Aquifer (Rkc) identified under the WFD as the Carrick-on-Shannon GWB, moving into the Carrick-on-Shannon 4 GWB between Churchstreet and Frenchpark Demesne. Between the Townlands of Cloonshanville and Carrigeenynaghtan it crosses a Locally Important Aquifer (Ll) identified as the Castlerea Bellangare GWB. The remaining section is predominantly on the Regionally Important Aquifer (Rkc) identified as the Carrick-on-Shannon GWB. The most easterly section from Treanaceeve to the eastern tie-in is on the Scramoge North GWB, a Locally Important Aquifer (Lm).

| Aquifer Type | % of Corridor Route |
|---|---|
| Regionally Important Karstified Aquifer (Rkc) | 93.57% |
| Locally Important Aquifer (Lm) | 0.81% |
| Locally Important Aquifer (Ll) | 5.61% |

**Table 3.1:** *Percentage of aquifer type traversed by Route Corridor 1*

### 3.2.2 Corridor 1A

The corridor starts off on a Regionally Important Aquifer (Rkc) identified as the Carrick-on-Shannon 4 GWB. Between the Townlands of Derreen and Drummin it crosses a Locally Important Aquifer (Ll) identified as the Castlerea Bellangare GWB. The remaining section is predominantly on the Regionally Important Aquifer (Rkc) identified as the Carrick-on-Shannon GWB. The most easterly section from Treanaceeve is on the Scramoge North GWB, a Locally Important Aquifer (Lm).

| Aquifer Type | % of Corridor Route |
|---|---|
| Regionally Important Karstified Aquifer (Rkc) | 88.837% |
| Locally Important Aquifer (Lm) | 6.10% |

| | |
|---|---|
| Locally Important Aquifer (Ll) | 5.06% |

**Table 3.2:** *Percentage of aquifer type traversed by Route Corridor 1A*

### 3.2.3 Corridor 2

The corridor starts off on a Regionally Important Aquifer (Rkc) identified as the Carrick-on-Shannon 4 GWB. Between the Townlands of Derreen and Drummin it crosses a Locally Important Aquifer (Ll) identified as the Castlerea Bellangare GWB. The remaining section is predominantly on the Regionally Important Aquifer (Rkc) identified as the Carrick-on-Shannon GWB, apart an eastern section south of Strokestown between the Townlands of Cloonfinlough and Ballyhammon that is the Carrick-on-Shannon 3 GWB. The most easterly section from Treanaceeve is on the Scramoge North GWB, a Locally Important Aquifer (Lm).

| Aquifer Type | % of Corridor Route |
|---|---|
| Regionally Important Karstified Aquifer (Rkc) | 91.96% |
| Locally Important Aquifer (Lm) | 0.80% |
| Locally Important Aquifer (Ll) | 7.23% |

**Table 3.3:** *Percentage of aquifer type traversed by Route Corridor 2*

### 3.2.4 Corridor 2A

The aquifers and GWBs traversed are similar to Option 2.

| Aquifer Type | % of Corridor Route |
|---|---|
| Regionally Important Karstified Aquifer (Rkc) | 95.15% |
| Locally Important Aquifer (Lm) | 0.40% |
| Locally Important Aquifer (Ll) | 4.45% |

**Table 3.4:** *Percentage of aquifer type traversed by Route Corridor 2A*

### 3.2.5 Corridor 2B

The aquifers and GWBs traversed are similar to Option 2.

| Aquifer Type | % of Corridor Route |
|---|---|
| Regionally Important Karstified Aquifer (Rkc) | 91.99% |
| Locally Important Aquifer (Lm) | 0.62% |
| Locally Important Aquifer (Ll) | 7.39% |

**Table 3.5:** *Percentage of aquifer type traversed by Route Corridor 2B*

### 3.2.6 Corridor 3

The corridor starts off on a Regionally Important Aquifer (Rkc) identified as the Carrick-on-Shannon 4 GWB. Between the Townlands of Derreen / Keanspark and approximately 0.5 km east of Bellanagare it crosses a Locally Important Aquifer (Ll) identified as the Castlerea Bellangare GWB. The remaining section is predominantly on the Regionally Important Aquifer (Rkc) identified as the Carrick-on-Shannon GWB, apart from two short sections to the southwest of Strokestown at Cloonfree Bridge and to the southeast in the Townland of Farnbeg that is the Carrick-on-Shannon 3 GWB. The most easterly section from Treanaceeve is on the Scramoge North GWB, a Locally Important Aquifer (Lm).

| Aquifer Type | % of Corridor Route |
|---|---|
| Regionally Important Karstified Aquifer (Rkc) | 91.12% |

| | |
|---|---|
| Locally Important Aquifer (Lm) | 0.72% |
| Locally Important Aquifer (Ll) | 8.16% |

**Table 3.6:** *Percentage of aquifer type traversed by Route Corridor 3*

### 3.2.7 Corridor 4

The aquifers and GWBs traversed are similar to Option 2 apart from the Castlerea Bellangare GWB extending from Derreen to Kilcorkey, rather than Drummin. A short length of the corridor is located on the Suck South GWB at Rathmolye.

| Aquifer Type | % of Corridor Route |
|---|---|
| Regionally Important Karstified Aquifer (Rkc) | 92.77% |
| Locally Important Aquifer (Lm) | 0.72% |
| Locally Important Aquifer (Ll) | 6.51% |

**Table 3.7:** *Percentage of aquifer type traversed by Route Corridor 4*

### 3.2.8 Summary of aquifer classifications

Table 3.8 summarises the percentage of each corridor within the different aquifer classifications.

| Aquifer Classification | Option % | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 1A | 2 | 2A | 2B | 3 | 4 |
| Regionally Important Karstified Aquifer (Rkc) | 0.94 | 0.89 | 0.92 | 0.95 | 0.92 | 0.91 | 0.93 |
| Locally Important Aquifer (Lm) | 0.01 | 0.06 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 |
| Locally Important Aquifer (Ll) | 0.06 | 0.05 | 0.07 | 0.04 | 0.07 | 0.08 | 0.07 |
| Order of preference | 6th | 1st | 3rd | 7th | 3rd | 2nd | 5th |

**Table 3.8:** *Order of preference regarding percentage of underlying aquifer type*

# 4 Aquifer Characteristics

## 4.1 Recharge

Aquifer recharge refers to the amount of water replenishing the groundwater flow system. The recharge rate is generally estimated on an annual basis, and is assumed to consist of input (i.e. annual rainfall) less water losses prior to entry into the groundwater system (i.e. annual evapotranspiration and runoff). The estimation of a realistic recharge rate is important in source protection delineation as it is used to estimate the size of the zone of contribution (i.e. the outer source protection area) (GSI, 2003b). Point recharge occurs within the study area via swallow holes and collapse features associated with the karstified limestone. Diffuse recharge occurs over the entire area via rainfall percolating through the subsoil.

Mean annual rainfall in Roscommon for the 1961 to 1990 period varied from 900 to 1000 mm in the lower lying southern and eastern areas of the county, and from 1000 to 1200 mm in the higher northern and western regions (Fitzgerald and Forrestal, 1996).

As there are no Met Eireann synoptic weather stations within the county the mean annual potential evapotranspiration (PE) has been calculated based on data available from the nearest stations located at Claremorris, Mullingar and Birr. This gives an estimated rate of approximately 400 to 450 mm per annum, with the actual evapotranspiration estimated at about 90 to 95 % of the PE (GSI and Roscommon County Council, 2003).

Potential recharge representing an estimation of the excess soil moisture available for either vertical downward flow to groundwater or lateral flow through soil and overland flow to surface water is restricted in many areas due to the cover of low permeability till, which also reduces the groundwater vulnerability. The mean annual potential recharge (rainfall minus actual evaporation) for County Roscommon is estimated to be in the range of 500 to 800 mm, with the lowest levels in the low-lying areas in the south and east. The actual annual recharge to the groundwater depends on the relative rates of infiltration and surface runoff. In many areas the recharge is likely to be as low as 25% of the potential recharge (GSI, 2003b).

### 4.1.1 Carrick-on-Shannon GWB

Both point and diffuse recharge occur in this GWB. Swallow holes and collapse features provide the means for point recharge. Diffuse recharge will occur over the entire GWB via rainfall percolating through the subsoil. Where the GWB is covered by 'low' permeability subsoil this can restrict percolation of recharge and increase runoff. Despite the presence of peat and low permeability till, point recharge to the underlying aquifer still occurs by means of swallow holes and collapse features / dolines. Dolines have been recorded even in areas of thick peat deposits. In areas where point recharge is common and / or subsoils are relatively thin, groundwater generally shows a rapid response to recharge. Where gravels overlie the karstic aquifer they provide a permeable pathway for recharge to the underlying karstic aquifer, and can also act to augment storage (GSI 2003f).

### 4.1.2 Castlerea Bellangare GWB

Recharge is diffuse, with most occurring on the higher ground in the southeast of the body where the subsoil thickness is thinnest (GSI 2003d).

### 4.1.3 Suck South GWB

Both point and diffuse recharge occur in this GWB. Swallow holes and collapse features provide the means for point recharge. Diffuse recharge will occur over the entire GWB via rainfall percolating through the subsoil. The lack of surface drainage in several parts of this GWB indicates that potential recharge readily percolates

into the groundwater system. Except for the extreme north of the body, some areas along the River Suck and smaller isolated areas within the body, the subsoil is primarily of 'moderate' permeability which will generally not restrict percolation of recharge though it. Subsoils of 'low' permeability occur in remaining areas and may restrict the percolation of recharge. In this highly permeable aquifer there can be some rejected recharge in low-lying areas with a high water table where a proportion of the effective rainfall is rejected due to lack of storage space in the aquifer. Groundwater in this body generally shows a rapid response to recharge (GSI 2003g).

#### 4.1.4 Scramoge North GWB

Diffuse recharge will occur over the entire groundwater body via rainfall soaking through the subsoil. More recharge will occur where overlying strata are thinner (GSI 2003e)

### 4.2 Flow and storage

#### 4.2.1 Visean Limestones (Carrick-on-Shannon GWB & Suck South GWB)

Karst features are abundant and widespread through this aquifer, influencing potential flow and storage capacity. Most of the groundwater flows in an epikarstic layer a couple of metres thick and in a zone of interconnected solutionally enlarged fissures and conduits that extends approximately 30m below this layer. Deeper inflows can occur in areas associated with faults or dolomitisation.

There is a notable interconnection between surface water and groundwater in particular on the higher topographic areas such as northwest of Tulsk and east of Castlerea, where the ground is frequently devoid of streams and surface runoff is drained through the numerous karst features including swallow holes, caves and enclosed depressions. Flow paths can be several kilometres in length and are usually extremely complex and difficult to predict, not necessarily following the assumed groundwater table contours. Several turloughs are also present resulting from the up-welling of winter groundwater levels through springs and estavelles.

Localised groundwater flow through solutionally enlarged conduits and fissures is evident from geophysical work carried out to the east of Castlerea which inferred the presence of at least seven large conduits (McGrath, 2001). Rapid velocities of large volumes have been recorded in several tracer tests carried out including a flow rate of 110 m/hr between Pollnagran Cave and Cloonshanville Spring southeast of Frenchpark, and 68 to 107 m/hr between several connections east of Castlerea (GSI, 2001). The conduit flow and frequently associated large springs often result in the bedrock having a relatively low storage capacity with rapid flow in response to rainfall events.

A ground elevation survey carried out in September 2009 out by Roscommon NRDO and Hydro Environmental Ltd around the northern part of Bellanagare Bog looked at the hydraulic gradients between the surface water features on the bog, the channels draining off it and groundwater levels entering and leaving the underlying aquifer. The water level at the entrance to Pollnagran Cave was measured at 80.814 maOD and at the Cloonshanville Spring emergence approximately (measured a few metres downstream as no access at actual spring) 69.117 maOD. This represented a drop of 11.70 m over a 1.5 km distance.

Transmissivity in karstified aquifers with conduit flow can range up to a few thousand $m^2/d$. A pumping test carried out at Ballinlough estimated a bulk transmissivity of between 80 $m^2/d$ and 90 $m^2/d$ although the transmissivity of the associated intensely fractured zone is estimated as 400 $m^2/d$ (K.T. Cullen & Co., 1999).

Within the study area the general groundwater flow is towards the River Lung to the west, the River Suck to the south and the River Shannon to the east. The karstic nature of the bedrock results in very variable localised flow directions.

Wells in these rocks should have (or be capable of having) a large number of 'excellent' yields, in excess of approximately 400 $m^3$/d (4000 gph). Table 4.1 gives a summary of well productivity and yield categories in this Regionally Important Karstified Aquifer in County Roscommon (GSI, 2003b):

| Well productivity index | | | | | Well yield ($m^3$/d) | | | | | Spring yield ($m^3$/d) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I | II | III | IV | V | E (>400) | G (400-100) | M (100-40) | P (<40) | F (<3) | H | I |
| 5 | 2 | | 5 | 7 | 9 | 13 | 2 | 9 | 3 | 7 | 11 |

**Table 4.1:** *Summary of Regionally Important Karstified Aquifer yields within County Roscommon*

where the well yields are excellent (E), Good (G), Moderate (M), Poor (P) or Fail (F); the spring yields are High (H) or Intermediate (I).

### 4.2.2 Boyle Sandstones (Castlerea Bellangare GWB)

The basal and upper beds of this sandstone are reasonably competent devoid of intergranular permeability, which suggests that faults and fractures will remain relatively open and be able to transmit significant quantities of groundwater. The middle unit comprises muddier rock interbedded with sandstone, which is likely to be less permeable. Flow paths to discharge points / zones are generally short, usually 30 to 300 m.

The groundwater flow is mostly near the surface of the rock, with the effective thickness of the aquifer likely to be less than 15 m, comprising a weathered zone of a few metres and a connected fracture zone below this. Deeper flow can also occur in areas where a higher degree of structural deformation and faulting have taken place.

Overall, general flow directions within the GWB will be in a south easterly direction away from the higher ground in the southeast towards the river valley of the Oweenaforeesha, and in the north and northeast of the GWB generally in the direction of the Breedoge River.

A spring in Deerpark, Ballinagare has been reported to have an abstraction of 4 $m^3$/d. Transmissivity values of 15 to 20 $m^2$/d (Longworth, 1987) and 4 to 356 $m^2$/d (Ibbotson, 2000) have been reported.

A summary of well productivity and yield categories for this Locally Important Aquifer within the County is given below (GSI, 2003b):

| Well productivity index | | | | | Well yield ($m^3$/d) | | | | | Spring yield ($m^3$/d) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I | II | III | IV | V | E (>400) | G (400-100) | M (100-40) | P (<40) | F (<3) | H | I |
| | 1 | 3 | 2 | 1 | 1 | 6 | 2 | 4 | 1 | | |

**Table 4.2:** *Summary of Regionally Important Karstified Aquifer yields within County Roscommon*

### 4.2.3 Fearnaght Formation (Scramoge North GWB)

No data is available for well productivities or yields within this Locally Important Aquifer. Stratigrahicaly, the Fearnaght sandstone sits unconformably on much less permeable Lower Palaeozoic (Ordovician) rocks, and beneath thin bands of the Meath Formation and Moathill Formation rocks which are also less permeable. This would indicate that the sandstone aquifer is likely to form a more permeable pathway for groundwater flow within these strata, and the rock's clean sandstone lithology suggests a potentially highly permeable aquifer (GSI, 2003e).

Groundwater flow is expected to be concentrated in fractures and weathered zones and in the vicinity of fault zones. The dominant sandstone lithology and lack of shale will generally result in a higher frequency of more open fractures and, consequently, higher fissure permeability. Where there has been more intense faulting and folding these zones of high permeability will be more common. Because of the nature of the lithology, the degree of interconnection of fissures is expected to be relatively high, enabling an element of regional groundwater flow. The direction of flow is likely to be in a north westerly direction towards the Carrick-on-Shannon GWB. Flow path lengths can be as long as 0.5 to 2 km in length.

## 4.3 Hydraulic conditions

As groundwater percolates downwards through the substrata the underlying aquifer becomes saturated. At the surface level of saturation the groundwater table or phreatic surface is formed. This may slope steeply and often mirrors the overlying topography, generally falling towards the nearest free water surface such as a lake, river of sea. Its stability is dependant on the supply of water from above, falling under dry summer conditions and rising through the wetter winter months.

Where there is an impermeable layer underlying the aquifer and this layer outcrops at the ground surface, then the groundwater will flow at the surface in a seepage zone of spring. When the aquifer is overlain by an impermeable layer it is subject to pressure. When this occurs with the groundwater being fed from a distance it becomes a confined aquifer, with the surface level to which the groundwater table would rise to if allowed termed as the piezometric surface.

### 4.3.1 Carrick-on-Shannon GWB

Groundwater in the Carrick-on-Shannon GWB is generally unconfined. Discharge is mainly to the streams and rivers crossing the body and to large springs found within it. In winter groundwater will also discharge to the numerous turloughs found throughout the area.

### 4.3.2 Castlerea Bellangare GWB

Groundwater in the Castlerea Bellangare GWB is generally unconfined. Groundwater will discharge to the rivers and streams that cross the GWB. As the rock units in this body are of relatively low permeability and the subsoil thicknesses greatest in the river valleys baseflow is expected to be generally low. There may also be some discharge to the surrounding karstified Carrick-on-Shannon GWB.

### 4.3.3 Suck South GWB

Groundwater in the Suck South GWB is generally unconfined. Discharge is mainly to the streams and rivers crossing the body and to large springs found within it. In winter groundwater will also discharge to the numerous turloughs found throughout the area.

### 4.3.4 Scramoge North GWB

Groundwater in the Scramoge North GWB is generally unconfined. Discharges will be in the form of baseflow to the streams crossing the GWB, to Loughs Boderg and Bofin and to the adjoining karstic Carrick-on-Shannon GWB to the northwest.

## 4.4 Artesian conditions

When boreholes are drilled into confined aquifers, they become artesian wells. If the piezometric surface within the ‘artesian aquifer’ is above the ground surface elevation then the artesian well is termed a ‘flowing well’, and a fracture or flaw in the impermeable overlaying material will in such conditions result in an artesian spring.

Occasionally a small area of impermeable material exists in a large aquifer, which may have resulted through geological faulting, or perhaps from the formation of a lens of clay occurring in an otherwise sandy glacial drift. A localised groundwater table, known as a perched groundwater table may result which may often be considerably above the actual true phreatic surface level.

A survey of the wells within the study area has not been carried out as part of this phase of the study to assess the presence of any artesian conditions.

## 4.5 Groundwater quality

In karst areas with thin overlying subsoils, the water quality can be affected due to rapid throughflow of groundwater to springs and boreholes. Water quality within the limestone aquifers is variable with over half of the Group Water Schemes in County Roscommon showing some degree of bacteriological contamination from faecal coliforms (GSI, 2003). The water is usually hard, around 300 mg/l as $CaCO_3$. Springs can also be susceptible to high concentrations of suspended solids due to surface runoff (GSI, 1997).

The 'Roscommon County Council Rural Water Monitoring Project', assessed the water quality in group water schemes for the period from March 1999 to March 2000 inclusive. The assessment revealed that many schemes were supplying drinking water of a much lower standard than that specified in European Communities (Quality of Water Intended for Human Consumption) Regulations, 1988. The following extract from the County Council website summarises the results:

> "For presumptive total coliforms it was found that only 2 out of a total of 65 sources consistently had zero presumptive total coliforms thus indicating that all except 2 sources require disinfection.
>
> For presumptive faecal coliforms, it was found that 58% of samples taken from private schemes and 4% of samples from semi-private schemes tested positive.
>
> Excessive levels of colour were observed for 22 out of a total of 61 sources over the study period. Out of a total of 64 sources, 24 exceeded the limit for turbidity, at least once during the study period. High turbidity in water can also cause problems in water treatment, by making disinfection difficult.
>
> Iron, manganese and to a lesser extent aluminium were also present in excessive levels in some waters-18.2% of source samples exceeded the national limit for iron, 21.1% of source samples exceeded the national limit for manganese and 7.7% exceeded the national limit for aluminium.
>
> Results for pH in all, except 3 samples, were within the required range for pH in potable waters and was not a cause for concern.
>
> During the study period 4 samples from 3 different sources exceeded the national limit for nitrite-a possible indication that water is organically polluted. It was found that 6 private sources, all ground waters, exceeded the national limit value for ammonia-indicating a nearby source of organic pollution. Results for nitrate, phosphorus, and heavy metals were not a cause for concern. 41% of private scheme samples and 3% of semi-private samples had no chlorine residual."

Water samples from 28 Public Group Schemes in County Roscommon indicated a dominance of bicarbonate and calcium ions, with the total hardness ranging from hard (250 to 350 mg/l $CaCO_3$) to very hard (>350 mg/l

$CaCO_3$), and a generally neutral pH value. Alkalinity was generally less than hardness and typical electrical conductivities ranged from 500 to 700 μS/cm.

EPA groundwater quality monitoring is carried out at one location within the study area, Strokestown Water Supply (code ROS43). This had a maximum faecal coliform count of 45 for the 2004 to 2006 period and an average nitrate level of 2.807 mg/l $NO_3$. Two supplies to the south of the area, the Castlerea Water Scheme (code ROS16) and Castlerea Regional Water Scheme (code ROS17) both had a maximum faecal coliform count of 18 and nitrate averages of 6.589 and 7.527 mg/l $NO_3$ respectively during this reporting period.

Site specific groundwater quality data was not available for this study, however one area that was noted during the desk study as a potential concern was a reference by the Environmental Section of Roscommon County Council that highlighted the presence of a burial pit at Cregga Hill (Grid Reference 191879, 285325). The pit contains carcasses of burnt meat from a fire at a meat processing plant (Roscommon Co. Co., 2007). The pit is approximately 375m west of Hanley's Quarry and 205m northeast of Route Corridors 1 and 1A. It is reported that there are 8 monitoring boreholes located next to the pit. As this area of concern is upgradient of the route corridors there may be potential for contaminated groundwater to flow into any associated cut sections.

#### 4.5.1 Carrick-on-Shannon GWB

The hydrochemistry of the carbonate rocks, especially pure limestones, is dominated by calcium and bicarbonate ions. Hardness can vary from slightly hard to very hard (typically ranging between 380 to 450 mg/l). Spring waters tend to be softer, as throughput is often quicker with less time for the dissolution of minerals into the groundwater. Alkalinity is variable, but can be high and is generally less than hardness indicating that ion exchange (where calcium or magnesium are replaced by sodium) is not a significant process.

These hydrochemical signatures are characteristic of clean limestone and are frequently associated with lime-scale issues. Electrical conductivities (EC) in limestone can vary greatly with typical values in the order of 500 to 700 μS/cm. Lower values suggest that groundwater residence times are very short.

In some springs and boreholes in karst areas, high turbidity occurs after heavy rainfall. This is caused where sediment that has collected in fissures and cavities is washed out at the start of recharge events, and where there is a direct link between the source and a swallow hole into which surface water containing sediment is flowing.

Microbial pollution is also a significant problem, and due to the high level of interaction between groundwater and surface water in karstic aquifers, pollution can travel very quickly from the surface into the groundwater system. The normal filtering and protective action of the subsoils is often bypassed due to the number of swallow holes, dolines and large areas of shallow rock.

#### 4.5.2 Castlerea Bellangare GWB

No relevant hydrochemical data are available in this GWB for assessment. Groundwater in the Dinantian Mixed Sandstones, Shales and Limestones has a calcium–bicarbonate signature with the Boyle Sandstone Formation being calcareous.

#### 4.5.3 Suck South GWB

The hydrochemical signature is similar to the Carrick-on-Shannon GWB.

#### 4.5.4 Scramoge North GWB

No relevant hydrochemical data are available in this GWB for assessment.

# 5 Aquifer Vulnerability

## 5.1 Groundwater vulnerability and guidelines

The risk to groundwater is defined through assessments of groundwater vulnerability, aquifer potential and source protection areas. Vulnerability represents the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. It depends on the:

- time of travel of infiltrating water (and contaminants);
- relative quantity of contaminants that can reach the groundwater; and
- contaminant attenuation capacity of the geological materials through which the water and contaminants infiltrate (DELG/EPA/GSI, 1999).

The above are a function of the following natural attributes of any area:

- type and permeability of the subsoils that overlie the groundwater;
- thickness of the unsaturated zone through which the contaminant moves; and
- recharge type, whether point of diffuse.

As all groundwater is hydrological connected to the land surface which is receiving the contaminants, the land can therefore be categorised based on the nature of the protecting geological layers between the ground surface and groundwater and the potential of bypassing these layers.

GSI guidelines as outlined in the Groundwater Protection Schemes publication (DELG/EPA/GSI, 1999) define four vulnerability categories: extreme, high, moderate and low. These can be combined with site investigation data i.e. the geological and hydrogeological characteristics to obtain appropriate groundwater vulnerability ratings for any particular area, as outlined below (Table 5.1).

| Vulnerability Rating | HYDROGEOLOGICAL CONDITIONS | | | | |
|---|---|---|---|---|---|
| | Subsoil Permeability (Type) and Thickness | | | Unsaturated Zone | Karst Features |
| | High permeability (sand/gravel) | Moderate permeability (e.g. Sandy subsoil) | Low permeability (e.g. Clayey subsoil, clay, peat) | (Sand/gravel aquifers only) | (< 30m radius) |
| **Extreme (E)** | 0 – 3.0m | 0 – 3.0m | 0 – 3.0m | 0 – 3.0m | n/a |
| **High (H)** | > 3.0m | 3.0 – 10.0m | 3.0 – 5.0m | > 3.0m | n/a |
| **Moderate (M)** | n/a | > 10.0m | 5.0 – 10.0m | n/a | n/a |
| **Low (L)** | n/a | n/a | > 10.0m | n/a | n/a |
| Notes: | (1) n/a = not applicable.<br>(2) Precise permeability values cannot be given at present.<br>(3) Release point of contaminants is assumed to be 1-2m below ground surface. | | | | |

**Table 5.1:** *Groundwater vulnerability assessment criteria (DoELG, EPA, GSI – 1999)*

The GSI mapping indicates the vulnerability of the groundwater closest to the ground surface, to contaminants released at depths of 1 to 2 m. It is used for guidance only and should be supported by site investigation, and contaminant specific assessments where appropriate. In unsaturated bedrock aquifers the target for protection is the groundwater table within the bedrock unit, and for saturated aquifers it is the top of the bedrock.

In karst areas groundwater is particularly vulnerable to contamination with an extreme rating as:-

- water can move rapidly through fissures widened by solution;
- sinking streams provide direct water entry points to groundwater, with little or no filtration or attenuation of contaminants;
- Solution hollows or dolines may also provide direct entry routes through vertical shafts; and
- The characteristic soil cover over karst limestone is very thin, maybe only a few centimetres deep, and so provides little protection (GSI, 2002).

## 5.2 Vulnerability mapping

### 5.2.1 Groundwater vulnerability within study area

The GWB summary of initial characterisation for the various aquifers identified under the WFD assessment that have been prepared by the GSI were reviewed to obtain the following details on groundwater vulnerability within each of the GWBs that are present within the study area.

The GSI groundwater vulnerability maps available for County Roscommon were then queried to obtain details on the vulnerability ratings specific to each corridor.

#### 5.2.1.1 Carrick-on-Shannon GWB

There are large areas of extreme vulnerability within this body, including areas around Frenchpark, northwest of Strokestown and in the southwest of the body. Areas in the vicinity of swallow holes and dolines (which allow point recharge) are delineated as extremely vulnerable. Some swallow holes and dolines occur in areas of reasonably thick peat cover (6 to 9 m). The main areas of moderate and low vulnerability are concentrated in the extreme west of the body, just west of the centre of the body near the Castlerea Bellanagare GWB, southwest of Carrick on Shannon and in the east of the body around Kilglass Lough.

#### 5.2.1.2 Castlerea Bellanagare GWB

Areas of extreme vulnerability occur on the higher ground in the southeast of the body and a small area northwest of Bellanagare. Narrow areas of high vulnerability skirt the areas of extreme vulnerability. Areas of moderate and low vulnerability occur in the lower lying river valley areas, particularly in the northeast of the body.

#### 5.2.1.3 Suck South GWB

There are large areas of extreme vulnerability particularly in the east of the body. Most of the rest of the eastern half of the body is an area of high vulnerability. There are some areas of moderate and low vulnerability south of Castlerea and in vicinity of the River Suck. The Groundwater Protection Scheme has been carried out by the GSI for the Castlerea Water Supply Scheme located within this GWB.

#### 5.2.1.4 Scramoge North GWB

Most of the GWB is in an area of extreme vulnerability, particularly in the south of the body, and on higher ground. Areas of high vulnerability skirt the extreme vulnerability areas. In more low lying areas where subsoil thickness is greater there are areas of moderate and low vulnerability.

### 5.2.2 Route corridor assessment methodology

To assess the level of vulnerability present in each of the corridors relative to each other, the GSI groundwater vulnerability maps have been used to calculate an approximate area covered by each category. The percentage has then been multiplied by the order of preference i.e. a low vulnerability rating which would

be most preferable is assigned a value of 1 and the least preferable, extreme a value of 4. The overall total for each route can then be assigned a corridor rank in respect to vulnerability.

The methodology and results are for guidance only as there is likely to be some degree of variance in the calculation of areas. Site investigation data when available for the preferred route can be used to re-assess the vulnerability ratings, and considerations will need to be given to whether the alignment is in cut or fill as this will influence the ratings.

#### 5.2.2.1 Corridor 1

The initial quarter of the route corridor from the western tie-in to Cloonshanville Townland is predominantly mapped as having an extreme rating with numerous small isolated pockets of bedrock outcrop or subcrop. The second quarter to Mantua is predominantly split in two halves with a low rating in the west and medium rating to the east. The third quarter eastwards to Largan has a predominant high vulnerability rating, with a pocket of low rating around Killeen East. The final quarter is predominantly extreme rated with considerable occurrences of bedrock outcrop or subcrop.

| Groundwater Vulnerability | Order of Preference | % of Route Corridor | Potential Impact Level | Overall Total | Corridor Rank |
|---|---|---|---|---|---|
| Extreme | 4 | 44.38% | 1.78 | 3.01 | 2nd |
| High | 3 | 27.15% | 0.81 | | |
| Medium | 2 | 13.70% | 0.27 | | |
| Low | 1 | 14.76% | 0.15 | | |

**Table 5.2:** *Percentage of groundwater vulnerability rating traversed by Route Corridor 1*

#### 5.2.2.2 Corridor 1A

The vulnerability rating distributions along this corridor are similar to Option 1 apart from in the second quarter from Bellanagare to Mantua where the western third is rated as predominantly low and the remaining two thirds as medium.

| Groundwater Vulnerability | Order of Preference | % of Route Corridor | Potential Impact Level | Overall Total | Corridor Rank |
|---|---|---|---|---|---|
| Extreme | 4 | 31.91% | 1.28 | 2.82 | 1st |
| High | 3 | 27.28% | 0.82 | | |
| Medium | 2 | 31.57% | 0.63 | | |
| Low | 1 | 9.24% | 0.09 | | |

**Table 5.3:** *Percentage of groundwater vulnerability rating traversed by Route Corridor 1A*

#### 5.2.2.3 Corridor 2

This corridor can be split into five general divisions. The western fifth from the tie-in to Leggatinty is predominantly rated as having an extreme vulnerability. The second fifth to Kilvoy is mostly low rated in the western part and medium in the eastern part. The next section it Castleland is predominantly high rated with an extreme rating running along most of the southern boundary. The forth section to Lisnahirka is mixed with pockets of medium, high and extreme ratings, and the final fifth is predominantly rated as high with pockets of extreme.

| Groundwater Vulnerability | Order of Preference | % of Route Corridor | Potential Impact Level | Overall Total | Corridor Rank |
|---|---|---|---|---|---|
| Extreme | 4 | 27.72% | 1.11 | 3.12 | 3rd |

| | | | | | |
|---|---|---|---|---|---|
| High | 3 | 59.05% | 1.77 | | |
| Medium | 2 | 11.20% | 0.22 | | |
| Low | 1 | 2.02% | 0.02 | | |

**Table 5.4:** *Percentage of groundwater vulnerability rating traversed by Route Corridor 2*

#### 5.2.2.4 Corridor 2A

The vulnerability rating distributions along this corridor are similar to Option 2.

| Groundwater Vulnerability | Order of Preference | % of Route Corridor | Potential Impact Level | Overall Total | Corridor Rank |
|---|---|---|---|---|---|
| Extreme | 4 | 31.84% | 1.27 | 3.16 | 5th |
| High | 3 | 53.94% | 1.62 | | |
| Medium | 2 | 12.25% | 0.24 | | |
| Low | 1 | 1.98% | 0.02 | | |

**Table 5.5:** *Percentage of groundwater vulnerability rating traversed by Route Corridor 2A*

#### 5.2.2.5 Corridor 2B

The vulnerability rating distributions along this corridor are similar to Option 2.

| Groundwater Vulnerability | Order of Preference | % of Route Corridor | Potential Impact Level | Overall Total | Corridor Rank |
|---|---|---|---|---|---|
| Extreme | 4 | 29.37% | 1.17 | 3.15 | 4th |
| High | 3 | 57.71% | 1.73 | | |
| Medium | 2 | 11.00% | 0.22 | | |
| Low | 1 | 1.92% | 0.02 | | |

**Table 5.6:** *Percentage of groundwater vulnerability rating traversed by Route Corridor 2B*

#### 5.2.2.6 Corridor 3

The western half of this corridor to Carrowntoosan is predominantly mapped as having an extreme vulnerability, and the eastern half as a high rating.

| Groundwater Vulnerability | Order of Preference | % of Route Corridor | Potential Impact Level | Overall Total | Corridor Rank |
|---|---|---|---|---|---|
| Extreme | 4 | 47.76% | 1.91 | 3.29 | 6th |
| High | 3 | 37.47% | 1.12 | | |
| Medium | 2 | 10.79% | 0.22 | | |
| Low | 1 | 3.99% | 0.04 | | |

**Table 5.7:** *Percentage of groundwater vulnerability rating traversed by Route Corridor 3*

#### 5.2.2.7 Corridor 4

The route corridor can be subdivided into three broad bands. The western third of the corridor to Rathineely is predominantly rated as having an extreme vulnerability, with two small areas of low rating to the northwest and southwest of Bellanagare. The second third has a predominant extreme rating with numerous small pockets of outcrop or subcrop. The final eastern third is predominantly rated as having a high rating, with two small areas of extreme rating.

| Groundwater Vulnerability | Order of Preference | % of Route Corridor | Potential Impact Level | Overall Total | Corridor Rank |
|---|---|---|---|---|---|
| Extreme | 4 | 50.73% | 2.03 | 3.39 | 7th |
| High | 3 | 42.32% | 1.27 | | |
| Medium | 2 | 2.49% | 0.05 | | |
| Low | 1 | 4.46% | 0.04 | | |

**Table 5.8:** *Percentage of groundwater vulnerability rating traversed by Route Corridor 4*

# 6 Karst Landscape & Features

## 6.1 Characteristics of karst landscape

Karst is a term used to describe the distinctive landforms that develop on rock types that are readily dissolved by water. In Ireland, limestone (composed of calcium carbonate) and to a lesser extent dolomite (calcium and magnesium carbonate) are by far the most widespread rocks that show karst features. Typically, karst regions lack rivers and other surface waters because the rain is swallowed up by fissures and conduits in the rock and then flows as underground streams in caves. Eventually the waters return to the land surface, often as large springs. Karst areas are indicated by a general absence of permanent surface streams and the presence of swallow holes and enclosed depressions. The water is usually all underground in solutionally enlarged channels, some of which are big enough to be termed caves (GSI, 2002).

Thus a mature karst landscape is devoid of surface water, and the surface may be pitted with deep hollows, conical or saucer shaped, and sometimes hundreds of metres deep and several kilometres in diameter. These dolines (small to medium sized enclosed depressions) act as funnels, collecting rainwater and leading it underground into cave systems.

## 6.2 Formation of karst features

Rain water, slightly acidic (carbonic acid) readily dissolves limestone rock. As it infiltrates through soil material it becomes more acidic increasing the capability to dissolve a greater quantity of rock. The water trickles down through cracks in the limestone, progressively enlarging them, which allows a greater quantity of water to enter forming fissures. In time, the fissures are sufficiently enlarged to engulf all rainwater within moments of its falling. In some areas, rivers which rise on non-limestone rocks flow on to the limestone and sink underground in swallow holes. Underground, the waters from fissures unite to form small streams and these in turn join and excavate correspondingly large conduits. Conduits accessible to humans are termed caves. At some point the underground waters return to the surface as springs, except where local geological conditions may cause the waters to emerge from the sea bed some distance off-shore. Caves and karst fissures are common at shallow depths beneath the ground surface but they are also known to exist at great depths (GSI, 2002).

## 6.3 Implications for road schemes

Karst regions may provide particular problems for engineering works associated with major road and bridge construction. These problems mainly arise from the unpredictable occurrence, extent and depth of underground cavities which may lead to subsequent road subsidence and inadequate foundation support for bridge structures.

An important feature of karst areas is the absence of surface water which often leads to groundwater being the main source of supply (GSI, 2002). The presence of private well supplies in the vicinity of the road development is therefore important regarding potential impacts to water quantity and in particular to the quality of the water that has an increased vulnerability to contamination.

## 6.4 Karst in study area

#### 6.4.1 Carrick-on-Shannon GWB

Karstification is widespread in this GWB. Current records of karst features are considered to represent only a fraction of existing features. Higher topographic areas are frequently devoid of surface water streams, as water is drained through karst features, including numerous areas of large clusters of features. Several seasonal lakes / turloughs are noted especially in the south of the GWB resulting from the up-welling of groundwater through springs and estavelles as the groundwater table rises in winter.

Apart from the scattered occurrences of features present in particular enclosed depressions, swallow holes and springs, there are five cluster areas that are of relevance to the locations of the route corridor options. One is located south of Frenchpark in Leggatinty within the Carrick-on-Shannon 4 GWB and the remainder within the main Carrick-on-Shannon GWB.

##### 6.4.1.1 Leggatinty

This area is of particular interest in that all route corridor options apart from Option 1 pass through it. The designated Bellangare Bog is located to the southwest with surface water drainage from the bog flowing through a number of small channels across the route corridors and discharging underground into karst features in Leggatinty. Mapped features comprise five enclosed depressions, five swallow holes, two caves (including Pollnagran Cave (grid reference 173520, 289698)), one spring (Cloonshanville Spring (grid reference 174008, 290285)) and one dry valley. A review of aerial photography indicates that there are likely to be further features present.

A large proportion of surface water runoff and seepage from the nearby area of the bog and the ground underneath the corridor footprints appears to flow into Pollnagran Cave, re-emerging at Cloonshanville Spring 780 m to the northeast. Tracer tests carried out in this area by the GSI in September 2004 found a link between the Pollnagran Cave and a nearby swallow hole (grid reference 173447, 289702) with the spring. A flow rate of 110 m/hr was measured during dry conditions. Pollnagran ?Cave represents the only recorded active stream fed cave system in County Roscommon and thus is considered to have a very high attritube rating in respect to hydrology and hydrogeology.

During site visits by Hydro Environmental Ltd on the 25th of August and 16th of September, 2009 the water discharging from the spring was noted to be very peaty and brown, being similar to the surface water run-off in the channels draining from Bellangare Bog.

##### 6.4.1.2 Carrowreagh and Moneylea

There are two locations on either side of Option 3 between Bellangare and Tulsk that are significant for the number of features present. In Carrowreagh to the north of the N5 there are at least twenty three enclosed depressions and sixteen swallow holes mapped in a corridor approximately 1km long running parallel to the road. And in Moneylea in a corridor approximately 800 m long to the south of the N5 there are at least forty two enclosed depressions, thirteen swallow holes and one dry valley mapped. This whole area is likely to be a main recharge zone for the aquifer.

##### 6.4.1.3 Ballymurry to Carrowntoosan and Tulsk to Cloonquin

There is a north – south line of at least fourteen springs mapped between Ballymurray and Carrowntoosan. Further springs to the east along the N61 between Tulsk and Cloonyquin are also present. It is possible that groundwater collected from the higher ground to the west is discharging to these springs and on to the numerous surface water channels and lakes further east.

##### 6.4.1.4 Kilvoy

The Townland of Kilvoy has a large number of mapped karst features present including at least ten enclosed depressions, twelve swallow holes, two springs and one dry valley. These are of relevance to Options 1A, 2, 2A and 2B.

#### 6.4.1.5 Ballyglass

A cluster of at least ten enclosed depressions and thirteen swallow holes has been mapped in Ballyglass, 3.7 km south of Bellanagare. The area is between 60 and 700 m east of Option 4. Recharged groundwater is likely to flow westwards towards the Owennaforeesha River and northwards towards two springs in Mountdruid and Gortmagoyne.

### 6.4.2 Castlerea Bellangare GWB

No karst features are present within this GWB.

### 6.4.3 Suck South GWB

Karstification is widespread in this GWB. Current records of karst features are considered to represent only a fraction of existing features. Two areas have been identified relative to the south western boundary of the study area.

#### 6.4.3.1 Lissalway

Karst mapping undertaken by the GSI in 2000 identified an unusually large number of features east of Castlerea. The mapping particularly highlighted the density of dolines and swallow holes and the alignment of these features, i.e. two lines of densely packed dolines and swallow holes were noted trending northwest to southeast. This cluster of features extends a short distance into the study area at Lissalway, with at least twenty two enclosed depressions, two swallow holes and one area of superficial solution feature at this location.

Tracer tests by the GSI have established underground flow paths away from this part of study area to the south west, flowing from Lissalway Swallow Hole (grid reference 173970, 279560) to Silver Island Spring, Corans Spring and Poolnacurragh Spring.

#### 6.4.3.2 Knockalegan East

Further east in Knockalegan East tracer tests have established links from the Knockalegan East Swallow Hole (grid reference 175730, 278050) to St. Elvia's Spring and St. Luke's Well both to the northeast and just west of Option 4.

### 6.4.4 Scramoge North GWB

No karst features are present within this GWB.

### 6.4.5 Summary of karst features within route corridors

Table 6.1 provides a summary of the occurrences of karst features listed on the GSI karst database within the route corridor options. Features just outside the boundary have not been included at this stage but should be investigated once the preferred corridor has been selected and the alignment known.

| Route | 1 | 1A | 2 | 2A | 2B | 3 | 4 |
|---|---|---|---|---|---|---|---|
| Springs | 1 | 1 | 10 | 10 | 8 | 3 | 4 |
| Swallow Holes | 0 | 10 | 13 | 13 | 13 | 2 | 1 |
| Enclosed Depressions | 0 | 8 | 5 | 7 | 7 | 3 | 2 |
| Caves | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Turloughs | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| Dry Valleys | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| Superficial Solution Features | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total number of features | 1 | 19 | 30 | 32 | 29 | 10 | 8 |
| Order of preference | 1st | 4th | 6th | 7th | 5th | 3rd | 2nd |

**Table 6.1:** *Number of karst features within each route corridor*

It is important to note that there are likely to be further unmapped features present on the ground, as well as underground features. The order of preference listed above is guideline only as major features that are either immediately upgradient or downgradient of the corridor may be impacted subject to whatever alignment is taken through the corridor.

# 7 Groundwater Resources

## 7.1 Wetland habitats

During the construction phase of a road scheme there may be a requirement for cut sections to be dewatered which could potentially impact on the hydrogeological regime of any nearby wetland habitats. The road itself may act as a 'barrier' within groundwater flow pathways. Recharge may also be impacted where fill sections impede surface runoff entering the underlying aquifer.

Under European and Irish law, the Department of the Environment, Heritage and Local Government is responsible for the designation of conservation sites in Ireland. There are three main types of designation:

- Natural Heritage Area (NHA). This is the basic designation for wildlife, and is an area considered important for the habitats present or which holds species of plants and animals whose habitat needs protection. Listed sites that were published on a non-statutory basis in 1995, but have not since been statutorily proposed or designated are regarded as proposed NHA i.e. pNHA. The GSI is compiling a list of geological / geomorphological sites in need of protection with the list of karst and early fossil sites available to date. Under the Wildlife Amendment Act (2000), NHAs are legally protected from damage from the date they are formally proposed for designation.

- Special Area of Conservation (SAC). This is regarded as a prime wildlife conservation area in the country, and considered to be important on a European as well as Irish level. SACs are selected and designated under the EU Habitats Directive, which is transposed into Irish law as the European Union (Natural Habitats) Regulations, 1997, amended in 1998 and 2005. The Directive lists certain habitats and species that must be protected within SACs. Irish habitats include raised bogs, blanket bogs, turloughs, sand dunes, machair (flat sandy plains on the north and west coasts), heaths, lakes, rivers, woodlands, estuaries and sea inlets. Sites not fully listed are regarded as candidate SACs i.e. cSAC.

- Special Protection Area (SPA). This is an area / habitat that under EU Directive requirements needs to be safeguarded. The EU Birds Directive (79/409/EEC) requires designation of SPAs for: listed rare and vulnerable bird species; regularly occurring migratory species, such as ducks, geese and waders; and wetlands, especially those of international importance (i.e. 1% of the population of a species uses the site, or more than 20,000 birds regularly use the site), which attract large numbers of migratory birds each year. Many existing and future SPAs overlap with SACs.

The NPWS website was queried regarding the presence of any listed wetland habitats within the study area. A total of eight sites were identified comprising two bogs and six loughs / turloughs. The two bogs (Cloonshanville and Bellanagare) located near Frenchpark are considered of international significance. Approximately 2.6 km separates the two areas and all route corridor options run between them. The area just north of Bellanagare Bog in the Townland of Leggatinty has a number of significant karst features including the Pollnagran Cave (grid reference 173520, 289698) and other swallow holes that discharge drainage water from the bog to the Cloonshanville Spring (grid reference 174008, 290285) approximately halfway between the bogs.

To assess the potential impact that the route corridor options would have on these designated sites the distance from each corridor to the site has been measured and an accumulative total used to assign an order of preference (Table 7.1). This can only be used for guidance as not all sites will have a hydrological / hydrogeological link to the corridor area, and once the preferred route corridor and alignment have been

selected it will be necessary to reconsider each designed site in relation to whether it is upgradient or downgradient of the alignment and if the nearest section is in cut or fill.

| Designated Site | Category | | | Route Corridors & Distance (km) from Designated Site | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 1A | 2 | 2A | 2B | 3 | 4 |
| Cloonshanville Bog | NHA | cSAC | | 0.00 | 1.87 | 1.87 | 1.87 | 1.87 | 0.89 | 1.95 |
| Bellanagare Bog | NHA | cSAC | SPA | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.66 | 0.00 |
| Annaghmore Lough | pNHA | cSAC | | 0.90 | 0.90 | 2.30 | 2.36 | 2.36 | 1.20 | 2.36 |
| Castleplunkett Turlough | pNHA | | | 10.08 | 9.60 | 7.08 | 7.08 | 7.24 | 5.34 | 1.02 |
| Mullygollan Turlough | pNHA | cSAC | | 8.20 | 8.20 | 4.43 | 4.43 | 4.60 | 3.05 | 0.60 |
| Brierfield | pNHA | | | 8.96 | 8.96 | 4.39 | 4.39 | 4.81 | 3.46 | 0.00 |
| Corbally Lough | pNHA | | | 6.27 | 6.27 | 0.00 | 0.00 | 1.00 | 0.00 | 1.65 |
| Ardakillin Lough | pNHA | | | 5.80 | 5.80 | 0.44 | 0.44 | 0.50 | 0.59 | 0.44 |
| Total distance (km) | | | | 41.43 | 42.10 | 21.01 | 21.07 | 22.88 | 15.19 | 8.02 |
| Corridor rank of preference | | | | 2nd | 1st | 5th | 4th | 3rd | 6th | 7th |

Notes: Distances have been sourced from data provided by Roscommon NRDO

**Table 7.1:** *Designated areas within study area and distance to each route corridor*

The following summary descriptions for each site have been collated from descriptions presented in the NPWS datasheets available from their website and from the Habitats Directive Article 6 Assessment for the Shannon iRBD which covers SACs. Details of any karst features present were obtained from the GSI website mapping section. A NPWS site synopsis is not currently available for pNHA sites.

### 7.1.1 Bellanagare Bog

Bellanagare Bog (site code 000592) is a raised bog that is a priority habitat listed on Annex I of the EU Habitat Directive and is listed as a NHA, cSAC and SPA. It is located 6 km northeast of Castlerea and 2 km south of Frenchpark (grid reference to central area 171400, 286700) and extends approximately 6 km north-south and 2.5 km east-west at the central point. Covering an approximate area of 1207.6 hectares, approximately 52% is identified as 'degraded raised bog still capable of natural regeneration' (habitat code 7110), 9% as 'active raised bog' (habitat code 7110), and 1% of depressions on peat substrates of the Rhynchosporion (habitat code 7150).

The bog is underlain by muddy Carboniferous limestone with a low permeability, and the subsoil is identified as predominantly clayey limestone till. It lies in an upland area at the top of a surface catchment divide. The surface is undulating with the peat concentrated on ridges and flushes occurring in between these. Flush types include an in-filling lake, an extensive Purple Moor-grass (*Molinia caerulea*) flush with a high diversity of plant species, a large swallow-hole flush and flushes associated with springs, rises and streams. One flush is coincident with a bog burst. Well developed hummocks and several quaking areas occur in some sections.

A number of streams including the Frances River rise on the site. The area is vulnerable to water loss through the extensive drain network in its northern half and from turf cutting, which occurs in places all around

the site. Because it is also quite a dry bog it is very vulnerable to burning. A large section of the site is in state ownership, and the area is traversed by several tracks used by private owners still engaged in active turf cutting.

The bog is unusual in that it supports plant species typically found on raised bogs as well as species more usually found on blanket bogs. For this reason it is classified as a western, or intermediate raised bog. It is also notable for its range of standing water habitats which include an in-filling lake, an extensive Purple Moor Grass area with a high diversity of plant species, a large swallow hole, springs, rises and streams. Among the other habitat types present are cutaway bog, small areas of heath, scrub, wet grassland and several small conifer plantations. The site provides habitat for a relatively large population of Red Grouse.

The Habitats Directive Article 6 Assessment for the Shannon iRBD gives the qualifying feature on this site as an 'active raised bog' (also for supporting a population of Red Grouse). The key environmental conditions to support site integrity are to maintain the Annex I habitats for which the cSAC has been selected at favourable conservation status. The main threats and impacts on the site are peat cutting; drainage and burning; afforestation; invasive species; grazing; dumping; fertilisation; restructuring agricultural land; communication routes; cultivation; mowing / cutting; modification of inland water structures; and sand and gravel extraction.

#### 7.1.2 Brierfield Turlough

Brierfield Turlough (site code 000594) is located 4.5km southwest of Tulsk (grid reference 181600, 276560). It covers approximately 136.9 hectares and is listed as a pNHA. The Brierfield Turlough Swallow Hole is present in the north of the site (grid reference 181810, 277100) and there is a small area of limestone pavement.

#### 7.1.3 Castleplunket Turlough

Castleplunket Turlough (site code 001617) is located 6.5 km southwest of Tulsk along the south of the R367 road, close to the village of Castleplunket (grid reference 177670, 277840). It covers approximately 85.9 hectares and is listed as a pNHA. A small pool is present at the site. No site synopsis information is currently available from the NPWS.

#### 7.1.4 Mullygollan Turlough

Mullygollan Turlough (site code 000612) is located in the Townland of Carrgarve approximately halfway between Castleplunket and Tulsk along the northern side of the R367 road (grid reference 180080, 279450). It is listed as a pNHA and cSAC. Covering an approximate area of 43.8 hectares, approximately 88% is identified as 'turlough' (habitat code 3180).

The turlough is sited in a noticeable basin, bordered by a rock outcrop to the north and sloping, drift covered fields to the south. A semi-permanent stream enters from the west and flows towards ponds and a swallow hole (grid reference 180080, 279450) located in the bedrock. The floor of the turlough retains a high water table with ditches in summer. There is significant peat accumulation covered by fen vegetation. There is little formation of marl at present (as reported in January 1997, in NPWS site synopsis). The contrast of wet and dry areas gives good diversity in the vegetation, which consists of peaty communities in the centre with more typical turlough vegetation around the edges.

The Habitats Directive Article 6 Assessment for the Shannon iRBD gives a qualifying feature on this site as a 'turlough' (habitat code 3180). The key environmental conditions to support site integrity are to maintain the Annex I habitats for which the cSAC has been selected at favourable conservation status. The main threats and impacts on the site are drainage, over-grazing, eutrophication, peat cutting, marl extraction and quarrying.

#### 7.1.5 Cloonshanville Bog

Cloonshanville Bog (site code 000614) is a raised bog that is a priority habitat listed on Annex I of the EU Habitat Directive and is listed as a NHA and cSAC. It is located approximately 2 km east of Frenchpark bounded along the east by the Breedoge River and the south by the Frenchpark / Elphin road (grid reference to central area 175250, 291500) and extends approximately 1.7 km north-south and 1.6 km east-west at the central point. Covering an approximate area of 225.8 hectares, approximately 63% is identified as 'degraded raised bog still capable of natural regeneration' (habitat code 7110), 21% as 'active raised bog' (habitat code 7110), 6% as 'bog woodland' (habitat code 91D0) and 1% of depressions on peat substrates of the Rhynchosporion (habitat code 7150).

The bog is underlain by low-permeability clayey limestones, and has developed in a shallow basin within a groundwater discharge zone. The regional groundwater table has been lowered, but evidence of groundwater inputs are seen on and around the high bog. Hummock / pool systems have developed in the wettest areas and a large flush area is present in the centre of the bog dome. The main body of the flush supports an extensive area of extremely rare Irish bog woodland. Three areas of coniferous plantation have been included within the site for hydrological reasons.

The Habitats Directive Article 6 Assessment for the Shannon iRBD gives the qualifying feature on this site as 'bog woodland'. The key environmental conditions to support site integrity are to maintain the Annex I habitats for which the cSAC has been selected at favourable conservation status. The main threats and impacts on the site are peat cutting; drainage and burning; afforestation; invasive species; grazing; dumping; fertilisation; restructuring agricultural land; communication routes; cultivation; mowing / cutting; modification of inland water structures; and sand and gravel extraction.

Restoration of the site has taken place as part of the 'Restoring Raised Bog in Ireland", which included the installation of twelve Walrags used to monitor groundwater level fluctuations prior to the work. Groundwater levels were found to be up to 0.5 m below the surface of the bog and adjacent plantations during the summer months. After trees were removed and drains unblocked as part of the restoration, there was a rise in the groundwater table within the plantations and on the high bog, with the levels remaining close to the bog surface throughout most of the year (Derwin, 2008).

#### 7.1.6 Ardakillin Lough

Ardakillin Lough (site code 001617) is located 5.5 km southwest of Strokestown (grid reference 188020, 278320). It covers approximately 91.3 hectares and is listed as a pNHA. A fen habitat is supported at the site. No site synopsis information is currently available from the NPWS.

#### 7.1.7 Annaghmore Lough

Annaghmore Lough (site code 001626) is located 5 km northwest of Strokestown (grid reference 189950, 283620). It is listed as a cSAC, selected for the presence of an alkaline fen, a habitat listed on Annex I of the EU Habitats Directive, and for *Vertigo geyeri*, a rare snail species listed on Annex II of the EU Habitats Directive. It is also listed as a pNHA. Covering an approximate area of 249.5 hectares, approximately 2% is identified as 'alkaline fen' (habitat code 7230).

The site lies at in the centre of a network of small lakes in a rolling, drift covered landscape. The shoreline which includes extensive areas of alkaline fen, slopes gently to the lake and these low-lying margins are extensively flooded in winter. In summer, when water levels recede, substantial areas of this shallow calcareous lake dry out leaving flat expanses of exposed marl. A small area of limestone pavement and an old cutover bog are also present. A smaller, less calcareous lake occurs to the south of the site.

This site is relatively intact with only minor damage caused by cattle poaching and some burning on the fen. Some infilling of wetland vegetation has occurred between the northern shore of the lake and the nearby road. Drainage is a potential threat to the site and associated floodlands.

The Habitats Directive Article 6 Assessment for the Shannon iRBD gives a qualifying feature on this site as a 'turlough' (habitat code 3180). The key environmental conditions to support site integrity are to maintain the Annex I habitats for which the cSAC has been selected at favourable conservation status. Pressures on the site arise from drainage, over-grazing, eutrophication, peat cutting, marl extraction and quarrying. Another qualifying feature is the presence of '*Vertigo geyeri* ' (species code 1013) with the main threats and impacts being adjacent infrastructure, agricultural, nutrient enrichment, and drainage.

#### 7.1.8 Corbally Lough

Corbally Lough (site code 001627) is located along the southern side of the N5 road 2 km southeast of Tulsk (grid reference 184900, 280160). It covers approximately 11.9 hectares and is listed as a pNHA. No site synopsis information is currently available from the NPWS.

### 7.2 Large springs and holy wells

The GSI borehole database and OSi Discovery Series mapping were queried regarding any large springs and holy wells present within the study area.

One large spring was identified on the GSI database (Reference 1727SWW089) as lying just within the study area, Lissian Spring (grid reference 165070, 292620). This is located approximately 2.9 km west of the western tie-in for all the corridor options at Teevnacreeva. The spring has a reported yield of 2,790 $m^3$/d and is used for agricultural usage only. Four other large springs that are part of the Roscommon County Council supply are located just outside the study area: Cloonmagunnaun Spring (grid reference 168530, 295630) with a yield of 2,791 $m^3$/d; a spring in Carrowreagh, close to Bella Bridge and Cloonshanville Bog (grid reference 175140, 292900) yielding 4,320 $m^3$/d; Longford Spring (grid reference 169130, 278320) with a yield of 2,955 $m^3$/d; and Silver Island Spring (grid reference 170060, 279730) with a yield of 1,595 $m^3$/d. The latter two comprise the Castlerea Group Water Scheme.

There is only one holy well identified on the OSi Discovery Series mapping that is located within a Route Corridor. This is located near the eastern tin-in for Option 1A at Gortlustia (grid reference 197335, 279250), southeast of Scramoge and lies just outside the study area. There are a further nine holy wells within the study area, with the nearest to corridor options being one located in the Townland of Peak (grid reference 177340, 287710) that is 105 m south of Options 2, 2A and 2B, and 140m south of Option 1A. A second one known as St. Elvia's Spring is located in Toberelva (grid reference 178410, 278840). This is 100 m southwest of Corridor Option 4, and was identified as receiving water from a swallow hole to the southwest at Knockalegan. A GSI tracer test indicated a rate of 30 m/hr between the 2 locations.

Table 7.2 provides a summary of the occurrences within the route corridor options.

| Route | 1 | 1A | 2 | 2A | 2B | 3 | 4 |
|---|---|---|---|---|---|---|---|
| Holy Well | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Large Spring | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

**Table 7.2:** *Summary of holy wells and large springs within route corridors*

### 7.3 Group and regional water supply schemes

#### 7.3.1 Regional Water Supply Schemes

There are three Regional Water Schemes operated by Roscommon County Council within or adjacent to the study area, two of which obtain water from groundwater sources:

#### 7.3.1.1 North Roscommon Regional Water Supply Scheme

The catchment area for this scheme is located in the north western portion of the study area and serves the population centres of Ballaghaderreen, Tibohine, Frenchpark, Fairymount and Bellanagare as well as the surrounding rural areas.

The primary sources are Lough Gara and an adjacent spring at Cloonmagunnaun located 700 m northwest of the study area (grid reference 168270, 295420), and 2.1 km north of all corridor options at the western N5 tie-in in Ratra / Teevnacreeva. A supplementary spring at Gortnagoyne, 1.3 km southeast of Bellanagare (grid reference 175588, 286438) is also used. The nearest corridors to this are 365 m northeast to Option 3 and 780m west to Option 4.

#### 7.3.1.2 Castlerea Rural and Urban Regional Water Supply Scheme

The catchment area for this scheme is located to the south west of the study area with a narrow portion up to 420 m wide overlying the study area. It serves Castlerea and its surrounding hinterland including the population centres of Kilmurry, Lissalway and Castleplunkett.

The source is from 2 large springs. The Longford Spring that supplies the Castlerea Rural Water Supply Scheme, which is located 7.45 km southwest from Option 4, and Silver Lisland Spring located 5.85 km southwest from Option 4 that supplies the Castlerea Urban Water Supply Scheme. The GSI has delineated a source protection scheme for the area, as detailed in section 7.6.

### 7.3.2 Group Water Supply Schemes

There are several Group Water Schemes (GWS) located within the study area, with five groundwater supplies that serve a population equivalent of more that 100 persons (Table 7.3). It is understood that Roscommon County Council is considering consolidating the smaller schemes, to be replaced by the main Council Water Supply Scheme. One of the five schemes is public (Bellanagare) with the reminder privately operated.

| Scheme | Type | Source | Townland | Population Equivalent | Yield ($m^3$/day) | Within Route Option |
|---|---|---|---|---|---|---|
| Ardkeenagh | Private | Spring | Castleland | 172 | 34.4 | 2 & 2A |
| Bellanagare | Public | Spring | Toberelk | 200 | 320 | None |
| Clooneyquinn | Private | Spring | Corracreigh | 172 | 34 | None |
| Corbally Borehole | Private | Spring | Corbally | 588 | 118 | None |
| Ogulla | Private | Spring | Ogulla | 185 | 37 | None |

**Table 7.3:** *Group Water Supply Schemes within study area*

The source for the Ardkeenagh and Cloonart Group Water Scheme is located at a spring (grid reference 183850, 281630; GSI reference 1727NWW059) in the Townland of Castleland. The location is in the middle of Corridors 2 and 2A, and 2B.

## 7.4 Commercial and industrial borehole supplies

The GSI borehole database was queried regarding any commercial and industrial borehole supplies within the study area, with no locations identified. It is possible that there may be commercial properties that do have wells and these would need to be located during the EIS phase of the work.

## 7.5 Domestic spring, well and borehole supplies

A preliminary domestic well audit was not carried out at this stage of the study, and is recommended for the EIS phase once the final alignment has been selected. The GSI well database was accessed to identify any known listed supplies. A total of 166 records were located within or bordering the study area (Table 7.4).

| Type | Borehole | Dug Well | Spring | Unknown |
|---|---|---|---|---|
| No. of Locations | 106 | 32 | 12 | 13 |

**Table 7.4:** *Summary of GSI listed well records within study area*

The wells are predominantly used for domestic usage only, with 51 of the known locations in this category. A total of 30 were listed as providing both a domestic and agricultural supply with 5 used for agriculture only. The large percentage of boreholes present indicates that bedrock is the main source within the area.

There were 68 records in the study area that had a reported yield class, the majority of which were classified as poor yielding (Table 7.5).

| Yield Class | No. of Locations | Average Reported Yield ($m^3/d$) |
|---|---|---|
| High Spring | 2 | 2,790 & 4,320 |
| Intermediate Spring | 2 | No data |
| Low Spring | 5 | 1 location reported at 109.1 |
| Excellent (>400 $m^3/d$) | 1 | 1090 |
| Good (100 - 400 $m^3/d$) | 6 | Average of 152.5 |
| Moderate (40 - 100 $m^3/d$) | 8 | Average of 57.1 |
| Poor (<40 $m^3/d$) | 43 | Average of 16.8 |
| Failure (<3 $m^3/d$) | 1 | No data |

**Table 7.5:** *Summary of GSI listed well records having a reported yield class within study area*

The following records exist on the GSI well database for those that are located within one or more of the actual route corridors (Table 7.6). It should be noted that the location accuracy ranges from 10 m up to 1 km on the database and therefore the approximately locations have been assumed. There are likely to be other wells not on record with the GSI. Once the preferred route alignment has been agreed then a field survey should be carried out comprising a domestic well audit of all properties within the selected corridor.

| Route Option | Description |
|---|---|
| 1, 1A, 2, 2B 3, 4 | Borehole (0.5m). Bedrock presumed (0.5m). 1729SWW064. Portaghard. Grid 170540, 292550. Drilled 01/10/2001. |
| 4 | Dug well (2.1m). 1727NWW023. Grid 173970, 287230. Ballincool. Agricultural & domestic use. Good quality. |
| 4 | Borehole (32m). Bedrock met 1727NWW039. Grid 173980, 287560. Knockroe. Agricultural & domestic use. Dries if pumped hard. Water strike at 18.3m when drilled. |
| 4 | Dug well (0.9m). 1727NWW021. Grid 174330, 286940. Ballincool. Domestic use only. |
| 2, 2A, 2B | Dug well (1.8m). Bedrock met 1727NWW042. Grid 174370, 288260. Derreen. Agricultural use only. Poor quality. |

| | |
|---|---|
| 2, 3 | Dug well (1.9m). Bedrock presumed (1.9m). Poor yield. 1727NWW044. Grid 174390, 289310. Leggatinty. Domestic use only. Good quality. |
| 4 | Borehole. Moderate yield - 106.3m3/d. 1727NWW051. Ballyglass. Grid 174680, 284620. Located in drift. |
| 4 | Borehole (4m). Bedrock presumed (4m). 1727NWW054. Caddellbrook. Grid 174950, 283200. Drilled 02/10/2001. |
| 1A, 2, 2A, 2B | Borehole (27.4m). 1727NWW046. Grid 175270, 288730. Ballaghcullia. Agricultural & domestic use. |
| 4 | Borehole (34.4m). Poor yield - 18.5m3/d. 1727NWW011. Rathmoyle. Grid 175660, 282100. Limestone (overburden clay & stones). |
| 4 | Borehole (53.6m). Poor yield - 10.7m3/d. 1727NWW009. Rathmore. Grid 175660, 282140. Limestone (overburden clay & stones). |
| 4 | Borehole (21.3m). 1727NWW010. Rathmoyle. Grid 175660, 282170. Limestone (overburden clay & stones). |
| 3 | Borehole (44.8m). Depth to bedrock (13.7m) Poor yield. 1727NWW034. Grid 176530, 286120. Tullaghan. Agricultural & domestic use. Good quality. |
| 3 | Borehole (53.3m). Bedrock met (1.2m). 1727NWW033. Grid 176920, 285760. Carrowreagh. Domestic use only. |
| 4 | Borehole (1.5m). Bedrock presumed (1.5m). 1727SWW093. Drishaghaun East. Grid 177620, 279660. Drilled 17/09/2001. |
| 1A, 2, 2A, 2B | Dug well (1.1m). 1727NWW047. Grid 178180, 288240. Mullenduff. Agricultural use only. Good quality. |
| 2, 2A, 2B | Borehole (2.5m). Bedrock presumed (2.5m). 1727NWW055. Cartron. Grid 180920, 286360. Drilled 02/10/2001. |
| 1A | Borehole (61m). 1727NWW052. Clogher Beg. Grid 181150, 287410. |
| 2A, 2B | Borehole (2.9m). Poor yield - 27.3m3/d. 1727NWW008. Grid 181230, 285680. Ballymurray. Agricultural & domestic use. Overburden boulder clay / black argillaceous oolitic limestone. |
| 1, 1A | Borehole (2m). Bedrock presumed (2m). 1727NWW056. Raheen. Grid 183180, 287250. Drilled 02/10/2001. |
| 3 | Borehole (14m). Bedrock met (12.2m). Good yield - 196m3/d. 1727NWW060. Tulsk. Grid 183460, 280870. Tulsk Garda Station Supply Source. |
| 2B | Borehole. 1727NEW017. Grid 185210, 281690. Lisnaneane. Domestic use only. |
| 2, 2A, 4 | Borehole (45.7m). Bedrock met (5.3m). Poor yield - 21.8m3/d. 1727SEW007. Grid 186530, 279290. Clooncullaan. Agricultural & domestic use. Drilled 01/06/1972. |
| 2, 2A, 3, 4 | Borehole (2.5m). Bedrock presumed (2.5m). 1727SEW117. Lissaphuca. Grid 186890, 279620. Drilled 13/09/2001. |
| 2, 2A, 3, 4 | Dug well (18.3m). 1727SEW001. Grid 188160, 279240. Ardakillin. Public supply (Co. Co.). |
| 1, 1A | Borehole (28m). Bedrock met (4.6m). Poor yield - 21.8m3/d. 1727NEW049. Grid 189910, 286400. Lugboy. Agricultural & domestic use. Drilled 15/04/1972. |
| 1, 1A | Borehole (31.1m). Bedrock met (4.6m). Poor yield - 21.8m3/d. 1727NEW048. Grid 189910, 286440. Lugboy. Domestic use only. Drilled 15/03/1973. |
| 2, 2A, 2B, 4 | Borehole (22.9m). Bedrock met (17.1m). Poor yield - 19.6m3/d. 1727SEW034. Grid 190910, 278690. Cloonfinlough. Agricultural & domestic use. Drilled 19/09/1973. |
| 2, 2A, 2B, 4 | Borehole (10m). 1727SEW115. Carrowclogher. Grid 191750, 278360. Drilled 13/09/2001. |
| 2, 2A, 2B, 4 | Borehole (31.1m). Bedrock met (7.6m). Good yield - 196m3/d. 1727SEW031. Grid 191910, 278770. Carrowclogher. Agricultural & domestic use. Drilled 21/12/1964. |
| 2, 2A, 2B, 4 | Borehole (52.4m). Bedrock met (0.6m). Poor yield - 11.8m3/d. 1727SEW025. Ballyhammon. Grid 194230, 278770. Drilled 05/11/1963. |
| 2, 2A, 2B, 4 | Borehole (40.2m). Bedrock met (1.8m). Poor yield - 13.6m3/d. 1727SEW044. Grid 194480, 278150. Lissaphobble. Agricultural & domestic use. Drilled 15/03/1973. |
| 1, 1A | Borehole (4.8m). Bedrock presumed (4.8m). 1727NEW062. Kilmore. Grid 194660, 281690. |
| 1, 1A, 2A, 2B | Borehole (19.8m). Bedrock met (6.7m). Poor yield - 10.9m3/d. 1727SEW028. Bumlin. Grid 195000, 279750. |
| 1, 1A, 2, 2A, 2B, 4 | Borehole (1.5m). Poor yield - 10.9m3/d. 1727SEW027. Bumlin. Grid 195000, 279800. Drilled 15/08/1972. |
| 2A, 2B, 4 | Borehole (15.2m). Bedrock met (4.3m). Poor yield - 11m3/d. 1727SEW048. Treanacreeve. Grid 195730, 279130. |
| 1, 1A, 2A, 2B | 1727SEW090. Scramoge. Grid 196060, 279850. Drilled 19/01/1998. |
| 1, 1A, 2A, 2B | 1727SEW093. Grid 197040, 279390. Gortlustia. Domestic use only. Drilled 02/02/1998. |

**Table 7.6:** *Summary of GSI listed well records located within route corridors*

Table 7.7 gives a summary of the total number of recorded wells in each corridor. It is not possible to give an order of preference as the current status of each is unknown, and it is likely that there will be numerous other well that have not been documented. Further investigation would be carried out at the EIS stage to assess the presence, usage and mitigation measures to supplement impacted supplies.

| Route | 1 | 1A | 2 | 2A | 2B | 3 | 4 |
|---|---|---|---|---|---|---|---|
| Total number of features | 9 | 12 | 15 | 18 | 17 | 7 | 20 |

**Table 7.7:** *Number of GSI listed well records within each route corridor*

From a total of 38 well supplies the following number are present in each corridor relative to their reported yield (Table 7.8).

| Yield ($m^3/d$) | Route Options | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 1A | 2 | 2A | 2B | 3 | 4 |
| High Spring | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Intermediate Spring | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Low Spring | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Excellent (>400 $m^3/d$) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Good (100 - 400 $m^3/d$) | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| Moderate (40 - 100 $m^3/d$) | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Poor (<40 $m^3/d$) | 4 | 4 | 6 | 0 | 1 | 2 | 8 |
| Failure (<3 $m^3/d$) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unknown | 5 | 8 | 7 | 8 | 4 | 4 | 10 |
| Total Wells | 9 | 12 | 14 | 19 | 5 | 7 | 20 |

**Table 7.8:** *Summary of GSI listed well records having a reported yield class within each route corridor*

## 7.6 Source protection schemes

The GSI carries out source protection mapping whereby source protection areas (SPAs) are delineated around significant groundwater supply sources. The areas are subdivided into inner and outer protection areas, based on the 100 day time of travel (TOT) and the catchment area respectively. The associated groundwater vulnerability is superimposed on these sub-divisions, to give source protection zones as listed in Table 7.9 (DoELG, EPA & GSI, 1999).

| VULNERABILITY RATING | SOURCE PROTECTION ZONE | |
|---|---|---|
| | Inner (SI) | Outer (SO) |
| Extreme (E) | SI/E | SO/E |
| High (H) | SI/H | SO/H |
| Moderate (M) | SI/M | SO/M |
| Low (L) | SI/L | SO/L |

**Table 7.9:** *Groundwater vulnerability rating relevant to source protection zones*

SPAs are delineated using several hydrogeological methods, varying in complexity, cost and the level of data and hydrogeological analysis required. Four methods, in order of increasing technical sophistication, that are used by the GSI are:-

- calculated fixed radius;
- analytical methods;
- hydrogeological mapping; and
- numerical modelling.

As each method has limitations the boundaries must be seen as a guide for decision-making which can be reappraised in the light of new knowledge or changed circumstances.

Inner protection zones are designed to protect against the effects of human activities that might have an immediate effect on the source and, in particular, against microbial pollution. The area is defined by a 100-

day time of travel (TOT) from any point below the water table to the source. In karst areas, it will not usually be feasible to delineate 100-day TOT boundaries, as there are large variations in permeability, high flow velocities and a low level of predictability. In these areas, the total catchment area of the source will frequently be classed as SI. If it is necessary to use the arbitrary fixed radius method, a distance of 300 m is normally used. A semi-circular area is used for springs. The distance may be increased for sources in karst aquifers and reduced in granular aquifers and around low yielding sources (DoELG, EPA & GSI, 1999).

The outer protection zone area covers the remainder of the zone of contribution (ZOC) (or complete catchment area) of the groundwater source. It is defined as the area needed to support an abstraction from long-term groundwater recharge i.e. the proportion of effective rainfall that infiltrates to the water table. The abstraction rate used in delineating the zone will depend on the views and recommendations of the source owner. A factor of safety can be taken into account whereby the maximum daily abstraction rate is increased (typically by 50%) to allow for possible future increases in abstraction and for expansion of the ZOC in dry periods. In order to take account of the heterogeneity of many Irish aquifers and possible errors in estimating the groundwater flow direction, a variation in the flow direction (typically ±10-20°) is frequently included as a safety margin in delineating the ZOC. If the arbitrary fixed radius method is used, a distance of 1000 m is recommended with, in some instances, variations in karst aquifers and around springs and low-yielding wells (DoELG, EPA & GSI, 1999).

The boundaries of the SPAs are based on the horizontal flow of water to the source and, in the case particularly of the Inner Protection Area, on the time of travel in the aquifer. Consequently, the vertical movement of a water particle or contaminant from the land surface to the water table is not taken into account. This vertical movement is a critical factor in contaminant attenuation, contaminant flow velocities and in dictating the likelihood of contamination, and can be taken into account by mapping the groundwater vulnerability to contamination (DoELG, EPA & GSI, 1999).

Source protection mapping has been carried out by the GSI for County Roscommon, with one area, the Castlerea Water Supply Scheme being the closest to the study area, located to southwest of the area, east of Castlerea. Two major springs are present the Longford Spring and Silver Island Spring.

The Longford Spring is located approximately 1.5 km southeast of Castlerea (grid reference 169130, 278320) and was developed in 1982. The ground elevation at the location is approximately 67 maOD with a depth to bedrock of approximately 4 m. The water level is at ground surface and discharges to an artificial channel which joins a small river flowing northwest into the River Suck south of Castlerea. In 2003 the reported normal abstraction rate was 2,700 to 3,200 $m^3$/d with an estimated total discharge of 5,200 to 5,700 $m^3$/d (GSI, 2003c).

The Silver Island Spring is located in the Townland of Rathleg approximately 2 km east of Castlerea (grid reference 170060, 279730) and was developed in 1938. The ground elevation at the location is approximately 82 maOD. The water level is at ground surface which discharges into a drainage channel that flows south west to the Francis River. In 2003 the reported normal abstraction rate was approximately 1,350 $m^3$/d with an estimated total discharge of 2,450 to 4,400 $m^3$/d (GSI, 2003c).

There are 3 other springs recorded in close proximity to these 2 main ones: the Poolacurragh Spring which emerges as two springs in the Ardass Townland and flows into the Termon River, with an estimated discharge of 2,200 $m^3$/d in 2000; 'Coran's Spring' located in Rathleg that discharges into the Termon River downstream of the Poolacurragh Spring, with an estimated discharge of 4,600 to 6,400 $m^3$/d in 2000; and 'New Spring' in Rathleg that forms the head of the Francis River , with an estimated discharge of 3,850 $m^3$/d in 2000.

All 5 springs are aligned approximately northeast to southwest, and would appear to drain the higher 'plateau' area to the east which may include the south western part of Corridor Option 4. The lack of surface water

drainage on this higher ground suggests that potential recharge readily infiltrates into the underlying karstified groundwater system. Tracer tests on the 3rd November 2000 by the GSI identified interconnected underground flow paths flowing to the northeast from a swallow hole at Knockalegan East (grid reference 175730, 278050) to Luke's Well in Lisheen (grid reference 176980, 279140) at 41 m/hr, and to St. Elvia's Spring in Toberelva (grid reference 178410, 278840) at 30 m/hr. These tests would suggest that the groundwater flow is towards the northeast and therefore in the opposite direction from the Castlerea SPA. St. Elvia's Spring is located 100 m southwest of Corridor Option 4.

The Outer Protection Zone encompassing the ZOC has been mapped for the springs extending eastwards, with approximately 400 m extending into the study area. Tracer tests carried out by the GSI show rapid flow velocities within the Visean Limestones, the results indicating that groundwater can possibly reach the spring sources from any point in the ZOC within five days. As it is therefore likely that all groundwater would reach the springs in less than one hundred days it has been suggested that the entire ZOC should be incorporated into the Inner Protection Area. Three protection zones have been identified around the Longford and Silver Island Springs comprising SI/E, SI/H and SI/M with the portion that lies within the study area predominantly classified as SI/E.

## 7.7 Aquifer protection schemes

Groundwater protection schemes are county based projects that are undertaken jointly between the GSI and the respective Local Authority, with the overall aim of preserving the quality of groundwater, particularly for drinking water purposes. The schemes are not intended to have any statutory authority, but provide a framework for decision making and guidelines for the Local Authorities in carrying out their functions. Since 2003, the Department of Environment, Heritage and Local Government has recommended that groundwater protection schemes are incorporated into County Development Plans (GSI website).

A groundwater protection scheme comprises two components:-

- land surface zoning map(s) ('groundwater protection zone map') produced by the GSI; and
- groundwater protection responses for existing and new potentially polluting activities, decided on by the statutory authorities.

Combining the hydrological conditions and the aquifer type as outlined in Section 5.1, it is possible to produce a vulnerability rating matrix for resource protection zones (Table 7.10).

| VULNERABILITY RATING | RESOURCE PROTECTION ZONES | | | | | |
|---|---|---|---|---|---|---|
| | Locally Important Aquifers (L) | | Locally Important Aquifers (L) | | Poor Aquifers (P) | |
| | Rk | Rf/Rg | Lm/Lg | Ll | Pl | Pu |
| **Extreme (E)** | Rk/E | Rf/E | Lm/E | Ll/E | Pl/E | Pu/E |
| **High (H)** | Rk/H | Rf/H | Lm/H | Ll/H | Pl/H | Pu/H |
| **Moderate (M)** | Rk/M | Rf/M | Lm/M | Ll/M | Pl/M | Pu/M |
| **Low (L)** | Rk/L | Rf/L | Lm/L | Ll/L | Pl/L | Pu/L |

**Table 7.10:** *Matrix of resource protection zones relevant to aquifer type*

# 8 Impact Assessment

## 8.1 Description of hydrogeological impacts

Road projects given their scale and nature have significant potential for causing impact to the groundwater environment both during their construction and on-going operation and consequently require careful planning and detailed assessment to ensure the best solution is attained.

The attributes and impacts that are assessed for each route corridor include the following:

- High yielding water supply springs and wells along each route corridor and increased risk presented by the road scheme;
- The classification (regionally important, locally important, poor) and extent of aquifers underlying each route corridor and increased risks presented to them by the road scheme (associated with aspects such as removal of subsoil cover, removal of aquifer (in whole or part), drawdown in water levels, alteration in established flow regimes, change in groundwater quality);
- Natural hydrogeological / karst features along each route corridor and the increased risk presented by the road scheme, and
- Groundwater fed ecosystems and the increased risk presented by the road scheme.

## 8.2 Assessment criteria

Estimation of the importance of hydrogeological attributes is based on criteria for rating site attributes as outlined in the NRA publication '*Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes*', and presented in Table 8.1.

| Importance | Criteria |
|---|---|
| Extremely High | Attribute has a high quality or value on an international scale |
| Very High | Attribute has a high quality or value on a regional or national scale |
| High | Attribute has a high quality or value on a local scale |
| Medium | Attribute has a medium quality or value on a local scale |
| Low | Attribute has a low quality or value on a local scale |

**Table 8.1:** *Criteria for rating site attributes*

The guidelines also define the impact significance level relative to the attribute importance (Table 8.2).

| Impact Level | Attribute Importance | | | | |
|---|---|---|---|---|---|
| | Extremely High | Very High | High | Medium | Low |
| Profound | Any permanent impact on attribute | Permanent impact on significant proportion of attribute | | | |
| Significant | Temporary impact on significant proportion of attribute | Permanent impact on small proportion of attribute | Permanent impact on significant proportion of attribute | | |
| Moderate | Temporary impact on small | Temporary impact on significant | Permanent impact on small | Permanent impact on significant | |

| | | | | | |
|---|---|---|---|---|---|
| | proportion of attribute | proportion of attribute | proportion of attribute | proportion of attribute | |
| Slight | | Temporary impact on small proportion of attribute | Temporary impact on significant proportion of attribute | Permanent impact on small proportion of attribute | Permanent impact on significant proportion of attribute |
| Imperceptible | | | Temporary impact on small proportion of attribute | Temporary impact on significant proportion of attribute | Permanent impact on small proportion of attribute |

**Table 8.2:** *Criteria for rating impact significance*

## 8.3 Impacts associated with each route corridor

### 8.3.1 Corridor 1

Table 8.3 gives a summary of the key hydrogeological attributes that have been identified along the route corridor and their importance within the environment. A description and level of potential impacts that the road scheme would have on the attribute is also given.

| Attribute | Attribute Importance | Impact | Level of Impact |
|---|---|---|---|
| Clonshanville Bog | Extremely high | Partial loss of cSAC & pNHA site with a groundwater supported ecosystem | Profound |
| Regionally Important Karstified (conduit) Aquifer – entire route | High | Contaminated surface water runoff entering karst system and impacting local supply wells and baseflow to local rivers and loughs | Slight |
| | | Restriction of groundwater flow by potential collapse of underground conduits during construction and blockage by suspended solids prior to appropriate designed drainage implemented | Slight |
| Regionally Important Karstified (conduit) Aquifer – southwest of Cloonshanville Bog | High | Restriction of shallow groundwater flow caused by subsoil consolidation under road footprint and road cutting | Moderate |
| Locally Important Aquifer – south of Cloonshanville Bog | Medium | Restriction of shallow groundwater flow towards Clonshanville Bog caused by subsoil consolidation under road footprint | Slight |
| Annaghmore Lough (Turlough) SAC and NHA | Extremely High | Potential interception of base flow to the Lough as route corridor is upstream (northeast) and comes to within *650m* of the SAC boundary | Profound |

**Table 8.3:** *Preliminary assessment of hydrogeological impacts for Route Corridor 1*

### 8.3.2 Corridor 1A

Table 8.4 gives a summary of the key hydrogeological attributes that have been identified along the route corridor and their importance within the environment. A description and level of potential impacts that the road scheme would have on the attribute is also given.

| Attribute | Attribute Importance | Impact | Level of Impact |
|---|---|---|---|
| Bellanagare Bog | Extremely high | Alterations to drainage rates through improvements / upgrade of local channels downgradient of cSAC and pNHA site | imperceptible |
| | | Restriction of localised drainage patterns on soft ground downgradient of cSAC and pNHA site during construction and prior to appropriate designed drainage implemented | imperceptible |
| Regionally Important Karstified (conduit) Aquifer – entire route | High | Contaminated surface water runoff entering karst system and impacting local supply wells and baseflow to local rivers and Loughs | Slight |
| Regionally Important Karstified (conduit) Aquifer – Leggatinty Townland (Pollnagran Cave / Swallow Hole System) | High | Restriction of groundwater flow by collapse of underground conduits and potential blockage during construction | Moderate |
| | High | Contaminated surface water runoff entering swallow holes and impacting local supply wells and baseflow to local rivers | Slight |
| Annaghmore Lough (Turlough) SAC and NHA | Extremely High | Potential interception of base flow to the Lough as route corridor is upstream (northeast) and comes to within *170m* of the SAC boundary | Profound |

**Table 8.4:** *Preliminary assessment of hydrogeological impacts for Route Corridor 1A*

### 8.3.3 Corridor 2

Table 8.5 gives a summary of the key hydrogeological attributes that have been identified along the route corridor and their importance within the environment. A description and level of potential impacts that the road scheme would have on the attribute is also given.

| Attribute | Attribute Importance | Impact | Level of Impact |
|---|---|---|---|
| Bellanagare Bog | Extremely high | Alterations to drainage rates through improvements / upgrade of local channels downgradient of cSAC and pNHA site | imperceptible |
| | | Restriction of localised drainage patterns on soft ground downgradient of cSAC and pNHA site during construction and prior to appropriate designed drainage implemented | imperceptible |
| Corbally Lough | Very high | Partial loss of pNHA site with a groundwater supported ecosystem | Profound |
| Ardakillin Lough | Very high | Potential interception of base flow to the Lough as route is slightly upstream and comes to within 150m of Lough | significant |
| Regionally Important Karstified (conduit) Aquifer – entire route | High | Contaminated surface water runoff entering karst system and impacting local supply wells and baseflow to local rivers | Moderate |
| Regionally Important Karstified (conduit) | High | Restriction of groundwater flow by collapse of underground conduits and potential | Moderate |

| | | | |
|---|---|---|---|
| Aquifer – Leggatinty Townland (Pollnagran Cave / Swallow Hole System) | | blockage during construction | |
| | High | Contaminated surface water runoff entering system during construction phase prior to appropriate designed drainage implemented | Imperceptible |
| Ardkeenagh and Cloonart Group Water Scheme | High | Deterioration in spring water quality and groundwater level during construction phase | Slight |

**Table 8.5:** *Preliminary assessment of hydrogeological impacts for Route Corridor 2*

### 8.3.4 Corridor 2A

Table 8.6 gives a summary of the key hydrogeological attributes that have been identified along the route corridor and their importance within the environment. A description and level of potential impacts that the road scheme would have on the attribute is also given.

| Attribute | Attribute Importance | Impact | Level of Impact |
|---|---|---|---|
| Bellanagare Bog | Extremely high | Alterations to drainage rates through improvements / upgrade of local channels downgradient of cSAC and pNHA site | imperceptible |
| | | Restriction of localised drainage patterns on soft ground downgradient of cSAC and pNHA site during construction and prior to appropriate designed drainage implemented | imperceptible |
| Corbally Lough | Very high | Partial loss of pNHA site with a groundwater supported ecosystem | Profound |
| | | Contaminated surface water runoff entering pNHA system during construction phase prior to appropriate designed drainage implemented | Moderate |
| Ardakillin Lough | Very high | Potential interception of base flow to the Lough as route is slightly upstream and comes to within 150m of Lough | significant |
| Regionally Important Karstified (conduit) Aquifer – entire route | High | Contaminated surface water runoff entering karst system and impacting local supply wells and baseflow to local rivers | Moderate |
| Regionally Important Karstified (conduit) Aquifer – Leggatinty Townland (Pollnagran Cave / Swallow Hole System) | High | Restriction of groundwater flow by collapse of underground conduits and potential blockage during construction | Moderate |
| | High | Contaminated surface water runoff entering system during construction phase prior to appropriate designed drainage implemented | Imperceptible |
| Ardkeenagh and Cloonart Group Water Scheme | High | Deterioration in spring water quality and groundwater level during construction phase | Slight |

**Table 8.6:** *Preliminary assessment of hydrogeological impacts for Route Corridor 2A*

### 8.3.5 Corridor 2B

Table 8.7 gives a summary of the key hydrogeological attributes that have been identified along the route corridor and their importance within the environment. A description and level of potential impacts that the road scheme would have on the attribute is also given.

| Attribute | Attribute Importance | Impact | Level of Impact |
|---|---|---|---|
| Bellanagare Bog | Extremely high | Alterations to drainage rates through improvements / upgrade of local channels downgradient of cSAC and pNHA site | Imperceptible |
| | | Restriction of localised drainage patterns on soft ground downgradient of cSAC and pNHA site during construction and prior to appropriate designed drainage implemented | Imperceptible |
| Ardakillin Lough | Very high | Potential interception of base flow to the Lough as route corridor is slightly upstream and comes to within 250m of Lough | Significant |
| Regionally Important Karstified (conduit) Aquifer – entire route | High | Contaminated surface water runoff entering karst system and impacting local supply wells and baseflow to local rivers | Moderate |
| Regionally Important Karstified (conduit) Aquifer – Leggatinty Townland (Pollnagran Cave / Swallow Hole System) | High | Restriction of groundwater flow by collapse of underground conduits and potential blockage during construction | Moderate |
| | High | Contaminated surface water runoff entering system during construction phase prior to appropriate designed drainage implemented | Imperceptible |

**Table 8.7:** *Preliminary assessment of hydrogeological impacts for Route Corridor 2B*

### 8.3.6 Corridor 3

Table 8.8 gives a summary of the key hydrogeological attributes that have been identified along the route corridor and their importance within the environment. A description and level of potential impacts that the road scheme would have on the attribute is also given.

| Attribute | Attribute Importance | Impact | Level of Impact |
|---|---|---|---|
| Corbally Lough | Very high | Partial loss of pNHA site with a groundwater supported ecosystem | Profound |
| Ardakillin Lough | Very high | Potential interception of base flow to the Lough as route is slightly upstream and comes to within 500m of Lough | significant |
| Regionally Important Karstified (conduit) Aquifer – entire route (in particular Carrowreagh to Moneylea) | High | Contaminated surface water runoff entering karst system and impacting local supply wells and baseflow to local rivers | Moderate |
| Regionally Important Karstified (conduit) Aquifer – Leggatinty Townland (Pollnagran Cave / Swallow Hole | High | Restriction of groundwater flow by collapse of underground conduits and potential blockage during construction | Moderate |

| | | | |
|---|---|---|---|
| System) | | | |

**Table 8.8:** *Preliminary assessment of hydrogeological impacts for Route Corridor 3*

### 8.3.7 Corridor 4

Table 8.9 gives a summary of the key hydrogeological attributes that have been identified along the route corridor and their importance within the environment. A description and level of potential impacts that the road scheme would have on the attribute is also given.

| Attribute | Attribute Importance | Impact | Level of Impact |
|---|---|---|---|
| Bellanagare Bog | Extremely high | Partial loss of cSAC, SPA & pNHA site with a groundwater supported ecosystem | Profound |
| | | Alterations to drainage rates through improvements / upgrade of local channels downgradient of cSAC, SPA & pNHA site | imperceptible |
| | | Restriction of localised drainage patterns on soft ground downgradient of cSAC, SPA & pNHA site during construction and prior to appropriate designed drainage implemented | imperceptible |
| Mullygollan Turlough | Extremely high | Potential interception of base flow to the Turlough as route is upstream and comes to within 350m of SAC Boundary | Profound |
| Brierfield Lough | Very high | Partial loss of pNHA site with a groundwater supported ecosystem | Profound |
| Castleplunkett Turlough | Very high | Potential interception of base flow to the Turlough as route is upstream and comes to within 800m of SAC Boundary | Significant |
| Ardakillin Lough | Very high | Potential interception of base flow to the Lough as route is slightly upstream and comes to within 600m of Lough | significant |
| Castlerea Rural and Urban Regional Water Supply Scheme | Very high | Possible contaminated surface water runoff entering karst system during construction phase in particular where haulage / access routes are from the south and impacting water quality of Inner / Outer source protection zone. | Slight |
| Regionally Important Karstified (conduit) Aquifer – entire route | High | Contaminated surface water runoff entering karst system and impacting local supply wells and baseflow to local rivers | Moderate |
| Regionally Important Karstified (conduit) Aquifer – Leggatinty Townland (Pollnagran Cave / Swallow Hole System) | High | Restriction of groundwater flow by collapse of underground conduits during construction and blockage by suspended solids prior to appropriate designed drainage implemented | Moderate |
| | High | Contaminated surface water runoff entering system during construction phase prior to appropriate designed drainage implemented | Imperceptible |

**Table 8.9:** *Preliminary assessment of hydrogeological impacts for Route Corridor 4*

## 8.4 Environmental mitigation measures

The following generalised mitigation measures should be considered in detail at the Environmental Impact Statement phase of the scheme.

### 8.4.1 Baseline investigation

Once an EPR Corridor has been selected and an idea known regarding the lateral and vertical alignments, it is recommended that baseline field investigations be carried out in sensitive area such as designated sites and concentrations of karst features that would be potentially impacted by the route. This work would be necessary for collating baseline data required by the subsequent EIS phase of reporting, to obtain a better understanding of the existing hydrological and hydrogeological interactions prior to any works.

If the EPR Corridor is likely to be one other than Option 1 then it is recommended that a detailed baseline investigation be carried in Leggatinty to consider the surface water and groundwater interactions between the northern part of the designated Bellanagare Bog, the Pollnagran Cave system and Clonshanville Spring. A profile of water level monitoring should be established linking water levels in the:

- Bellanagare Bog;
- Surface water channels draining north westwards off the bog;
- Discharge points to groundwater at the Leggatinty swallow holes and cave;
- Emergence point at Cloonshanville Spring; and
- Clonshanville River.

This would comprise the installation of staff gauges at the selected locations. The installation of a number of groundwater monitoring piezometers should also be considered. Monitoring work should be carried out over an extended period to obtain seasonal dry weather flows and winter high water levels. Basic water quality testing for field parameters such as pH and conductivity can be included to assess the variations between the acidic surface water and alkaline groundwater, and responses to rainfall events. An option of further tracer tests could be considered possibly in conjunction with the GSI.

As not all karst features have mapped by the GSI, it is recommended that a detailed survey be carried out on the ground surface to identify all features present that could be impacted or have an impact on the proposed road alignment. A geophysical survey would be recommended to identify any underground features and should at least be carried out in Leggatinty and any of the other highly karstified areas close to the EPR Corridor.

### 8.4.2 Construction phase

As an impact reduction strategy good environmental practices should be implemented during the construction of the development and including all ancillary areas, such as site compounds. These good environmental practices should be implemented by means of an environmental management plan and the implementation of a pollution incident control plan during construction to ensure that any incidents are dealt with should they occur. It is recommended that no ancillary areas be located within any sensitive areas e.g. where karst features are present at ground surface or near to designated sites, and no refuelling be allowed to reduce potential impacts.

During the design of the final alignment it is recommended that adequate drainage systems be incorporated into any sensitive areas e.g. the karstified area in Leggatinty if a corridor other than Option 1 is chosen, to ensure that the water balance regime associated with the Bellanagare Bog is not impacted. The drainage system along the length of road passing any identified karst features should be sealed to capture surface runoff and direct it suitable discharge points. In the Leggatinty area this could involve channelling it

northwards towards the Carricknabraher River rather than allowing it to infiltrate into the nearby groundwater system.

If groundwater infiltration areas are required away from the sensitive areas, then to mitigate potential localised flooding, detailed site investigation should be carried out to define the infiltration rate during winter periods. Based on these rates the size of infiltration field and necessary detention stormwater storage and controlled outflow to the infiltration field should be determined so as to meet the design drainage requirements without causing ponding of the infiltration field or adjacent lands. This should be undertaken during the detailed design stage of the project.

Provision should be made for the protection of exposed soil surfaces from rainfall erosion which would potentially influence groundwater vulnerability by removing the protective layer. Stockpiles and spoil heaps should be located well away from drainage ditches and watercourses.

It is essential to ensure that the use of cement and wet concrete in or close to any of the watercourses or karst features is carefully controlled. Any spillages of hydrocarbons should be immediately contained on site with suitable materials and the contaminated soil / material removed for appropriate disposal.

A large section of the alignment in this area is likely to require fill material to be imported. To reduce impacts on the hydrogeological environment it should be ensured that no contaminants are introduced within the fill. Where soft peaty subsoil is present it may be required to remove it and import fill material, however as the route may pass close to the either of the designated Bellanagare and Cloonshanville Bogs, removal of large volumes of peat may impact on the local water balance and consideration should therefore be given to alternatives such as piling to bedrock.

### 8.4.3 Operational phase

As there is a high degree of interconnection between surface water and groundwater within the main karstified aquifer in the study area it is important from a hydrogeological aspect that appropriate mitigation measures are implemented to reduce impacts before they can enter surface waters from where potential contaminants can rapidly migrated into the groundwater via the numerous karst features present.

Surface runoff from roads can adversely affect the water quality of the receiving stream as a result of routine road drainage discharges and accidental spillages. Of particular concern to the receiving waters is the impact of the “First Flush” runoff, where accumulated road waste material is washed off from the road surface and drainage system in relatively high concentrations, particularly when this coincides with dry weather flows in nearby streams. High concentrations of suspended solids could potentially rapidly infiltrate via karst features the underlying aquifer blocking the conduit flow paths. Properly designed treatment measures can mitigate such water quality impacts.

Accidental spillages are predominantly a function of traffic flows and pavement area draining to the nearest water body. Mitigation measures to prevent serious impact to the receiving waters comprise a combination of oil interceptors, storage areas and outlet facilities that can be shut off to capture harmful substances prior to discharge.

Road pavements and associated surface drainage have a potential to increase flows in the receiving streams. This results from a more rapid response to rainfall and an increase in runoff volume due to the impervious area. The road pavement draining to an outfall may also divert runoff towards the road’s drainage system, which in the absence of the road may flow in another direction. It is normally the reduced time of concentration factor that tends to have the greatest influence on peak flows. This increase in peak flow may

cause flooding of third party land where there is either a lack of channel capacity or a restrictive structure (i.e. culvert) downstream of the outfall.

Current practice in Ireland to deal with urban storm runoff is the introduction of sustainable urban drainage (SUDs) practices. This involves source control through the use of soakaways or infiltration fields and the minimisation of impervious areas (porous pavements), or the provision of detention ponds (surface ponds, underground tanks, and swales) to attenuate the flood peak to a permissible maximum runoff rate. These techniques also serve to treat surface water pollution through promotion of primary settlement (sedimentation) and natural filtering.

To mitigate potential flooding in the receiving streams from the road drainage storm runoff a SUDS (Sustainable Urban Drainage Systems) approach is recommended whereby road drainage runoff is attenuated to a permissible runoff rate (generally adopted as equivalent to the natural Greenfield flood flow) prior to it entering the receiving stream. The attenuation may be achieved by using a variety of devices such as, constructed detention ponds (dry or wet), natural surface ponds, lakes or wetlands, attenuated ditches (swales), soakaways and infiltration fields and these should be located away from any identified karst features.

# 9 Comparison of Route Corridors

## 9.1 Summary of key hydrogeological attributes

A review of the existing environment with regards to hydrogeology has been made to select a preferable order of route selection that will minimise the impact on the environment as well as reducing the likely cost implications from mitigation requirements.

Table 9.1 indicates the order of preference for each order based on the most significant hydrogeological categories.

| Hydrogeological Attribute Category | Route Corridor Preferences | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 1A | 2 | 2A | 2B | 3 | 4 |
| Aquifer type | 6th | 1st | 3rd | 7th | 3rd | 2nd | 5th |
| Groundwater vulnerability | 2nd | 1st | 3rd | 5th | 4th | 6th | 7th |
| Abundance of known karst features | 1st | 4th | 6th | 7th | 5th | 3rd | 2nd |
| Proximity to designated sites | 2nd | 1st | 5th | 4th | 3rd | 6th | 7th |
| Total Score | 11 | 7 | 17 | 23 | 15 | 17 | 21 |
| Order of preference | 2nd | 1st | 4th | 7th | 3rd | 4th | 6th |

**Table 9.1:** *Route corridor preferences relevant to hydrogeological attributes*

In relation to holy wells and large springs within the corridors, only one holy well was identified on the OS Discovery Series mapping, located in Option 1A in Gortlustia on the eastern edge of the corridor. It was considered that a comparative rating of preference between the corridors would be over biased in that all other corridors would have a 1st preference with a 7th preference for Option 1A, and this category was omitted. It is also noted that as the well is located close to the existing N5, all other options would actually be passing it. An investigation into the well and its protection could be carried out once the final alignment is known.

Likewise for major water supply schemes the category was omitted in that no corridor impeded on any inner or outer protection area, apart from the proximity of Option 4 to the Castlerea RWSS, which is outside of the study area. If Option 4 were to be selected as the preferential route then appropriate investigation and mitigation measures would be used to reduce any associated impacts that the scheme would have on the inner protection area.

The Ardkeenagh group water scheme located at Castleland and within Options 2 and 2A was not considered for comparison as should one of these options were chosen as the preferential route then it would be possible to apply appropriate mitigation measures to ensure the protection of the spring and surrounding area during the construction and operation phases.

The approach taken for private water sources is that a well / spring audit should be carried out as part of the EIS phase to collate baseline information on all supplies and their usage within the corridor. Once the alignment is known indicating cut and fill sections and distance upgradient or downgradient from the section then an impact assessment can be made for each location potentially at risk. Mitigation measures for either deepening the well, re-drilling in another location or connecting to a group scheme along with general water quality protection in the surrounding area would be carried out.

## 9.2 Summary of hydrogeological impacts

As outlined in Section 8.3 an assessment has been made of the likely impact each route will have on the various key hydrogeological attribute categories. Table 9.2 gives an order of preference based on the number of occurrences of impact level.

| Impact Level | Route Corridors | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 1A | 2 | 2A | 2B | 3 | 4 |
| Profound | 2 | 1 | 1 | 1 | 0 | 1 | 3 |
| Significant | 0 | 0 | 1 | 1 | 1 | 1 | 2 |
| Moderate | 1 | 1 | 2 | 3 | 2 | 2 | 2 |
| Slight | 3 | 2 | 1 | 1 | 0 | 0 | 1 |
| Imperceptible | 0 | 2 | 3 | 3 | 3 | 0 | 3 |
| Order of Preference | 6th | 2nd | 4th | 5th | 1st | 3rd | 7th |

**Table 9.2:** *Summary of Hydrogeological Impacts for route corridors*

Attributes with a high quality or value on an international scale such as SACs and SPAs are given priority in respect to impact rating, and any corridor options that infringe on part of one of these sites having a profound impact have been automatically assigned as being least preferable.

Option 4 is the least preferable in that it is located close to the most number of designated sites and cuts through a portion of a cSAC and SPA. It also has the highest proportion of extreme groundwater vulnerability rating along its length.

The next least preferable option is 1 as it also cuts thorough a portion of a cSAC at Cloonshanville Bog and crosses close to and up stream of Annaghmore Lough where it has a potential to interfere with groundwater Baseflow.

Options 2 and 2A have the next highest degree of impacts including the partial loss of ground within the pNHA designated Corbally Lough. As option 2A has the higher number of hydrogeological attributes it is the least preferable of the two options.

Option 3 is third in the order of preference as it follows the existing route with only a single profound impact as it cuts through a portion of the pNHA designated Corbally Lough.

Options 1A and 2B are relatively similar with neither options directly intersecting an SAC or a NHA area. The main impact difference between them is that 1A passes close to and upstream of Annaghmore Lough SAC and NHA and has the potential to interfere with groundwater baseflow to the Lough should the groundwater table or a preferential groundwater route be intercepted. The likelihood of this will depend on the location of the route and the vertical alignment within the corridor. Any potential permanent impact to an SAC however small is registered in the NRA route selection guidelines as a profound impact. In respect to 2B this corridor passes close to and slightly up-gradient of Ardakilin Lough NHA which is of national significance but not an SAC giving it a very high attribute rating as opposed to extremely high rating. Similarly there is a potential to intercept groundwater flow to the Lough should the road be constructed in cutting that intercepts the water table or subterranean flow paths. Such a potential impact on the Lough given the regional nature of the groundwater table is likely to be small but based on the NRA guidelines is classified as a significant impact. Overall Route 2B represents the preferred route option with 1A second.

Selection of either 2b or 1A will require mitigation so as to avoid any significant or profound impact on the integrity of the SAC or NHA. In this respect the SAC impact

Sympathetic road design in terms of fine tuning horizontal and vertical alignments so as to minimise the depth and extent of cutting and avoidance of cutting beneath regional water table or interception of karst conduit flow routes should ensure in both cases that the groundwater regime is fully protected and that no change to the hydrological regime of the Loughs occur.

## 9.3 Order of hydrogeological preference

Considering the number of hydrological attributes that are located within each corridor and the likely level of impact that a route would have on the attribute the following order of preference has been derived (Table 9.3).

| Order of Preference | Corridor Option |
|---|---|
| 1 | 2B |
| 2 | 1A |
| 3 | 3 |
| 4 | 2 |
| 5 | 2A |
| 6 | 1 |
| 7 | 4 |

**Table 9.3:** *Hydrogeological route corridor preference order*

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# 11 Glossary

**Aquifer:** Any stratum or combination of strata that stores or transmits groundwater (Local Government (Water Pollution) Act, 1990). *More commonly:* A permeable geological stratum or formation that stores and transmits water in significant quantities.

Confined Aquifer: An aquifer in which the groundwater is overlain by impermeable geological strata; confined groundwater is generally subject to pressure greater than atmosphere.

Unconfined Aquifer: An aquifer where the water table is exposed to the atmosphere through openings in the overlying material.

Granular Aquifer: An aquifer composed of discrete grains of material (usually sand and/or gravel) in which groundwater flows through the spaces (pores) between the grains (intergranular flow). Such an aquifer is said to have a *primary* porosity and permeability, as contrasted with secondary porosity and permeability which results from fracturing, etc. Flow through a granular aquifer is said to be *intergranular flow.*

Poor Aquifer: An aquifer which is normally capable of yielding only sufficient water from wells or springs to supply single houses, small farms or small group water schemes. These can be sub divided into: Bedrock aquifers which are generally unproductive except for local zones (Pl) and Bedrock aquifers which are generally unproductive (Pu).

Locally Important Aquifer: An aquifer which is moderately productive, i.e. capable of yielding enough water to boreholes or springs to supply villages, small towns or factories. These are divided into: Sand/gravel aquifers (Lg); Bedrock aquifers which are generally moderately productive (Lm); and Bedrock aquifers which are moderately productive only in local zones (Ll).

Regionally Important Aquifer: An aquifer which is sufficiently productive to be able to yield enough water to boreholes or springs to supply major regional water schemes. These are divided into: extensive sand/gravel aquifers (Rg); karst aquifers (Rk); and fissured aquifers (Rf).

**Attenuation:** The process of diminishing contaminant concentrations in groundwater, due to filtration, biodegradation, dilution, sorption, volatilisation and other processes. The breakdown or dilution of a contaminant in water.

**Baseflow:** That part of the flow in a stream which is not attributable to direct runoff from precipitation or snowmelt, usually sustained by groundwater discharge. That part of a stream discharge derived from groundwater seeping into the stream.

**Calcareous:** Composed of, or containing, calcium carbonate.

**Catchment:** That area determined by topographic features within which falling rain will contribute to run-off at a particular point under consideration.

**Cave:** A naturally occurring cavity large enough for human access.

**Conduit Flow:** A characterisation of some types of Karst aquifers, in which flow is concentrated in conduits created by the dissolution of the limestone bedrock.

**Contaminant Loading:** The amount (volume and concentration) of a contaminant discharged to soil or groundwater.

**Contaminant Transport:** The transport of a contaminant through topsoil, subsoil or bedrock.

**Carboniferous:** The geological time period from 355 to 290 million years ago when most limestones were deposited.

**Diffuse Flow:** A characterisation of some types of Karst aquifers, in which flow is distributed relatively evenly throughout the rock.

**Dissolution:** A form of chemical weathering in which water molecules, sometimes in combination with acid or another compound in the environment dissolve parts of a mineral or rock.

**Doline / Enclosed Depression:** A small to medium sized closed depression, a few metres to a few hundred metres in diameter and depth. Dolines are formed by slow, concentrated solutional removal of rock in an area, from the surface downwards, or by the collapse of overlying rock into a cave or chamber beneath (collapse doline). Dolines function as funnels, allowing point recharge of the karstic aquifer.

**Downgradient:** The direction in which groundwater or surface water flows (also referred to as down-slope). Opposite of upgradient.

**Drumlin:** A long, egg-shaped hill that develops when pressure from an overriding glacier reshapes a moraine. Drumlins range in height from 5 to 50 meters and in length from 400 to 2000 meters. They slope down in the direction of the ice flow.

**Effective Rainfall:** The amount of rainfall that will be able to reach the underlying aquifer. It is determined as the actual rainfall, less evapotranspiration and soil moisture deficit.

**Ecology:** The study of the relationships among organisms and the relationship between them and their physical environment.

**Estevelle:** A karst feature that can function as a spring or as a swallow hole depending on underground water levels.

**Evapotranspiration:** Evaporation from a surface covered by vegetation (usually grass). It depends on both meteorological conditions and on the type of vegetation and is also influenced by the soil moisture status. The term evapotranspiration is used to indicate the combined amount of water evaporated from the soil surface and transpired from the soil moisture storage through vegetation.

**Fault:** A fracture in rock along which there has been relative displacement of the two sides.

**Fissure:** Natural crack in rock which allows rapid water movement.

**Groundwater:** That part of the subsurface water that is in the saturated zone, i.e. below the water table.

**Groundwater Protection Response:** Control measures, conditions or precautions recommended as a response to the acceptability of an activity within a groundwater protection zone.

**Groundwater Protection Scheme:** A scheme comprising two main components: a land surface zoning map which encompass the hydrogeological elements of risk and a groundwater protection response for different activities.

**Groundwater Protection Zone:** Zones delineated by integrating aquifer categories or source protection areas and associated vulnerability ratings. The zones are shown on a map, each zone being identified by a code e.g. SO/H (outer source area with a high vulnerability) or Rk/E (regionally important aquifer with an extreme vulnerability). Groundwater protection responses are assigned to these zones for different potentially polluting activities.

**Groundwater Source:** A source of water supply which depends on groundwater, usually a well (dug well or borehole) or a spring, occasionally an infiltration gallery.

**Groundwater Table:** The uppermost level of saturation in an aquifer at which the pressure is atmospheric.

**Karst:** An area of limestone or other highly soluble rock, in which the landforms are of dominantly solutional origin, and in which the drainage is usually underground in solutionally enlarged fissures and conduits.

**Karst Feature:** Landscape feature which results from karstification (solution of limestone) such as a turlough, swallow hole, cave, etc.

**Lacusterine:** Pertaining to a lake.

**Limestone:** A sedimentary rock composed primarily of calcium carbonate. Some 10% to 15% of all sedimentary rocks are limestones. Limestone is usually organic, but it may also be inorganic.

**Limestone Pavement:** Bare limestone surface from which soil and loose rocks have been stripped – usually by relatively recent ice erosion during a glacial period.

**Mudstone:** Argillaceous or clay-bearing sedimentary rock which is non-plastic and has a massive non-foliated appearance.

**Perched Groundwater Table:** When impermeable strata or lenses are present in the subsurface, the volume immediately above the impermeable unit can become saturated as the water is unable to percolate further down into the aquifer. The convex surface that this creates is a perched groundwater table.

**Permeability:** The ability of a medium to transmit fluids under a potential gradient (units = $L^3/t/L^2$ or L/t). Measure of a soil or rock's capacity to transmit water.

**Piezometric Surface:** (Potentiometric Surface) The surface representative of the level to which water will rise in a well cased to the impermeable layer above a confined aquifer. In unconfined aquifers, this surface corresponds with the groundwater table.

**Potential Evapotranspiration (PE):** The term used to describe the process under conditions of unrestricted availability of water at the vegetation surface. In drier conditions, actual evapotranspiration is usually less than

PE. The term potential evapotranspiration (PE) is used when the water supply available to the plant is not limited. If the water supply in the soil is limited, the actual evapotranspiration (AE) will be less than the potential value.

**Point (Pollution) Source:** Any discernible, confined, or discrete conveyance from which pollutants are or may be discharged, including (but not limited to) pipes, ditches, channels, tunnels, conduits, wells, containers, slatted sheds and animal rearing sheds.

**Porosity:** The total of all void spaces present withina rock, but not all these spaces will be interconnected and thus able to contain and transmit fluids.

**Precipitation:** Any form of water, such as rain, snow, sleet, or hail, that falls to the earth's surface.

**Recharge:** The addition of water to the zone of saturation; also, the amount of water added.

**Sandstone:** A clastic rock composed of particles that range in diameter from 1/16 millimetre to 2 millimetres in diameter. Sandstones make up about 25% of all sedimentary rocks.

**Saturated Zone:** The zone below the water table in which all pores and fissures are full of water.

**Shale:** A rock formed from fine-grained clay-size sediment.

**Siltstone:** A typically layered and flaggy rock composed of two thirds silt-sized particles.

**Source Protection Area (SPA):** The catchment area around a groundwater source which contributes water to that source (Zone of Contribution), divided into two areas; the Inner Protection Area (SI) and the Outer Protection Area (SO).

> The **SI** is designed to protect the source against the effects of human activities that may have an immediate effect on the source, in particular in relation to microbiological pollution. It is defined by a 100-day time of travel (TOT) from any point below the water table to the source.
>
> The **SO** covers the remainder of the zone of contribution of the groundwater source.

**Spring:** A flow of water that occurs where the groundwater table intercepts the ground surface.

**Storage:** The volume of water held within a certain volume of saturated aquifer.

**Subsoil:** The material between the topsoil and the bedrock.

**Swallow Hole:** A small steep depression caused in karst topography by the dissolution and collapse of subterranean caverns in carbonate formations.

**Till:** A glacial sediment composed of rounded rock fragments in a clay rich matrix.

**Time of Travel (TOT):** The time required for a contaminant to move in the saturated zone from a specific point to a well. It is the average linear velocity of flowing groundwater using Darcy's Law: $V = k/ne \cdot dh/dx$, where: ne = effective porosity; k = permeability; dh/dx = groundwater gradient

**Turlough:** Seasonal lakes found in the lowland karsts of western Ireland. They often fill and empty via estavelles.

**Unsaturated Zone:** The zone between the land surface and the water table, in which pores and fissures are only partially filled with water. Also known as the vadose zone.

**Vulnerability:** A term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.

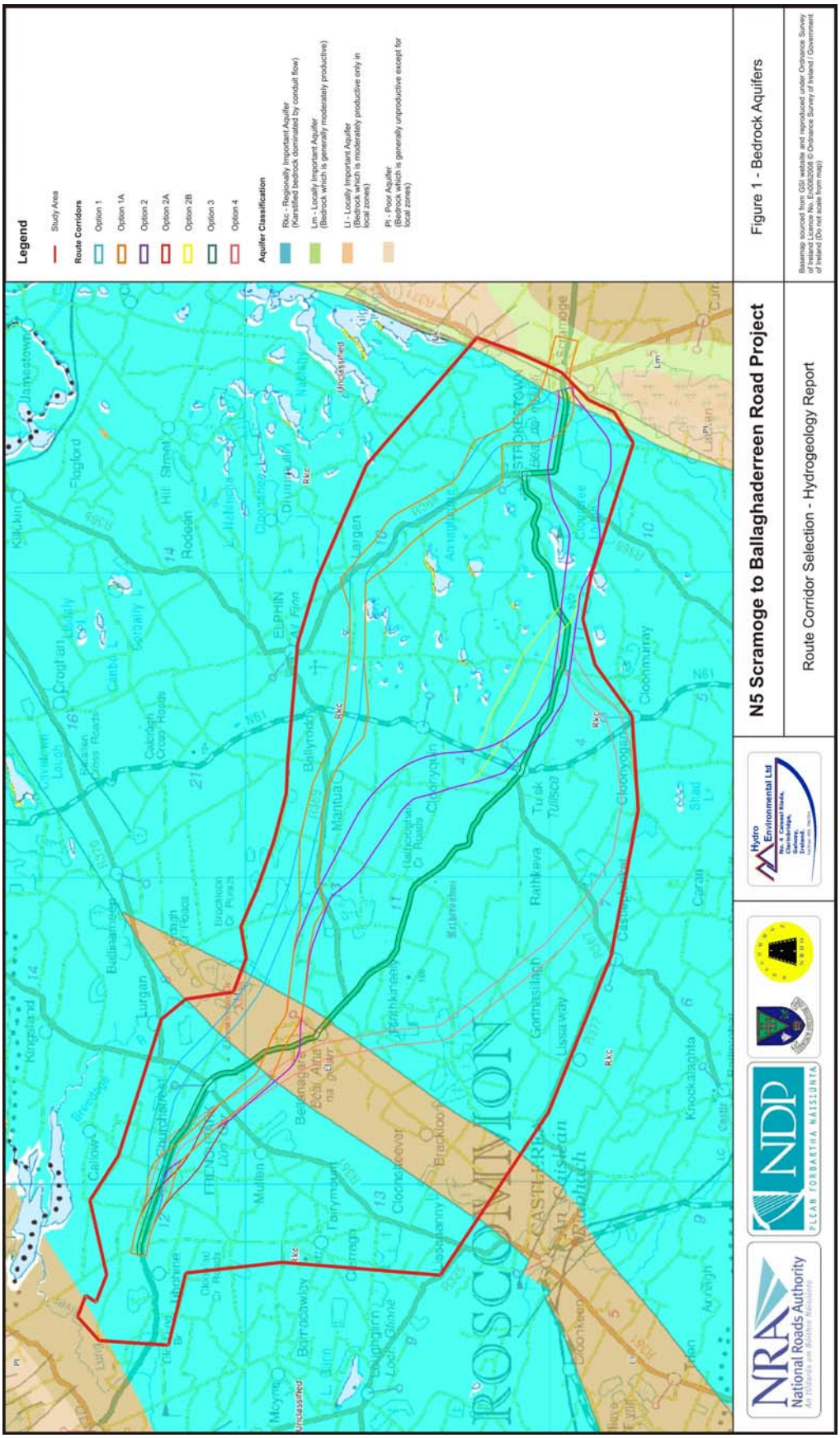
**Zone of Contribution (ZOC):** The area surrounding a pumped well that encompasses all areas or features that supply groundwater recharge to the well. It is defined as the area required to support an abstraction from long-term groundwater recharge.

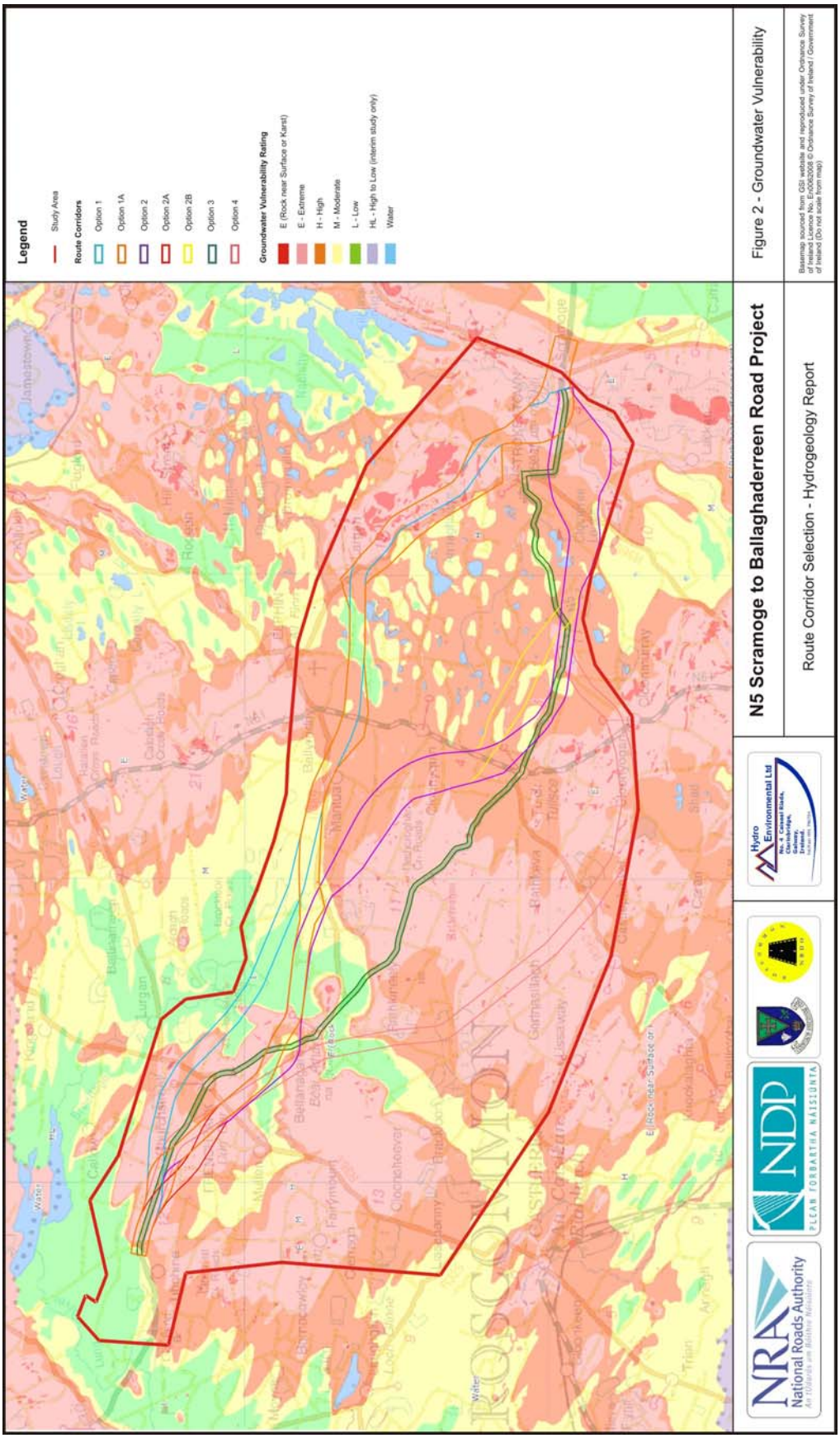
# Maps

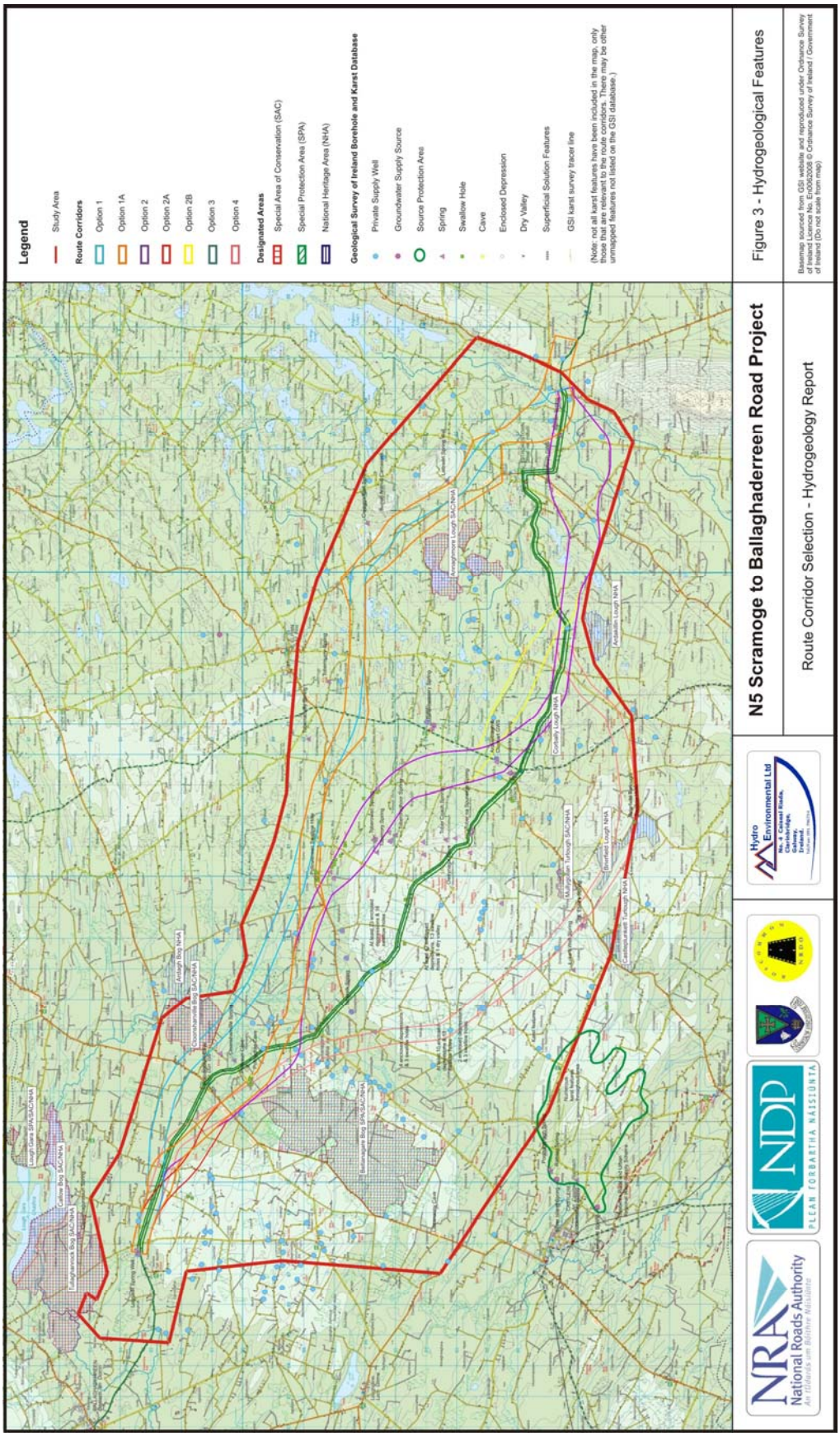
Map 1 Bedrock Aquifers

Map 2 Aquifer Vulnerability

Map 3 Hydrogeological Features


Legend
Study Area
Route Corridors
Option 1
Option 1A
Option 2
Option 2A
Option 2B
Option 3
Option 4
Aquifer Classification
Rkc - Regionally Important Aquifer (Karstified bedrock dominated by conduit flow)
Lm - Locally Important Aquifer (Bedrock which is generally moderately productive)
Ll - Locally Important Aquifer (Bedrock which is moderately productive only in local zones)
Pl - Poor Aquifer (Bedrock which is generally unproductive except for local zones)
ROSCOMMON
N5 Scramoge to Ballaghaderreen Road Project
Route Corridor Selection - Hydrogeology Report
Figure 1 - Bedrock Aquifers
Basemap sourced from GSI website and reproduced under Ordnance Survey of Ireland Licence No. EN0062008 © Ordnance Survey of Ireland / Government of Ireland (Do not scale from map)


Legend
Study Area
Route Corridors
Option 1
Option 1A
Option 2
Option 2A
Option 2B
Option 3
Option 4
Groundwater Vulnerability Rating
E (Rock near Surface or Karst)
E - Extreme
H - High
M - Moderate
L - Low
HL - High to Low (interim study only)
Water
Figure 2 - Groundwater Vulnerability
N5 Scramoge to Ballaghaderreen Road Project
Route Corridor Selection - Hydrogeology Report
Hydro Environmental Ltd
NRA National Roads Authority
NDP
PLEAN FORBARTHA NAISIÚNTA


Legend
Study Area
Route Corridors
Option 1
Option 1A
Option 2
Option 2A
Option 2B
Option 3
Option 4
Designated Areas
Special Area of Conservation (SAC)
Special Protection Area (SPA)
National Heritage Area (NHA)
Geological Survey of Ireland Borehole and Karst Database
Private Supply Well
Groundwater Supply Source
Source Protection Area
Spring
Swallow Hole
Cave
Enclosed Depression
Dry Valley
Superficial Solution Features
GSI karst survey tracer line
(Note: not all karst features have been included in the map, only those that are relevant to the route corridors. There may be other unmapped features not listed on the GSI database.)
N5 Scramoge to Ballaghaderreen Road Project
Route Corridor Selection - Hydrogeology Report
Figure 3 - Hydrogeological Features
Basemap sourced from GSI website and reproduced under Ordnance Survey of Ireland Licence No. EN0062006 © Ordnance Survey of Ireland / Government of Ireland (Do not scale from map)
NRA National Roads Authority
NDP
Hydro Environmental Ltd