Appendix A.10.3

Water Level Monitoring Report

A.10.3 Water Level Monitoring Report

ARUP

Galway County Council

N6 Galway City Ring Road

Water Level Monitoring Report

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1. Introduction

This report presents groundwater level monitoring undertaken within the hydrogeological study area for the proposed N6 Galway City Ring Road (GCRR).

The aim of this work was to collect groundwater levels across the study area so that groundwater flow directions, pathways and connectivity can be characterised and described.

In 2014 a survey of monitoring wells from the 2006 Galway City Outer Ring Road (GCOB) project was undertaken to assess their condition. The 2014 Well Condition Report is presented in Appendix A.10.1.A. As part of this updated EIAR, a 2023 survey of monitoring wells was undertaken to assess their condition and suitability prior to groundwater monitoring during 2023 and 2024. The 2023 Well Condition Report is presented in Appendix A.10.1.B.

This report is an updated version of the Appendix A.10.3 produced in 2018 to inform the hydrogeology assessment as part of the response to the request by ABP for further information in December 2023 where they requested Galway County Council to *"Update the Environmental Impact Assessment Report"* (EIAR) submitted to An Bord Pleanála in October 2018 as part of the application for approval of the proposed N6 GCRR pursuant to Section 51 of the Roads Act 1993 (as amended). This Appendix has been updated to incorporate all data presented during the oral hearing, including hydrographs, maps and tables. The data presented also includes subsequent data that has been collected during the intervening period since the 2020 Oral Hearing, which includes data that is publicly available, and data specifically collected for this project.

All groundwater monitoring locations used in this updated EIAR are presented in Figure 1 of this report and all groundwater level data is presented in Annex A. Hydrographs for selected areas are presented in Annex B. A cumulative rainfall plot is presented in Annex C to provide context of rainfall variation, showing 2015-2016 which had high rainfall (particularly in December 2015 to January 2016) and 2016-2017, which was significantly drier year (dataset period 2014 to 2020). Groundwater levels from this Appendix are used in the main body of the updated EIAR to support the delineation of groundwater bodies and their sub-catchments. Maximum and minimum groundwater levels are presented in EIAR Figure 10.6 for the mainline of the proposed N6 GCRR and link roads.

Where groundwater levels present a simple flow regime, such as in the granite bedrock where the groundwater generally follows the surface topography, then the groundwater levels are described and not plotted as contour maps. However, where the groundwater level data indicate a more complex regime, such as in the limestone bedrock, then groundwater level contour maps are plotted. Summary tables of maximum and minimum groundwater levels are presented for both the Galway Granite Batholith and the Visean Undifferentiated Limestone.

Groundwater levels are measured on site to the nearest centimetre below top of casing. All effort has been made to ensure the accuracy of the data. The Project has used water level loggers to characterise the aquifers in response to recharge and to provide greater resolution on groundwater fluctuations at key sites where groundwater surface water interactions occur.

2. Groundwater Level Methodology

Groundwater level monitoring was carried out by Arup in 54 (No.) boreholes, two springs and one lough between February 2015 to April 2017. Furthermore, as part of the updated EIAR, groundwater level monitoring was undertaken in 15 (No.) monitoring wells between November 2023 to July 2024 (Refer to Appendix A.10.1 B).

Field monitoring comprised of:

- Groundwater level
- Borehole depth

Groundwater level results are presented in Annex A of this report.

2.1 Monitoring Locations

The locations of the groundwater monitoring wells are presented in Figure 1 and summarised in Table 1 and Table 2. As there are a number of groundwater fed receptors, including springs, lakes and loughs there are also a number of surface water monitoring locations and these are presented in Figure 1 (also included in Annex D). The monitoring locations are distributed along the alignment of the Project to monitor groundwater levels in both the Galway Grante Batholith and the Visean Undifferentiated Limestone.

2.2 Water level monitoring

Water level monitoring was carried out in accordance with BS 5930:2015 prior to water quality sampling, ensuring the water level was not disturbed before the measurement was taken.

The water level was measured using a manual electric dip-meter. The distance from the top of the casing to the top of the water level was recorded on site. The height of the top of the casing above ground level was also measured to then allow the depth to water below ground level (mbgl) to be calculated.

The ground level in m above ordnance datum (OD) are recorded on the borehole logs allowing the conversion of the groundwater level in mbgl to mOD.

At selected sites water level data loggers have been used. The locations for deployment of the water level data loggers were selected to target areas near sensitive groundwater habitats (such as Coolagh lakes and Ballindooley Lough) but also to characterise how the aquifer responds to recharge. The water level data from the loggers are calibrated using the manual dataset.

The water level results are presented in Annex A, which include all manual water level data. A summary of the groundwater levels from monitoring boreholes is presented in Table 1 and Table 2. Groundwater levels recorded at selected surface water features (rivers, springs, loughs and lakes) are presented in Table 3. The water level data is grouped according to geology.

In the 2018 EIAR Appendix 10.3 has 57 (No.) monitoring locations in the groundwater monitoring database, which comprised of:

- 18 groundwater monitoring wells in granite
- 1 groundwater monitoring well in the subsoil overlying granite
- 33 groundwater monitoring wells in limestone
- 1 abstraction well in limestone (listed as GRC2 in this database and W50-13 in the EIAR groundwater supplies)
- 1 groundwater monitoring well in the subsoil overlying limestone
- 2 springs
- 1 surface water / groundwater interaction monitoring location (Ballindooley Lough)

Furthermore, there are 3 surface water monitoring locations, which are used to supplement the groundwater monitoring data, these comprise of:

- 2 lakes (upper and lower Coolagh Lakes)
- 1 OPW gauging station (River Corrib)

In this updated EIAR Appendix 10.3 includes the same 57 (No.) monitoring locations in the groundwater monitoring database. There is one additional OPW monitoring location, which is a river gauging station that was installed at the Terryland River in 2021.

As noted in Appendix A.10.1.B 2023 Well conditioning report, the groundwater supply at the Galway Racecourse stables is provided by two pumping wells (GRC1 and GRC2), which are located adjacent to each other and tap into the same groundwater. Whilst these wells are included in the groundwater monitoring network and their water level is recorded, these data are not used in the assessment of the natural groundwater levels in the aquifer. Note that as these are pumping wells there are cables, pipework and pumps in the well, which makes it difficult to measure the depth to water and also collect a sample. Note in the 2018 EIAR the well is listed as GRC2 as this was the well bore that was sampled. For the N6 GCRR 2023-2024 monitoring network due to obstructions in the GRC2 well the adjacent well was used, which is GRC1. Based on review of these wells it is assessed that these wells draw from the same aquifer and groundwater. For completeness this report lists either GRC1 or GCR2 depending on which bore was accessible at the time of sampling. However, for this Project it is considered that the wells abstract from the same aquifer and the same groundwater. It remains the case that these are pumping wells and that the water level in each well is not representative of the natural groundwater level. As such, neither GRC1 nor GRC2 are representative of natural groundwater levels but can be used for water quality monitoring, which is presented in Appendix A.10.4.

Additionally, monitoring data is included in Appendix A.10.5 aquifer testing. The Appendix A.10.5 data is not included in the groundwater monitoring database as it was short term monitoring that is specific to the aquifer testing programme.

Figure 1 Groundwater and surface water level monitoring locations

3. Groundwater Monitoring Results

3.1 Galway Granite Batholith

In higher ground the water table is within 2m of ground level and on lower lying ground the water table is at ground level. Areas of low-lying ground typically include saturated peat with ponding at surface caused by naturally poor drainage. Due to the low aquifer properties of the granite, interaction between groundwater and surface water is minimal. A summary table of minimum and maximum groundwater levels from the 18 (No.) wells in the Galway Granite Batholith are presented in Table 1. The full record of all 18 (No.) monitoring wells are presented in Annex A and grouped into their respective groundwater bodies. In addition to the 18 (No.) groundwater monitoring wells with their response zone in the Galway Granite Batholith one well (BH-3-21) has its response zone in the subsoil overlying granite bedrock. This well is included in the database for completeness but has not been used in the development of aquifer cross-sections and maps.

Table 1 Groundwater levels measured in the Galway Granite Batholith

Monitoring Borehole	Source	East (ITM)	North (ITM)	Ground Elevation (mOD)	Groundwater Level		
					Min (mOD)	Max (mOD)	Range (m)
RC422	N6 GCOB	524196	724742	21.20	19.45	20.75	1.30
RC435	N6 GCOB	524479	725777	59.19	56.13	56.58	0.45
RC451A*	N6 GCOB	525153	726691	71.70	69.43	70.04	0.61
RC 548	N6 GCOB	521102	723826	50.84	49.67	50.73	1.06
RC 687	N6 GCOB	522901	725359	69.56	68.78	69.16	0.38
RC 739	N6 GCOB	524763	725951	59.64	58.45	58.86	0.41
BH-3-04R	N6 GCRR	523646	724287	36.82	36.23	36.70	0.47
BH-3-06R	N6 GCRR	524241	724825	23.09	21.59	22.22	0.63
BH-3-08R	N6 GCRR	524621	725069	42.05	39.85	41.39	1.54
BH-3-10R	N6 GCRR	525321	725604	66.51	63.37	64.66	1.29
BH-3-11R	N6 GCRR	525784	725831	54.24	52.83	53.27	0.44
BH-3-13R	N6 GCRR	526079	726036	58.65	52.85	57.12	4.27
BH-3-16R	N6 GCRR	526765	726611	61.66	57.64	58.45	0.81
BH-3-17R	N6 GCRR	527021	726805	65.33	62.46	63.07	0.61
BH-3-18R	N6 GCRR	527254	726894	70.64	68.03	69.11	1.08
BH-3-20R	N6 GCRR	527214	727669	51.63	47.83	48.61	0.78
BH-3-23R	N6 GCRR	527774	727346	26.93	22.32	23.46	1.14
BH-3-24R	N6 GCRR	528036	727521	25.16	20.97	22.77	1.80

Notes: Seasonal fluctuation in the Galway granite batholith is generally within 4m for rocky ridges and 1-2m where the ground has slight gradients. Where the ground forms depressions/basins then the groundwater level remains at surface throughout the year.

Those monitoring location marked with an asterisk * have included monitoring using water level loggers.

Groundwater elevations confirm that groundwater flow follows the general topography and surface water drainage. In the Spiddal GWB the groundwater contours conform to the surface water drains and flow towards Galway Bay by seeping into the surface watercourses that drain the area. In the Maam-Clonbur GWB the groundwater contours also conform to surface topography and surface water drainage and flow eastwards to the River Corrib.

In the steep eastern granite slopes draining towards the River Corrib there are several seepages, which emerge where the topography steepens and intersects the groundwater table. The largest of these is spring at W1000-01 (EIAR Figure 10.5.001), which is used as a private water supply (see EIAR, Chapter 10, Section 10.3.4). Other smaller seepages occur in both groundwater bodies and these drain to surface water streams and ditches.

Seepages in the Galway Granite Batholith are generally associated with weathering and/or fault zones (refer to Chapter 9, Soils and Geology) and generally the seepages dry out in the summer. As per GSI descriptions (2004a and 2004b) these locally productive pathways are relatively short and to have limited lateral extent. On this basis, they are likely to have limited storage and rely on recharge, which would suggest they will respond to storm events and reduce in flow during the summer (GSI 2004a and 2004b).

Based on GSI descriptions of groundwater bodies in granite the length of the flow paths is considered to have a general maximum of 100m.

3.2 Visean Undifferentiated Limestone

A total of 34 (No.) limestone wells are presented in the Annex A monitoring database and these are grouped by lithology as well as the groundwater body that they are located in. In the database, one well (GRC2), is an abstraction well that supplies groundwater. Although included in the monitoring database, GRC2 is not included in the summary Table 2 below for all monitoring wells in the Visean Undifferentiated Limestone. This is because groundwater levels recorded in GRC2 are not representative of the true groundwater level in the aquifer. Instead, the groundwater level in GRC2 represents a pumped water level. GRC2 has been included in the groundwater supply assessment in the EIAR, where it is listed as supply well W50-13. As Table 2 excludes GRC2 (W50-13) a total of 33 (No.) limestone monitoring wells are listed in that table.

Additional to the 34 (No.) monitoring wells in limestone presented in Annex A one well (BH06) has its response zone in the subsoil overlying limestone bedrock. This well is included in the Annex A database for completeness but like well GRC2, it has not been used in the development of the groundwater level in cross-sections and maps for the limestone aquifer.

A summary of the surface features is presented in Table 3, which comprise of rivers, loughs, lakes and springs. These include the Office of Public Works (OPW) gauging stations at Dangan and Terryland plus five Project surface monitoring locations (one lough, two lakes and two springs).

Table 2 Groundwater levels measured in the Visean Undifferentiated Limestone

Monitoring Borehole	Source	Easting ITM	Northing ITM	Ground Elevation (mOD)	Groundwater Level		
					Min (mOD)	Max (mOD)	Range (m)
MW 01*	2006 GCOB	528670	727956	16.14	10.61	13.89	3.28
MW 02	2006 GCOB	528715	728095	13.37	6.15	7.90	1.75
MW 03*	2006 GCOB	528920	727970	6.70	5.80	6.46	0.66
BH-3-27R	N6 GCRR	528960	728133	9.10	5.90	6.41	0.51
RC133*	2006 GCOB	529325	728185	11.66	5.73	8.16	2.43
BH972	2006 GCOB	529462	728292	12.33	7.41	8.20	0.79
BH-3-29R	N6 GCRR	529489	728334	13.73	Dry (<6.83)	9.23	>2.40

Monitoring Borehole	Source	Easting ITM	Northing ITM	Ground Elevation (mOD)	Groundwater Level		
					Min (mOD)	Max (mOD)	Range (m)
RP-2-05D*	N6 GCRR	529701	727145	19.96	5.73	7.78	2.06
RP-2-05S*	N6 GCRR	529704	727141	20.22	8.86	12.01	3.15
BH04	N6 GCRR	530151	728400	32.17	8.20	15.74	7.54
BH05	N6 GCRR	530187	728378	34.14	8.08	19.46	11.38
LQ MW6	Private	529919	727971	15.40	12.11	13.20	1.09
LQ MW5	Private	530389	728285	7.40	10.71	19.17	8.46
LQ MW4	Private	530522	728557	16.76	8.71	15.41	6.71
RC 1104	2006 GCOB	531165	728927	9.39	7.24	8.56	1.32
BH-3-31R	N6 GCRR	531274	728424	11.08	9.45	9.78	0.33
RC206*	N6 GCRR	531237	729433	28.49	19.26	21.10	1.84
RP-2-03*	N6 GCRR	531478	728278	22.44	4.95	9.23	4.28
BH-3-46R	N6 GCRR	531750	728392	29.81	16.79	17.32	0.53
RP-2-01*	N6 GCRR	531726	728689	21.38	7.86	10.28	2.42
RC 1206	N6 GCRR	531986	729388	27.67	17.05	19.45	2.40
BH-3-32R	N6 GCRR	531971	728318	24.43	<9.43	10.24	>0.81
RC 1211	N6 GCRR	532454	729601	25.91	20.25	22.03	1.78
BH-3-34R	N6 GCRR	532405	728275	32.57	19.69	25.91	6.22
BH-3-35R	N6 GCRR	532851	728226	17.52	7.91	9.15	1.24
BH-3-47R	N6 GCRR	533062	728286	37.74	27.55	27.74	0.19
BH-3-36R	N6 GCRR	533125	728205	24.43	32.80	34.00	1.20
RC-2-02	N6 GCRR	533685	728102	25.91	44.02	44.61	0.59
BH-3-38R	N6 GCRR	534249	727541	32.57	42.21	43.83	1.62
BH-3-40R	N6 GCRR	534439	727295	17.52	39.30	39.89	0.69
BH-3-48R	N6 GCRR	534397	727197	51.78	38.92	39.32	0.40
BH-3-41R	N6 GCRR	534580	727065	54.92	35.57	38.36	2.79
BH-3-42R	N6 GCRR	534756	726840	45.17	22.68	30.12	7.44

Notes:

Monitoring wells LQMW5 and BH05 both straddle a thin black argillaceous limestone that overlies a clay wayboard in the geology sequence, which perches recharge above the main groundwater body. The groundwater levels recorded in LQMW5 and BH05 represent interaction between the main groundwater body and recharge. The water levels in LQMW5 and BH05 are not representative of groundwater levels in the main groundwater body.

Those monitoring location marked with an asterisk * have included monitoring using water level loggers (selected logger data is presented in Annex B (Hydrographs))

Table 3 Surface water monitoring locations

Surface water monitoring	Reference	Easting ITM	Northing ITM	Water Level		
				Min mOD	Max mOD	Range m
River Corrib OPW Dangan	30098	528302	727805	5.48	6.90	1.42
Terryland River OPW	300117	530584	726665	1.69	2.96	1.28
Ballindooley Lough*	SW-2-1	531620	728723	8.67	9.94	1.27
Lower (South) Coolagh Lake*	SW-2-2	529401	727334	5.70	6.40	0.70
Upper (North) Coolagh Lake*	SW-2-3	529247	727765	5.70	6.40	0.70
Western Coolagh Spring*	SW-2-4	529045	727934	5.70	6.40	0.70
Eastern Coolagh Spring*	SW-2-5	529900	728162	7.55	7.63	0.08

Notes

Those monitoring location marked with an asterisk * have included monitoring using water level loggers

Based on the water levels measured in the Visean Undifferentiated Limestone there are two distinct areas where groundwater responds with distinct and different characteristics:

- The area from the River Corrib to the Tuam Road
- The area south and east of the Tuam Road encompassing Galway Racecourse, Briarhill and connection to existing N6

In the area between the River Corrib and the Tuam Road, groundwater levels tend to have relatively low base levels but with greater fluctuation, often being quite flashy in their groundwater response. The characteristics of the groundwater responses in this area typically reflect that of a karst aquifer, which has high recharge with fracture and conduit flow connectivity. Included in Annex B are groundwater and surface water responses for the limestone aquifer at Coolagh Lakes and Lackagh Quarry (Hydrograph 1) and Ballindooley Lough (Hydrograph 2).

In the area south and east of the Tuam Road the groundwater levels are generally significantly higher, near surface with a significantly lower fluctuation. This is specifically the case at Briarhill and the connection to the existing N6. There is an indication that a deeper aquifer is also present in this area, specifically at depth below the Galway racecourse. The deeper aquifer appears similar to the karst aquifer identified between the River Corrib and the Tuam Road. These data from south and east of the Tuam Road indicate that a tiered aquifer is likely present, with an upper part of the aquifer that has low permeability and low connectivity but with an underlying aquifer that has higher connectivity via fractures and conduits.

The boundary between these two areas (River Corrib to Tuam Road and Tuam Road to existing N6) is the N83 Tuam Road. By coincidence, the line of the Tuam Road is formed upon a major buried palaeochannel that extends north-eastwards from Terryland towards Claregalway (refer to Chapter 10.3 for discussion on palaeochannel). This major palaeochannel along the line of the Tuam Road has been proven to be greater than 60m deep and primarily clay filled. This palaeochannel forms a boundary condition that isolates the Clare-Corrib groundwater body and the Clarinbridge Groundwater body. Further discussion on the groundwater levels between the River Corrib to Tuam Road and Tuam Road to existing N6 is presented below.

3.2.1 River Corrib to Tuam Road

Groundwater sub-catchments

EIAR Figures 10.6.007 to 10.6.110 present cross-sections along the alignment of the maximum and minimum groundwater level between the limestone on the west bank of the River Corrib and the N83 Tuam Road. The groundwater levels show that the water table is undulating along the alignment with notable low points at the River Corrib, Coolagh Lake, Ballindooley Lough and monitoring well RP-2-03 at Castlegar. These low points in the groundwater table are areas at or close to discharges from the aquifer to surface water. Between the groundwater low points are groundwater highs and these form sub catchment divides within the groundwater body.

The main groundwater high in this section is plotted between Menlough and Lackagh Quarry. At this location the water table forms a distinct divide between westward groundwater flow towards Coolagh Western Spring, which feeds Coolagh Lakes, and eastward flow to the groundwater low towards Ballindooley Lough and monitoring well RP-2-03.

The range in groundwater levels shown in Table 2 shows differing seasonal variability in the Visean Undifferentiated Limestone. Discounting those monitoring wells where the recorded range was not representative (refer to notes in Table 2) (BH-3-29R, BH3-31R LQMW5, BH05 and BH-3-32R), then the minimum and maximum ranges recorded are 7.54m (BH04) and 0.51m (BH-3-27R). BH04 is located close to the groundwater divide between Menlough and Lackagh Quarry, whilst BH-3-27R is located close to Western Coolagh Spring. Based on the data presented, those monitoring locations close to discharge points (rivers and springs) show the least seasonal fluctuation, whilst those at or near groundwater divides have the greatest seasonal fluctuation.

Based on the data collected, groundwater levels have been used to present groundwater contours for the area between the River Corrib and the Tuam Road for baseline summer groundwater levels and peak winter groundwater levels, which are presented in Figure 2 and Figure 3 respectively[1]. These are reproduced in full for clarity in Annex D to this updated Appendix A.10.3. The peak groundwater levels are collected during December 2015 / January 2016, and these data correspond to peak stage levels in the River Corrib at Dangan, which is presented in the section below. These groundwater level data identify the groundwater flow directions within this area and confirm the split between the sub-catchment that drains to Coolagh Lakes and the sub-catchment that drains to Ballindooley Lough. Refer to cumulative rainfall data presented in Annex C.

The data collected for the Project provides significant new data for the extent and boundaries of the groundwater bodies as defined by the GSI groundwater body mapping. These data sets have allowed refinement of the groundwater body extents but also internal subdivision into sub-catchments.

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[1] https://www.n6galwaycityringroad.ie/sites/default/files/media/GCRR-4.03.34.17%20Response%20to%20Queries%20Raised%20in%20Module%201_appendices.pdf

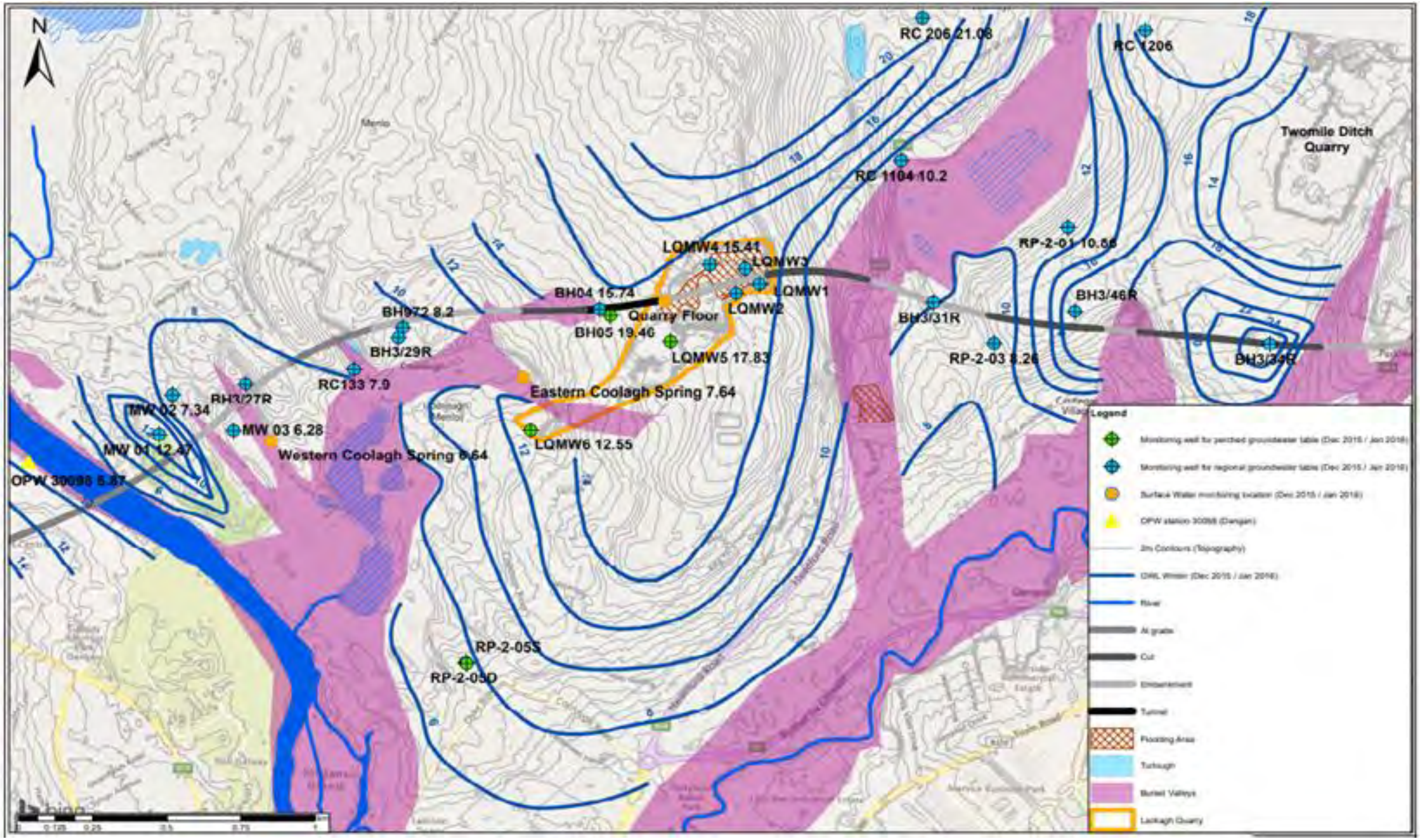


Figure 2 Winter groundwater levels (Winter 2015/2016)

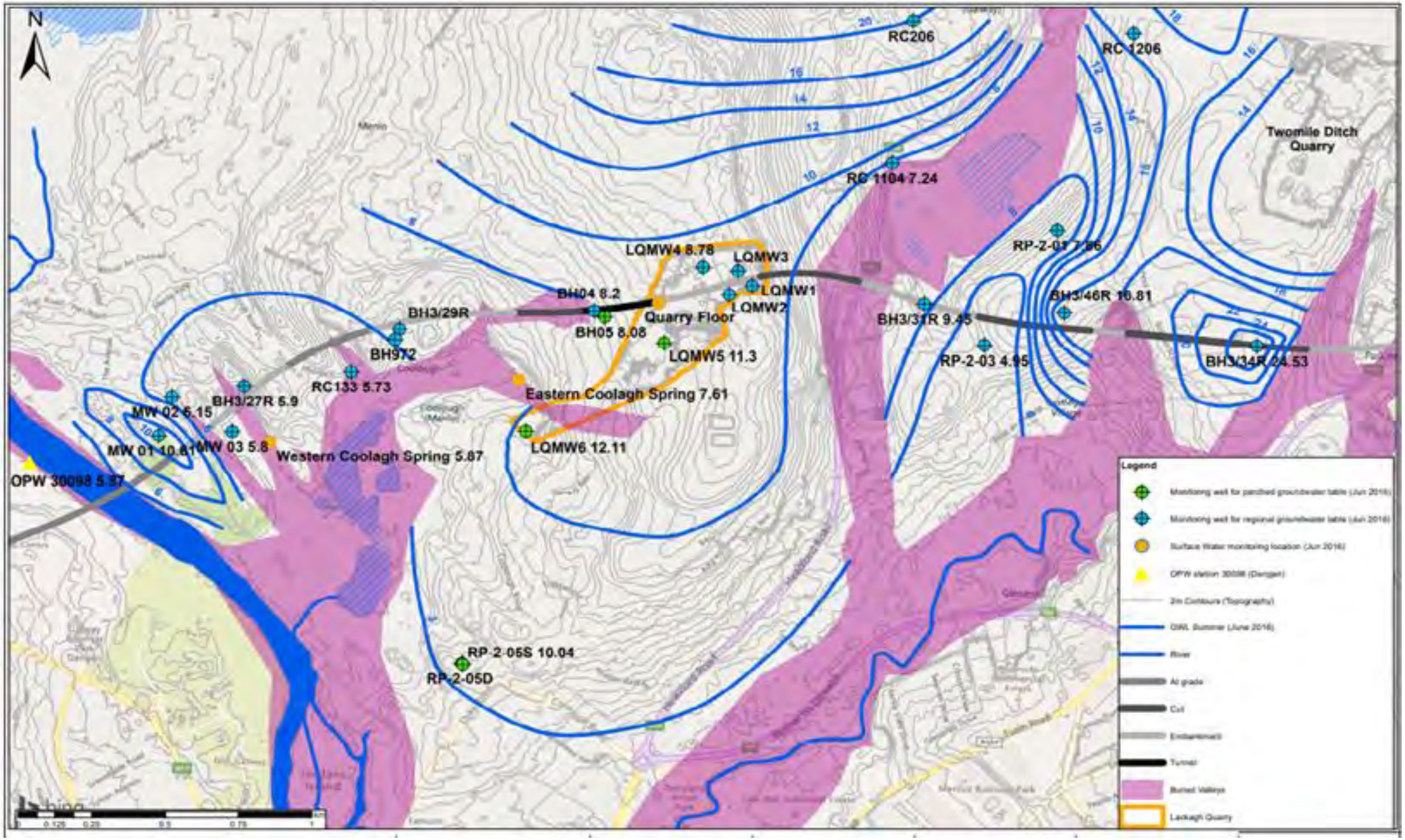


Figure 3 Summer groundwater levels (Summer 2016)

The River Corrib

The River Corrib together with the Coolagh Lakes and the Terryland River form the base water level to which all groundwater flows towards in the Visean Undifferentiated Limestone in this area between the River Corrib and the Tuam Road (Section 3 of the Project). The seasonal water level response in the river, particularly to storm events, is an important consideration when determining the seasonal responses in groundwater level.

At the Coolagh Lakes, winter flood events in the River Corrib causes water level rise in the Coolagh Lakes, so that the lakes are initially slightly higher than in the aquifer. In the summer the river level drops below the groundwater level at the lake margins and the lake remains slightly higher than the river.

Data is available from the Office of Public Works for the water level in the River Corrib near to the Coolagh lakes at Dangan (Figure 4), and the data is available since 2003. This data is presented as a hydrograph below in Figure 5 and are useful to compare seasonal variation. It is noted that the highest peak on record for the river stage (6.90m aOD) occurred on 2 January 2016. Each year the river generally reaches a base level of 5.78m aOD (with the lowest level achieved being 5.48m aOD). It is noted that the base level in the river at Dangan is controlled by a weir, c.3km downstream.

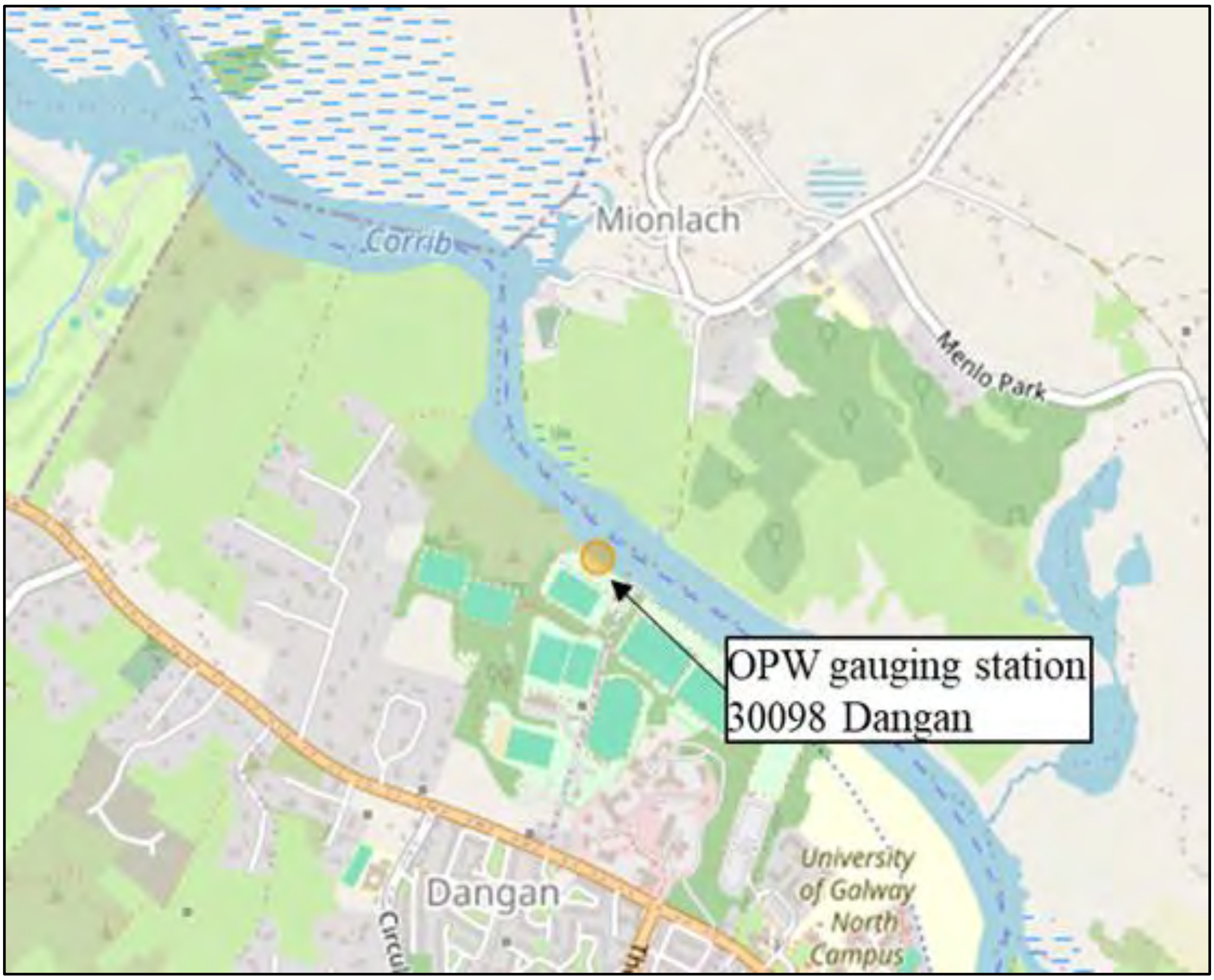


Figure 4 Location of the Dangan gauge on the River Corrib (OPW)

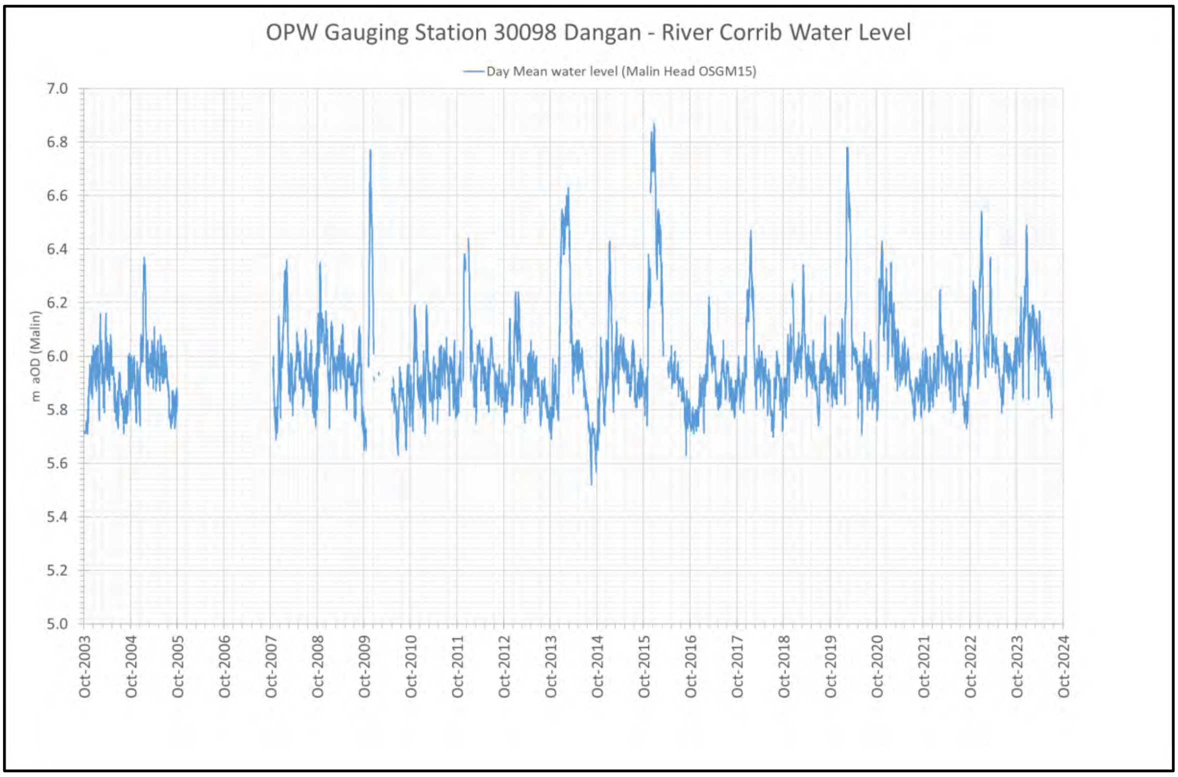


Figure 5 Hydrograph for the River Corrib at Dangan (OPW 2024 station 30098)

The Terryland River bifurcates from the River Corrib approximately 1km downstream from the Coolagh Lakes. From the bifurcation the Terryland River meanders for approximately 3km before it sinks into the ground at a limestone cliff (1.53m AOD) at stream sinks K87 and K96 (refer to EIAR Figure 10.1 and EIAR Appendix 10.2) near Glenanail. From the bifurcation to the sink the Terryland River loses c.3.8m elevation.

The OPW installed a gauging station in the Terryland River in July 2021 to continuously record the water level. The gauging station is mid-way along the length of Terryland River, the location is shown below in Figure 6. This water level data shows that the Terryland River is influenced by the tides in Galway Bay, which is where the stream sinks in the river drains to. The tidal relationship is clearly shown below in and Figure 8, which show responses during a dry month and wet month. Full record of the water levels recorded in the Terryland River, the River Corrib and Galway Bay are presented in Figure 9.

Figure 6 Location of the Terryland River gauge.

Based on these data, the tide in Galway Bay causes the Terryland River to fluctuate twice daily by up to 0.5m, depending on the tidal range in Galway Bay. The fluctuation in the Terryland River is most likely caused by high tide impeding flow from karst pathways into Galway Bay, which causes the river stage to rise along most of the length of the Terryland River. Rainfall also has an influence on the Terryland River, moderate storm events on the 14 - 15 July 2023 caused a 0.7m rise in the river stage. On this basis, combined storm and high tide events could cause higher stage levels in the Terryland River. From the water level data to the end of July 2024 the highest recorded water level in the Terryland River is 2.96m, which remains significantly lower than the lowest recorded stage in the River Corrib (5.48m) (Figure 5).The lowest recorded stage in the Terryland River is 1.69m.

The OPW dataset shows that rainfall and tidal effects frequently cause flooding in the valley of the Terryland River. However, for the data period available the flooding in the Terryland River has never been high enough to cause it to backup into the River Corrib. Data is not available from winter 2015/2016, which is when the highest levels occurred both in the River Corrib and groundwater. Certainly, during winter 2015/16 the flooding in the Terryland River valley would have been more significant than the data period presented.

It has been observed that the Terryland Stream sinks do occasionally reverse flow, becoming resurgences. This is likely from elevated groundwater levels in the limestone aquifer that extends east of the N83 Tuam Road (Section 4 of the Project).

Peak flooding in the Terryland River will be caused by high groundwater levels and storm events but it would be further amplified by high tide in Galway Bay. The increased water level in the limestone aquifer will occur via karst pathways that are known to be present. These will be recharged locally in the Ballybrit and the Galway Racecourse area and will include water sinking into swallow hole K328 (Refer to EIAR Figure 10.1.01 and EIAR Appendix 10.2) as well as recharge infiltration.

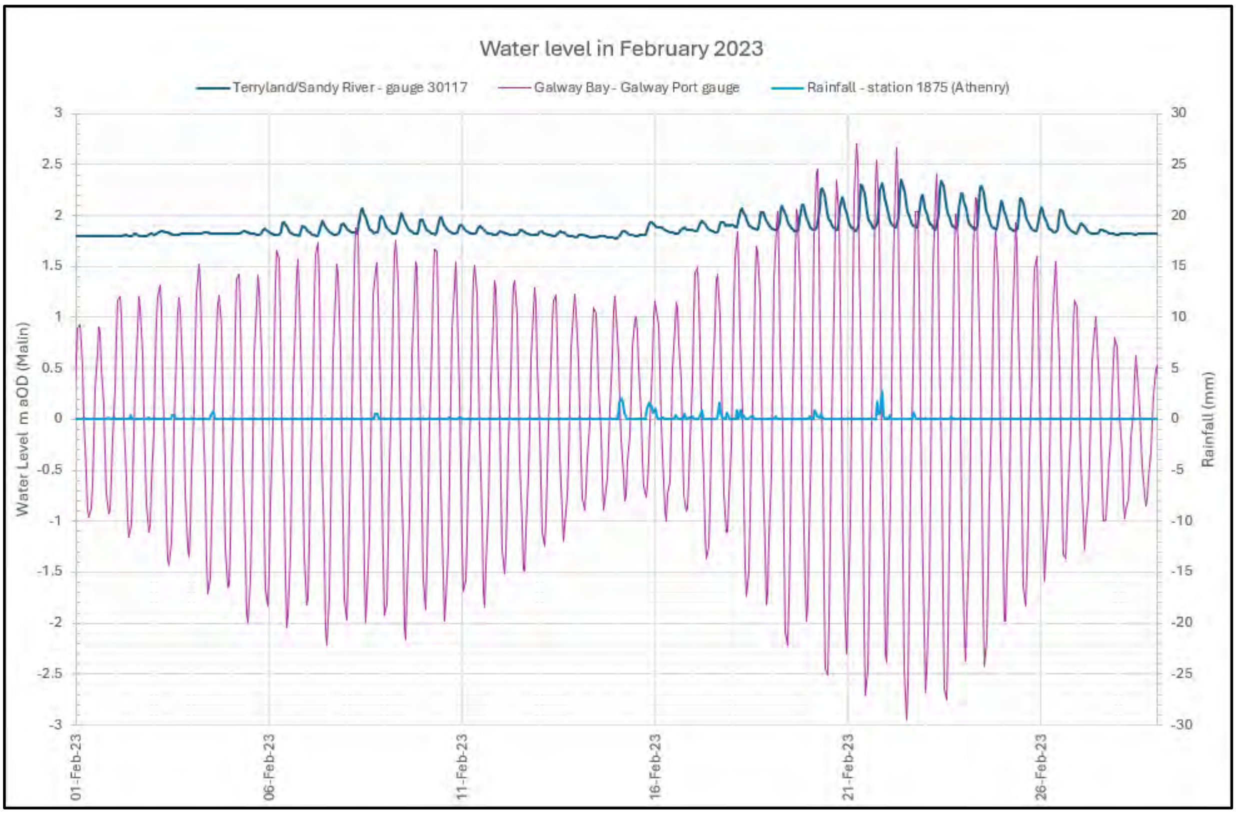


Figure 7 River level in Terryland River and tide level Galway Bay (February 2023)

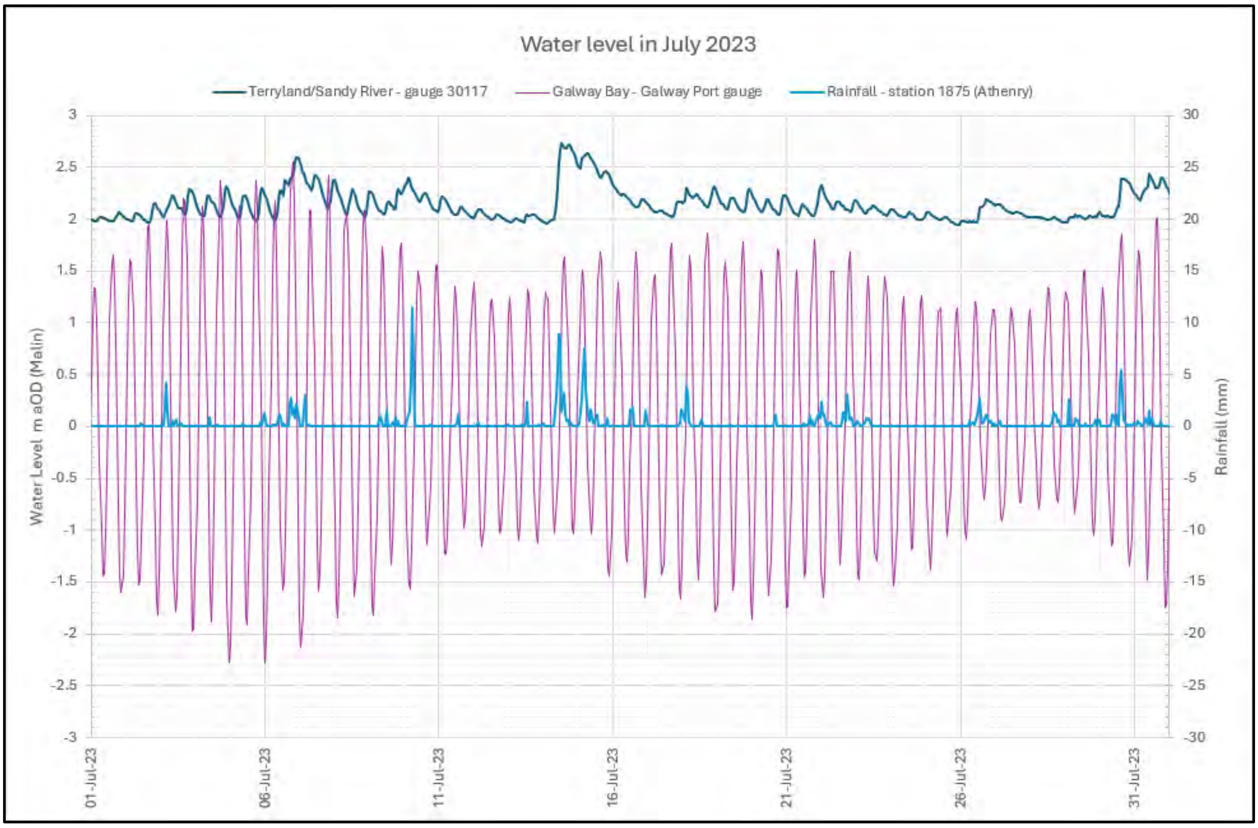


Figure 8 River level in Terryland River and tide level in Galway Bay (July 2023)

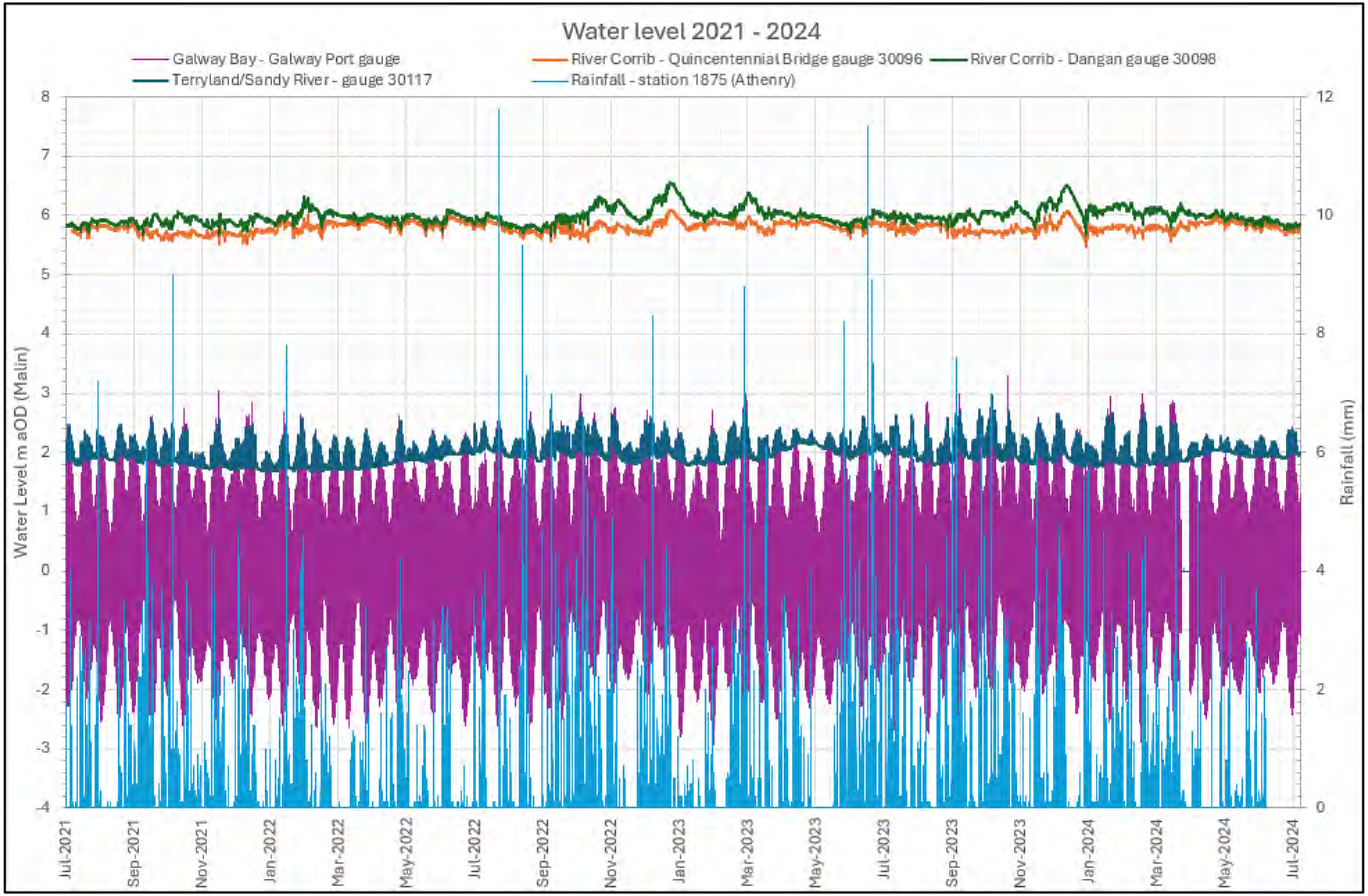


Figure 9 Water level data in Terryland River and River Corrib with tidal level in Galway Bay and rainfall

3.2.2 Tuam Road to existing N6 (including Galway Racecourse and Briarhill)

Groundwater level data from Briarhill shows that the water table lies near surface across the area, furthermore, a walkover of the site indicated that during storm events there is often standing water and runoff. Although the Briarhill area comprises of limestone, it contracts to other areas of the region, such as Menlough, Castlegar and Ballinfoyle where groundwater levels are significantly deeper, and rainfall rapidly recharges to ground.

Based on the data presented and the observation made on site it is anticipated that the shallow limestone at Briarhill generally has poor connectivity and recharge acceptance. As no significant karst features have been observed at Briarhill, the shallow limestone in this area is considered not to be karstic.

East from Briarhill at the Galway Racecourse trial well drilling encountered significantly deep groundwater levels, which lie 44 - 49m below ground level. The trial well drilling also indicates that higher permeabilities and karst connectivity are likely with depth. On this basis, it is apparent that the higher groundwater level at Briarhill is related to a perched groundwater level that occurs locally in the area. Other perched groundwater levels have been identified in the region, such as at Lackagh Quarry where a siliceous (chert) layer locally perches the groundwater table at Lackagh Quarry, and Ballindooley Lough, where a buried valley perches groundwater level during the summertime. However, at both locations the perching is very localised and at Lackagh, the perched layer readily leaks into the underlying karst aquifer. At Briarhill it is likely that the limestone geology is the reason for the perching as no buried valley has been identified at the location. As the perched water table is present all year round and runoff is common, it is also unlikely that significant leakage occurs to the underlying deeper aquifer.

4. Conclusions

Arup carried out groundwater level monitoring between February 2015 to April 2017 and between November 2023 and July 2024 in monitoring boreholes and surface water locations within the study area for the N6 Galway City Ring Road. These data comprise on manual water level measurements with automatic water level measurements at selected locations. These data have been compiled into a database and have been used to develop maximum and minimum groundwater levels across the alignment.

The groundwater level data includes data from December 2015 and January 2016, which coincides with a period of significant rainfall and corresponds to highest river levels recorded by OPW at Dangan gauging station on the River Corrib. The OPW gauge at the Terryland River was installed in 2021 and as such data for that gauge is not available for the December 2015 / January 2016 period.

The aquifers can broadly be divided into three areas across the Project, these are:

- The Galway granite batholith, where groundwater levels are generally near surface all year round.
- The limestone area between the west bank River Corrib and the Tuam Road, where groundwater responses indicate karstified limestone with a high level local, but leaky, perched aquifer. The groundwater in this area (both perched and main body) has high connectivity but is bound laterally by clay filled buried valleys that limit the lateral extent of the aquifer.
- The limestone area from the Tuam Road to existing N6 (including Briar hill and the Galway Racecourse). At Briarhill the shallow limestone has minimal groundwater resource and low connectivity with high runoff. At depth the limestone has greater connectivity and has karst (as proven at the Galway Racecourse) with groundwater level being >40m below ground level. The shallow perched groundwater and the deep karst aquifer are likely separate. Groundwater levels in the perched aquifer at Briarhill remain near surface all year and contribute water to land drains and the local drainage system.

Annex A – Water Levels Records

Monitoring Point	Hydrogeological feature	Geology	Groundwater Body	Source	Easting ITM	Northing ITM	Ground Elevation (mOD)	No. of Records	Seasonal Variation			Monthly Water Level Record 2015															
									m OD		m	m OD															
												Feb-15	Apr-15	Jun-15			Jul-15		Aug-15		Sep-15	Oct-15			Nov-15	Dec-15	
									Min	Max	Range	26th	26th	4th	24th	25th	21st	22nd	20th	21st	29th	14th	15th	16th	18th	15th	21st
RC422	Monitoring well	Granite	Spiddal	N6 GCOB	524196	724742	21.20	14	19.45	20.75	1.30					19.67	20.33			20.07			19.91		20.75		20.56
RC435	Monitoring well	Granite		N6 GCOB	524479	725777	59.19	14	56.13	56.58	0.45					56.24	56.49			56.34			56.31		56.58		56.57
RC451A	Monitoring well	Granite		N6 GCOB	525153	726691	71.70	14	69.43	70.04	0.61					69.64	69.72			69.66			56.31		69.85		70.04
RC 548	Monitoring well	Granite		N6 GCOB	521102	723826	50.84	14	49.67	50.73	1.06					49.67	50.64			49.90			50.32		50.65		50.63
RC 687	Monitoring well	Granite		N6 GCOB	522901	725359	69.56	14	68.78	69.16	0.38					68.90	69.06			68.97			68.99		69.09		69.09
RC 739	Monitoring well	Granite		N6 GCOB	524763	725951	59.64	14	58.45	58.86	0.41					58.52	58.79			58.65		58.66			58.85		58.83
BH-3-04R	Monitoring well	Granite		N6 GCRR	523646	724287	36.82	11	36.23	36.70	0.47																
BH-3-06R	Monitoring well	Granite		N6 GCRR	524241	724825	23.09	11	21.59	22.22	0.63																
BH-3-08R	Monitoring well	Granite		N6 GCRR	524621	725069	42.05	8	39.85	41.39	1.54																
BH-3-10R	Monitoring well	Granite		N6 GCRR	525321	725604	66.51	7	63.37	64.66	1.29																
BH-3-11R	Monitoring well	Granite		N6 GCRR	525784	725831	54.24	9	52.83	53.27	0.44																
BH-3-13R	Monitoring well	Granite		N6 GCRR	526079	726036	58.65	6	52.85	57.12	4.27																
BH-3-16R	Monitoring well	Granite		N6 GCRR	526765	726611	61.66	7	57.64	58.45	0.81																
BH-3-17R	Monitoring well	Granite	Maam-Clonbur	N6 GCRR	527021	726805	65.33	11	62.46	63.07	0.61																
BH-3-18R	Monitoring well	Granite		N6 GCRR	527254	726894	70.64	9	68.03	69.11	1.08																
BH-3-20R	Monitoring well	Granite		N6 GCRR	527214	727669	51.63	7	47.83	48.61	0.78																
BH-3-21	Monitoring well	Subsoil		N6 GCRR	527144	726345	37.76	4	36.21	36.49	0.28																
BH-3-23R	Monitoring well	Granite		N6 GCRR	527774	727346	26.93	8	22.32	23.46	1.14																
BH-3-24R	Monitoring well	Granite		N6 GCRR	528036	727521	25.16	8	20.97	22.77	1.80																
MW 01	Monitoring well	Limestone	Lough Corrib Fen 1	N6 GCOB	528670	727956	16.14	16	10.61	13.89	3.28				11.04			12.26	11.07					11.03	13.57		13.45
MW 02	Monitoring well	Limestone		N6 GCOB	528715	728095	13.37	16	6.15	7.90	1.75				6.22			6.86	6.43				6.31		7.90		7.64
MW 03	Monitoring well	Limestone		N6 GCOB	528920	727970	6.70	21	5.80	6.46	0.66				5.86			6.08	5.96		6.05		5.90		5.95		6.46
SW-2-4	Western Coolagh Spring K25	Limestone		N6 GCRR	529045	727934	5.41	5	5.73	5.87	0.14				5.73				5.81					5.86			
BH-3-27R	Monitoring well	Limestone		N6 GCRR	528960	728133	9.10	4	5.90	6.41	0.51																
RC133	Monitoring well	Limestone		N6 GCOB	529325	728185	11.66	23	5.73	8.16	2.43	7.91			6.19		7.53	7.46	6.71				6.30		7.91		7.90
RP-2-05D	Monitoring well	Limestone		N6 GCRR	529701	727145	19.96	15	5.73	7.78	2.06										6.59			6.14	7.63		7.78
RP-2-05S	Monitoring well	Limestone		N6 GCRR	529704	727141	20.22	17	8.86	12.01	3.15										8.86			10.06	12.01		11.94
BH972	Monitoring well	Limestone		N6 GCOB	529462	728292	12.33	2	7.41	8.20	0.79	7.41														8.20	
BH-3-29R	Monitoring well	Limestone		N6 GCRR	529489	728334	13.73	6	<6.83	9.23	>2.40																
SW-2-5	Eastern Coolagh Spring K45	Subsoil		N6 GCRR	529900	728162	7.06	5	7.55	7.63	0.08				7.60				7.63					7.60			
LQ MW6	Monitoring well	Limestone		Private	529919	727971	15.40	19	12.11	13.20	1.09			12.47	12.13			12.49	12.27					12.53	13.20		12.62
BH04	Monitoring well	Limestone		N6 GCRR	530151	728400	32.17	11	8.20	15.74	7.54															15.69	
BH05	Monitoring well	Limestone		N6 GCRR	530187	728378	34.14	11	8.08	19.46	11.38															18.63	
BH06	Monitoring well	Subsoil		N6 GCRR	530125	728383	30.80	11	15.20	27.97	12.77															15.20	
LQ MW5	Monitoring well	Limestone	Clare Corrib	Private	530389	728285	7.40	16	10.71	19.17	8.46				11.24			14.89	12.41				10.71		19.17		17.83
LQ MW4	Monitoring well	Limestone		Private	530522	728557	16.76	21	8.71	15.41	6.70		10.40	10.08		8.71		11.06	9.27		10.36		8.93		13.93		15.31
RC 1104	Monitoring well	Limestone		N6 GCOB	531165	728927	9.39	11	7.24	8.56	1.32				7.36			8.46	7.91				7.62				
BH-3-31R	Monitoring well	Limestone		N6 GCRR	531274	728424	11.08	3	9.45	9.78	0.33																

Monitoring Point	Hydrogeological feature	Geology	Groundwater Body	Source	Easting ITM	Northing ITM	Ground Elevation (mOD)	No. of Records	Seasonal Variation			Monthly Water Level Record 2015															
									m OD		m	m OD															
									Min	Max	Range	Feb-15	Apr-15	Jun-15			Jul-15		Aug-15		Sep-15	Oct-15			Nov-15	Dec-15	
												26th	26th	4th	24th	25th	21st	22nd	20th	21st	29th	14th	15th	16th	18th	15th	21st
RC206	Monitoring well	Limestone		N6 GCRR	531237	729433	28.49	17	19.26	21.10	1.84				19.26			21.03	21.02		21.02		21.02		21.09		21.08
SW-2-01	Ballindooley Lough	Subsoil		N6 GCRR	531620	728723	8.43	5	8.67	9.94	1.27			9.07					9.02					9.04			
RP-2-03	Monitoring well	Limestone		N6 GCRR	531478	728278	22.44	16	4.95	9.23	4.28										6.51			5.50	9.09		8.26
RP-2-01	Monitoring well	Limestone		N6 GCRR	531726	728689	21.38	17	7.86	10.28	2.42										8.15		8.50		10.09		10.28
BH-3-46R	Monitoring well	Limestone		N6 GCRR	531750	728392	29.81	8	16.79	17.32	0.53																
RC 1206	Monitoring well	Limestone		N6 GCRR	531986	729388	27.67	16	17.05	19.45	2.40	19.45			17.08			17.18	17.11			17.10			17.25		17.25
BH-3-32R	Monitoring well	Limestone		N6 GCRR	531971	728318	24.43	7	<9.43	10.24	>0.81																
RC 1211	Monitoring well	Limestone		N6 GCRR	532454	729601	25.91	15	20.25	22.03	1.78	21.09			20.25			20.76	20.51				20.28		21.05		21.03
BH-3-34R	Monitoring well	Limestone		N6 GCRR	532405	728275	32.57	7	19.69	25.91	6.22																
BH-3-35R	Monitoring well	Limestone		N6 GCRR	532851	728226	17.52	7	7.91	9.15	1.24																
BH-3-47R	Monitoring well	Limestone	Clarinbridge	N6 GCRR	533062	728286	37.74	5	27.55	27.74	0.19																
BH-3-36R	Monitoring well	Limestone		N6 GCRR	533125	728205	51.78	13	32.80	34.00	1.20																
RC-2-02	Monitoring well	Limestone		N6 GCRR	533685	728102	54.92	5	44.02	44.61	0.59																
GRC2	Supply well (W50-13)	Limestone		Private	533934	727949	53.22	11	5.11	10.99	5.88														10.99		
BH-3-38R	Monitoring well	Limestone		N6 GCRR	534249	727541	45.17	18	42.21	43.83	1.62																
BH-3-40R	Monitoring well	Limestone		N6 GCRR	534439	727295	42.39	13	39.20	39.89	0.69																
BH-3-41R	Monitoring well	Limestone		N6 GCRR	534580	727065	41.49	15	35.57	38.36	2.79																
BH-3-42R	Monitoring well	Limestone		N6 GCRR	534756	726840	32.60	17	22.68	30.12	7.44																
BH-3-48R	Monitoring well	Limestone		N6 GCRR	534397	727197	40.48	16	38.92	39.32	0.40																

Monitoring Point	Hydrogeological feature	Geology	Groundwater Body	Monthly Water Level Record 2016																									
				m OD																									
				Jan-16					Mar-16						Apr-16				May-16				Jun-16			Jul-16			
				5th	11th	14th	18th	19th	1st	3rd	11th	12th	16th	21st	6th	7th	8th	14th	10th	11th	13th	24th	8th	9th	13th	18th	20th	21st	22nd
RC422	Monitoring well	Granite	Spiddal				20.34		20.51						20.27				19.84				19.45				19.91		
RC435	Monitoring well	Granite					56.49		56.53						56.47				56.43				56.13				56.32		
RC451A	Monitoring well	Granite					69.97			69.98							69.81			69.61				69.44					69.43
RC 548	Monitoring well	Granite					50.64			50.73							50.62			50.11				49.71					50.39
RC 687	Monitoring well	Granite					69.06			69.07							69.05			69.01				68.78					69.16
RC 739	Monitoring well	Granite					58.82			58.86							58.85			58.74				58.45					58.67
BH-3-04R	Monitoring well	Granite									36.36			36.30				36.35				36.23			36.24	36.34			
BH-3-06R	Monitoring well	Granite									22.22							22.14				21.95			21.87	21.99			
BH-3-08R	Monitoring well	Granite									40.53							41.39				40.03			39.86	40.25			
BH-3-10R	Monitoring well	Granite																63.37				64.08			63.88	64.16			
BH-3-11R	Monitoring well	Granite									53.27			52.96				53.13				52.84			52.83	53.09			
BH-3-13R	Monitoring well	Granite																56.94				53.27			52.85	56.66			
BH-3-16R	Monitoring well	Granite																57.74				57.72			57.64	57.72			
BH-3-17R	Monitoring well	Granite	Maam-Clonbur											62.72				62.86				62.54			62.46	62.68			
BH-3-18R	Monitoring well	Granite												68.03				69.11							68.09	68.34			
BH-3-20R	Monitoring well	Granite																48.61				48.13			47.83	48.47			
BH-3-21	Monitoring well	Subsoil																36.44				36.21				36.49			
BH-3-23R	Monitoring well	Granite												23.46				22.62				22.38			22.32	22.93			
BH-3-24R	Monitoring well	Granite												22.64				22.77				21.76			21.92	21.91			
MW 01	Monitoring well	Limestone	Lough Corrib Fen 1					12.47	13.89						12.03				11.01				10.61				11.29		
MW 02	Monitoring well	Limestone						7.34	7.80							7.14			6.33				6.15				6.48		
MW 03	Monitoring well	Limestone						6.28	6.37						6.14				5.96				5.80				5.98		
SW-2-4	Western Coolagh Spring K25	Limestone										5.84											5.87						
BH-3-27R	Monitoring well	Limestone																6.41				6.13			5.90	6.20			
RC133	Monitoring well	Limestone						7.70	8.16						7.45				6.83					5.73			7.01		
RP-2-05D	Monitoring well	Limestone						7.70	7.48						7.28				7.03				6.88				7.02		
RP-2-05S	Monitoring well	Limestone						11.33	11.85						11.04				10.67				10.04				11.03		
BH972	Monitoring well	Limestone																											
BH-3-29R	Monitoring well	Limestone																7.54							dry	dry			
SW-2-5	Eastern Coolagh Spring K45	Subsoil										7.55															7.59		
LQ MW6	Monitoring well	Limestone						12.55							12.46				12.27				12.11				12.32		
BH04	Monitoring well	Limestone		14.29	15.74							12.52			11.78				9.46				8.20				9.84		
BH05	Monitoring well	Limestone		19.46	16.66							12.44			11.51				9.40				8.08				9.80		
BH06	Monitoring well	Subsoil		27.97	27.75							26.78			26.38				24.85				23.58				25.74		
LQ MW5	Monitoring well	Limestone	Clare Corrib					16.29	17.19						14.62				13.53				11.30				12.83		
LQ MW4	Monitoring well	Limestone			15.41			15.06	13.76						10.97				9.24				8.78				9.97		
RC 1104	Monitoring well	Limestone																		7.75				7.24				7.78	
BH-3-31R	Monitoring well	Limestone																9.55							9.45	9.78			

Monitoring Point	Hydrogeological feature	Geology	Groundwater Body	Monthly Water Level Record 2016																									
				m OD																									
				Jan-16					Mar-16						Apr-16				May-16				Jun-16			Jul-16			
				5th	11th	14th	18th	19th	1st	3rd	11th	12th	16th	21st	6th	7th	8th	14th	10th	11th	13th	24th	8th	9th	13th	18th	20th	21st	22nd
RC206	Monitoring well	Limestone						21.06	21.10							21.02				19.61				20.14				21.02	
SW-2-01	Ballindooley Lough	Subsoil										9.94																8.67	
RP-2-03	Monitoring well	Limestone						7.90	7.70							7.40				5.52				4.95				5.58	
RP-2-01	Monitoring well	Limestone						10.28	9.98							9.59				8.80				7.86				8.54	
BH-3-46R	Monitoring well	Limestone												17.03				17.10				17.06			16.81	17.07			
RC 1206	Monitoring well	Limestone						17.95	17.19							17.12				17.09				17.05					
BH-3-32R	Monitoring well	Limestone																dry				dry			dry	dry			
RC 1211	Monitoring well	Limestone						20.91	22.03							20.71				20.46				20.27				20.33	
BH-3-34R	Monitoring well	Limestone																25.05				24.79			24.53	25.91			
BH-3-35R	Monitoring well	Limestone																8.61				8.42			7.91	8.38			
BH-3-47R	Monitoring well	Limestone	Clarinbridge															27.69				27.58			27.55	27.74			
BH-3-36R	Monitoring well	Limestone											32.80					33.26				33.71		33.77	33.82	33.88		33.78	
RC-2-02	Monitoring well	Limestone																						44.02				44.59	
GRC2	Supply well (W50-13)	Limestone						9.03	8.60							7.13				5.85				5.16				5.87	
BH-3-38R	Monitoring well	Limestone									43.01		42.92					42.69				42.61		42.34	42.58	42.99		42.40	
BH-3-40R	Monitoring well	Limestone									39.69		39.40					39.39						39.24	39.31	39.70		39.32	
BH-3-41R	Monitoring well	Limestone									38.36		37.85					37.74						37.00	37.51	38.09		37.46	
BH-3-42R	Monitoring well	Limestone											29.93					29.68				29.93		29.78	29.50	30.12		29.75	
BH-3-48R	Monitoring well	Limestone									39.31		39.27					39.17						38.92	39.26	39.32		38.99	

Monitoring Point	Hydrogeological feature	Geology	Groundwater Body	Monthly Water Level Record 2016																	Monthly Water Level Record 2017			
				m OD																	m OD			
				Aug-16						Sep-16			Nov-16				Dec-16				Jan-17	Apr-17		
				18th	22nd	23rd	24th	25th	26th	28th	29th	30th	2nd	3rd	4th	9th	6th	7th	8th	9th	23rd	11th		
RC422	Monitoring well	Granite			20.17					20.43														
RC435	Monitoring well	Granite			56.37					56.54														
RC451A	Monitoring well	Granite							69.52	69.62														
RC 548	Monitoring well	Granite							50.57	50.43														
RC 687	Monitoring well	Granite							68.99	69.05														
RC 739	Monitoring well	Granite							58.78	58.86														
BH-3-04R	Monitoring well	Granite	Spiddal	36.28							36.32					36.70								
BH-3-06R	Monitoring well	Granite		21.95							22.01		22.07			22.13	21.97							
BH-3-08R	Monitoring well	Granite		39.85							39.85					40.36								
BH-3-10R	Monitoring well	Granite		63.92							64.07					64.66								
BH-3-11R	Monitoring well	Granite		52.86							52.94					53.10								
BH-3-13R	Monitoring well	Granite		53.99												57.12								
BH-3-16R	Monitoring well	Granite		57.67							57.88					58.45								
BH-3-17R	Monitoring well	Granite		62.48							62.49		62.93			62.50								
BH-3-18R	Monitoring well	Granite		68.06							68.16					68.34								
BH-3-20R	Monitoring well	Granite		47.98							48.08					48.48								
BH-3-21	Monitoring well	Subsoil	Maam-Clonbur													36.41								
BH-3-23R	Monitoring well	Granite		22.41							22.63					22.83								
BH-3-24R	Monitoring well	Granite		20.97							21.06					22.10								
MW 01	Monitoring well	Limestone				12.25				11.86					11.32			11.10						
MW 02	Monitoring well	Limestone				6.64				6.56					6.43			6.41						
MW 03	Monitoring well	Limestone				6.05				6.06	6.08				5.96			5.92				6.05		
SW-2-4	Western Coolagh Spring K25	Limestone																						
BH-3-27R	Monitoring well	Limestone																						
RC133	Monitoring well	Limestone				7.54				7.56	7.62		6.87			6.39	6.55					7.08		
RP-2-05D	Monitoring well	Limestone						7.41		5.73				6.97				6.80						
RP-2-05S	Monitoring well	Limestone	Lough Corrib Fen 1					11.23		11.45				10.96				10.71						
BH972	Monitoring well	Limestone																						
BH-3-29R	Monitoring well	Limestone		dry						dry						9.23								
SW-2-5	Eastern Coolagh Spring K45	Subsoil																						
LQ MW6	Monitoring well	Limestone					12.50			12.51	12.60			12.42			12.25							
BH04	Monitoring well	Limestone					11.47				10.38			9.55										
BH05	Monitoring well	Limestone					11.42				11.17			9.51										
BH06	Monitoring well	Subsoil					24.45				25.62			25.66										
LQ MW5	Monitoring well	Limestone					15.77							15.01			13.73					11.34		
LQ MW4	Monitoring well	Limestone	Clare Corrib				10.93							9.39			9.18							
RC 1104	Monitoring well	Limestone						8.08				8.56			7.71					7.63				
BH-3-31R	Monitoring well	Limestone																						

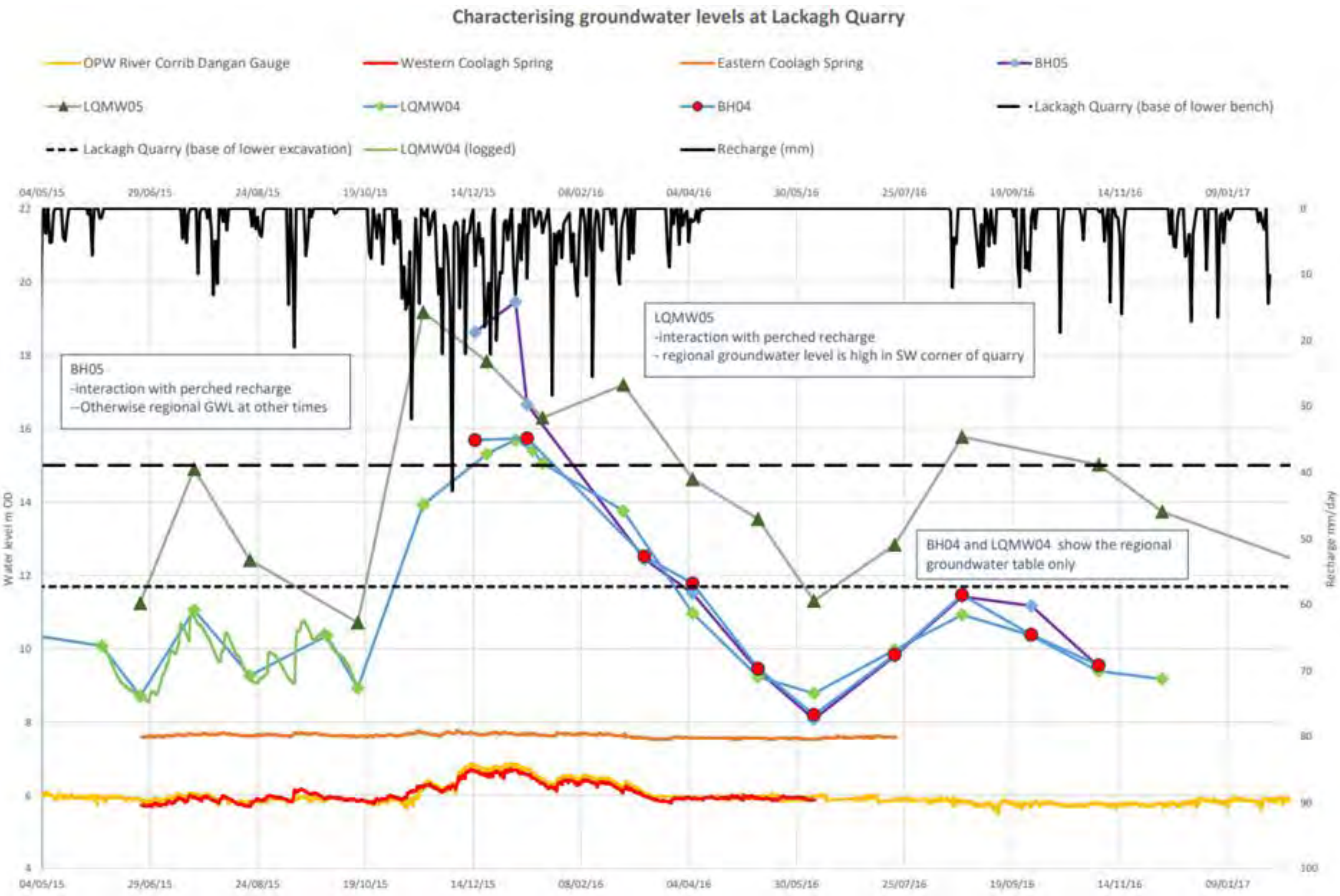
Monitoring Point	Hydrogeological feature	Geology	Groundwater Body	Monthly Water Level Record 2016																	Monthly Water Level Record 2017			
				m OD																	m OD			
				Aug-16						Sep-16			Nov-16				Dec-16				Jan-17	Apr-17		
				18th	22nd	23rd	24th	25th	26th	28th	29th	30th	2nd	3rd	4th	9th	6th	7th	8th	9th	23rd	11th		
RC206	Monitoring well	Limestone						21.03				21.02			21.03					21.02				
SW-2-01	Ballindooley Lough	Subsoil																						
RP-2-03	Monitoring well	Limestone			5.41					6.25					5.96									
RP-2-01	Monitoring well	Limestone			8.70						9.18				8.58				8.66					
BH-3-46R	Monitoring well	Limestone		16.79							16.81					17.32								
RC 1206	Monitoring well	Limestone						17.15				17.20			17.11				17.13					
BH-3-32R	Monitoring well	Limestone		10.24							dry					dry								
RC 1211	Monitoring well	Limestone						20.71				20.46												
BH-3-34R	Monitoring well	Limestone		19.69							24.07					24.87								
BH-3-35R	Monitoring well	Limestone		8.03							8.32					9.15								
BH-3-47R	Monitoring well	Limestone	Clarinbridge													27.72								
BH-3-36R	Monitoring well	Limestone	Clarinbridge	33.85			33.78				33.88	33.77				34.00	33.79							
RC-2-02	Monitoring well	Limestone	Clarinbridge					44.60				44.61	44.59											
GRC2	Supply well (W50-13)	Limestone	Clarinbridge					6.59				7.92		6.28					5.11					
BH-3-38R	Monitoring well	Limestone	Clarinbridge	42.55				42.51			42.67	42.88		42.44		43.83	42.43							
BH-3-40R	Monitoring well	Limestone	Clarinbridge	39.35			39.83				39.30		39.28			39.89			39.20					
BH-3-41R	Monitoring well	Limestone	Clarinbridge				38.29					37.44	35.57			38.32		37.31			37.65			
BH-3-42R	Monitoring well	Limestone	Clarinbridge	29.80							29.85	29.85	22.68			29.99		29.75			29.77			
BH-3-48R	Monitoring well	Limestone	Clarinbridge	39.24			39.06				39.22		39.00			39.32			38.98					

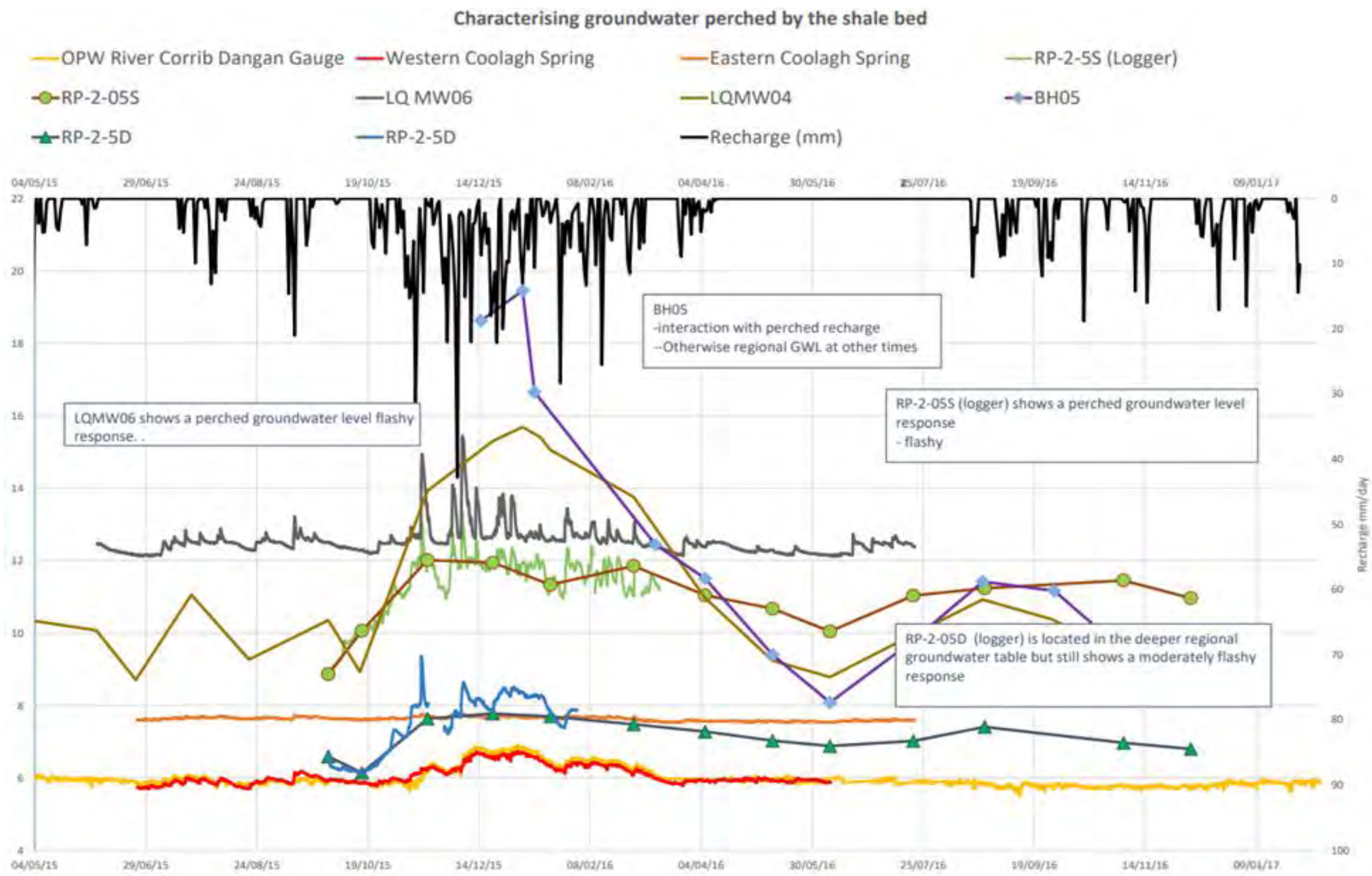
Monitoring Point	Hydrogeological feature	Geology	Groundwater Body	Monthly Water level Record 2023	Monthly Water level Record 2024		
				m OD	m OD		
				Nov-23	Jan-24	Mar-24	Jul-24
				15th	29th	21st	18th
RC422	Monitoring well	Granite	Spiddal				
RC435	Monitoring well	Granite					
RC451A	Monitoring well	Granite					
RC 548	Monitoring well	Granite					
RC 687	Monitoring well	Granite					
RC 739	Monitoring well	Granite					
BH-3-04R	Monitoring well	Granite		36.35	36.24		
BH-3-06R	Monitoring well	Granite		21.59			
BH-3-08R	Monitoring well	Granite					
BH-3-10R	Monitoring well	Granite					
BH-3-11R	Monitoring well	Granite					
BH-3-13R	Monitoring well	Granite					
BH-3-16R	Monitoring well	Granite					
BH-3-17R	Monitoring well	Granite	Maam-Clonbur	63.07	62.83		
BH-3-18R	Monitoring well	Granite		68.13	68.13		
BH-3-20R	Monitoring well	Granite					
BH-3-21	Monitoring well	Subsoil					
BH-3-23R	Monitoring well	Granite					
BH-3-24R	Monitoring well	Granite					
MW 01	Monitoring well	Limestone	Lough Corrib Fen 1				
MW 02	Monitoring well	Limestone					
MW 03	Monitoring well	Limestone		6.20	6.19		
SW-2-4	Western Coolagh Spring K25	Limestone					
BH-3-27R	Monitoring well	Limestone					
RC133	Monitoring well	Limestone		7.69	7.67		

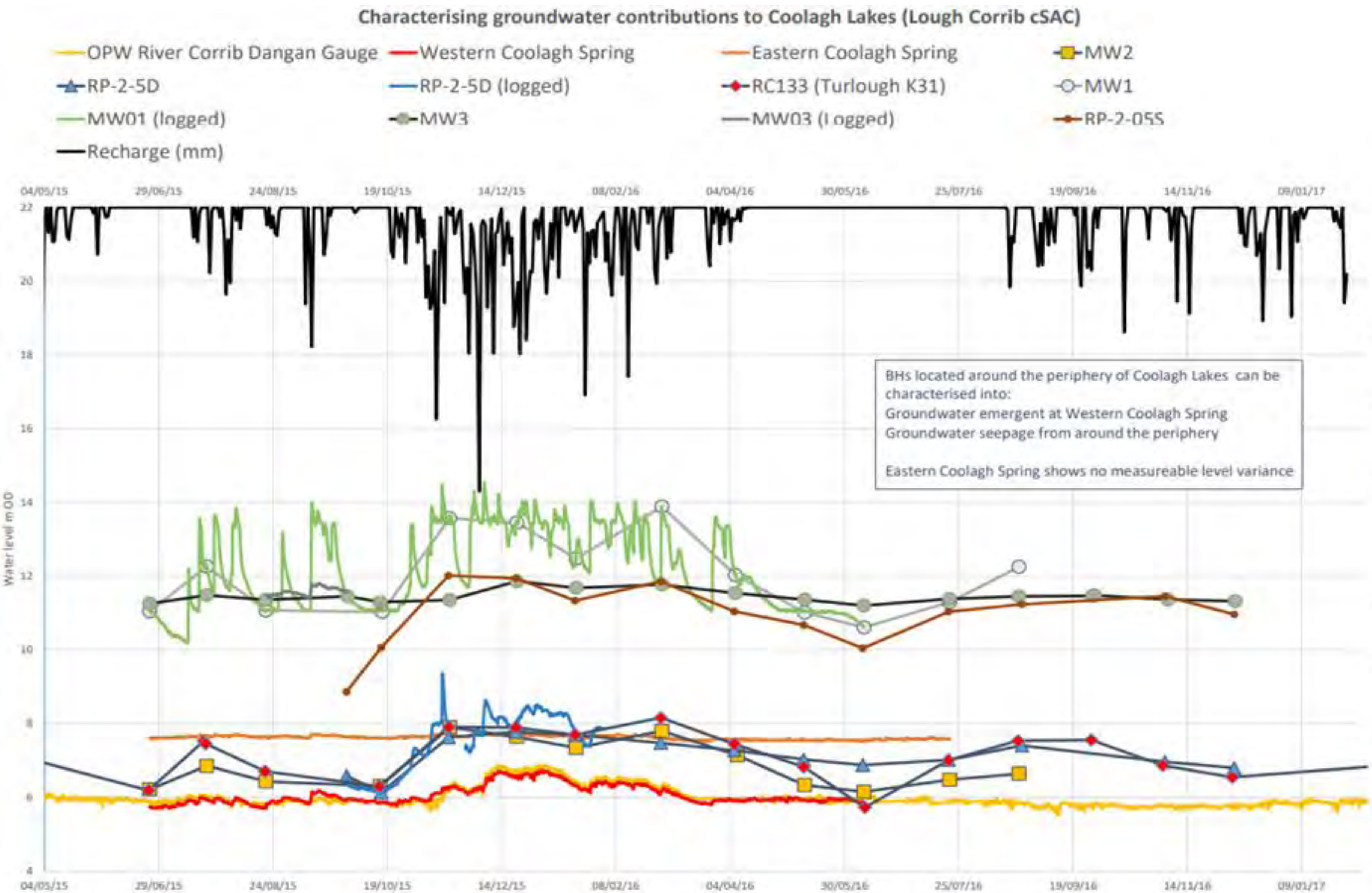
Monitoring Point	Hydrogeological feature	Geology	Groundwater Body	Monthly Water level Record 2023	Monthly Water level Record 2024		
				m OD	m OD		
				Nov-23	Jan-24	Mar-24	Jul-24
				15th	29th	21st	18th
RP-2-05D	Monitoring well	Limestone				6.85	
RP-2-05S	Monitoring well	Limestone		11.63	11.63	11.29	
BH972	Monitoring well	Limestone					
BH-3-29R	Monitoring well	Limestone					
SW-2-5	Eastern Coolagh Spring K45	Subsoil					
LQ MW6	Monitoring well	Limestone	Clare Corrib	12.60	12.40		
BH04	Monitoring well	Limestone					
BH05	Monitoring well	Limestone					
BH06	Monitoring well	Subsoil					
LQ MW5	Monitoring well	Limestone					
LQ MW4	Monitoring well	Limestone		13.83	12.23		
RC 1104	Monitoring well	Limestone					
BH-3-31R	Monitoring well	Limestone					
RC206	Monitoring well	Limestone					
SW-2-01	Ballindooley Lough	Subsoil					
RP-2-03	Monitoring well	Limestone		9.23	9.23	8.34	
RP-2-01	Monitoring well	Limestone		8.41	8.41	9.75	
BH-3-46R	Monitoring well	Limestone					
RC 1206	Monitoring well	Limestone					
BH-3-32R	Monitoring well	Limestone					
RC 1211	Monitoring well	Limestone					
BH-3-34R	Monitoring well	Limestone					
BH-3-35R	Monitoring well	Limestone					
BH-3-47R	Monitoring well	Limestone	Clarinbridge				
BH-3-36R	Monitoring well	Limestone					

Monitoring Point	Hydrogeological feature	Geology	Groundwater Body	Monthly Water level Record 2023	Monthly Water level Record 2024		
				m OD	m OD		
				Nov-23	Jan-24	Mar-24	Jul-24
				15th	29th	21st	18th
RC-2-02	Monitoring well	Limestone					
GRC2	Supply well (W50-13)	Limestone					
BH-3-38R	Monitoring well	Limestone		42.51	42.51		42.21
BH-3-40R	Monitoring well	Limestone					
BH-3-41R	Monitoring well	Limestone		38.30	38.34		
BH-3-42R	Monitoring well	Limestone		29.14	29.14		28.39
BH-3-48R	Monitoring well	Limestone		39.31	39.31		39.22

Annex B – Hydrographs

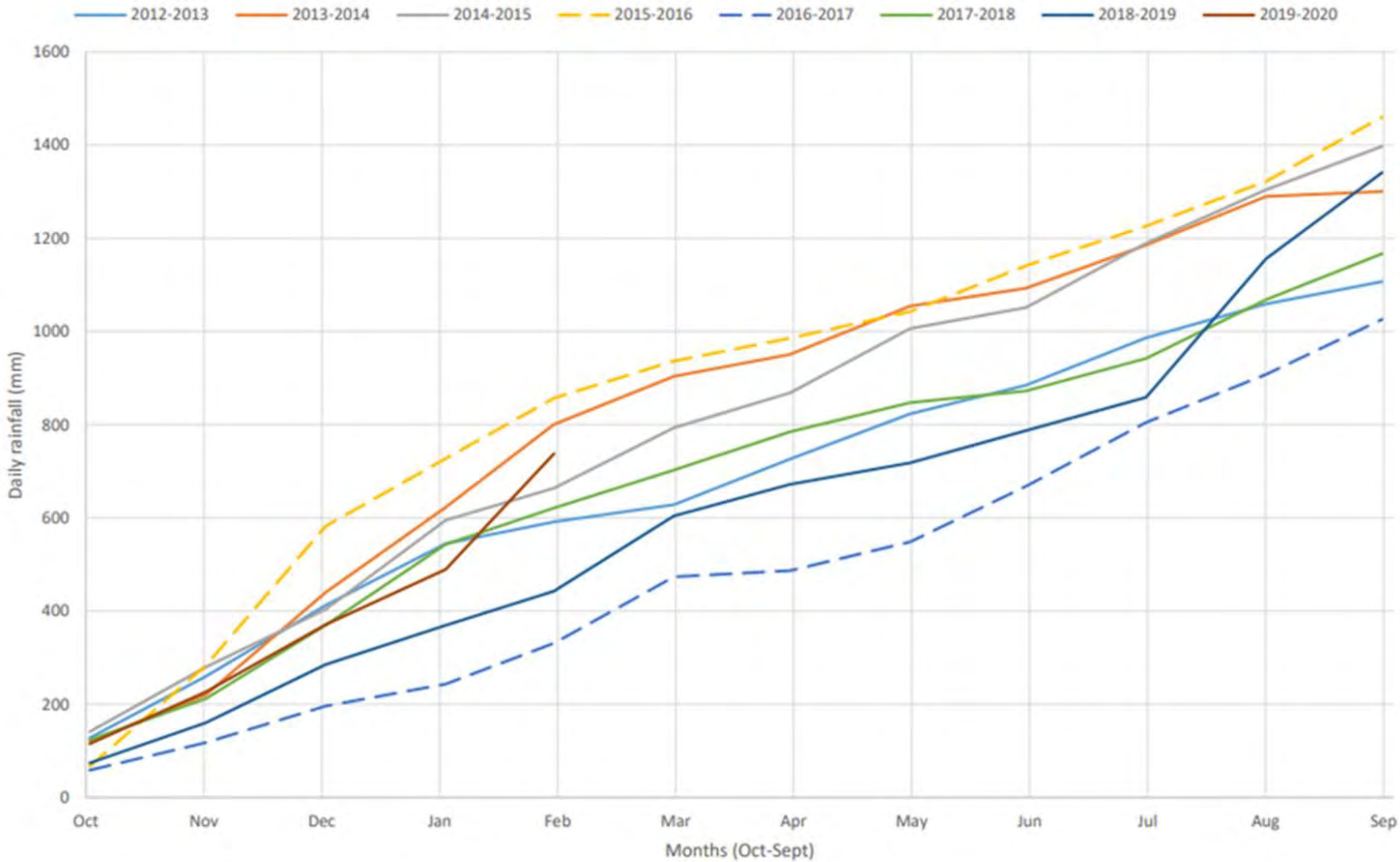

Characterising groundwater levels at Lackagh Quarry
OPW River Corrib Dangan Gauge
Western Coolagh Spring
Eastern Coolagh Spring
BH05
LQMW05
LQMW04
BH04
Lackagh Quarry (base of lower bench)
Lackagh Quarry (base of lower excavation)
LQMW04 (logged)
Recharge (mm)
BH05
-interaction with perched recharge
--Otherwise regional GWL at other times
LQMW05
-interaction with perched recharge
- regional groundwater level is high in SW corner of quarry
BH04 and LQMW04 show the regional groundwater table only
Water level m OD
Recharge mm/day
04/05/15
29/06/15
24/08/15
19/10/15
14/12/15
08/02/16
04/04/16
30/05/16
25/07/16
19/09/16
14/11/16
09/01/17


Characterising groundwater perched by the shale bed
OPW River Corrib Dangan Gauge
Western Coolagh Spring
Eastern Coolagh Spring
RP-2-5S (Logger)
RP-2-05S
LQ MW06
LQMW04
BH05
RP-2-5D
RP-2-5D
Recharge (mm)
BH05
-interaction with perched recharge
--Otherwise regional GWL at other times
LQMW06 shows a perched groundwater level flashy response. .
RP-2-05S (logger) shows a perched groundwater level response
- flashy
RP-2-05D (logger) is located in the deeper regional groundwater table but still shows a moderately flashy response
Recharge mm/day
04/05/15
29/06/15
24/08/15
19/10/15
14/12/15
08/02/16
04/04/16
30/05/16
25/07/16
19/09/16
14/11/16
09/01/17



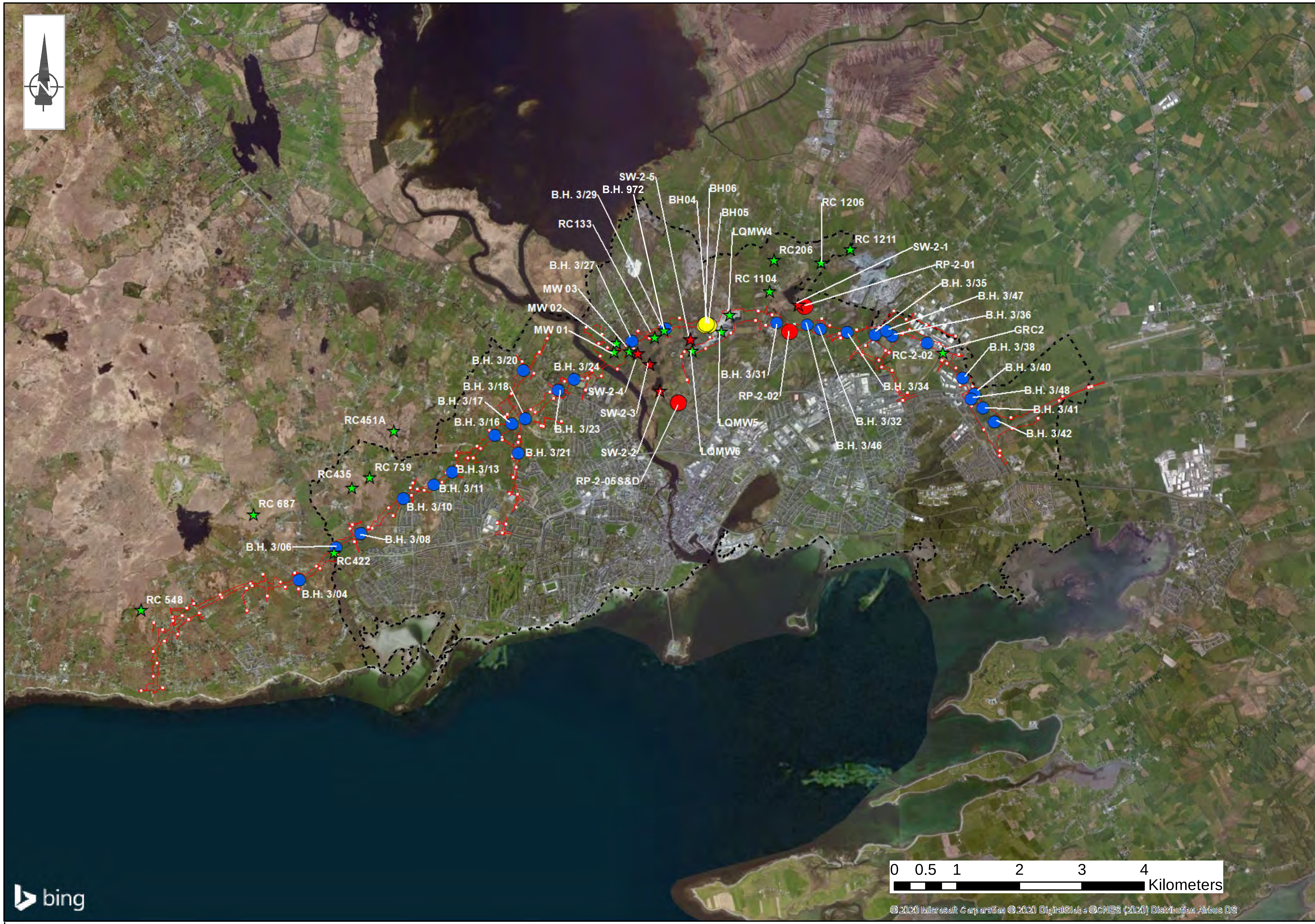
Characterising groundwater contributions to Coolagh Lakes (Lough Corrib cSAC)
OPW River Corrib Dangan Gauge
Western Coolagh Spring
Eastern Coolagh Spring
MW2
RP-2-5D
RP-2-5D (logged)
RC133 (Turlough K31)
MW1
MW01 (logged)
MW3
MW03 (Logged)
RP-2-05S
Recharge (mm)
BHs located around the periphery of Coolagh Lakes can be characterised into:
Groundwater emergent at Western Coolagh Spring
Groundwater seepage from around the periphery
Eastern Coolagh Spring shows no measureable level variance
Water level m OD
Recharge mm/day
04/05/15
29/06/15
24/08/15
19/10/15
14/12/15
08/02/16
04/04/16
30/05/16
25/07/16
19/09/16
14/11/16
09/01/17

Annex C – Cumulative rainfall plot 2015-2016 (wetter) and 2017-2018 (drier)


2012-2013
2013-2014
2014-2015
2015-2016
2016-2017
2017-2018
2018-2019
2019-2020
Daily rainfall (mm)
1600
1400
1200
1000
800
600
400
200
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Months (Oct-Sept)

Annex D – Figures

A3



FOR INFORMATION

Legend

- City Boundary
- Assessment boundary
- Pre-existing monitoring wells
- Monitoring wells installed as part of GI
- Additional monitoring wells installed at lackagh tunnel
- Surface water monitoring as sensitive limestone locations
- Wells at sensitive limestone locations

Clients

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Galway County Council
N6 Galway City Transport Project
An Roinn Iompair Turasóireachta agus Spóirt
TII

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Scale:

Date: **March 2020**

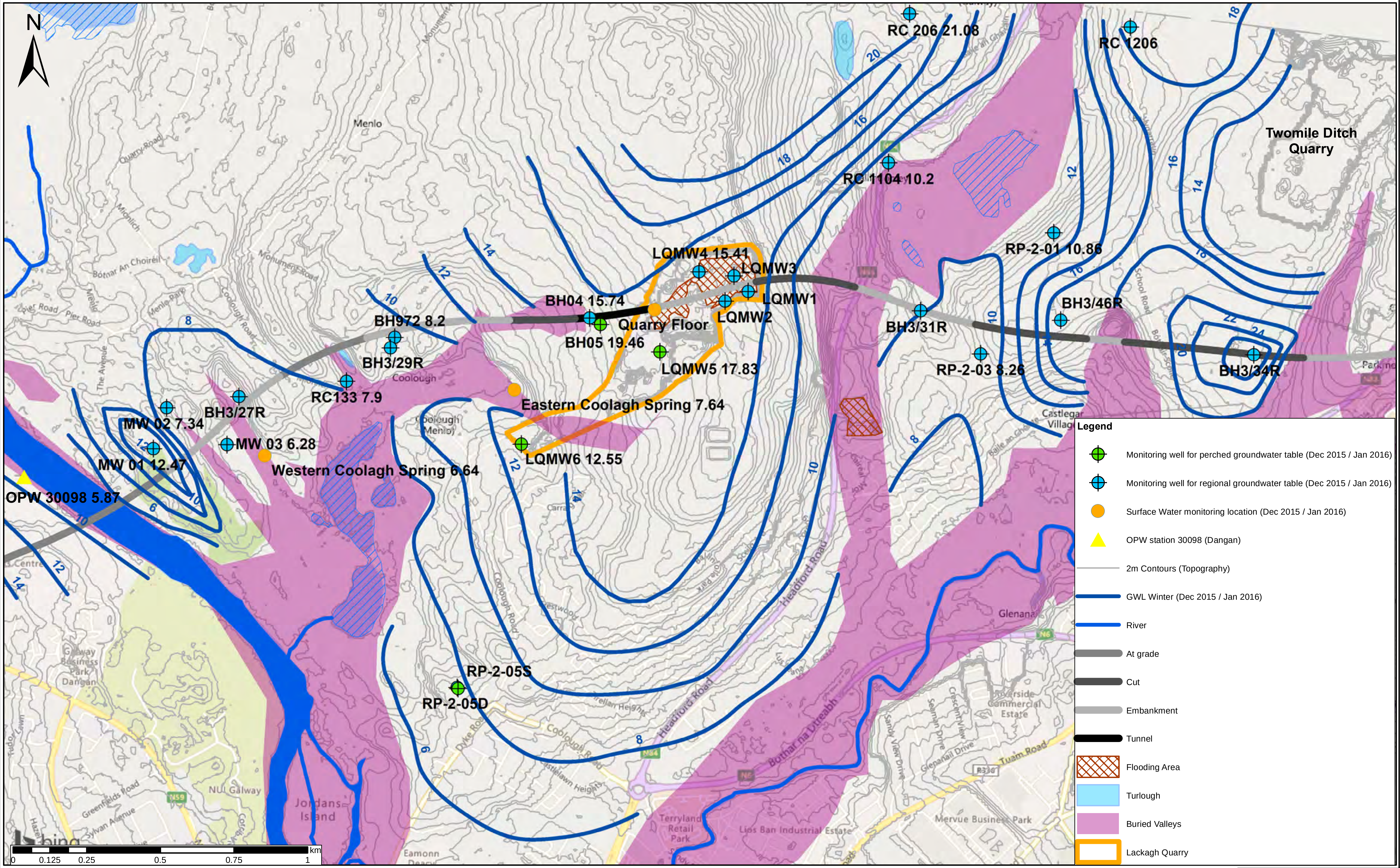
I1	06/03/2020	AG	LB	EMC
Issue	Date	By	Chkd	Appd

Locations of groundwater monitoring network

Drawing Status
For Information

Job No	Drawing No	Issue
233985-00	**Figure 1**	**I1**

A3



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Scale:

Date: **March 2020**

All elevations mOD

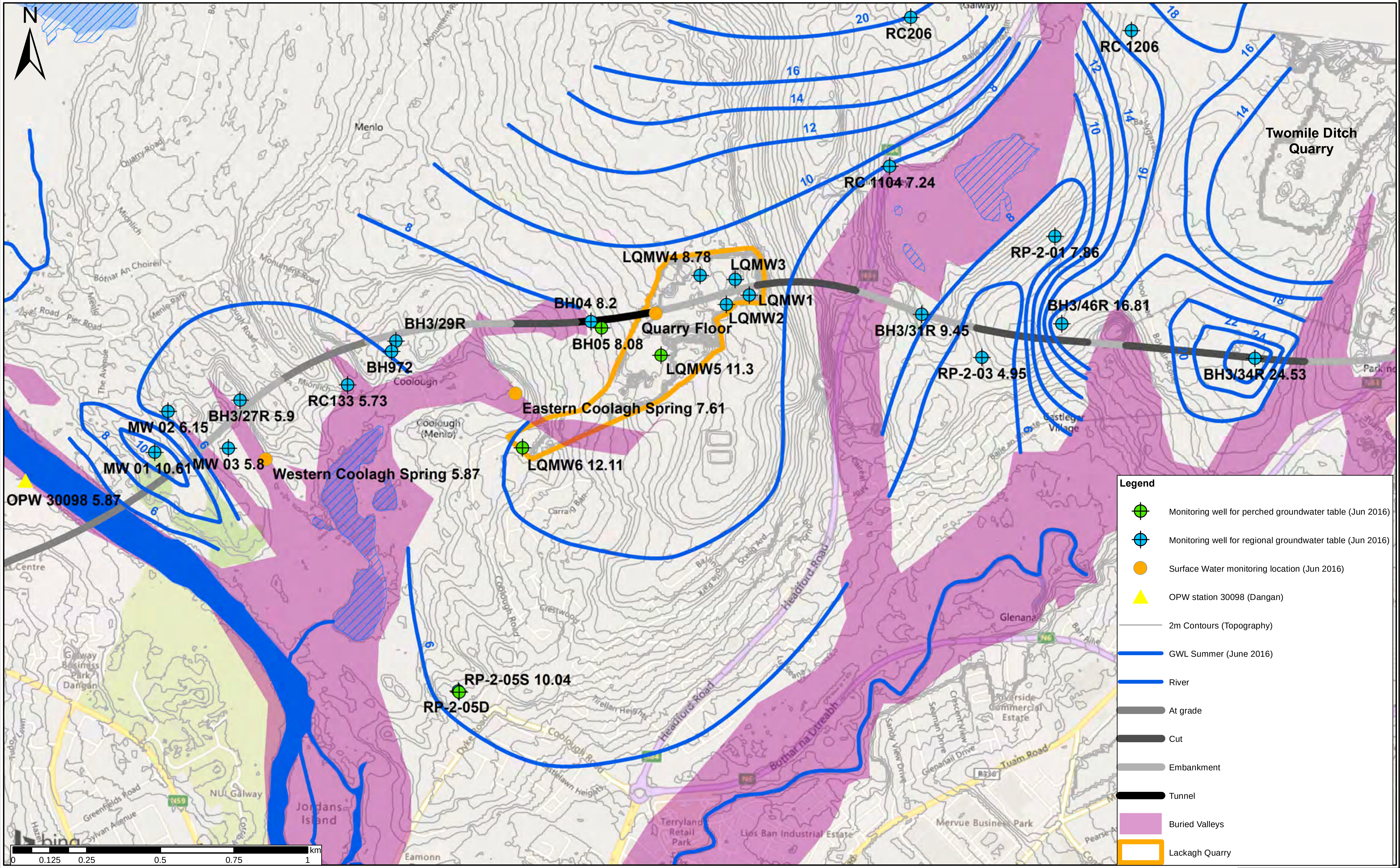
I1	04/03/2020	MK	LB	CB
Issue	Date	By	Chkd	Appd

Drawing Title
Winter Groundwater Levels

Drawing Status
For Information

Job No	Drawing No	Issue
233985-00	Figure 2	I1

A3



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Scale:
Date: March 2020

All elevations mOD

I1	04/03/2020	MK	LB	CB
Issue	Date	By	Chkd	Appd

Drawing Title
Summer Groundwater Levels

Drawing Status
For Information

Job No	Drawing No	Issue
233985-00	Figure 3	I1