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O'Callaghan Moran & Associates
ENVIRONMENTAL MANAGEMENT FOR BUSINESS

# APPROPRIATE ASSESSMENT

## STAGE 1 SCREENING

## PROPOSED LICENCE ALTERATION

## KILLARNEY WASTE DISPOSAL

## AUGHACURREEN

## COUNTY KERRY



**Prepared For: -**
Killarney Waste Disposal
Aughacurreen
County Kerry

**Prepared By: -**
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**November 2019**

| Project | Stage 1 Screening Assessment Aughacurreen | | | |
|---|---|---|---|---|
| Client | KWD | | | |
| Report No. | Date | Status | Prepared By | Reviewed By |
| 192330701 | 25/10/2019 | Initial Draft | Austin Hynes MSc | Jim O'Callaghan MSc |
| | 01/11/2019 | Final | | |
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## 1. INTRODUCTION

Killarney Waste Disposal, trading as KWD Recycling, intends to request the Environmental Protection Agency (EPA) to technically amend its waste licence (Reg No. W0217-01) to rectify a clerical error relating to the on-site surface water treatment system. The request must be accompanied by a screening for Appropriate Assessment in accordance with the document *`Appropriate Assessment of Plans and Projects in Ireland — Guidance for Planning Authorities',* issued in 2009 by the Department of the Environment, Heritage and Local Government, and revised in 2010.

### 1.1 Appropriate Assessment

The European Union (EU) Habitats Directive (92/43/EC) and the EU Birds Directive (2009/147/EC) identify designated areas (Special Areas of Conservation (SAC) and Special Protection Areas (SPA) respectively) that are collectively known as Natura 2000 Sites. The Habitats Directive, which is implemented under the European Communities Birds and Natural Habitats) Regulations 2011 (S.I. No 477 of 2011), requires an "appropriate assessment" of the potential impacts any proposed development that may have an impact on the conservation objectives of any Natura 2000 site.



Article 6(3) of the Directive stipulates that *any plan or project not directly connected with or necessary to the management of a Natura 2000 site, but likely to have a significant effect thereon…shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives.*

Guidance documents issued by Department of Environment, Heritage and Local Government and the National Parks and Wildlife Services recommend that the assessment be completed in a series of Stages, which comprise:

*Stage 1: Screening*

The purpose of this Stage is to determine, on the basis of a preliminary assessment and objective criteria, whether a plan or project, alone and in combination with other plans or projects, could have significant effects on a Natura 2000 site in respect of the site's conservation objectives.

*Stage 2: Appropriate Assessment*

This Stage is required if the Stage 1 Screening exercise identifies that the project is likely to have a significant impacts on a Natura 2000 site.

*Stage 3: Assessment of Alternative Solutions*.

If Stage 2 determines that the project will have an adverse impact upon the integrity of a Natura 2000 site, despite the implementation of mitigation measures, it must be objectively concluded that no alternative solutions exist before the plan can proceed.

*Stage 4: Compensatory Measures*:

Where no alternative solutions are feasible and where adverse impacts remain but imperative reasons of overriding public interest require the implementation of a project an assessment of compensatory measures that will effectively offset the damage to the Natura site 2000 is required.

KWD Recycling commissioned O'Callaghan Moran & Associates (OCM) to complete a Stage 1 Screening to determine the effects of the operation of the stormwater treatment plant on nearby Natura 2000 sites.

## 1.2 Methodology

The Screening Assessment was based on the nature and scale of the proposed development. It followed the guidance presented The DEHLG (2009, revised February 2010) Appropriate Assessment of Plans and Projects in Ireland and the NPWS (2010) Circular NPW 1/10 & PSSP 2/10 Appropriate Assessment under Article 6 of the Habitats Directive: Guidance for Planning Authorities. The information sources included

- National Parks & Wildlife Service (NPWS) - www.npws.ie
- Environmental Protection Agency (EPA) – www.epa.ie
- National Biodiversity Data Centre – www.biodiversityireland.ie
- Kerry County Council Development Plan 2011-2017.

## 2. PROJECT DESCRIPTION

KWD Recycling currently accepts, processes and stores non-hazardous residual mixed municipal waste, dry recyclables, food waste and construction and demolition waste. The licence limits the amount waste that can be accepted annually to 59,000 tonnes and the operational hours are 7.00am to 8.00pm Monday to Saturday.

The residual mixed municipal waste (black bin) is mechanically processed inside the main building to remove the organic and metal materials. The organic matter is loaded into a trailer parked inside the building and when this is full it is sent off site for biological treatment. The metals are baled on site and stored pending consignment to a recycling plant. The remaining materials are stored inside the building before being sent to other waste management facilities for further processing.

The dry recyclables are sorted and bulked and stored inside the main processing buildings and a separate bulk plastics shed before being sent off-site for further processing. The food waste (brown bin) is not handled at the site, apart from bulking up. The incoming waste is off-loaded directly into a trailer that is parked in a fully enclosed structure (compost bay). When the trailer is full it is sent to an off-site biological treatment facility.

The construction and demolition wastes are handled inside the main building, where they are sorted into the different parts, concrete rubble, metal, timber, plastics etc. The metals are then brought to the metal baling area where they are stored before being baled and cut for transport and then sent to metal recycling plants. The timber is brought to a timber storage yard, where it used to be shredded and stored before being sent off-site. The shredding stopped in 2016.



Water is obtained from the mains supply and electricity from a utility company. Sanitary wastewater is treated in an on-site treatment plant and the treated effluent discharged to ground. Diesel for the waste collection trucks and the plant used to handle the waste is stored in above ground tanks located at the southern boundary. Diesel for the on-site electricity generator is stored in an internal tank. With the exception of the timber and metals all wastes are stored inside buildings or fully enclosed structures.

### 2.1 Storm Water Drainage Systems

There are three separate storm water drainage systems. The first collects rainwater run-off from the roof of the materials recovery building and discharges it at two locations (R1 and R2 as authorised by the licence) to a drain that runs through the site.

Rainwater run-off from the operational areas where there is the potential for significant contamination to occur (bin washing area and compost bay), is directed to tow above ground holding tanks where it is stored pending removal from the site for off-site treatment in the Irish Water Wastewater Treatment Plant (WWTP) in Killarney.

Rainwater run-off from the yards where KWD Recycling considered the risk of contamination to be low, including the area around the metal and timber storage areas, is collected and directed to an on-site treatment system comprising three settlement tanks and a Class 1 Full Retention Oil Interceptor, two reed beds with the treated water discharging to a percolation area at an authorised location (SW-1). There is a manually operated shut-off valve on the outlet from the final reed bed that can be closed in the event of an on-site incident that has the potential to contaminate the stormwater drainage system.

### *2.1.1 Storm Water Treatment System*

The original treatment system was designed by Waste Works and comprised a reception tank and pumps, oil/water separator, settlement lagoon and wetland. Subsequently the layout was reconfigured by installing an additional lagoon and converting the original lagoon to a settlement pond. Due to the method of lagoon construction method, de-sludging was not efficient and in 2015 KWD Recycling commissioned Waste Works, who had designed the original system to carry out upgrades. The proposed design is in Appendix 1 and it comprised;

- A second oil/water separation tank
- New solids settlement tank 30m$^3$ (primary treatment)
- New aeration tank 30m$^3$ (first stage secondary treatment)
- New sludge settlement tank 30m$^3$
- New vertical flow reed bed (second-stage secondary treatment) in place of the lagoon
- No change to existing wetland (tertiary treatment)
- No change to the existing percolation area and discharge point.



An assessment of the upgrade completed by Waste Works in September 2015 concluded the system was operating as a vertical flow reed bed/percolating filter under mainly aerobic conditions and was very effective at reducing the level of suspended solids and biochemical oxygen demand (BOD) and the ammonia levels were expected to reduce over time. A copy of the Waste Works assessment report is in Appendix 1.

In 2015 the Office of Environmental Enforcement (OEE) instructed KWD Recycling to cease operating the aeration and sludge settlement tanks. KWD Recycling complied with the instruction; however the aerator remains functional. The aeration and sludge settlement tanks now serve as additional solids settlement units.

## 2.2 Foul Water Drainage System

There is no connection to the municipal foul sewer and sanitary wastewater was originally treated in an on-site septic tank located to the north-west of the weighbridge. In 2016 this was replaced by a proprietary wastewater treatment system (puraflo) located close to the northern site boundary, with the treated effluent pumped to an on-site raised percolation area (SE-1) in the north-west of the site. Details of the proposed system were submitted to and approved by the OEE as a specified engineering works. The septic tank was decommissioned.

Samples of the treated effluent that discharges to the percolation area are collected and analysed to assess performance and in compliance with Schedule 3.3.3 of the licence. The monitoring has

confirmed that the treatment system meets the manufacturer's performance specification and those set in the EPA's Guidance Manual on Wastewater Treatment Systems for Single Houses.

Liquid seeps from the waste handled inside the materials recovery building is collected in an underground effluent holding tank (6.92m$^3$). The tank is made of pre-cast concrete and sits in a second underground concrete tank that acts as a containment bund. The wastewater accumulating in the holding tank is removed for treatment at an off-site Irish Water WWTP.

Liquid seeps from the food waste storage area are collected in a sump and pumped to an above ground, double skinned, storage tank (2.5m$^3$). The wastewater accumulating in the tank is removed for treatment at the Irish Water WWTP.

Bins and trucks are pressure washed in a contained area (un-roofed) with separated drainage connecting to a below-ground pump chamber, from where it is pumped to an above ground covered holding tank (9m$^3$), where it is stored pending consignment to the Irish Water WWPT for treatment. The holding tank has the capacity to store washwater generated over a five-day period, along with rainwater run-off during the same period.

As required by Condition 3.19 of the licence all of the storage tanks whose contents comprise environmentally significant materials, are fitted with high-level alarms. In addition, the tanks are subject to regular inspection to ensure the contents are removed for off-site treatment as required and that there is always adequate retention capacity. Given the quality of the treated storm water in the reed beds high level alarms are not considered necessary.

## 3. NATURA 2000 SITES

SACs are selected for the conservation and protection of habitats listed on Annex I and species (other than birds) listed on Annex II of the Habitats Directive, and their habitats. The habitats listed in Annex I require special conservation measures. SPAs are selected for the conservation and protection of bird species listed on Annex I of the Birds Directive and regularly occurring migratory species, and their habitats, particularly wetlands. The selected habitats and species are termed Qualifying Interests.

A statement of Conservation Objectives is prepared for each designated site which identifies the qualifying interests or conservation features. The Conservation Objectives are intended to ensure that the relevant habitats and species present on a site are maintained, and where necessary restored, at a Favourable Conservation Status.

Favourable Conservation Status of a habitat, as defined in 2011 Birds and Natural Habitats Regulations, is when:

- Its natural range, and area it covers within that range, are stable or increasing,
- The specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and
- The conservation status of its typical species is favourable



Conservation Status of a species is when:

- The Favourable population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats,
- The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

There are three Natura 2000 sites within 10 km of the site, as listed in Table 3.1 and shown on Figure 3.1. The closest are the Castlemaine Harbour SAC, the Killarney National Park, McGillicuddy Reeks and Caragh River Catchment SAC, and the Killarney National Park SPA

**Table 3.1 Natura 2000 Sites**

| Natura 2000 Site | Site Code | Distance |
|---|---|---|
| Castlemaine Harbour SAC | 000343 | 3.7 km North |
| Killarney National Park, McGillicuddy Reeks and Caragh River Catchment SAC | 000363 | 4 km South |
| Killarney National Park SPA | 004038 | 4 km South |

### 3.1 Castlemaine Harbour SAC

*Qualifying Interests*

The Castlemaine Harbour SAC contains a high diversity of habitats and plant communities, including habitats and species listed on Annex I/II of the E.U. Habitats Directive. The habitats and species of conservation interest are listed in Table 3.2 and the Site Synopsis is in Appendix 1.

**Table 3.2**

| Habitat/Species | Code |
|---|---|
| Estuaries | 1130 |
| Tidal Mudflats and Sandflats | 1140 |
| Annual Vegetation of Drift Lines | 1210 |
| Perennial Vegetation of Stony Banks | 1220 |
| Vegetated sea cliffs of the Atlantic and Baltic Coasts | 1230 |
| *Salicornia* Mud | 1310 |
| Mediterranean Salt Meadows | 1330 |
| Embryonic Shifting Dunes | 2110 |
| Marram Dunes (White Dunes) | 2120 |
| Fixed Dunes (Grey Dunes) | 2130 |
| Dunes with Creeping Willow | 2170 |
| Humid Dune Slacks | 2190 |
| Alluvial Forests | 91E0 |
| Sea Lamprey *(Petromyzon marinus)* | 1095 |
| River Lamprey *(Lampetra fluviatilis)* | 1099 |
| Atlantic Salmon *(Salmo salar)* | 1106 |
| Otter *(Lutra lutra)* | 1355 |
| Petalwort *(Patalophyllum ralfsii)* | 1395 |



*Conservation Objectives*

The conservation objective is to maintain or restore the favorable conservation condition of the Annex I habitat(s) and/or the Annex II species for which the SAC has been selected is accessible at: https://www.npws.ie/protected-sites/sac/000343

### 3.2 Killarney National Park, MacGillicuddy Reeks and Caragh River Catchment SAC

*Qualifying Interests*

The Killarney National Park, MacGillycuddy Reeks and Caragh River Catchment SAC contains a high diversity of habitats and plant communities, including habitats and species listed on Annex I/II of the E.U. Habitats Directive. The habitats and species of conservation interest are listed in Table 3.3 and the Site Synopsis is in Appendix 1.

Table 3.3

| Habitat/Species | Code |
|---|---|
| Oligotrophic Waters containing very few minerals | 3110 |
| Oligotrophic to Mesotrophic Standing Waters | 3130 |
| Floating River Vegetation | 3260 |
| Wet Heath | 4010 |
| Alpine and Subalpine Heaths | 4060 |
| Juniper Scrub | 5130 |
| Calaminarian Grassland | 6130 |
| *Molinia* Meadows | 6410 |
| Blanket Bogs (Active) | 7130 |
| Rhyncosporion Vegetation | 7150 |
| Old Oak Woodlands | 91A0 |
| Alluvia Forests | 91E0 |
| Yew Woodlands | 91J0 |
| Kerry Slug *(Geomalacus maculosus)* | 1024 |
| Freshwater Pearl Mussel *(Margaritifera margaritifera)* | 1029 |
| Marsh Fritillary *(Euphydryas marinus)* | 1065 |
| Sea Lamprey *(Petromyzon marinus)* | 1095 |
| Brook Lamprey *(Lampetra planeri)* | 1096 |
| River Lamprey *(Lampetra fluviatilis)* | 1099 |
| Twaite Shad *(Alosa falax)* | 1103 |
| Atlantic Salmon (*Salmo salar)* | 1106 |
| Lesser Horseshoe Bat *(Rhinolophus hipposideros)* | 1303 |
| Otter *(Lutra lutra)* | 1355 |
| Killarney Fern *(Trichomanes speciosum)* | 1421 |
| Slender Naiad *(Naja flexilis)* | 1833 |



*Conservation Objectives*
The conservation objective is to maintain or restore the favorable conservation condition of the Annex I habitat(s) and/or the Annex II species for which the SAC has been selected is accessible at:

https://www.npws.ie/protected-sites/sac/000365

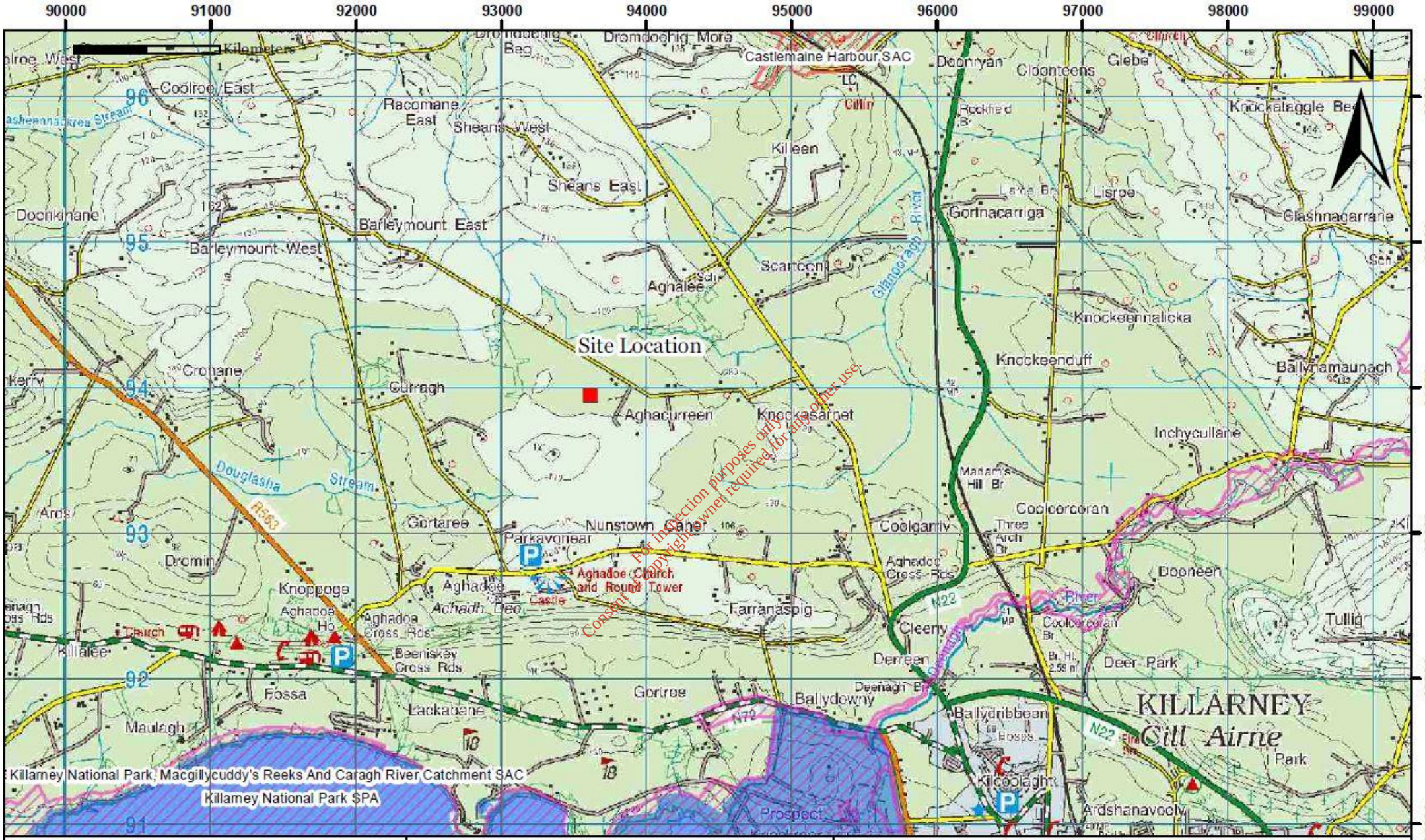
## 3.3 Killarney National Park SPA

Qualifying Interests
The Killarney National Park SPA is regarded as of special conservation interest for the following species;

- Greenland White-fronted Goose
- Marlin

*Conservation Objectives*

https://www.npws.ie/protected-sites/spa/004038

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CLIENT
Killarney Waste Disposal

TITLE
Natura 2000 Sites

Details:
- Site Location
- Castlemaine Harbour SAC
- Killarney National Park, Macgillycuddy's Reeks And Caragh River Catchment SAC
- Killarney National Park SPA

Figure 3.1

## 4. LIKELY EFFECTS

### 4.1 Environmental Setting

The site is in the catchment of the Glanooragh River. The Glanooragh is part of the 'Glanooragh, Trib of Laune' Water Body designated in the Southwestern River Basin District Plan. The Water Body is ranked as being of 'Poor' Status based on the overall ecological status and is 'At Risk' of not meeting its objective of 'Restore' by 2021.

A local high point, approximately 500m to the south-west of the site, forms a watershed between tributaries of the Glanooragh River to the north and the Douglasha Stream to the west. A surface water drain which flows through the site joins a tributary of the Glanooragh River, approximately 250m from the site.

The site is underlain by a peat and low permeability till that range in thickness from 3m in the east to 5m in the west of the site. The subsoils are not significantly water bearing and the underlying bedrock is classified as a 'Locally Important aquifer' bedrock, which is moderately productive only in Local Zones.

Permeability in the bedrock is highest in the upper few metres, but generally decreases rapidly with depth. Groundwater flow paths are generally short, typically 10s -100s of meters, with groundwater typically discharging to small springs, or streams. The water levels recorded in the on and off-site monitoring wells indicate confined conditions beneath the site, with artesian conditions to the north of the site. The direction of groundwater flow is from south to north.



Rainwater run-off from the roof of the main processing building discharges at two locations (R1 and R2) authorised in the licence to the drain that runs through the site. Treated sanitary wastewater from the on-site proprietary wastewater treatment system and the treated storm water from the discharge to ground at the locations (SE-1 and SW-1 respectively) authorised in the licence.

### 4.2 Potential Direct and Cumulative Effects

The facility is not located in or adjacent to a Natura 2000 Site. The closest Natura 2000 Site where there is a potential pathway from the facility is the Castlemaine Harbour SAC, 3.7km to the north. The drain that runs through the facility connects to a tributary of the Glanooragh River, which itself is a tributary of the River Laune. The majority of the Laune catchment is in the Castlemaine Harbour SAC.

The rainwater run-off from the roof of the main processing area is the only direct discharge to the drain that runs through the site. The treated stormwater and sanitary wastewater discharge to separate percolation areas. Given the confined conditions, which inhibit vertical migration it is likely that shallow groundwater in the subsoils in the vicinity of the sanitary waste water and storm water percolation areas discharges to the drain.

### 4.3 Assessment of Effects

The Castlemaine Harbour SAC is the only Natura 2000 Site where there is a pathway (surface water drain and tributary of the Glanooragh River) between it and the KWD Recycling facility. As referred to above, the rainwater run-off from the roof of the main processing building is the only direct discharge to the drain and this is weather dependent and periodic.

Details of the proposed sanitary waste water treatment system were submitted to and approved by the OEE as a specified engineering works. Samples of the treated effluent that discharges to the percolation area (SE-1) are collected and analysed to assess performance and in compliance with Schedule 3.3.3 of the licence. The monitoring has confirmed that the treatment system meets the manufacturer's performance specification and those set in the EPA's Guidance Manual on Wastewater Treatment Systems for Single Houses.

Samples of the treated stormwater discharging to the percolation area (SW-1) are collected weekly and analysed. The licence does not specify any emission limit values, but it does require the establishment of suitable trigger levels. Action and warning trigger levels were calculated based on the results of the monitoring carried out between January 2018 and May 2019. The data set are in Appendix 3 and the proposed trigger levels for the parameters for which there was sufficient data to calculate trigger levels in accordance with the EPA guidance are in Table 4.1.

**Table 4.1 Treated Stormwater Trigger Levels**

| Parameter | Warning Limit | | Action Limit | |
|---|---|---|---|---|
| pH | 6.82 | 7.54 | 6.64 | 7.73 |
| Conductivity | 517 µS/cm | | 614 µS/cm | |
| Total Ammonia | 0.47 mg/l | | 0.63 mg/l | |
| TSS | 22.32 | | 31.42 | |
| Chloride | 38.34 mg/l | | 45.49 mg/l | |
| Sulphate | 90.47 mg/l | | 116.44 mg/l | |
| COD | 81.23 mg/l | | 97.66 mg/l | |



It should be noted that as the treated stormwater discharges to ground an exceedance of the Action Limit does not automatically mean that there is a risk of polluting the groundwater, as the assimilative capacity of the percolation area and underlying soils have not been factored into the trigger limit calculations

A hydrogeological assessment of the site completed in February 2017 in response to OEE concerns relating to elevated ammonia levels in the groundwater concluded that there are naturally occurring reducing conditions in the bedrock aquifer and that groundwater quality was not being impacted by the site operations, including the authorised discharges to ground. A copy of the report, which includes a Conceptual Site Model and Source-Pathway-Receptor assessment is in Appendix 4. The subsequent groundwater monitoring has confirmed that site activities are not impacting on groundwater.

Condition 6.15.6 of the licence requires KWD Recycling to undertake an investigation of the suitability of the current storm water drainage and treatment system. This was carried out in 2019 and involved the collection of samples in August and September at the locations shown on Drawing 19015-SUR 0001 and described in Table 4.2.




| Location | Frequency of Sampling and Analysis | Description | ITM E | ITM N |
|---|---|---|---|---|
| D3 | Quarterly | Dust Monitoring | 493588.6371 | 593924.0396 |
| D2 | Quarterly | Dust Monitoring | 493467.8960 | 594022.9016 |
| D1 | Quarterly | Dust Monitoring | 493554.3004 | 594045.9564 |
| R1 | Weekly | Roof Water | 493659.5184 | 593961.4757 |
| R1 u/s | Biannually | Roof Water Upstream | 493658.1607 | 593969.2332 |
| R1 d/s | Biannually | Roof Water Downstream | 493789.1906 | 594067.8318 |
| R2 | Weekly | Roof Water | 493603.1721 | 593989.2662 |
| R2 u/s | Biannually | Roof Water Upstream | 493474.9604 | 594015.3886 |
| R2 d/s | Biannually | Roof Water Downstream | 493597.7734 | 594057.3921 |
| SW1 | Weekly | Stormwater | 493526.3484 | 594021.2051 |
| P1/EFF | Annually | Process effluent (show or roof of main building over entrance) | 493590.5977 | 593957.2998 |
| SE1 | Biannually | Sanitary Effluent | 493545.5448 | 594053.5805 |
| SP u/s | Biannually | Percolation Area u/s | 493509.2847 | 594033.6267 |
| SP d/s | Biannually | Percolation Area d/s | 493555.6436 | 594073.1319 |
| A1 | Quarterly | Air Emission Point from Negative Air system | 493554.3000 | 593949.8000 |
| MW1 | Biannually | Groundwater Monitoring | 493693.6075 | 594041.7415 |
| MW2 | Biannually | Groundwater Monitoring | 493640.2043 | 594082.4525 |
| MW3 | Biannually | Groundwater Monitoring | 493547.8337 | 593992.9229 |
| MW4 | Biannually | Groundwater Monitoring | 493562.0725 | 593934.5021 |

| REV | DATE | REVISION INFO. |
|---|---|---|
| | | |

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CHARTERED ENGINEER

CLIENT: KWD

PROJECT: WASTE TRANSFER FACILITY AT AUGHACURREEN, KILLARNEY, COUNTY KERRY

DRAWING: SITE PLAN

SCALE: As Shown@A3 DATE: 29/08/2019

Dwg No.: 19015-SUR-0001

**Table 4.2 Surface Water Sample Locations**

| Sample | Location | Rationale |
|---|---|---|
| R1 D/S | North-east of facility | Assess quality of surface water after the discharge point from the roof of the processing building. |
| R1 U/S | North-east Corner of Processing building | Assess surface water quality upstream of the discharge point from processing building roof. |
| R2 U/S | Upstream in drain to the west of the facility | Assess surface water upstream of the site. Provides background water quality |
| R2 D/S | Field drain to the north of site boundary. Downstream of facility | Assess surfaces water in field drain after runoff from site. |

The results are presented in Table 4.3.

**Table 4.3: Surface Water Monitoring Results**

| Date | 21/08/2019 | | | | 04/09/2019 | |
|---|---|---|---|---|---|---|
| **Sample** | **R1 U/S** | **R1 D/S** | **R2 D/S** | **R2 U/S** | **R1 U/S** | **R2 U/S** |
| Coliforms | Dry | 3448 | 2359 | 410 | Dry | |
| Faecal Coliforms | Dry | 158 | 262 | 41 | Dry | |
| Conductivity (uS/cm) | Dry | 327 | 259 | 210 | Dry | 174 |
| pH | Dry | 7.5 | 7.1 | 6.8 | Dry | 7.2 |
| Total Ammonia (mg/L) | Dry | 1.1 | 0.45 | 0.39 | Dry | 0.22 |
| TSS (mg/L) | Dry | | | | Dry | 7 |
| BOD (mg/L) | Dry | | | | Dry | 1.1 |
| COD (mg/L) | Dry | | | | Dry | 83 |
| Chloride (mg/L) | Dry | | | | Dry | 19 |
| Sulphate (mg/L) | Dry | | | | Dry | 24.9 |
| Total Nitrogen (mg/L) | Dry | | | | Dry | 1.63 |
| Arsenic (ug/L) | Dry | | | | Dry | 1 |
| Cadmium (ug/L) | Dry | | | | Dry | < 0.45 |
| Chromium (ug/L) | Dry | | | | Dry | < 1 |
| Copper (mg/L) | Dry | | | | Dry | 2 |
| Lead (ug/L) | Dry | | | | Dry | < 1 |
| Mercury (ug/L) | Dry | | | | Dry | < 0.5 |
| Nickel (ug/L) | Dry | | | | Dry | 1 |
| Zinc (ug/L) | Dry | | | | Dry | < 8 |
| Mineral Oil (mg/L) | Dry | | | | Dry | < 10 |



It was not possible to collect a sample upstream of R1, as the drain was dry during both sampling events. The ammonia level in the sample downstream of R1 was elevated, as were levels in the samples upstream of R2.

## 4.4 Conclusion

Given the nature of the direct and potential indirect emission to the drain and the distance between the site and the stretch of the Laune that is in the Castlemaine Harbour from the Natura 2000 Sites, the on-site stormwater treatment system does not present a significant risk either on its own or cumulatively, to the Conservation Objectives for the Castlemaine SAC.

## 5. SCREENING CONCLUSION & STATEMENT

The operation of the storm water treatment system does not present a significant risk to the Conservation Objectives of any of the Natura 2000 Sites within 15km of the MRF. Therefore Stage 2 Appropriate Assessment is not required.

**APPENDIX 1**

# WasteWorks

***Modification of existing yard-water runoff treatment system***
***KWD Ltd, Killarney***
***10/02/2015***

## 1.0 Background

KWD Ltd has a wetland and lagoon system treating yard-water runoff, which was designed by WasteWorks. This system comprises oil/water separator, settlement lagoon and wetland. Due to expanded operations at the site, a second lagoon was subsequently added by KWD to provide some aeration, with the existing lagoon used as a settlement pond. These lagoons require periodic de-sludging. Due to the lagoon construction method, de-sludging is not efficient and requires a lot of labour to clean the system.

Recommended modifications are proposed to improve the efficiency and practical operation of aeration, sludge settlement and de-sludging as follows;

- Install second oil/water separator operating in parallel with existing separator
- Replace existing settlement lagoon system with three concrete tanks providing equal capacity to then existing lagoon.
- Install a similar aeration system in the first of these tanks; with two further tanks in series providing sludge settlement
- Install pipework to facilitate regular de-sludging



In addition, we recommend installation of a vertical flow reedbed to treat effluent from the above aeration/settlement to be installed in place of the existing aeration lagoon.

The existing wetland should be retained to act as a tertiary treatment system.

WasteWorks have installed a large number of vertical flow reedbeds including a development of 700pe. Vertical flow reedbeds provide effective reliable and consistent secondary treatment of effluents with little power input (pumping only). As an example, the attached information sheet provides details of the system installed at Clonakilty Agricultural College/Department of Agriculture area offices. This has been in operation for over 14 years providing consistent effective treatment of wastewater from these combined premises.

## 2.0 Design summary

The existing system was based on the following parameters and has in general performed well.

### 2.1 Flows

| **Rainfall** | |
|---|---|
| Average rainfall 180 days (mm) | 500 |
| Total surface area (m2) | **4600** |
| Total 180d rainwater (m3) | 2300 |
| Av rainwater/day (m3/d) | 12.8 |

### 2.2 Oil/water interceptors

A second oil/water separator will be added to the existing 13.5m3 tank - mainly for practical reasons

*Ventry, Tralee, Co Kerry, Ireland. www.wasteworks.ie mob 087 7787283 email* tmclarke@iol.ie

| Stage 1 - Interceptor | |
|---|---|
| Total capacity - 2 off tanks (m3) | 27.0 |
| Retention time (days) | 2.1 |

## 2.3 Aeration and settlement

The modified lagoon aeration/settlement system will comprise a series of concrete tanks including one aeration tank of 38m3 capacity, and two sludge settlement tanks designed for ease of de-sludging.

| Stage 2 - Aeration and settlement | |
|---|---|
| Average wastewater (m3/d) | 12.8 |
| Aeration tank capacity (m3) | 38.0 |
| Average retention time (days) | 3.0 |
| Settlement tank capacity (m3) | 114.0 |
| Average retention time (days) | 8.9 |
| Maximum average BOD influent (mg/l) | 500 |
| Estimated average SS influent (mg/l) | 200 |
| BOD reduction (%) | 60 |
| BOD outlet (mg/l) | 200 |
| SS reduction (%) | 50 |
| SS outlet (mg/l) | 100 |
| BOD outlet (g/d) | 2556 |

## 2.4 Vertical flow reedbed

Following aeration and sludge settlement, the wastewater will be pumped to the new vertical flow reedbed. This will be installed in the location of the existing aeration lagoon. The average performance is estimated as follows;



| Stage 3 - vertical flow reedbed | |
|---|---|
| Max quantity of effluent (l/day) | 12,778 |
| BOD of influent (mg/l) | 200 |
| SS of influent (mg/l) | 100 |
| BOD of influent from PS (kg/day) | 2.56 |
| Design BOD loading (g BOD/m2/day) | **35** |
| Design BOD loading (kg BOD/m2/day) | 0.035 |
| Minimum Area Required (m2) | **73** |
| Design Area (m2) | **150** |
| No Cells | **1** |
| Average dimensions of each cell (mxm) | 12.25 |
| Design width (m) | **10.0** |
| Design length (m) | 15.0 |
| Operational hydraulic loading (l/m2/day) | 85 |
| Av depth of media (m) | **0.8** |
| Volume of media (m3) | 120 |
| Av hydraulic loading (l/m2/day) | **175** |
| Reduction in BOD (%) | **80** |
| BOD outlet (kg/day) | 0.51 |
| BOD outlet (mg/l) | **40** |
| Reduction in SS (%) | **85** |
| SS outlet (mg/l) | 15 |
| | |

Effluent from the reedbed will flow to the existing wetland.

# *WasteWorks*

**KWD Recycling Ltd**
**2015 Modifications to Paved Area Surface Water Treatment System**
**24/09/2015**

## *1.0 Introduction*

A surface water treatment system was installed by KWD recycling in 2003; comprising reception tank and pumps, oil/water separator, settlement lagoon and wetland. This worked well for many years. However in the last few years, the increasing quantities of waste managed by the recycling facility has resulted in increasing levels of contamination of paved area surface waters.

Several years ago the lagoon was converted into an aeration system with regular sludge settlement and disposal. However, this occasionally resulted in carryover of sludge solids to the wetland causing increased ammonia levels in the outlet of the wetland.

## *2.0 2015 modifications*

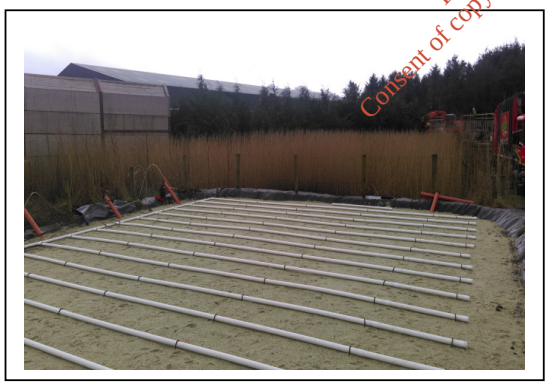
### *2.1 Spring 2015-09-24*

In 2015, the system was changed as follows;

- Oil/water separation tank (existing)
- New solids settlement tank 30m3 (primary treatment)
- New aeration tank 30m3 (first stage secondary treatment)
- New sludge settlement tank 30m3
- New vertical flow reedbed (second-stage secondary treatment)
- Existing wetland (tertiary)

During the course of the summer months, the effluent level in the vertical flow reedbed was maintained at a high level to ensure satisfactory growth of reeds. High water level in a vertical flow reedbed produces a mixture of aerobic and anoxic conditions.





### *2.2 Recent work - September 2015*

The reeds are now well established, and the water level of the reedbed has been dropped to the design operating (low) level. The system is now operating as a vertical flow reedbed/percolating filter operating under mainly aerobic conditions. The system is very effective at reducing the level of suspended solids and BOD.

## *3.0 Ammonia*

The amount of suspended solids entering the wetland is now negligible. Ammonia levels from outlet of the tertiary wetland will hopefully gradually be reduced over the coming months at the same time as sludge present in the wetland is decomposed.

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**APPENDIX 2**

# SITE SYNOPSIS

**Site Name: Castlemaine Harbour SAC**

**Site Code: 000343**

This is a large site located on the south-east corner of the Dingle Peninsula, Co. Kerry. It consists of the whole inner section of Dingle Bay, i.e. Castlemaine Harbour, the spits of Inch and White Strand/Rosbehy and a little of the coastline to the west. The River Maine, almost to Castlemaine, and much of the River Laune catchment, including the Gaddagh, Gweestion, Glanooragh, Cottoner's River and the River Loe, are also included within the site.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

[1130] Estuaries
[1140] Tidal Mudflats and Sandflats
[1210] Annual Vegetation of Drift Lines
[1220] Perennial Vegetation of Stony Banks
[1230] Vegetated sea cliffs of the Atlantic and Baltic coasts
[1310] *Salicornia* Mud
[1330] Atlantic Salt Meadows
[1410] Mediterranean Salt Meadows
[2110] Embryonic Shifting Dunes
[2120] Marram Dunes (White Dunes)
[2130] Fixed Dunes (Grey Dunes)*
[2170] Dunes with Creeping Willow
[2190] Humid Dune Slacks
[91E0] Alluvial Forests*

[1095] Sea Lamprey (*Petromyzon marinus*)
[1099] River Lamprey (*Lampetra fluviatilis*)
[1106] Atlantic Salmon (*Salmo salar*)
[1355] Otter (*Lutra lutra*)
[1395] Petalwort (*Petalophyllum ralfsii*)



Inch Spit holds a fine sand dune system. It is one of the largest and best remaining dune systems in the country. Fore dunes are found on the western side of Rosbehy and Inch. In these younger, mobile dunes, Marram (*Ammophila arenaria*) is common, with Groundsel (*Senecio vulgaris*), Sea Rocket (*Cakile maritima*) and Dandelion

(*Taraxacum* agg.) also present. Other characteristic species include Sand Couch (*Elymus farctus*), Lyme-grass (*Leymus arenarius*) and Sea Spurge (*Euphorbia paralias*). Fixed dune, a priority habitat under the E.U. Habitats Directive, is well-represented at the site, and in particular towards the tip of Inch Spit. Such areas support species such as Lady's Bedstraw (*Galium verum*), Common Bird's-foot-trefoil (*Lotus corniculatus*), Wild Thyme (*Thymus praecox*), Kidney Vetch (*Anthyllis vulneraria*), Wild Pansy (*Viola tricolor*), Biting Stonecrop (*Sedum acre*), Common Centuary (*Centaurium erythraea*), Thyme-leaved Sandwort (*Arenaria serpyllifolia*) and Common Whitlowgrass (*Erophila verna*), among others. There is also a rich lichen and bryophyte flora. The slightly damper conditions which prevail in dune slacks support Creeping Bent (*Agrostis stolonifera*), Crested Dog's-tail (*Cynosurus cristatus*), Glaucous Sedge (*Carex flacca*), Creeping Willow (*Salix repens*) and Jointed Rush (*Juncus articulatus*). The rare bryophyte Petalwort (*Petalophyllum ralfsii*), which is listed on Annex II of the E.U. Habitats Directive, has been recorded in this system. A smaller spit, with a similar diversity of dune types, occurs at Rosbehy on the southern shore, from where Yellow Centaury (*Cicendia filiformis*) and Knotted Pearlwort (*Sagina nodosa*) have been recorded from a dune slack along with other, more common, species.

The sand spits, and also the Coomore peninsula, are underlain by shingle and in places the shingle is exposed and supports a characteristic flora. Species present include Lyme-grass and Sea Sandwort (*Honkenya peploides*). Strandline communities are well-developed along Inch spit, with the exception of the north-western end where recreational pressure is high. Typical species of the strandline include Prickly Saltwort (*Salsola kali*), Sea Rocket, oraches (*Atriplex* spp.) and Sea Sandwort. Two Red Data Book plants, Sea Pea (*Lathyrus japonicus* subsp. *maritimus*) and Sea-kale (*Crambe maritima*), are found associated with the shingle and strandline communities.



The coastline is fringed in many places by saltmarsh. The vegetation here includes Thrift (*Armeria maritima*), Common Saltmarsh-grass (*Puccinellia maritima*), Sea Aster (*Aster tripolium*), Sea Rush (*Juncus maritimus*) and Sea Plantain (*Plantago maritima*). Upper saltmarsh communities extend inland, along estuarine channels, where they are mixed with freshwater communities. Sea Club-rush (*Scirpus maritimus*) and Common Reed (*Phragmites australis*) occur at these locations. Common Cord-grass (*Spartina anglica*) has colonised the lower part of the saltmarsh at Inch and extends out onto the open mudflat. Glassworts (*Salicornia* spp.) occur in association with saltmarsh.

West of Inch, cliffs of glacial drift occur, which support such plants as Ivy (*Hedera helix*), Red Fescue (*Festuca rubra*), Heather (*Calluna vulgaris*), Thrift, Sea Plantain, Sea Mayweed (*Matricaria maritima*), Kidney Vetch and Honeysuckle (*Lonicera periclymenum*). Along the cliff-tops there is coastal grassland with species such as Sweet Vernal-grass (*Anthoxanthum odoratum*), Cock's-foot (*Dactylis glomerata*) and Wood Sage (*Teucrium scorodonia*).

Much of the site consists of intertidal sand and mudflats, supporting a number of soft sediment communities, including beds of eelgrass (mostly *Zostera noltii*) in some

places. A subtidal mixed sediment community complex is also present in the channel between Rossbehy Point and Inch Point.

The rivers and their associated habitats also make up a considerable portion of the site. These associated habitats include wet grassland, woodland, scrub and bog/heath. In the valley up-river of Killorglin, is an interesting area of alluvial wet woodland, dominated by Alder (*Alnus glutinosa*) and willows (*Salix* spp.). The vegetation is quite diverse, and there are spectacular tussocks of Greater Tussock-sedge (*Carex paniculata*). Other species which occur include Ash (*Fraxinus excelsior*), Wild Angelica (*Angelica sylvestris*), Cuckooflower (*Cardamine pratensis*), Meadowsweet (*Filipendula ulmaria*), Common Nettle (*Urtica dioica*), Remote Sedge (*Carex remota*) and a range of bryophytes. While small in area, this is one of the few examples in Ireland of woodland on riverine alluvium dominated by native tree species.

Five plants listed in the Irish Red Data Book have been recorded at this site: Sea-kale, Corn Cockle (*Agrostemma githago*), Sea Pea, Pennyroyal (*Mentha pulegium*) and Irish Lady's-tresses (*Spiranthes romanzoffiana*). The three last-named are legally protected under the Flora (Protection) Order, 1999, as is the rare bryophyte, Petalwort. Other scarce species which occur here are Yellow Bartsia (*Parentucellia viscosa*), Lax-flowered Sea-lavender (*Limonium humile*) and Blue-eyed-grass (*Sisyrinchium bermudiana*).



The vicinity of Castlemaine Harbour is also important as one of few areas in Ireland (all of which are in Co. Kerry) where the Natterjack Toad naturally occurs. This amphibian is listed in the Irish Red Data Book and on Annex IV of the E.U. Habitats Directive.

The site also supports a small colony of Common Seal, while two Lamprey species have been recorded in the Laune river catchment. The Laune catchment is used by Otter and is also an important Salmon system with nurseries, riffles pools and glides.

Castlemaine Harbour is a very important site for passage and wintering waterfowl. The following figures are derived from counts between 1994/5 and 1996/7. One species occurs here in internationally important numbers - Brent Goose (734) - with 16 species having populations of national importance: Cormorant (215), Shelduck (129), Pintail (167), Scaup (138), Wigeon (3,513), Red-breasted Merganser (51), Oystercatcher (1,539), Ringed Plover (330), Golden Plover (1,940), Grey Plover (122), Knot (347), Sanderling (207), Dunlin (1,360), Redshank (299), Greenshank (26) and Turnstone (296).

Castlemaine Harbour is of major ecological importance. It contains a range of coastal habitats of excellent quality, including many that are listed on Annex I of the E.U. Habitats Directive, and two which are listed with priority status (fixed dunes and alluvial forests). It also includes long stretches of river and stream which are excellent habitats for Salmon, Lamprey and Otter. Inch dunes are recognised as among the finest in the country, with particularly well-developed dune slacks. The

site supports internationally important waterfowl populations, rare plant species, the rare Natterjack Toad, as well as populations of several animal species that are listed on Annex II of the E.U. Habitats Directive. Part of the site is designated a Special Protection Area (SPA) and is listed as a site under the Ramsar Convention. Part of Castlemaine Harbour is a Statutory Nature Reserve, while Inch and Rosbehy are Wildfowl Sanctuaries.

**Site Name: Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC**

**Site Code: 000365**

This very large site encompasses the mountains, rivers and lakes of the Iveragh Peninsula, and the Paps Mountains which stretch eastward from Killarney towards Millstreet. The majority of the site is in Co. Kerry, with a small portion in Co. Cork. This is the most mountainous region in Ireland and includes Carrauntoohil, the highest peak in the country at 1,039 m. The underlying geology is almost entirely Old Red Sandstone, although Carboniferous limestone occurs on the eastern shores of Lough Leane, and rhyolitic lavas occur above Lough Guitane. The dramatic sandstone ridges and valleys have been shaped by glacial processes and many of the lakes are impounded by glacial moraines. Located close to the Atlantic in the south-west of Ireland, the site is subject to strong oceanic influences. Generally, Lusitanian flora and fauna is well-represented, while the high peaks and cliffs support arctic-alpine relicts.



The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the EU Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

[3110] Oligotrophic Waters containing very few minerals
[3130] Oligotrophic to Mesotrophic Standing Waters
[3260] Floating River Vegetation
[4010] Wet Heath
[4030] Dry Heath
[4060] Alpine and Subalpine Heaths
[5130] Juniper Scrub
[6130] Calaminarian Grassland
[6410] *Molinia* Meadows
[7130] Blanket Bogs (Active)*
[7150] Rhynchosporion Vegetation
[91A0] Old Oak Woodlands
[91E0] Alluvial Forests*
[91J0] Yew Woodlands*

[1024] Kerry Slug (*Geomalacus maculosus*)
[1029] Freshwater Pearl Mussel (*Margaritifera margaritifera*)
[1065] Marsh Fritillary (*Euphydryas aurinia*)
[1095] Sea Lamprey (*Petromyzon marinus*)

[1096] Brook Lamprey (*Lampetra planeri*)
[1099] River Lamprey (*Lampetra fluviatilis*)
[1103] Twaite Shad (*Alosa fallax*)
[1106] Atlantic Salmon (*Salmo salar*)
[1303] Lesser Horseshoe Bat (*Rhinolophus hipposideros*)
[1355] Otter (*Lutra lutra*)
[1421] Killarney Fern (*Trichomanes speciosum*)
[1833] Slender Naiad (*Najas flexilis*)

The Oak woodlands, occurring mostly around the Killarney lakes, are the habitat for which the area is perhaps best known. They form the most extensive area of native woodland remaining in Ireland and include Derrycunihy Wood, described as perhaps the most natural Sessile Oak (*Quercus petraea*) wood in the country. The woods are typically dominated by Sessile Oak, with an understorey of Holly (*Ilex aquifolium*). The Strawberry-tree (*Arbutus unedo*) is a notable component of the woods and there are scattered areas of Yew (*Taxus baccata*). The herb layer is not particularly species-rich, but the woods support perhaps the best developed Atlantic bryophyte community in Europe. Several rare species are present including *Lejeunea flava, Cyclodictyon laetivirens, Daltonia splachnoides, Sematophyllum demissum* and *Radula carringtonii*.



The only sizeable Yew woodland in Ireland is found on the limestone of the Muckross peninsula. Here, some of the trees are up to 200 years old. The dense shade beneath the tree results in few herbs in the ground flora, but the bryophyte layer is well-developed and almost continuous.

Wet woodland, or carr, occurring on the low-lying limestone areas within the floodplain of Lough Leane, forms one of the most extensive areas of this woodland type in Ireland. The dominant canopy species are Alder (*Alnus glutinosa*), willows (*Salix* spp.), Ash (*Fraxinus excelsior*) and Downy Birch (*Betula pubescens*), while the field layer is dominated by Remote Sedge (*Carex remota*) and Creeping Bent (*Agrostis stolonifera*).

Adding to the diversity of the woodland component of this site are a number of mixed woodlands, including those of Ross Island which support one of the richest herb layers of the Killarney woods.

The most common habitat types within the overall site are blanket bog, heath and upland grassland. The heath and grassland generally occur on areas with shallow peat and on the mineral soils of the steep mountain sides, while the blanket bog occurs on the more gentle slopes, plateaux and other level ground. Often the habitats occur in a mosaic, with exposed rock frequently occurring.

A variety of blanket bog types are represented from lowland valley to mountain blanket bog. Some of the best include: Cummeragh River Bog Nature Reserve, a

domed bog which is perhaps the most southern intact blanket bog in the country; Ballygisheen, which contains one of the most extensive areas of intact lowland blanket bog in Co. Kerry; Coomacheo/Caherbarnagh, which combine to form the largest mountain blanket bog in the south-west; Eirk Bog Nature Reserve, a classic example of a bog intermediate between a raised and blanket bog; Mangerton Bog, an upland bog which grades into an unusual lichen heath seen at no other site; and Oolagh East, a quaking basin mire. Generally, the bogs have a characteristic flora. The Lusitanian species, Large-flowered Butterwort (*Pinguicula grandiflora*), is common. The bogs also support a number of unusual species, including mosses (*Sphagnum pulchrum, S. fuscum, S. platyphyllum, S. strictum, S. contortum* and *Calliergon stramineum*), liverworts (*Cladopodiella francisci* and *Calypogeia azurea*) and lichens (*Cladonia mediterranea, C. macilenta, C. rangiferina, C. arbuscula* and *Cetraria islandica*).

Rhynchosporion vegetation is confined to wet areas within the lowland blanket bogs, with one of the best areas for the habitat being to the north-east of the Ballygisheen Pass. On a portion of this bog there is an extensive area of quaking flats and pools dominated by the bog mosses *Sphagnum cuspidatum* and *S. auriculatum*. These areas have a typically species-poor flora which includes Bogbean (*Menyanthes trifoliata*), White Beak-sedge (*Rhynchospora alba*), Bog Asphodel (*Narthecium ossifragum*), Common Cottongrass (*Eriophorum angustifolium*) and Great Sundew (*Drosera anglica*). Brown Beak-sedge (*R. fusca*), a locally rare plant of wet bog pools, is occasional within the site. Although the habitat is best developed in very wet areas of intact bog, it may also occur in wet areas of regenerating cutover blanket bog.



Wet heath often occurs in association with blanket bog and features Cross-leaved Heath (*Erica tetralix*). Dry heath is more frequent in this site, and is dominated by Heather (*Calluna vulgaris*), Bell Heather (*Erica cinerea*) and Western Gorse (*Ulex gallii*), with occasional Bilberry (*Vaccinium myrtillus*). This habitat is well-developed on the Paps Mountains. Elsewhere it is often over-grazed, with upland grassland becoming more frequent. Some of the highest ridges support alpine heath (referable to the *Lycopodium alpinum - Racomitrium lanuginosum* association). Widespread plant species of the alpine heath include Bog-myrtle (*Vaccinium myrtillus*), Crowberry (*Empetrum nigrum*) and Fir Clubmoss (*Huperzia selago*), while species such as Juniper (*Juniperus communis* subsp. n*ana*) and Dwarf Willow (*Salix herbacea*) have a much more restricted distribution.

The site contains many lakes, but these can be broadly divided into two types: small upland corrie lakes and larger lowland lakes. Examples of the first type are Lough Murtagh and Lough Gortavehy in the Paps Mountains. They are oligotrophic and typically species-poor, with Quillwort (*Isoetes lacustris*), Water Lobelia (*Lobelia dortmanna*) and Shoreweed (*Littorella uniflora*) occurring most commonly. The lowland lakes are mostly oligotrophic, although Lough Leane, the largest freshwater body in the region, has become somewhat mesotrophic as a result of pollution from Killarney town. These lowland lakes tend to be more species-rich than those at higher altitudes, with additional species such as Awlwort (*Subularia aquatica*), Six-stamened Waterwort (*Elatine hexandra*) and Alternate Water-milfoil (*Myriophyllum*

*alterniflorum*). Good examples include Lough Caragh, Upper Lake and Muckross Lake.

The rivers associated with these lakes are also of importance. The Caragh is relatively unpolluted from headwater to estuary, a rare phenomenon in Europe. The Flesk runs over Old Red Sandstone in its upper reaches and limestone as it nears Lough Leane. Both rivers support floating and submerged vegetation and rare invertebrates. Rocks around the smaller mountain streams often support a lush vegetation of ferns and bryophytes, most notably at Torc Waterfall.

Other habitats of note include: Juniper scrub found on islands in the Upper Lake and on dry ridges in nearby Newfoundland Bog; damp meadows, with Purple Moor-grass (*Molinia caerulea*), supporting scarce species such as Whorled Caraway (*Carum verticillatum*) and Ivy-leaved Bellflower (*Wahlenbergia hederacea*); and Calaminarian grasslands, associated with the old copper mines on Ross Island, with species such as Sea Campion (*Silene vulgaris* subsp. *maritima*) and Thrift (*Armeria maritima*).

A large number of plant and animal species of interest occur within the site. For example, two plant species listed on Annex II of the E.U. Habitats Directive occur. Slender Naiad (*Najas flexilis*) is found in some of the lakes at the site. The Killarney Fern (*Trichomanes speciosum*) is another listed and well-known rarity. An additional twenty-two Red Data Book plant species have been recorded, but only twelve of these have been seen recently. These are Pillwort (*Pilularia globulifera*), Kerry Lily (*Simethis planifolia*), Irish Lady's-tresses (*Spiranthes romanzoffiana*), Slender Cottongrass (*Eriophorum gracile*), Small Cudweed (*Logfia minima*), Betony (*Stachys officinalis*), Heath Cudweed (*Omalotheca sylvatica*), Alder Buckthorn (*Frangula alnus*), Alpine Saw-wort (*Saussurea alpina*), Hoary Whitlowgrass (*Draba incana*), Smooth Brome (*Bromus racemosus*) and Holly Fern (*Polystichum lonchitis*). The first seven of these species are legally protected under the Flora (Protection) Order, 1999, as are Slender Naiad and Killarney Fern.



Additional plant species of interest include a fern (*Dryopteris affinis* subsp. *stilluppensis*) and a Whitebeam (*Sorbus anglica*), both at their only Irish locations.

The site is very important for oceanic bryophytes, particularly the woodland species. It also contains good representative examples of the Northern Atlantic Hepatic Mat community and other oceanic montane communities. Killarney Oak woods and mountains have been nominated as a site of international importance for bryophytes.

The Killarney Woods are notable for the number of rare species of Myxomycete fungus that have been recorded, namely *Collaria arcyrionema*, *Craterium muscorum*, *Cribraria microcarpa* (only known Irish site), *C. rufa*, *C. violacea*, *Diderma chondrioderma*, *D. lucidum*, *D. ochraceum*, *Fuligo muscorum* and *Licea marginata*.

The site has six bird species which are listed on Annex I of the E.U. Birds Directive. A small flock of Greenland White-fronted Goose, which winters on the boglands within the National Park, is now the only regular flock in the south-west. The site has one of

the highest concentrations of breeding Peregrines in the country, as well as some breeding Merlin. Chough is found both in the coastal and inland areas of the site, with possibly up to 30 pairs breeding. Kingfisher is a species associated with the lakes and rivers, especially in the National Park and probably breeds. Finally, a few pairs of Common Tern breed within the site.

The woodlands provide habitat for a variety of breeding birds, most notably Garden Warbler, Blackcap, and probably a few pairs each of the rare Redstart and Wood Warbler. Lough Leane is a site for wintering wildfowl with the following average counts for the two winters 1995/96 and 1996/97: Teal (208), Mallard (350), Pochard (81), Tufted Duck (323) and Coot (169).

The site supports most of the Irish mammal species. Of particular note is the occurrence of two E.U. Habitats Directive Annex II species: Lesser Horseshoe Bat, with a total population of about 300 individuals distributed at several locations, including both nursery and hibernation sites, and Otter. Perhaps the best known mammals of the Killarney National Park are the Red Deer, which form the only remaining native herd in Ireland, comprised of around 600 animals. Sika Deer also occur. Pine Marten is another notable species.



The site is valuable for its rare fish species, five of which are listed on Annex II of the E.U. Habitats Directive: Brook Lamprey (*Lampetra planeri*), River Lamprey (*Lampetra fluviatilis*), Sea Lamprey (*Petromyzon marinus*), Atlantic Salmon (*Salmo salar*) and Killarney Shad (*Alosa fallax killarnensis*). The Killarney Shad is a unique land-locked subspecies confined to the Killarney lakes. Also of note is the glacial relict, Arctic Char (*Salvelinus alpinus*), a Red Data Book species, a unique form of which is found in Lough Coomasaharn.

There are numerous rare invertebrates within the site. These include three E.U. Habitats Directive Annex II species: Kerry Slug (*Geomalacus maculosus*), the Freshwater Pearl Mussel (*Margaritifera margaritifera*) and the Marsh Fritillary (*Euphydryas aurinia*). The Kerry Slug and Pearl Mussel populations are of particular importance in a national context. Other species of note include: three chironomids of international importance found in the River Flesk; a wood ant (*Formica lugubris*) at one of only four Irish sites; a snail (*Limnaea involuta*), in Lough Crincaum, at its only known location; two dragonflies (*Cordulea aenea* and *Somatochlora arctica*), the former at one of only two known sites in Ireland and the latter at its only known Irish location; and several other aquatic and woodland species at their only known Irish locations.

The main land use within the site is grazing by sheep. In and around the National Park deer grazing is also common. The extensive grazing has caused damage to many of the terrestrial habitats, resulting in degradation of heath and blanket bogs and prevention of woodland regeneration. In the upland habitats the erosion caused by grazing is exacerbated by the exposed nature of the terrain. Apart from grazing, the woodlands are particularly threatened by Rhododendron (*Rhododendron ponticum*) invasion: approximately two thirds of the Oak woodlands are affected,

although a Rhododendron removal programme is underway in the National Park. The Yew wood has been adversely affected by heavy grazing for many years, but it is intended to control this in the near future by erection of a deer fence. The bogs are sensitive to grazing and are also threatened by turbary, burning and afforestation. Most of the lakes are very acid-sensitive and therefore vulnerable to afforestation within the catchment areas. Lough Leane has been subject to some eutrophication, although water quality appears to have improved since phosphates were removed from the sewage in 1985.

A management plan was drawn up for the Killarney National Park in 1991. The park is managed primarily for conservation purposes although recreation is also provided for.

Overall, the site is of high ecological value because of the diversity, quality and extensiveness of many of the habitats, and impressive list of rare species of flora and fauna. In recognition of its importance the Killarney National Park has been designated a World Biosphere Reserve.

# SITE SYNOPSIS

## SITE NAME: KILLARNEY NATIONAL PARK SPA

## SITE CODE: 004038

This large site encompasses the lakes and part of the Macgillycuddy's Reeks in the vicinity of the town of Killarney in Co. Kerry. The underlying geology is Old Red Sandstone and, on the eastern shores of Lough Leane, Carboniferous limestone. Lough Leane is the largest (8.6 km along its long axis) of the lakes in the site, and is classified as a mesotrophic system. Muckross Lake and the Upper Lake are both high quality oligotrophic systems.

Killarney National Park is perhaps best known for its Oak woodlands. They form the most extensive area of native woodland remaining in Ireland and include Derrycunihy Wood, described as perhaps the most natural Sessile Oak wood in the country. The higher areas of the site are dominated by blanket bog and wet heath.

At the time this site was designated as a Special Protection Area (SPA) it was being utilised by Greenland White-fronted Goose. This, along with the nearby Eirk Bog, is the most southerly site in Ireland utilised by this species and it is also one of the few flocks that continues to utilise peatland habitats. The site continues to be used by Greenland White-fronted Goose in small numbers (<20 birds) and is regarded as a special conservation interest for this SPA.



While Killarney National Park has not been subject to a complete upland breeding bird survey the habitat within the site is estimated to support up to 5 pairs of Merlin and therefore this species is regarded as a special conservation interest for this SPA.

Other upland species which breed within the site include Peregrine (1 pair), Ring Ouzel (1-2 pairs) and Red Grouse. The extensive woodlands support some scarce breeding birds, notably Redstart (1-2 pairs), Wood Warbler (1-2 pairs) and Garden Warbler (possibly up to 10 pairs).

Lough Leane, and to a lesser extent the other lakes, support a variety of wintering waterfowl species including Mute Swan (38), Teal (184), Mallard (361), Pochard (54), Tufted Duck (271), Goldeneye (23), Little Grebe (11), Cormorant (86), Coot (124) and Black-headed Gull (84) – all counts are three year mean peaks for the period 1995/96-1997/98. Several research programmes have been carried out on the birds in the site, including studies on the communities associated with the Yew woodlands, and the wildfowl associated with the lakes. Part of Killarney National Park SPA is a Wildfowl Sanctuary.

7.7.2014

# SITE SYNOPSIS

**Site Name: Castlemaine Harbour SAC**

**Site Code: 000343**

This is a large site located on the south-east corner of the Dingle Peninsula, Co. Kerry. It consists of the whole inner section of Dingle Bay, i.e. Castlemaine Harbour, the spits of Inch and White Strand/Rosbehy and a little of the coastline to the west. The River Maine, almost to Castlemaine, and much of the River Laune catchment, including the Gaddagh, Gweestion, Glanooragh, Cottoner's River and the River Loe, are also included within the site.

The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the E.U. Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

[1130] Estuaries
[1140] Tidal Mudflats and Sandflats
[1210] Annual Vegetation of Drift Lines
[1220] Perennial Vegetation of Stony Banks
[1230] Vegetated sea cliffs of the Atlantic and Baltic coasts
[1310] *Salicornia* Mud
[1330] Atlantic Salt Meadows
[1410] Mediterranean Salt Meadows
[2110] Embryonic Shifting Dunes
[2120] Marram Dunes (White Dunes)
[2130] Fixed Dunes (Grey Dunes)*
[2170] Dunes with Creeping Willow
[2190] Humid Dune Slacks
[91E0] Alluvial Forests*

[1095] Sea Lamprey (*Petromyzon marinus*)
[1099] River Lamprey (*Lampetra fluviatilis*)
[1106] Atlantic Salmon (*Salmo salar*)
[1355] Otter (*Lutra lutra*)
[1395] Petalwort (*Petalophyllum ralfsii*)



Inch Spit holds a fine sand dune system. It is one of the largest and best remaining dune systems in the country. Fore dunes are found on the western side of Rosbehy and Inch. In these younger, mobile dunes, Marram (*Ammophila arenaria*) is common, with Groundsel (*Senecio vulgaris*), Sea Rocket (*Cakile maritima*) and Dandelion

(*Taraxacum* agg.) also present. Other characteristic species include Sand Couch (*Elymus farctus*), Lyme-grass (*Leymus arenarius*) and Sea Spurge (*Euphorbia paralias*). Fixed dune, a priority habitat under the E.U. Habitats Directive, is well-represented at the site, and in particular towards the tip of Inch Spit. Such areas support species such as Lady's Bedstraw (*Galium verum*), Common Bird's-foot-trefoil (*Lotus corniculatus*), Wild Thyme (*Thymus praecox*), Kidney Vetch (*Anthyllis vulneraria*), Wild Pansy (*Viola tricolor*), Biting Stonecrop (*Sedum acre*), Common Centuary (*Centaurium erythraea*), Thyme-leaved Sandwort (*Arenaria serpyllifolia*) and Common Whitlowgrass (*Erophila verna*), among others. There is also a rich lichen and bryophyte flora. The slightly damper conditions which prevail in dune slacks support Creeping Bent (*Agrostis stolonifera*), Crested Dog's-tail (*Cynosurus cristatus*), Glaucous Sedge (*Carex flacca*), Creeping Willow (*Salix repens*) and Jointed Rush (*Juncus articulatus*). The rare bryophyte Petalwort (*Petalophyllum ralfsii*), which is listed on Annex II of the E.U. Habitats Directive, has been recorded in this system. A smaller spit, with a similar diversity of dune types, occurs at Rosbehy on the southern shore, from where Yellow Centaury (*Cicendia filiformis*) and Knotted Pearlwort (*Sagina nodosa*) have been recorded from a dune slack along with other, more common, species.

The sand spits, and also the Coomore peninsula, are underlain by shingle and in places the shingle is exposed and supports a characteristic flora. Species present include Lyme-grass and Sea Sandwort (*Honkenya peploides*). Strandline communities are well-developed along Inch spit, with the exception of the north-western end where recreational pressure is high. Typical species of the strandline include Prickly Saltwort (*Salsola kali*), Sea Rocket, oraches (*Atriplex* spp.) and Sea Sandwort. Two Red Data Book plants, Sea Pea (*Lathyrus japonicus* subsp. *maritimus*) and Sea-kale (*Crambe maritima*), are found associated with the shingle and strandline communities.



The coastline is fringed in many places by saltmarsh. The vegetation here includes Thrift (*Armeria maritima*), Common Saltmarsh-grass (*Puccinellia maritima*), Sea Aster (*Aster tripolium*), Sea Rush (*Juncus maritimus*) and Sea Plantain (*Plantago maritima*). Upper saltmarsh communities extend inland, along estuarine channels, where they are mixed with freshwater communities. Sea Club-rush (*Scirpus maritimus*) and Common Reed (*Phragmites australis*) occur at these locations. Common Cord-grass (*Spartina anglica*) has colonised the lower part of the saltmarsh at Inch and extends out onto the open mudflat. Glassworts (*Salicornia* spp.) occur in association with saltmarsh.

West of Inch, cliffs of glacial drift occur, which support such plants as Ivy (*Hedera helix*), Red Fescue (*Festuca rubra*), Heather (*Calluna vulgaris*), Thrift, Sea Plantain, Sea Mayweed (*Matricaria maritima*), Kidney Vetch and Honeysuckle (*Lonicera periclymenum*). Along the cliff-tops there is coastal grassland with species such as Sweet Vernal-grass (*Anthoxanthum odoratum*), Cock's-foot (*Dactylis glomerata*) and Wood Sage (*Teucrium scorodonia*).

Much of the site consists of intertidal sand and mudflats, supporting a number of soft sediment communities, including beds of eelgrass (mostly *Zostera noltii*) in some

places. A subtidal mixed sediment community complex is also present in the channel between Rossbehy Point and Inch Point.

The rivers and their associated habitats also make up a considerable portion of the site. These associated habitats include wet grassland, woodland, scrub and bog/heath. In the valley up-river of Killorglin, is an interesting area of alluvial wet woodland, dominated by Alder (*Alnus glutinosa*) and willows (*Salix* spp.). The vegetation is quite diverse, and there are spectacular tussocks of Greater Tussock-sedge (*Carex paniculata*). Other species which occur include Ash (*Fraxinus excelsior*), Wild Angelica (*Angelica sylvestris*), Cuckooflower (*Cardamine pratensis*), Meadowsweet (*Filipendula ulmaria*), Common Nettle (*Urtica dioica*), Remote Sedge (*Carex remota*) and a range of bryophytes. While small in area, this is one of the few examples in Ireland of woodland on riverine alluvium dominated by native tree species.

Five plants listed in the Irish Red Data Book have been recorded at this site: Sea-kale, Corn Cockle (*Agrostemma githago*), Sea Pea, Pennyroyal (*Mentha pulegium*) and Irish Lady's-tresses (*Spiranthes romanzoffiana*). The three last-named are legally protected under the Flora (Protection) Order, 1999, as is the rare bryophyte, Petalwort. Other scarce species which occur here are Yellow Bartsia (*Parentucellia viscosa*), Lax-flowered Sea-lavender (*Limonium humile*) and Blue-eyed-grass (*Sisyrinchium bermudiana*).



The vicinity of Castlemaine Harbour is also important as one of few areas in Ireland (all of which are in Co. Kerry) where the Natterjack Toad naturally occurs. This amphibian is listed in the Irish Red Data Book and on Annex IV of the E.U. Habitats Directive.

The site also supports a small colony of Common Seal, while two Lamprey species have been recorded in the Laune river catchment. The Laune catchment is used by Otter and is also an important Salmon system with nurseries, riffles pools and glides.

Castlemaine Harbour is a very important site for passage and wintering waterfowl. The following figures are derived from counts between 1994/5 and 1996/7. One species occurs here in internationally important numbers - Brent Goose (734) - with 16 species having populations of national importance: Cormorant (215), Shelduck (129), Pintail (167), Scaup (138), Wigeon (3,513), Red-breasted Merganser (51), Oystercatcher (1,539), Ringed Plover (330), Golden Plover (1,940), Grey Plover (122), Knot (347), Sanderling (207), Dunlin (1,360), Redshank (299), Greenshank (26) and Turnstone (296).

Castlemaine Harbour is of major ecological importance. It contains a range of coastal habitats of excellent quality, including many that are listed on Annex I of the E.U. Habitats Directive, and two which are listed with priority status (fixed dunes and alluvial forests). It also includes long stretches of river and stream which are excellent habitats for Salmon, Lamprey and Otter. Inch dunes are recognised as among the finest in the country, with particularly well-developed dune slacks. The

site supports internationally important waterfowl populations, rare plant species, the rare Natterjack Toad, as well as populations of several animal species that are listed on Annex II of the E.U. Habitats Directive. Part of the site is designated a Special Protection Area (SPA) and is listed as a site under the Ramsar Convention. Part of Castlemaine Harbour is a Statutory Nature Reserve, while Inch and Rosbehy are Wildfowl Sanctuaries.

# SITE SYNOPSIS

**Site Name: Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC**

**Site Code: 000365**

This very large site encompasses the mountains, rivers and lakes of the Iveragh Peninsula, and the Paps Mountains which stretch eastward from Killarney towards Millstreet. The majority of the site is in Co. Kerry, with a small portion in Co. Cork. This is the most mountainous region in Ireland and includes Carrauntoohil, the highest peak in the country at 1,039 m. The underlying geology is almost entirely Old Red Sandstone, although Carboniferous limestone occurs on the eastern shores of Lough Leane, and rhyolitic lavas occur above Lough Guitane. The dramatic sandstone ridges and valleys have been shaped by glacial processes and many of the lakes are impounded by glacial moraines. Located close to the Atlantic in the south-west of Ireland, the site is subject to strong oceanic influences. Generally, Lusitanian flora and fauna is well-represented, while the high peaks and cliffs support arctic-alpine relicts.



The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I / II of the EU Habitats Directive (* = priority; numbers in brackets are Natura 2000 codes):

[3110] Oligotrophic Waters containing very few minerals
[3130] Oligotrophic to Mesotrophic Standing Waters
[3260] Floating River Vegetation
[4010] Wet Heath
[4030] Dry Heath
[4060] Alpine and Subalpine Heaths
[5130] Juniper Scrub
[6130] Calaminarian Grassland
[6410] *Molinia* Meadows
[7130] Blanket Bogs (Active)*
[7150] Rhynchosporion Vegetation
[91A0] Old Oak Woodlands
[91E0] Alluvial Forests*
[91J0] Yew Woodlands*

[1024] Kerry Slug (*Geomalacus maculosus*)
[1029] Freshwater Pearl Mussel (*Margaritifera margaritifera*)
[1065] Marsh Fritillary (*Euphydryas aurinia*)
[1095] Sea Lamprey (*Petromyzon marinus*)

| |
|---|
| [1096] Brook Lamprey (*Lampetra planeri*) |
| [1099] River Lamprey (*Lampetra fluviatilis*) |
| [1103] Twaite Shad (*Alosa fallax*) |
| [1106] Atlantic Salmon (*Salmo salar*) |
| [1303] Lesser Horseshoe Bat (*Rhinolophus hipposideros*) |
| [1355] Otter (*Lutra lutra*) |
| [1421] Killarney Fern (*Trichomanes speciosum*) |
| [1833] Slender Naiad (*Najas flexilis*) |

The Oak woodlands, occurring mostly around the Killarney lakes, are the habitat for which the area is perhaps best known. They form the most extensive area of native woodland remaining in Ireland and include Derrycunihy Wood, described as perhaps the most natural Sessile Oak (*Quercus petraea*) wood in the country. The woods are typically dominated by Sessile Oak, with an understorey of Holly (*Ilex aquifolium*). The Strawberry-tree (*Arbutus unedo*) is a notable component of the woods and there are scattered areas of Yew (*Taxus baccata*). The herb layer is not particularly species-rich, but the woods support perhaps the best developed Atlantic bryophyte community in Europe. Several rare species are present including *Lejeunea flava, Cyclodictyon laetivirens, Daltonia splachnoides, Sematophyllum demissum* and *Radula carringtonii*.



The only sizeable Yew woodland in Ireland is found on the limestone of the Muckross peninsula. Here, some of the trees are up to 200 years old. The dense shade beneath the tree results in few herbs in the ground flora, but the bryophyte layer is well-developed and almost continuous.

Wet woodland, or carr, occurring on the low-lying limestone areas within the floodplain of Lough Leane, forms one of the most extensive areas of this woodland type in Ireland. The dominant canopy species are Alder (*Alnus glutinosa*), willows (*Salix* spp.), Ash (*Fraxinus excelsior*) and Downy Birch (*Betula pubescens*), while the field layer is dominated by Remote Sedge (*Carex remota*) and Creeping Bent (*Agrostis stolonifera*).

Adding to the diversity of the woodland component of this site are a number of mixed woodlands, including those of Ross Island which support one of the richest herb layers of the Killarney woods.

The most common habitat types within the overall site are blanket bog, heath and upland grassland. The heath and grassland generally occur on areas with shallow peat and on the mineral soils of the steep mountain sides, while the blanket bog occurs on the more gentle slopes, plateaux and other level ground. Often the habitats occur in a mosaic, with exposed rock frequently occurring.

A variety of blanket bog types are represented from lowland valley to mountain blanket bog. Some of the best include: Cummeragh River Bog Nature Reserve, a

domed bog which is perhaps the most southern intact blanket bog in the country; Ballygisheen, which contains one of the most extensive areas of intact lowland blanket bog in Co. Kerry; Coomacheo/Caherbarnagh, which combine to form the largest mountain blanket bog in the south-west; Eirk Bog Nature Reserve, a classic example of a bog intermediate between a raised and blanket bog; Mangerton Bog, an upland bog which grades into an unusual lichen heath seen at no other site; and Oolagh East, a quaking basin mire. Generally, the bogs have a characteristic flora. The Lusitanian species, Large-flowered Butterwort (*Pinguicula grandiflora*), is common. The bogs also support a number of unusual species, including mosses (*Sphagnum pulchrum, S. fuscum, S. platyphyllum, S. strictum, S. contortum* and *Calliergon stramineum*), liverworts (*Cladopodiella francisci* and *Calypogeia azurea*) and lichens (*Cladonia mediterranea, C. macilenta, C. rangiferina, C. arbuscula* and *Cetraria islandica*).

Rhynchosporion vegetation is confined to wet areas within the lowland blanket bogs, with one of the best areas for the habitat being to the north-east of the Ballygisheen Pass. On a portion of this bog there is an extensive area of quaking flats and pools dominated by the bog mosses *Sphagnum cuspidatum* and *S. auriculatum*. These areas have a typically species-poor flora which includes Bogbean (*Menyanthes trifoliata*), White Beak-sedge (*Rhynchospora alba*), Bog Asphodel (*Narthecium ossifragum*), Common Cottongrass (*Eriophorum angustifolium*) and Great Sundew (*Drosera anglica*). Brown Beak-sedge (*R. fusca*), a locally rare plant of wet bog pools, is occasional within the site. Although the habitat is best developed in very wet areas of intact bog, it may also occur in wet areas of regenerating cutover blanket bog.



Wet heath often occurs in association with blanket bog and features Cross-leaved Heath (*Erica tetralix*). Dry heath is more frequent in this site, and is dominated by Heather (*Calluna vulgaris*), Bell Heather (*Erica cinerea*) and Western Gorse (*Ulex gallii*), with occasional Bilberry (*Vaccinium myrtillus*). This habitat is well-developed on the Paps Mountains. Elsewhere it is often over-grazed, with upland grassland becoming more frequent. Some of the highest ridges support alpine heath (referable to the *Lycopodium alpinum - Racomitrium lanuginosum* association). Widespread plant species of the alpine heath include Bog-myrtle (*Vaccinium myrtillus*), Crowberry (*Empetrum nigrum*) and Fir Clubmoss (*Huperzia selago*), while species such as Juniper (*Juniperus communis* subsp. n*ana*) and Dwarf Willow (*Salix herbacea*) have a much more restricted distribution.

The site contains many lakes, but these can be broadly divided into two types: small upland corrie lakes and larger lowland lakes. Examples of the first type are Lough Murtagh and Lough Gortavehy in the Paps Mountains. They are oligotrophic and typically species-poor, with Quillwort (*Isoetes lacustris*), Water Lobelia (*Lobelia dortmanna*) and Shoreweed (*Littorella uniflora*) occurring most commonly. The lowland lakes are mostly oligotrophic, although Lough Leane, the largest freshwater body in the region, has become somewhat mesotrophic as a result of pollution from Killarney town. These lowland lakes tend to be more species-rich than those at higher altitudes, with additional species such as Awlwort (*Subularia aquatica*), Six-stamened Waterwort (*Elatine hexandra*) and Alternate Water-milfoil (*Myriophyllum*

*alterniflorum*). Good examples include Lough Caragh, Upper Lake and Muckross Lake.

The rivers associated with these lakes are also of importance. The Caragh is relatively unpolluted from headwater to estuary, a rare phenomenon in Europe. The Flesk runs over Old Red Sandstone in its upper reaches and limestone as it nears Lough Leane. Both rivers support floating and submerged vegetation and rare invertebrates. Rocks around the smaller mountain streams often support a lush vegetation of ferns and bryophytes, most notably at Torc Waterfall.

Other habitats of note include: Juniper scrub found on islands in the Upper Lake and on dry ridges in nearby Newfoundland Bog; damp meadows, with Purple Moor-grass (*Molinia caerulea*), supporting scarce species such as Whorled Caraway (*Carum verticillatum*) and Ivy-leaved Bellflower (*Wahlenbergia hederacea*); and Calaminarian grasslands, associated with the old copper mines on Ross Island, with species such as Sea Campion (*Silene vulgaris* subsp. *maritima*) and Thrift (*Armeria maritima*).

A large number of plant and animal species of interest occur within the site. For example, two plant species listed on Annex II of the E.U. Habitats Directive occur. Slender Naiad (*Najas flexilis*) is found in some of the lakes at the site. The Killarney Fern (*Trichomanes speciosum*) is another listed and well-known rarity. An additional twenty-two Red Data Book plant species have been recorded, but only twelve of these have been seen recently. These are Pillwort (*Pilularia globulifera*), Kerry Lily (*Simethis planifolia*), Irish Lady's-tresses (*Spiranthes romanzoffiana*), Slender Cottongrass (*Eriophorum gracile*), Small Cudweed (*Logfia minima*), Betony (*Stachys officinalis*), Heath Cudweed (*Omalotheca sylvatica*), Alder Buckthorn (*Frangula alnus*), Alpine Saw-wort (*Saussurea alpina*), Hoary Whitlowgrass (*Draba incana*), Smooth Brome (*Bromus racemosus*) and Holly Fern (*Polystichum lonchitis*). The first seven of these species are legally protected under the Flora (Protection) Order, 1999, as are Slender Naiad and Killarney Fern.



Additional plant species of interest include a fern (*Dryopteris affinis* subsp. *stilluppensis*) and a Whitebeam (*Sorbus anglica*), both at their only Irish locations.

The site is very important for oceanic bryophytes, particularly the woodland species. It also contains good representative examples of the Northern Atlantic Hepatic Mat community and other oceanic montane communities. Killarney Oak woods and mountains have been nominated as a site of international importance for bryophytes.

The Killarney Woods are notable for the number of rare species of Myxomycete fungus that have been recorded, namely *Collaria arcyrionema*, *Craterium muscorum*, *Cribraria microcarpa* (only known Irish site), *C. rufa*, *C. violacea*, *Diderma chondrioderma*, *D. lucidum*, *D. ochraceum*, *Fuligo muscorum* and *Licea marginata*.

The site has six bird species which are listed on Annex I of the E.U. Birds Directive. A small flock of Greenland White-fronted Goose, which winters on the boglands within the National Park, is now the only regular flock in the south-west. The site has one of

the highest concentrations of breeding Peregrines in the country, as well as some breeding Merlin. Chough is found both in the coastal and inland areas of the site, with possibly up to 30 pairs breeding. Kingfisher is a species associated with the lakes and rivers, especially in the National Park and probably breeds. Finally, a few pairs of Common Tern breed within the site.

The woodlands provide habitat for a variety of breeding birds, most notably Garden Warbler, Blackcap, and probably a few pairs each of the rare Redstart and Wood Warbler. Lough Leane is a site for wintering wildfowl with the following average counts for the two winters 1995/96 and 1996/97: Teal (208), Mallard (350), Pochard (81), Tufted Duck (323) and Coot (169).

The site supports most of the Irish mammal species. Of particular note is the occurrence of two E.U. Habitats Directive Annex II species: Lesser Horseshoe Bat, with a total population of about 300 individuals distributed at several locations, including both nursery and hibernation sites, and Otter. Perhaps the best known mammals of the Killarney National Park are the Red Deer, which form the only remaining native herd in Ireland, comprised of around 600 animals. Sika Deer also occur. Pine Marten is another notable species.



The site is valuable for its rare fish species, five of which are listed on Annex II of the E.U. Habitats Directive: Brook Lamprey (*Lampetra planeri*), River Lamprey (*Lampetra fluviatilis*), Sea Lamprey (*Petromyzon marinus*), Atlantic Salmon (*Salmo salar*) and Killarney Shad (*Alosa fallax killarnensis*). The Killarney Shad is a unique land-locked subspecies confined to the Killarney lakes. Also of note is the glacial relict, Arctic Char (*Salvelinus alpinus*), a Red Data Book species, a unique form of which is found in Lough Coomasaharn.

There are numerous rare invertebrates within the site. These include three E.U. Habitats Directive Annex II species: Kerry Slug (*Geomalacus maculosus*), the Freshwater Pearl Mussel (*Margaritifera margaritifera*) and the Marsh Fritillary (*Euphydryas aurinia*). The Kerry Slug and Pearl Mussel populations are of particular importance in a national context. Other species of note include: three chironomids of international importance found in the River Flesk; a wood ant (*Formica lugubris*) at one of only four Irish sites; a snail (*Limnaea involuta*), in Lough Crincaum, at its only known location; two dragonflies (*Cordulea aenea* and *Somatochlora arctica*), the former at one of only two known sites in Ireland and the latter at its only known Irish location; and several other aquatic and woodland species at their only known Irish locations.

The main land use within the site is grazing by sheep. In and around the National Park deer grazing is also common. The extensive grazing has caused damage to many of the terrestrial habitats, resulting in degradation of heath and blanket bogs and prevention of woodland regeneration. In the upland habitats the erosion caused by grazing is exacerbated by the exposed nature of the terrain. Apart from grazing, the woodlands are particularly threatened by Rhododendron (*Rhododendron ponticum*) invasion: approximately two thirds of the Oak woodlands are affected,

although a Rhododendron removal programme is underway in the National Park. The Yew wood has been adversely affected by heavy grazing for many years, but it is intended to control this in the near future by erection of a deer fence. The bogs are sensitive to grazing and are also threatened by turbary, burning and afforestation. Most of the lakes are very acid-sensitive and therefore vulnerable to afforestation within the catchment areas. Lough Leane has been subject to some eutrophication, although water quality appears to have improved since phosphates were removed from the sewage in 1985.

A management plan was drawn up for the Killarney National Park in 1991. The park is managed primarily for conservation purposes although recreation is also provided for.

Overall, the site is of high ecological value because of the diversity, quality and extensiveness of many of the habitats, and impressive list of rare species of flora and fauna. In recognition of its importance the Killarney National Park has been designated a World Biosphere Reserve.

# SITE SYNOPSIS

## SITE NAME: KILLARNEY NATIONAL PARK SPA

## SITE CODE: 004038

This large site encompasses the lakes and part of the Macgillycuddy's Reeks in the vicinity of the town of Killarney in Co. Kerry. The underlying geology is Old Red Sandstone and, on the eastern shores of Lough Leane, Carboniferous limestone. Lough Leane is the largest (8.6 km along its long axis) of the lakes in the site, and is classified as a mesotrophic system. Muckross Lake and the Upper Lake are both high quality oligotrophic systems.

Killarney National Park is perhaps best known for its Oak woodlands. They form the most extensive area of native woodland remaining in Ireland and include Derrycunihy Wood, described as perhaps the most natural Sessile Oak wood in the country. The higher areas of the site are dominated by blanket bog and wet heath.

At the time this site was designated as a Special Protection Area (SPA) it was being utilised by Greenland White-fronted Goose. This, along with the nearby Eirk Bog, is the most southerly site in Ireland utilised by this species and it is also one of the few flocks that continues to utilise peatland habitats. The site continues to be used by Greenland White-fronted Goose in small numbers (<20 birds) and is regarded as a special conservation interest for this SPA.



While Killarney National Park has not been subject to a complete upland breeding bird survey the habitat within the site is estimated to support up to 5 pairs of Merlin and therefore this species is regarded as a special conservation interest for this SPA.

Other upland species which breed within the site include Peregrine (1 pair), Ring Ouzel (1-2 pairs) and Red Grouse. The extensive woodlands support some scarce breeding birds, notably Redstart (1-2 pairs), Wood Warbler (1-2 pairs) and Garden Warbler (possibly up to 10 pairs).

Lough Leane, and to a lesser extent the other lakes, support a variety of wintering waterfowl species including Mute Swan (38), Teal (184), Mallard (361), Pochard (54), Tufted Duck (271), Goldeneye (23), Little Grebe (11), Cormorant (86), Coot (124) and Black-headed Gull (84) – all counts are three year mean peaks for the period 1995/96-1997/98. Several research programmes have been carried out on the birds in the site, including studies on the communities associated with the Yew woodlands, and the wildfowl associated with the lakes. Part of Killarney National Park SPA is a Wildfowl Sanctuary.

7.7.2014

APPENDIX 3

**2017**

| Parameter | Units | 25-Jan | 01-Feb | 08-Feb | 15-Feb | 17-Feb | 22-Feb | 01-Mar | 08-Mar | 22-Mar | 29-Mar |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | | 7.2 | 7.1 | 7.2 | 7.3 | 7.2 | 7.2 | 7.1 | 7.1 | 7.2 | 7.2 |
| **Conductivity** | uS/cm | 319 | 263 | 321 | 218 | 321 | 238 | 285 | 277 | 420 | 298 |
| **Total Ammonia** | mg/l | 0.12 | 0.03 | 0.12 | 0.06 | 0.12 | 0.07 | 0.12 | 0.12 | 0.21 | 0.03 |
| **COD** | mg/l | 45 | 48 | 32 | 50 | 32 | 67 | 30 | 19 | 41 | 55 |
| **Suspended Solids** | mg/l | 5 | <2 | 3 | <2 | 3 | 38 | <2 | <2 | 5 | <2 |
| **Chloride** | mg/l | 49.6 | 20.6 | 17.1 | 18.6 | 17.1 | 18.1 | 19 | 15.2 | 25.3 | 21.8 |
| **Sulphate** | mg/l | 26.3 | 31.6 | 41 | 16.3 | 41 | 14.2 | 28.2 | 49.5 | 68.9 | 27.8 |

| Parameter | Units | 05-Apr | 19-Apr | 28-Jun | 30-Jun | 04-Jul | 19-Jul | 26-Jul | 02-Aug | 09-Aug | 30-Aug |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | | 7.4 | 7.4 | 7.4 | 7.1 | 7.1 | 7.2 | 7.2 | 7.3 | 7.2 | 7.2 |
| **Conductivity** | uS/cm | 423 | 263 | 371 | 374 | 353 | 460 | 349 | 319 | 348 | 294 |
| **Total Ammonia** | mg/l | 0.21 | 0.1 | 0.16 | 0.63 | 0.32 | 0.68 | 0.57 | 0.27 | 0.24 | 0.3 |
| **COD** | mg/l | 39 | 59 | 60 | 73 | 65 | 50 | 42 | 62 | 38 | 70 |
| **Suspended Solids** | mg/l | <2 | 25 | 2 | <2 | 3 | 4 | 3 | 3 | 2 | 3 |
| **Chloride** | mg/l | 26.3 | 20.6 | 26.1 | 21.1 | 21 | 34.2 | 21.1 | 21.3 | 22.2 | 19.6 |
| **Sulphate** | mg/l | 57.4 | 10.4 | 27.3 | 9.96 | 8.56 | 23.9 | 36.6 | 16.7 | 23.4 | 10.6 |

**2018**

| Parameter | Units | 13-Sep | 12-Oct | 25-Oct | 01-Nov | 12-Dec | 17-Dec | 11-Jan | 17-Jan | 26-Jan | 31-Jan |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | | 7.1 | 7.1 | 7.3 | 7.2 | 7.3 | 7.2 | 6.7 | 7.4 | 7.3 | 7.4 |
| **Conductivity** | uS/cm | 260 | 313 | 242 | 242 | 433 | 238 | 235 | 365 | 365 | 323 |
| **Total Ammonia** | mg/l | 0.05 | 0.22 | 0.07 | 0.05 | 0.65 | 0.04 | 0.03 | 0.04 | 0.16 | 0.32 |
| **COD** | mg/l | 72 | 53 | 61 | 63 | 25 | 52 | 73 | 27 | 20 | 36 |
| **Suspended Solids** | mg/l | 12 | 4 | <2 | <2 | <2 | 2 | 2 | 0 | 0 | 0 |
| **Chloride** | mg/l | 23.1 | 16.8 | 22.1 | 21.5 | 31.1 | 22.7 | 30 | 32.2 | 28.3 | 28.1 |
| **Sulphate** | mg/l | 20.4 | 26.5 | 18.2 | 14.5 | 70.3 | 14.3 | 18.3 | 32.6 | 67.2 | 32.1 |

| Parameter | Units | 08-Feb | 14-Feb | 07-Mar | 16-Mar | 21-Mar | 28-Mar | 04-Apr | 18-Apr | 25-Apr | 09-May |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | | 7.2 | 7.1 | 7 | 7 | 7 | 7 | 7.5 | 7.1 | 7.1 | 7.4 |
| **Conductivity** | uS/cm | 457 | 575 | 416 | 252 | 223 | 398 | 227 | 421 | 219 | 252 |
| **Total Ammonia** | mg/l | 0.15 | 0.13 | 0.46 | 0.08 | 0.02 | 0.17 | 0 | 0.25 | 0 | 0 |
| **COD** | mg/l | 18 | 20 | 19 | 55 | 34 | 24 | 41 | 45 | 46 | 50 |
| **Suspended Solids** | mg/l | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 3.6 |
| **Chloride** | mg/l | 29.5 | 57.2 | 36 | 27 | 25.7 | 23.8 | 20.6 | 20.7 | 19 | 21.4 |
| **Sulphate** | mg/l | 52.7 | 95.7 | 64.2 | 21.4 | 16 | 69.98 | 15.5 | 98 | 17.9 | 15.9 |

| Parameter | Units | 16-May | 23-May | 31-May | 08-Aug | 05-Sep | 21-Sep | 24-Sep | 26-Sep | 11-Oct | 17-Oct |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | | 7.4 | 7.3 | 7.4 | 7.2 | 7.4 | 6.8 | 7 | 7.1 | 7.3 | 7.1 |
| **Conductivity** | uS/cm | 244 | 241 | 255 | 664 | 649 | 370 | 347 | 344 | 427 | 309 |
| **Total Ammonia** | mg/l | 0 | 0.05 | 0.05 | 0.1 | 0.06 | 0.3 | 0.04 | 0.14 | 0.22 | 0.05 |
| **COD** | mg/l | 70 | 32 | 74 | 35 | 61 | 70 | 52 | 72 | 70 | 65 |
| **Suspended Solids** | mg/l | 0 | 0 | 2.4 | 48 | 15 | 4 | 0 | 0 | 3 | 0 |
| **Chloride** | mg/l | 19.7 | 20.87 | 18.1 | 30 | 32.7 | 24.1 | 24.9 | 23.8 | 30.9 | 23 |
| **Sulphate** | mg/l | 14.3 | 16.42 | 11.5 | 209 | 126 | 79.5 | 54.6 | 68 | 64.6 | 59.6 |

**2019**

| Parameter | Units | 07-Nov | 16-Nov | 21-Nov | 07-Dec | 20-Dec | 03-Jan | 16-Jan | 25-Jan | 06-Feb | 15-Feb |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | | 7.4 | 6.9 | 6.8 | 7 | 7 | 7.2 | 7.2 | 6.8 | 7 | 6.9 |
| **Conductivity** | uS/cm | 308 | 247 | 228 | 243 | 251 | 224 | 270 | 259 | 249 | 218 |
| **Total Ammonia** | mg/l | 0.26 | 0.15 | 0.24 | 0.25 | 0.32 | 0.03 | 0.1 | 0.04 | 0.1 | 0.05 |
| **COD** | mg/l | 52 | 52 | 51 | 52 | 44 | 59 | 69 | 85 | 45 | 47 |
| **Suspended Solids** | mg/l | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 0 | 0 |
| **Chloride** | mg/l | 21.4 | 20.1 | 20.2 | 18.6 | 19.9 | 23.2 | 23.2 | 19.5 | 19.7 | 15.6 |
| **Sulphate** | mg/l | 53.8 | 52.8 | 37.7 | 43.9 | 42.6 | 20.1 | 28 | 63.1 | 33.2 | 24.3 |



| Parameter | Units | 19-Feb | 07-Mar | 14-Mar | 27-Mar | 04-Apr | 10-Apr | 24-Apr | 01-May | 14-Aug | 13-Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **pH** | | 7.1 | 7.2 | 7.4 | 7.6 | 7.2 | 7.3 | 7.5 | 7.1 | 7.4 | 7.9 |
| **Conductivity** | uS/cm | 229 | 478 | 435 | 267 | 277 | 305 | 293 | 316 | 290 | 367 |
| **Total Ammonia** | mg/l | 0.05 | 0.34 | 0.09 | 0.02 | 0.1 | 0.03 | 0.03 | 0.03 | 0.15 | 0.15 |
| **COD** | mg/l | 46 | 24 | 59 | 48 | 10 | 54 | 59 | 58 | 89 | 97 |
| **Suspended Solids** | mg/l | 0 | 5 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Chloride** | mg/l | 15.3 | 22.3 | 37.1 | 22 | 23 | 22.7 | 21 | 28.1 | 19.4 | 23.6 |
| **Sulphate** | mg/l | 23.1 | 97.3 | 84.6 | 22 | 36 | 30.9 | 15.6 | 26.3 | 29.2 | 23.4 |

| Parameter | Units | 19-Sep | 18-Oct |
|---|---|---|---|
| **pH** | | 7.2 | 7.2 |
| **Conductivity** | uS/cm | 288 | 281 |
| **Total Ammonia** | mg/l | 0.1 | 0.09 |
| **COD** | mg/l | 85 | 63 |
| **Suspended Solids** | mg/l | 0 | 0 |
| **Chloride** | mg/l | 22.5 | 18 |
| **Sulphate** | mg/l | 9.7 | 26.6 |

APPENDIX 4

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# HYDROGEOLOGICAL SURVEY REPORT

## KILLARNEY WASTE DISPOSAL LTD

## AUGHACURREEN

## WASTE LICENCE NO. W0217-01



**Prepared For: -**

Killarney Waste Disposal Ltd,
Aughcureen,
Killarney,
County Kerry.

**Prepared By: -**

O' Callaghan Moran & Associates,
Unit 15
Melbourne Business Park,
Model Farm Road,
Cork

**February 2017**

| Project | Groundwater Quality Assessment | | | |
|---|---|---|---|---|
| Client<br>Licence | Killarney Waste Disposal Ltd<br>W0217-01 | | | |
| Report No | Date | Status | Prepared By | Reviewed By |
| 1602330201 | 14/07/2017 | Draft Client Review | Jim O'Callaghan MSc, CEnv, MCIWM, IEMA | Sean Moran MSc, PGeol, Euro Geol MCIWEM |
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## EXECUTIVE SUMMARY

Killarney Waste Disposal Ltd (KWD) operates its facility at Aughacureen under Waste Licence Reg. No. W0217-01. In 2008 KWD commissioned OES to carry out a Hydrogeological Survey of the site in compliance with Condition 3.21 of the licence. The survey included the installation of four on-site groundwater wells (MW-1, MW-2, MW-3 and MW-4) and the collection and analysis of groundwater samples. Elevated ammonia levels were detected in three of the wells (MW-1, MW-2 and MW-3) and OES concluded that the source was off site agricultural and forestry land use.

The Agency, based on the continued detection of elevated ammonia levels in a number of the wells, requested KWD to submit an up-to-date hydrogeological investigation report that examined the reasons for the high concentrations. KWD commissioned O'Callaghan Moran & Associates (OCM) to update the OES report.

The facility encompasses 2.2 hectares (ha) and consists of a material recovery building (3,223m$^2$), concrete yards, weighbridge and administration building. Ancillary infrastructure includes fuel storage, storm water drainage system and reed bed, and a sanitary effluent treatment system.

The soils and subsoils at the site comprise peat overlying till and the combined thickness ranges from 3m in the east to the site to 5m in the west. The underlying bedrock is shale and sandstone, the upper 3 to 5m of which is weathered. The bedrock is classified as a locally important aquifer, which is moderately productive only in local zones. It is not used locally as a water supply source. The aquifer vulnerability to pollution from the ground surface ranges from Moderate to High. The direction of groundwater flows is from the south-west to north-east.

During the installation of the monitoring wells water strikes were encountered between 10 and 20m below ground level. Subsequently the water levels in all of the wells rose above the top of the weathered bedrock, indicating confined conditions. This is confirmed by the water level data recorded during the routine monitoring and OCM field observations of artesian conditions in one of the wells.

The on-site potential sources of groundwater contamination are a leachate sump inside the materials recovery building; a sump at the timber and metal storage area; an oil storage tank, oil interceptor; the reed beds and percolation area, and the percolation area associated with the 'puraflo' sanitary waste treatment system installed in 2016. The sumps, oil interceptor and oil tank bund are subjected to routine integrity tests. The most recent were completed in 2016 and confirmed the structures were fit for purpose. Testing of the treated sanitary effluent has confirmed that the 'puraflo' system is functioning properly.

Past operational practices, including the discharge of surface water run-off from the bin washing area and compost bay to the reed beds; the original septic tank, and the discharge of water from the sumps at the timber storage area and at the weighbridge had the potential to cause groundwater contamination.

The site is in a rural area and the surrounding land use is primarily agricultural, with some forestry. There are approximately twenty (20) residences within 500m of the facility, the majority of which are in a 'ribbon development' along the local road to the north of the site. It is understood that the houses are served by septic tanks.

Monitoring wells MW-3 and MW-4 are up gradient of waste activities and MW-1 and MW-2 are down gradient. All of the wells are exclusively screened in the bedrock, however at MW-2 and MW-4 the screen extends into the weathered zone.

Since monitoring began in 2009, elevated ammonia has been detected in MW-1, MW-2 and MW-3. Nitrate has never been detected in any of the wells and sulphate, while present in MW-4, has only very occasionally been detected at very low levels in the other wells. The redox potential in all of the wells, in conjunction with the low nitrate and presence of dissolved iron, indicates reducing conditions, which is consistent with confined aquifer conditions.

While the wastes activities are a potential source of organic matter that typically is required to allow reducing conditions to develop, the monitoring data does not indicate this is the case, as the electrical conductivity, chloride and Chemical Oxygen Demand (COD) levels are consistent with uncontaminated groundwater.

Faecal coliforms were detected in MW-3 and MW-4 in January 2017. The headworks of both wells are damaged and there are no well caps, meaning the wells are susceptible to faecal contamination by birds and small mammals, and, in the case of MW-4, the entry of surface water run-off.

The elevated ammonia detected in MW-1, MW-2 and MW-3 is due to naturally occurring reducing conditions in the aquifer. The condition of the well heads at MW-3 and MW-4 means they are vulnerable to contamination from the ground surface and it is recommended that they be repaired and the wells disinfected.

# 1. INTRODUCTION

## 1.1 General Introduction

KWD operates its Materials Recovery Facility at Aughacureen under Waste Licence Reg. No. W0217-01 issued by the Environmental Protection Agency (Agency). In 2008 KWD commissioned OES to carry out a Hydrogeological Survey of the site in compliance with Condition 3.21 of the licence. The survey included the installation of on-site groundwater wells and the collection and analysis of groundwater samples in 2009 and 2019. Elevated ammonia levels were detected in a number of the wells and OES concluded that based on the direction of groundwater flow the sources were off-site.

Bi-annual groundwater monitoring began in 2012. The Agency, based on elevated ammonia levels persistently detected in a number of the wells requested KWD to submit an up-to-date hydrological investigation report that examined the reasons for the high concentrations. KWD commissioned O'Callaghan Moran & Associates (OCM) to update the OES report.

The revised report is based on information in the Environmental Impact Statement (EIS) prepared in 2005, the OES report, databases maintained by Teagasc and the Geological Survey of Ireland (GSI) and the results of the groundwater monitoring carried out by KWD.



## 1.2 Objective and Background Information

The objectives of the updated report were at a minimum to clarify the precise groundwater flow direction contours around the site based on datum levels of water within the wells; provide analysis results for the total and faecal coliforms from the well; provide integrity test results for all sumps, lagoons and underground pipelines handling effluent or sanitary waste and clarify the presence and use of any private groundwater abstraction wells at residential properties within 200m of the facility.

*Site History*

The site was developed as a waste management facility in 1987 on lands that had previously been used for agricultural purposes. It operated under a series of Waste Permits issued by Kerry County Council that authorised the acceptance and processing of 16,500 tonnes/annum of non-hazardous waste. In 2005 the Agency granted a Waste Licence that authorised the acceptance and processing of 40,000 tonnes of non-hazardous waste.

## 1.3 Summary of Previous Assessments

OES submitted the proposed scope of the hydrological survey to the Agency and, following receipt of approval, completed the assessment. It comprised a desk study of geological and hydrogeological databases maintained by the GSI the installation of four groundwater monitoring wells (MW-1, MW-2, MW-3 and MW-4); the collection and analysis of groundwater samples on three occasions and an assessment of potential on and off-site contaminant sources. A copy of the report is in Appendix 1.

OES established that the underlying bedrock is a Locally Important aquifer, bedrock which is moderately productive only in Local Zones (**Ll**) and that secondary permeability is dominant. The nearest groundwater well to the site was more than 1km upgradient, with the closest down gradient well 2.7km away.

Two of the monitoring wells (MW-1 and MW-2) were positioned to the south and down topographic gradient of the operational area, with MW-3 and MW-4 being to the north and up gradient. The wells were installed using an air rotary rig.

The borehole logs indicate the soils and subsoils comprise peat overlying 'mottled clay'. The peat was up to 2m thick and the clay was between 1 and 3m thick. The underlying bedrock is described as a weathered black shale.

The borings extended to between 18 and 24 m below ground level and water strikes were encountered in the bedrock at depths ranging from 11 to 20m below ground level (bgl). The water levels recorded in the wells during subsequent groundwater sample collection ranged from 0.1 m below the top of the well pipe in MW-1, to 1.71m in MW-3; however OES did not survey the wells to datum level. More detail on the well construction is provided in Section 4.

OES conducted groundwater quality monitoring on three occasions (04/09/2009, 26/11/2009 and 27/05/2010) for pH, electrical conductivity, total dissolved solids, ammonia, chloride, nitrate, sulphate and extractable petroleum hydrocarbons (EPH).

Elevated ammonia levels were detected in MW-1, MW-2 and MW-3 on all three occasions, with the levels in the up-gradient well (MW-3) ranging from 1.32 to 2.86 mg/l. Ammonia was not detected in the other upgradient well (MW-4). The maximum levels in the down gradient wells were 1.71 mg/l in MW-1 and 2.83 mg/l in MW-2. Nitrate and sulphate were not detected in MW-1, MW-2 and MW-3, but sulphate was detected in MW-4 on one occasion. The electrical conductivity and total dissolved solids levels in MW-4 were significantly lower than in the other wells.

OES identified two potential on-site contaminant sources for the elevated ammonia, which were the leachate holding tank in the materials recovery building and the reed beds. Off-site potential sources included septic tanks, the land application of farm animal slurry and forestry. OES concluded that the leachate tank and reed beds were not the sources of the elevated ammonia and, given its detection in the up gradient well, the source was outside the site boundary.

## 2. ENVIRONMENTAL SETTING

### 2.1 Site Location & Description

The facility is located at Aughacurren approximately 4km km to the north-west of Killarney (Figure 2.1). The site layout is shown on Drawing No. 01 Rev A. It encompasses 2.2 hectares (ha) and consists of a material recovery building (3,223m$^2$), concrete yards, weighbridge and administration building. Ancillary infrastructure includes fuel storage, storm water drainage system and reed bed, and a sanitary effluent treatment system.

### 2.2 Waste Activities

#### *2.2.1 Surface Water Drainage*

There are three separate surface water drainage systems. The first collected rainwater run-off from the roof of the materials recovery building and discharges it to a drain that runs through the site.

Rainwater run-off from the operational yards, where there is the potential for contamination to occur (bin washing area and compost bay), is directed to holding tanks where it is stored pending removal from the site for off-site treatment in the Irish Water Wastewater Treatment Plant (WWTP) in Killarney.

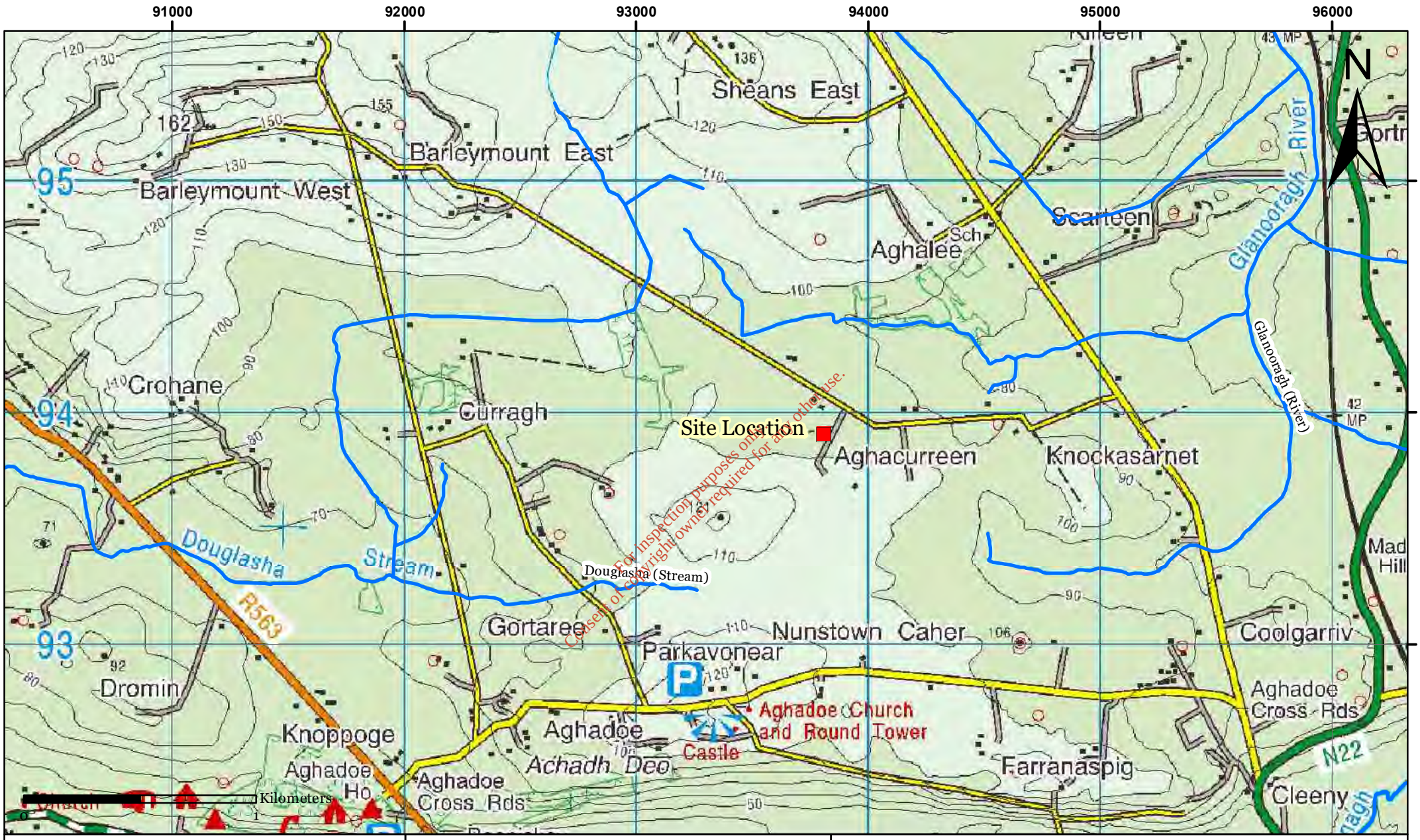
Rainwater run-off from the yards where the risk of contamination is low, including the area around the office and the timber storage area, is collected and directed via a Class 1 Oil Interceptor and three settlement tanks to the on-site reed beds. The reed beds comprise an initial 'glass' bed followed by a 'lagoon' bed. The outflow from the 'lagoon' bed is to an on-site percolation area in the north-west of the site.



#### *2.2.2 Foul Water Drainage*

Liquid seeps from the waste handled inside the materials recovery building is collected in an underground effluent holding tank (6,92m$^3$). The tank is made of pre-cast concrete and sits in a second underground concrete tank that provides secondary containment (bund). The wastewater accumulating in the tank is removed for treatment at the Irish Water WWTP.

Sanitary wastewater is treated in an on-site proprietary wastewater treatment system (puraflo) located close to the northern site boundary, with the treated effluent pumped to an on-site percolation area located to the north of the reed bed percolation area. The system was installed and certified in 2016 to replace a former septic tank located to the north-west of the weighbridge that has now been decommissioned.

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CLIENT
Killarney Waste Disposal

TITLE
Site Location

Details:
Site Location

Figure 2.1

NOTES:

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DO NOT SCALE FROM THIS DRAWING.
WORK ONLY FROM FIGURED DIMENSIONS.
ALL ERRORS AND OMMISIONS TO BE REPORTED TO THE ARCHITECT.

N

Site Area = 2.202 HA

New Pump Main From Puraflo System To Wastewater Treatment Area. Of 4No. Pods On A Polishing Filter.

R 2 & SW 2 drain to external land drain

Glass Reed Bed

Existing Storm Water Settling Tanks x3No.

New Wastewater Treatment Area. Of 4No. Pods On A Polishing Filter.

SEE Drawing K-W-D-04-2016-Rev-A SEW (SPECIFIED ENGINEERING WORKS)

SEE Drawing K-W-D-03-2016-Rev-A SEW (SPECIFIED ENGINEERING WORKS)

Post and Wire Fence

Lagoon Reed Bed 0.5m Freeboard

Solids Separator

stream

New Puraflo System

Existing Septic Tank No Longer In Use

Area of Paving served by Reed Bed = 2550 sq. m

SW 2

SW 1

Storm water (SW 1) drains to percolation ditch

SEE Drawing K-W-D-03-2016-Rev-A SEW (SPECIFIED ENGINEERING WORKS)

Existing Metal Shearing Yard

100mm pipe

ESB Pole

Proposed Borehole 1

SEE Drawing K-W-D-02-2016-Rev-A SEW (SPECIFIED ENGINEERING WORKS)

Baled Plastic Shed

Water drains from wooded area to 400mm land drain

Timber Shredding Yard

Proposed Borehole 2

Proposed new holding tank

750mm Pipe under track

Weigh Bridge

Entrance

Roof Water Discharges to drain.

Proposed Gulley

Heat Exchangers

Proposed Offices

Proposed Gulley

Dryer

Two Air Compressors

New effluent holding tank

Concrete Pipe

Private access road

Baling Shed

MRF Building

R1

Roof stormwater(R1) discharges to roadside drain

Diesel Generator

4.55 cubic metre holding tank

Foul Sewer Pipe

Storm Drainage off Roc

Yard Drainage Pipe

750mm Proposed Drainag

Proposed New Building

Designated Parking Are

Concrete Area

Existing Material Recov

| REV | DATE | REVISION INFO. |
|---|---|---|
| A | 03/10/16 | INFORMATION. |

CLIENT: KWD RECYCLING LTD
MRF FACILITY AT AUGHACUREEN.

PROJECT: SEW (SPECIFIED ENGINEERING WORKS)

DRAWING: SITE LAYOUT PLAN.

SCALE: 1:500 | DATE: 03.10.2016

DWG No. : 01

DONAL MOYNIHAN
B.E, C.Eng., M. IEI.
CHARTERED ENGINEER

## 2.3 Surrounding Land Use

The facility is located in a rural area and the surrounding land use is primarily agricultural, with some forestry (Figure 2.2). There are approximately twenty (20) residences within 500m of the facility, the majority of which are in a 'ribbon development' along the local road to the north of the site. These residences obtain their water supply from the Irish Water mains.

## 2.4 Hydrology

There is a local high point (121mOD) approximately 500 m to the south-west of the site, from where the ground falls away in all directions (Figure 2.3). This high point forms a watershed between tributaries of the Glanooragh River to the north of the site and the Douglasha Stream to the west. Both watercourses are tributaries of the River Laune. The site is in the catchment of the Glanooragh River, which is a tributary of the Gweestin River.

A surface water drain flows through the site in a south-west to north-east direction. At the north-eastern boundary, the drain changes direction to flow south-east along the boundary to the access road, where it turns in a north-easterly direction and joins a tributary of the Glanooragh River, approximately 250m from the site.

## 2.5 Geology

### *2.5.1 Subsoils*

The Teagasc maps (Figure 2.4) indicate that the subsoils are till derived from Namurian shales and sandstones. The logs of the boreholes installed by OES (refer to Appendix 1) indicate the soils comprise peat overlying tills. The combined thickness ranges from 3m in the east of the site to 5m in the west.



### *2.5.2 Bedrock*

The GSI bedrock map (Figure 2.5) indicates the site is underlain by Namurian shales and sandstones. The OES borehole logs indicate the bedrock comprises a black shale, the upper 3 to 5m of which is weathered.

## 2.6 Hydrogeology

### *2.6.1 Aquifer Classification*

The subsoils are not significantly water bearing. The underlying bedrock is characterised by the GSI as a Locally Important aquifer, which is moderately productive only in Local Zones (**Ll**) (Figure 2.6). Permeability in the bedrock is highest in the upper few metres but generally decreases rapidly with depth. In general, groundwater flow is concentrated in the upper 15 m of the aquifer, although deeper inflows from along fault zones or connected fractures can be encountered.

The OES borehole logs show water strikes at between 11 and 20m below ground level. The water levels recorded by OES in the wells in 2009 and 2010 were all significantly above the top of the bedrock, indicating confined conditions.




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CLIENT
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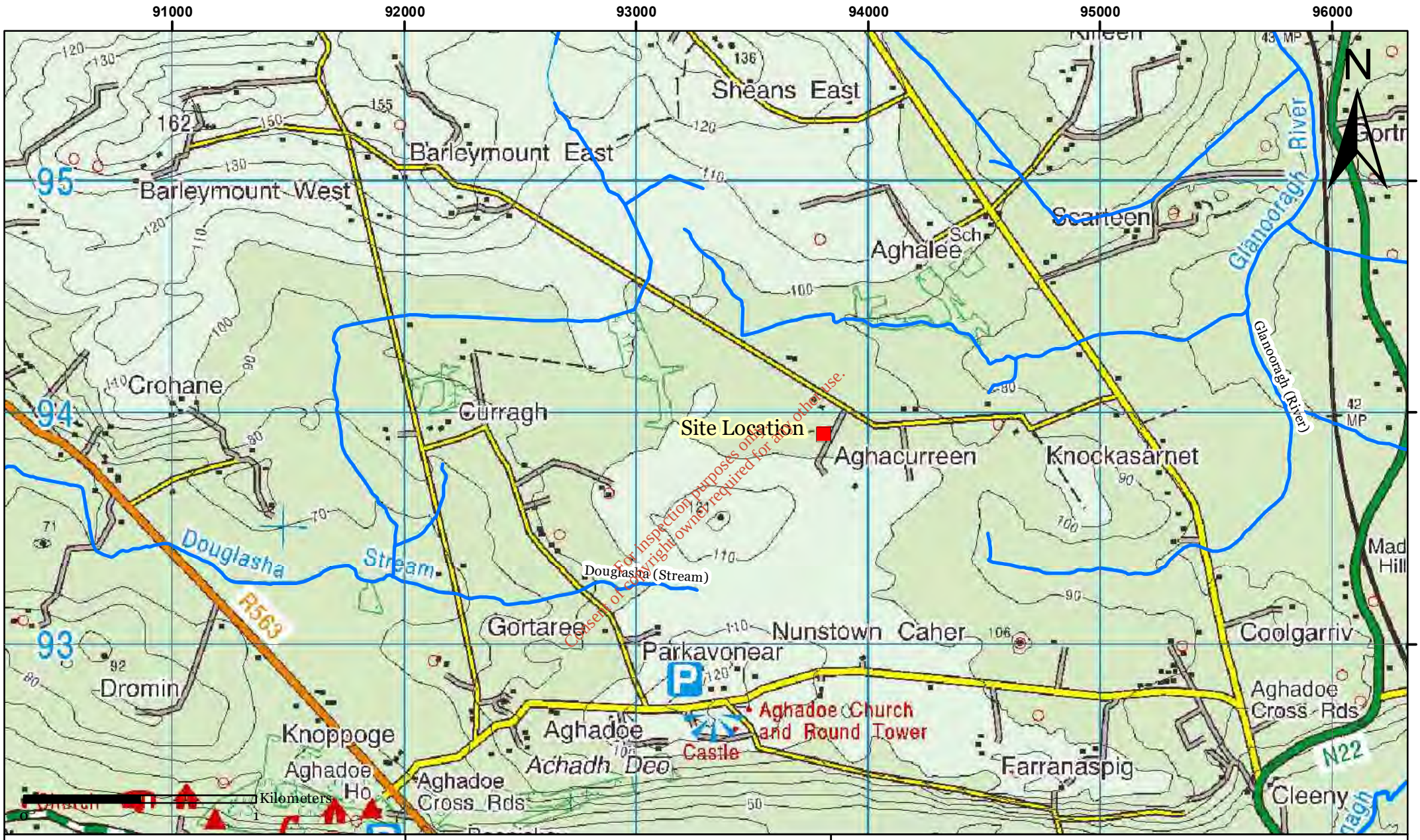
TITLE
Surrounding Land Use

Details:
Site Location

Figure 2.2

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TITLE
Hydrology

Details:
- Site Location
- Rivers

Figure 2.3


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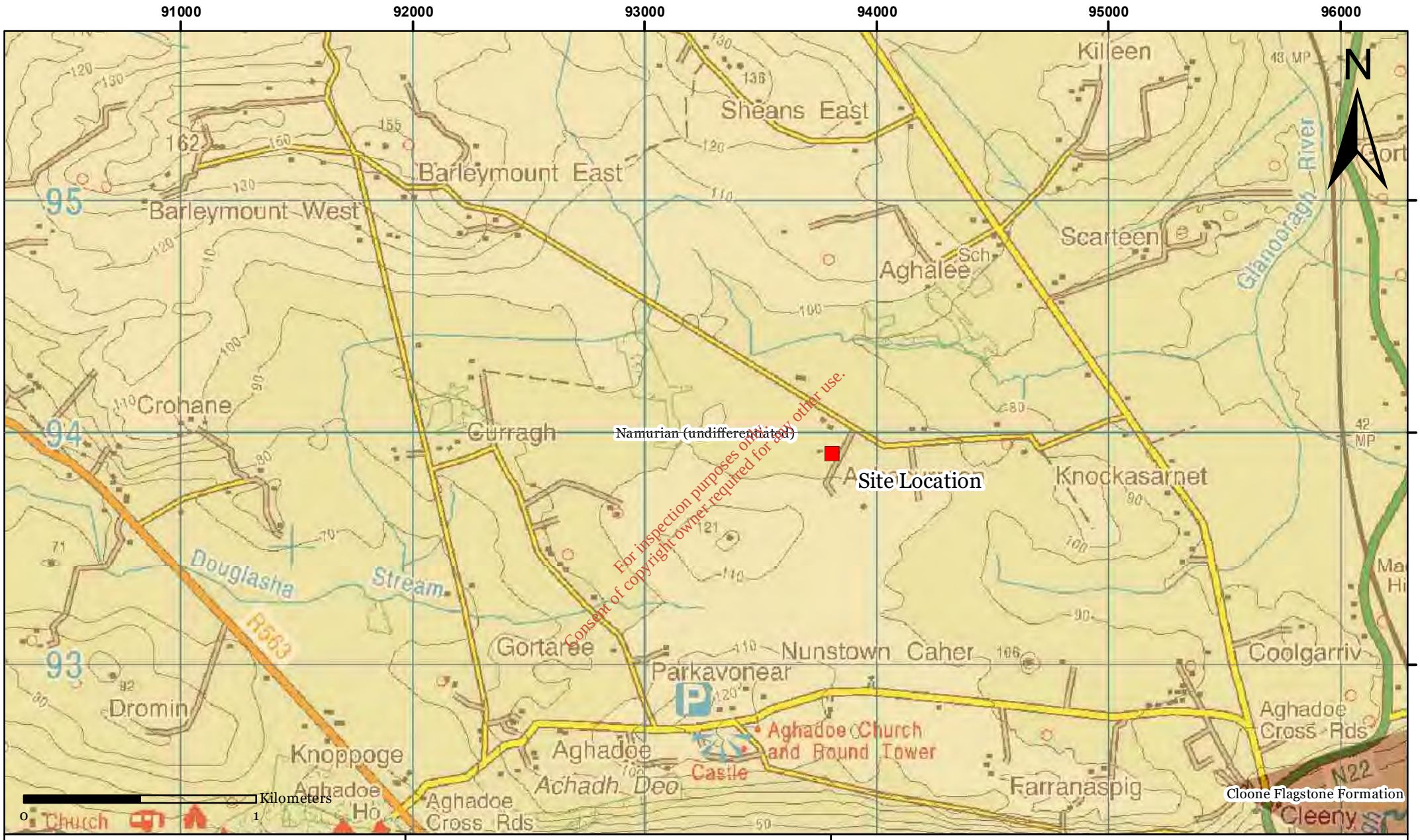
CLIENT
Killarney Waste Disposal

TITLE
Subsoils

Details:
- Site Location
- A - Alluvium undifferentiated
- BktPt - Blanket peat
- Made - Made Ground
- Rck - Bedrock at surface
- TDSs - Sandstone till (Devonian)
- TNSSs - Shales and sandstones till (Namurian)

Figure 2.4

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CLIENT
Killarney Waste Disposal

TITLE
Bedrock Geology

Details:
- Site Location
- Cloone Flagstone Formation-Greywacke,Siltstone & Shale
- Namurian (undifferentiated)-Shale & Sandstone

Figure 2.5

Significant yields can sometimes be obtained from this formation type where boreholes are drilled into known fault zones; however, the yields are not necessarily sustainable, as the fracture networks are generally not extensive or well connected, but primarily concentrated in the vicinity of the fault zones.

The aquifer is part of the Scartaglin Groundwater Body. The GSI's initial characterisation of this water body (Appendix 2) states that the sandstone beds in the bedrock formation have a slightly higher permeability than the shales due to their greater ability to fracture and that there are a number of artesian supplies where the sandstone beds are confined by the shales and mudstones.

### *2.6.2 Aquifer Vulnerability*

Vulnerability is defined as the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. Vulnerability categories range from Extreme (rock close to surface) to **Extreme** to **High** to **Moderate** to **Low** and are dependent on the nature and thickness of subsoils above the water table.

The Namurian till has a low permeability and although in some areas it has a stony matrix there is still generally a high clay content due to the weathering of shale clasts. The GSI Vulnerability Map (Figure 2.7) indicates that the vulnerability across the site is **Low** however the borehole logs describe the soil and subsoil (peat and till) thickness as ranging from 3 to 5m, indicating the vulnerability ranges from **Extreme to High**.

### *2.6.3 Groundwater Flow Paths and Direction*

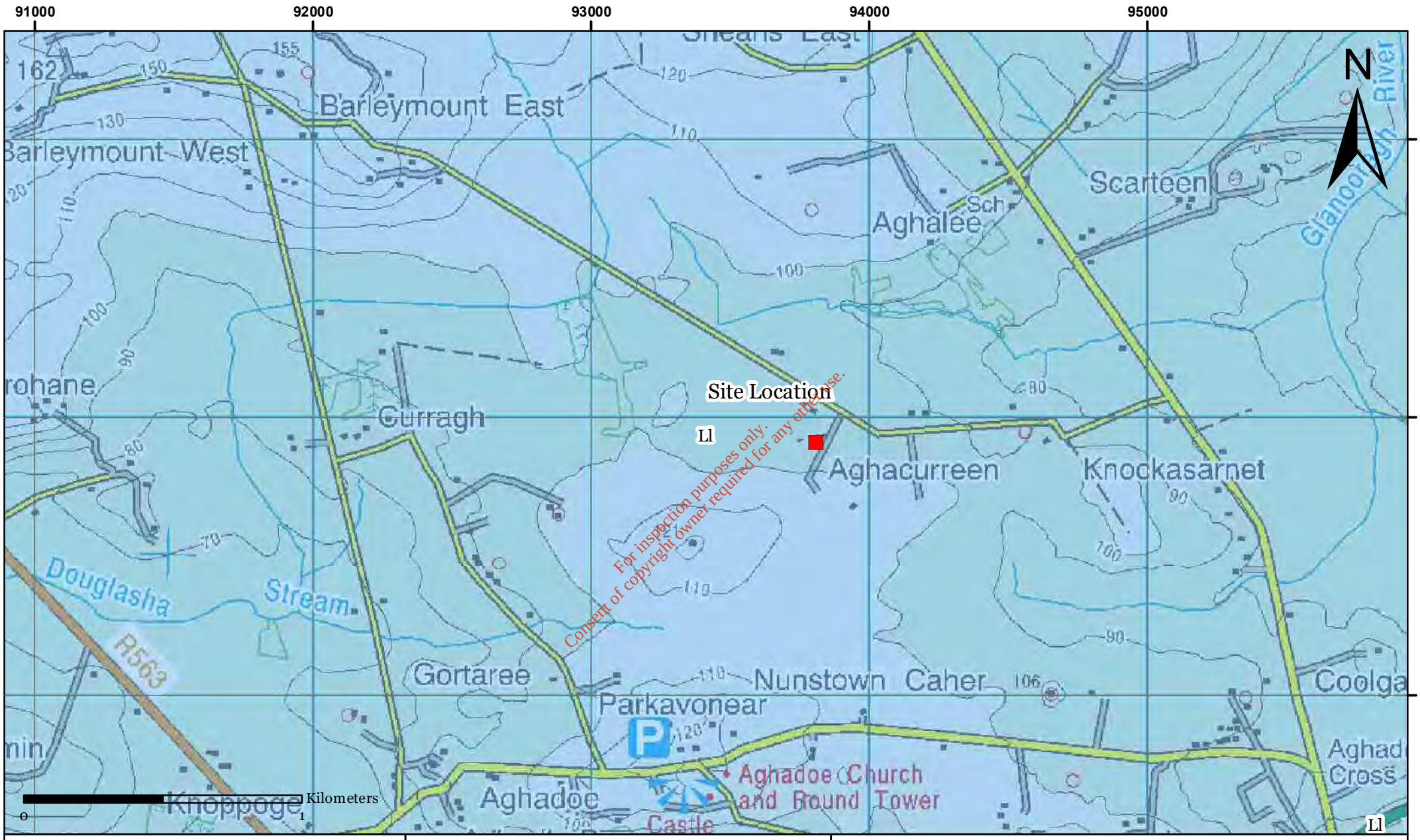
Groundwater flow paths in the bedrock beneath the site are generally short, typically 30-300 m, with groundwater typically discharging to small springs, or to the streams and rivers that traverse the aquifer. Flow directions are expected to mirror the local surface water catchments. The local direction of groundwater flow is likely to be influenced by the topography and be the north-east, towards the tributary of the Glanooragh Stream.



OES recorded the groundwater levels on three occasions in 2009 and 2010; however they did not survey the wells to a datum level and therefore they estimated the direction of groundwater flow as being to the north-east based on the local topography. In October 2016 KWD surveyed the wells to Ordnance Datum (OD) and the level of the top of the casing at each of the wells is shown in Table 2.1.

**Figure 2.1 Monitoring Well Levels**

| Well | Easting | Northing | OD Top of Casing (m) |
|---|---|---|---|
| MW-1 | 493661 | 594052 | 91.792 |
| MW-2 | 493612 | 594086 | 92.814 |
| MW-3 | 493519 | 593989 | 93.645 |
| MW-4 | 493570 | 593933 | 92.816 |

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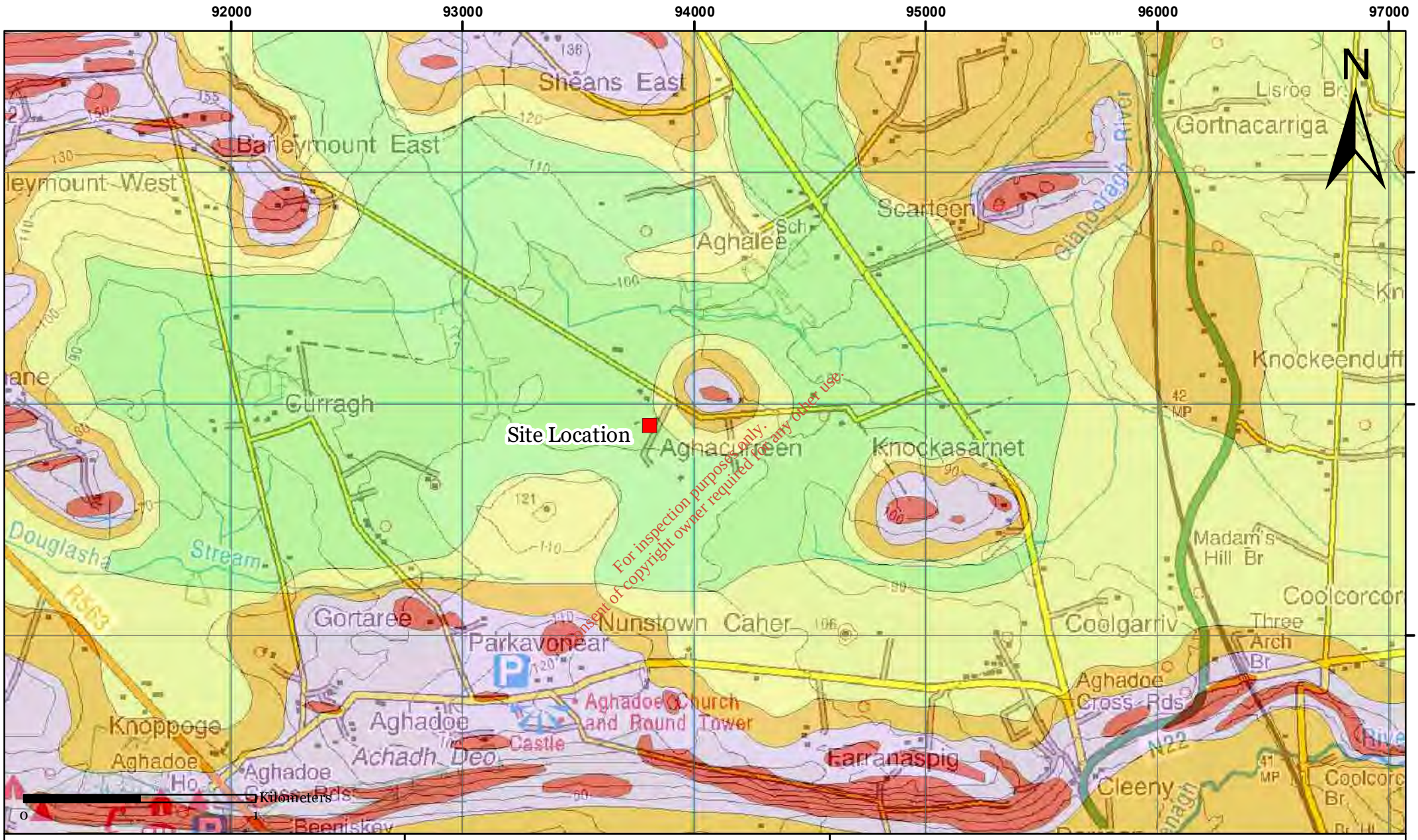
CLIENT
Killarney Waste Disposal

TITLE
Aquifer Classification

Details:
- Site Location
- Ll-Bedrock which is moderately productive only in Local Zones

Figure 2.6

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CLIENT
Killarney Waste Disposal

TITLE
Groundwater Vulnerability

Details:

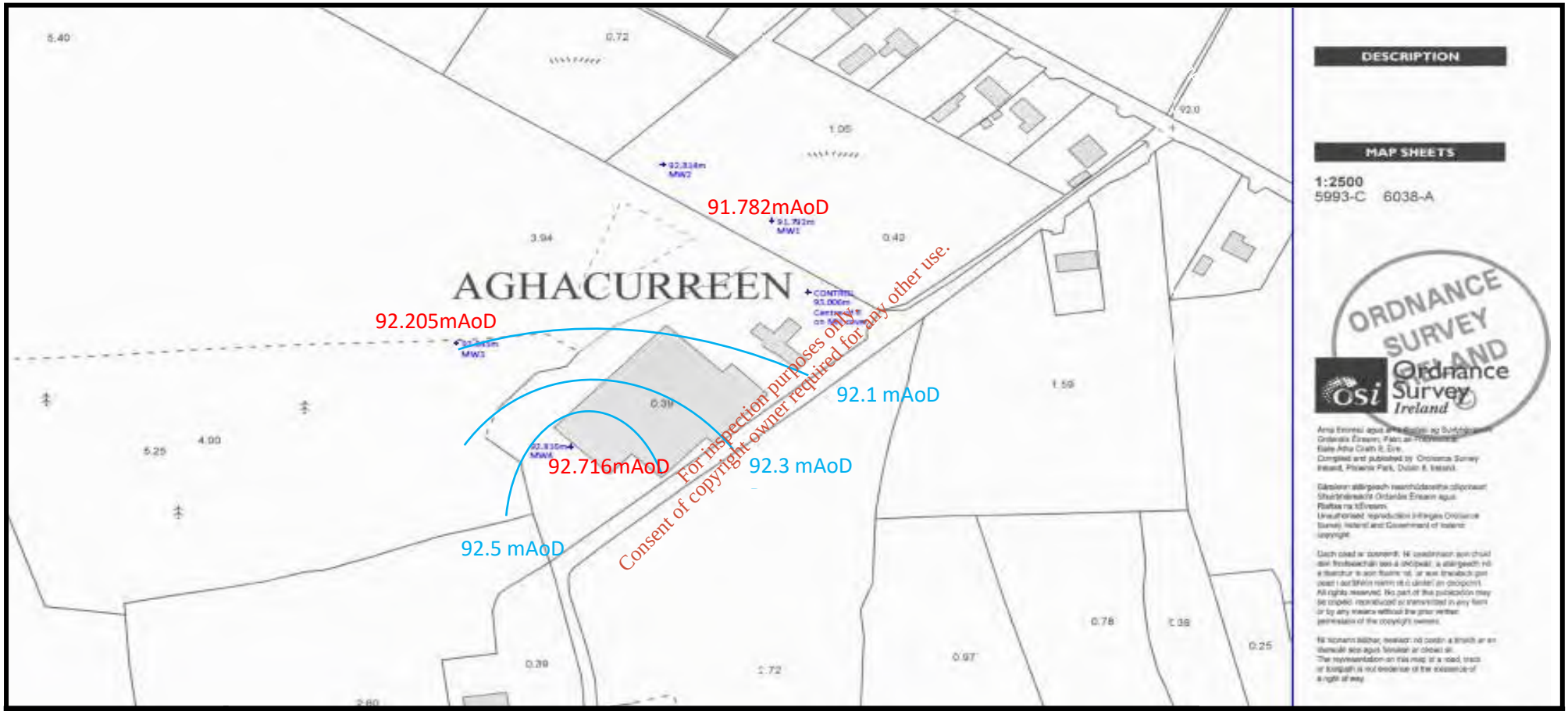
- Site Location
- Bedrock near Surface
- Extreme
- High
- Moderate
- Low

Figure 2.7

Although the groundwater wells have been routinely monitored since 2012 groundwater level data has only been recorded since June 2016. OCM used the water levels recorded in wells MW-1, MW-3 and MW-4 in November 2009 and June 2016 to calculate the groundwater flow direction to compare with the OES estimated direction of flow and the current position and these are shown on Figures 2.8 and 2.9. The flow is from south to north, meaning that wells MW-4 is up gradient and MW-3 Is side gradient of the operational area, while wells MW-1 and MW-2 are downgradient.

### *2.6.4 Groundwater Abstraction Wells*

KWD informed OCM that the private residences to the north of the site obtain their water supplies from the Irish Water mains. A review of the GSI water well database did not identify any additional wells to those described in the OES and the nearest recorded well is 1km up gradient of the site, with the closest down gradient well 2.7km away (Figure 2.10).

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**Title:**

**Figure 2.8**

**Groundwater Contours November 2009**

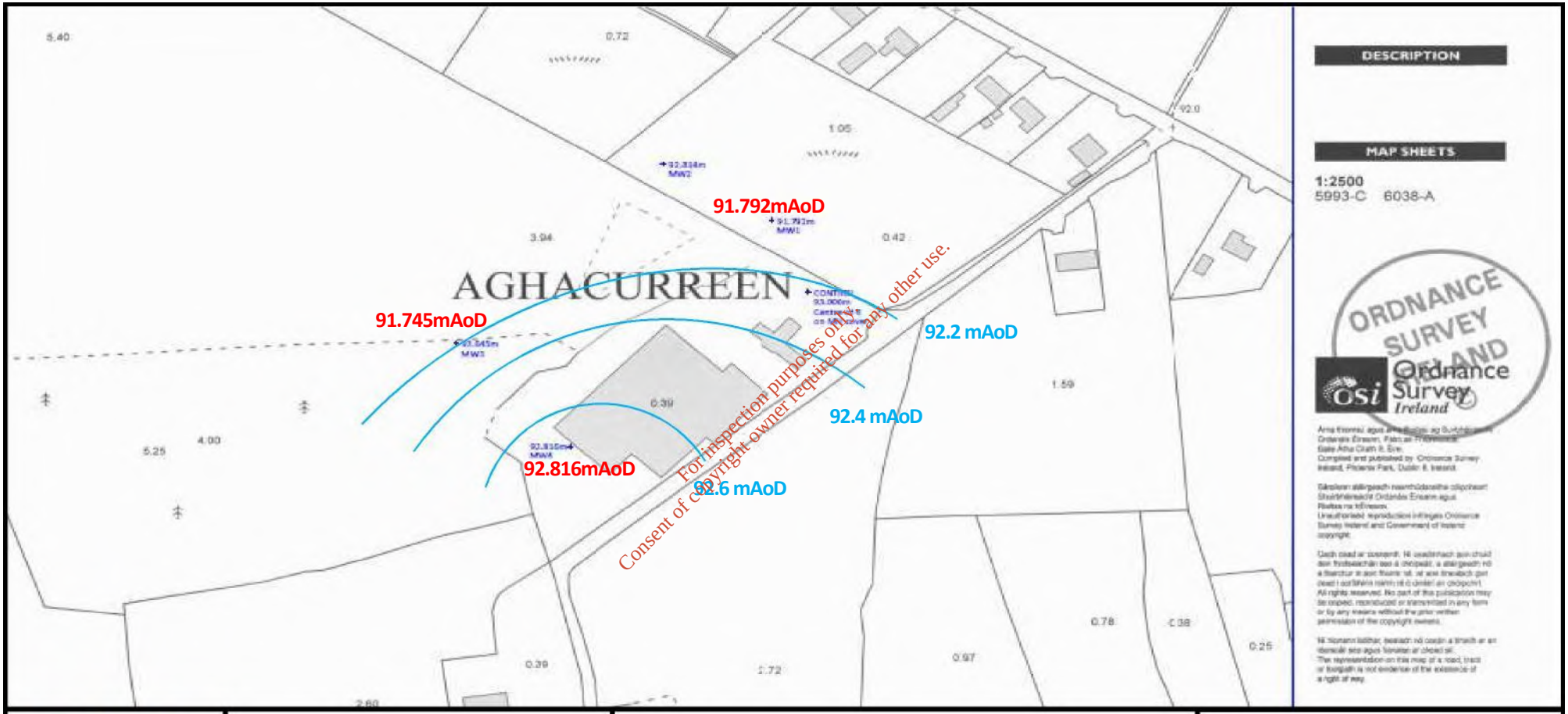
**Legend**

= Groundwater Contour

92.214mAoD= Dip Levels

**Client:**

**Killarney Waste Disposal Ltd.**

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**Title:**

**Figure 2.9**

**Groundwater Contours June 2016**

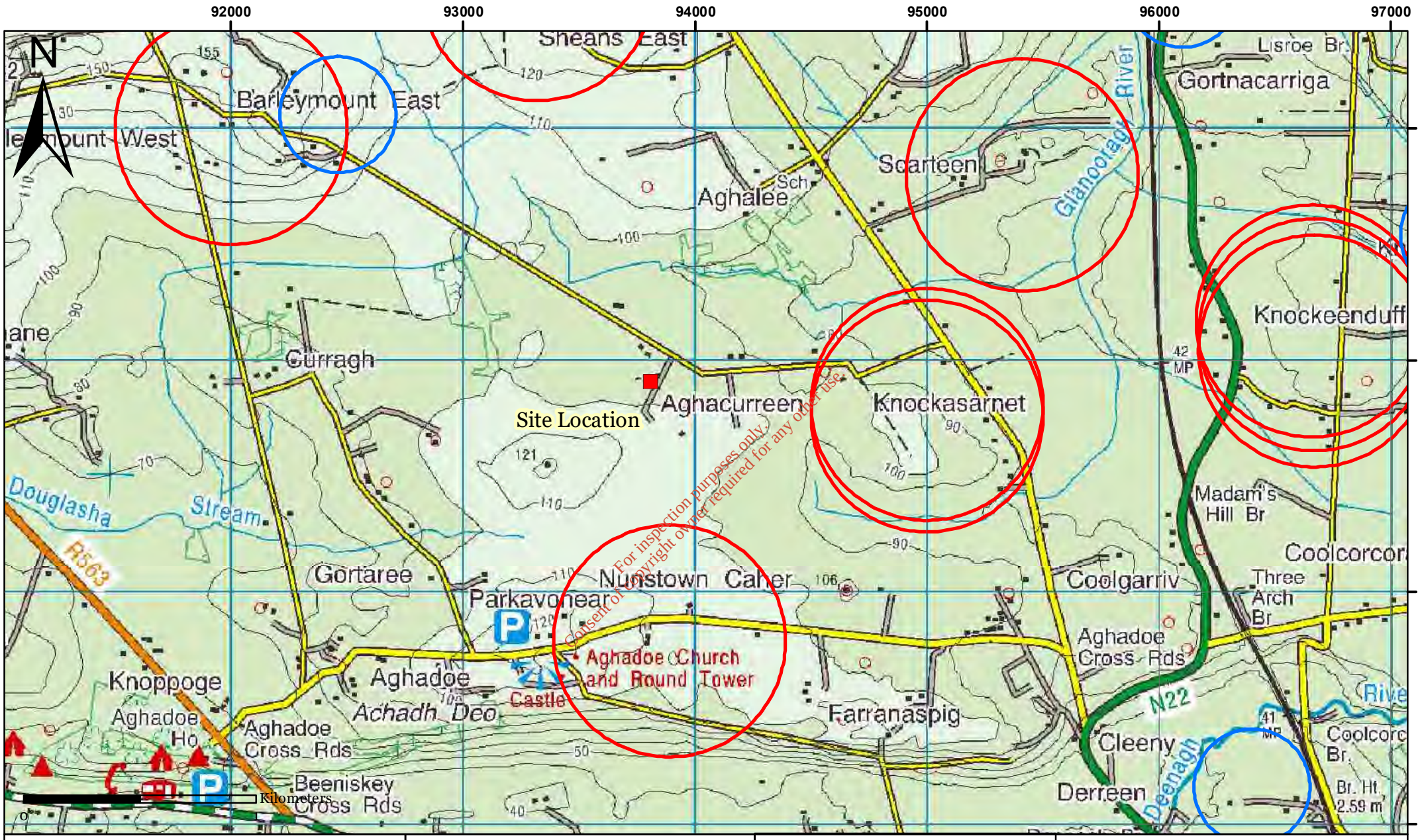
**Legend**

= Groundwater Contour

92.214mAoD= Dip Levels

**Client:**

**Killarney Waste Disposal Ltd.**

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CLIENT
Killarney Waste Disposal

TITLE
GSI Well Location Data

Details:
Unfortunately many of the borehole logs in the GSI database do not contain accurate location information. The size of the circles shown above is inversely proportional to the accuracy of the well location (i.e. small circles represent high accuracy, where relatively larger circles represent lower accuracy).

- Site Location
- 250m-500m
- 500m-1km

Figure 2.10

## 3. CONCEPTUAL SITE MODEL

A Conceptual Site Model (CSM) is shown on Figure 3.1. The site is underlain by a peat and low permeability till that range in thickness from 3 in the east to 5m in the west of the site. The subsoils are not significantly water bearing and the underlying bedrock is classified as a 'Locally Important aquifer, bedrock which is moderately productive only in Local Zones'.

In MW-1, MW-3 and MW-4 the depth to water ranges from 0.35 to 1.9m below the top of the well casing, with discernible seasonal variation in MW-3. There are artesian conditions in MW-1, with water overflowing the top of the well pipe in the winter. The water levels indicate that bedrock aquifer is confined, with the piezometric head above the top of the weathered bedrock. The direction of groundwater flow is from the south-west to the north east.

The operational area is entirely covered by buildings or concrete paving, but the reminder of the site is unpaved. There are two reed beds in the northern unpaved area that treat rainwater run-off from clean paved areas, with the treated water discharging to an on-site percolation area. Sanitary wastewater is treated in the 'puraflo' system and the treated effluent discharges to ground.



### 3.1 Contaminant Sources

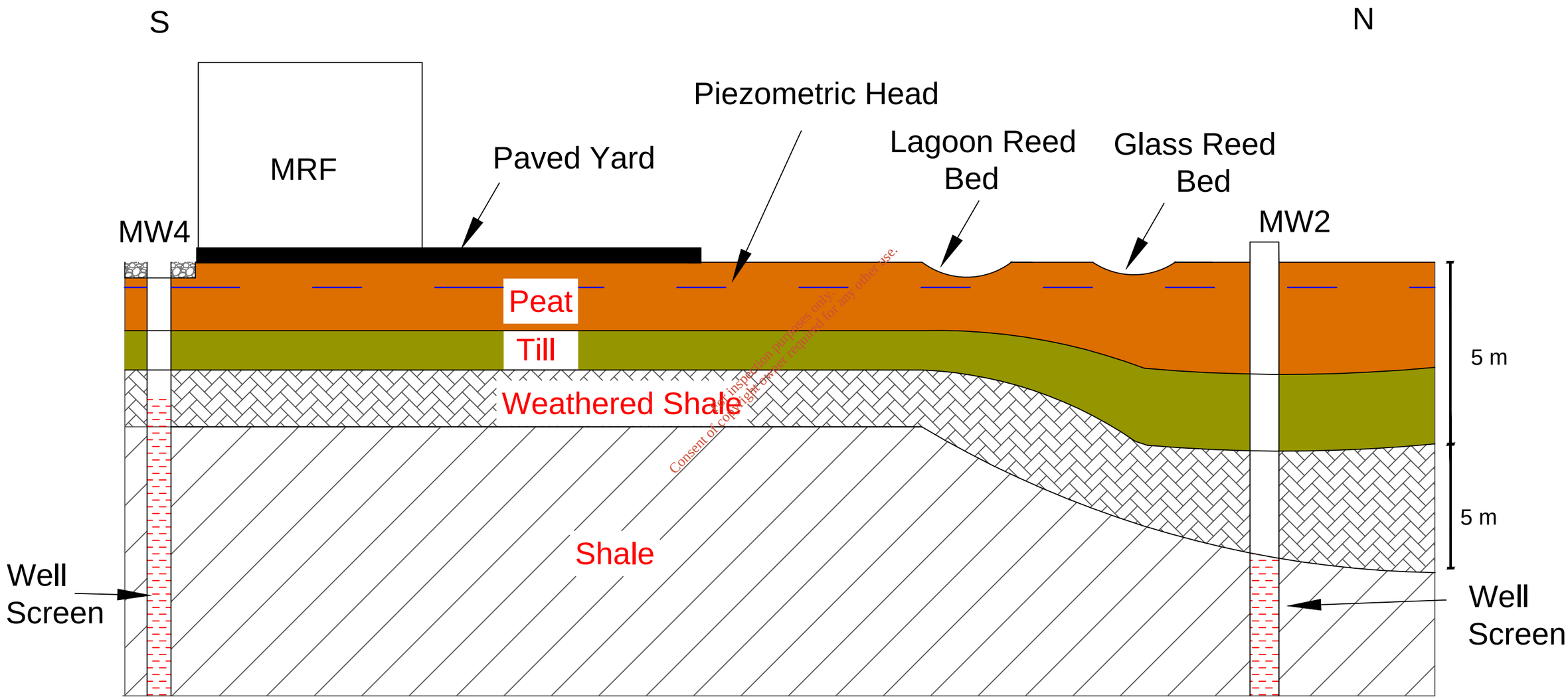
Waste Activities

All wastes other than timber and metal are off loaded and processed/transferred inside the materials recovery building. Liquid seeps from the waste is collected in an underground effluent holding tank (6,92m$^3$). The tank is made of pre-cast concrete and sits in a second underground concrete tank that provides secondary containment (bund). The wastewater is removed for treatment at the Irish Water WWTP.

Metal and timber wastes were handled in open paved areas where the timber was shredded and the metal cut. Rainwater run-off from the area is collected in an underground sump. In 2016 KWD ceased the external processing of the timber and metal, but the external storage of the timber and metal continues.

Originally rainwater run-off from all the paved open yard areas discharged via an oil interceptor and settling tanks to the on-site reed beds. The outfall from the 'lagoon' reed bed discharges to ground. In 2016 the run-off from the operational yards, where there was the potential for rainwater run-off to become contaminated (including the bin washing area and compost bay), was diverted from the reed beds and into a holding tank, where it is stored pending removal for off-site treatment.

Sanitary wastewater was previously discharged to an on-site septic tank and associated percolation area located in the north-west of the site. In 2016 the 'puraflo' system and a new percolation area were installed and the original septic tank was decommissioned. Testing of treated effluent before it enters the percolation area is carried out and the results confirm that system is operating satisfactorily and meeting the performance standards set in the Agency's Code of Practice: Wastewater Treatment and Disposal Systems Serving Single Houses.



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CLIENT: Killarney Waste Disposal

TITLE: Conceptual Site Model

FIGURE No. 3.1

SCALE: NTS

REV.: A

Due to high groundwater levels in the vicinity of the weighbridge, which were attributed to a spring, KWD installed a sump from which groundwater was pumped to the drain that runs along the north-eastern site boundary. Following concerns raised by the Agency on the quality of the water, the discharge was stopped.

Rainwater accumulating in the sump beneath the weighbridge use to overflow to the drain along the north-eastern boundary. In 2016 this overflow was sealed and the water is now removed from the tank using a vacuum tanker and stored in the wastewater tank in the materials recovery building.

All underground sumps, the oil tank bund and the oil interceptor are subject to regular integrity tests, as required by the licence conditions. The foul water pipe network was surveyed in 2014 and no defects were found. The most recent tests on the sumps, bund and interceptor were completed in 2016 and all of the structures were found to be fit for purpose. Copies of the underground line survey and sump test report are in Appendix 3.

Off-Site Sources

The facility is located in a rural area and the land use in the vicinity of the site is primarily agricultural, with some forestry. There are approximately twenty (20) residences within 500m of the facility, the majority of which are in a 'ribbon development' along the local road to the north of the site. It is understood that the houses are served by septic tanks.



### 3.2 Pathways

The operational areas where wastes are handled are either paved with concrete or covered with buildings, which prevents the direct infiltration of rainfall on the site to the subsoils and eliminates the pathway by which any contaminants at the ground surface can move towards the bedrock.

The north-western part of the licensed area is not paved and contains the reed beds and associated percolation area and the percolation area for the recently installed 'puraflo' system. The reed beds and percolation areas provide pathways for rain-water run-off from the yards and the treated sanitary wastewater effluent to the bedrock aquifer. However the confined conditions means there is an upward groundwater pressure head, which would inhibit the entry of contaminants into the aquifer.

The confined conditions in the aquifer means that groundwater does not provide baseflow to the drain and with the exception of MW-1 which is artesian, there are no pathways between the groundwater beneath the site and the drain that runs through the site.

### 3.3 Receptors

The known receptors that could potentially be impacted by on-site contamination sources are the groundwater in the bedrock aquifer and the surface water drain that flows through the site. However, as referred to above the confined conditions inhibit the entry of contaminants into the aquifer. The houses to the north of the site obtain their water supply from the Irish Water mains, and there is no record of any abstraction well within 1km of the site.

## 4. GROUNDWATER QUALITY ASSESSMENT

### 4.1 Groundwater Monitoring Wells

The description of the wells is based on the borehole logs in Attachment A of the OES Report. At MW-1 there is 2m of peat which is underlain by 3m of till. The top 2m of the bedrock is weathered and the total depth of the well is 18m. A water strike was encountered at 10m bgl. Slotted well pipe extends from the bottom of the hole to the base of the weathered bedrock, with plain pipe extending from there to above ground level. There is a bentonite seal from ground level to the base of the weathered bedrock. The well construction details indicate the well is screened exclusively in the competent bedrock.

The well is located in a wooded area to the north of the drain that flows along the north-eastern boundary. The headworks are intact (Photograph 1) but there is evidence of artesian conditions.



**Photograph 1 MW-1**

At MW-2 there is approximately 1.8m of peat, which is underlain by 1.2 m of till. The top 3m of the bedrock is weathered and the total depth of the well is 24m. A water strike was encountered at 20m below ground level. Slotted well pipe extends from the bottom of the hole to the base of the weathered bedrock, with plain pipe extending from there to above ground level. There is a bentonite seal from ground level to the base of the weathered bedrock. The well construction details indicate the well is screened exclusively in the competent bedrock.

The well is located in a wooded area to the north of the drain that flows along the north-eastern boundary. The headworks are intact.



**Photograph 2 MW-2**

At MW-3 there is approximately 1.8m of peat which is underlain by almost 3m of till. The top 3.5m of the bedrock is weathered and the total depth of the well is 18m. A water strike was encountered at 11m below ground level. Slotted well pipe extends from the bottom of the hole into the weathered bedrock, with plain pipe extending from there to above ground level. There is a bentonite seal from ground level to the middle of the weathered bedrock. The well construction details indicate it is possible for water in the weathered zone and the competent rock to enter the well pipe.

The well is located in the south-west of the site. The on the top of the steel casing has been removed and there is no cap on the top of the well pipe.

**Photograph 3 MW-3**



At MW-4 there is approximately 1.8m of peat, underlain by almost 1.2m of till. The top 5m of the bedrock is weathered and the total depth of the well was 18m. A water strike was encountered at 11m below ground level. Slotted well pipe extends from the bottom of the hole into the weathered bedrock, with plain pipe extending from there to above ground level. There is a bentonite seal from ground level to the middle of the weathered bedrock. The well construction details indicate it is possible for water in the weathered zone and the competent rock to enter the well pipe.

MW-4 is located in the south-east of the site close to the rear wall of the materials recovery building. The top of the well pipe is approximately 1m below ground level as a result of the raising of the access road to the rear of the building.

The well was protected by placing a large diameter plastic pipe on the ground and backfilling around it. However the lid on top of the casing has been remove and there is no well cap. OCM observed water had accumulated in the base of the protective pipe and the level was just below the top of the well pipe and there were leaves and litter around the well pipes. It was not possible to determine if the water in the base was overtopping groundwater or surface water.

**Photograph 4 MW-4**



### 4.2 Water Quality Data

The wells were installed in 2009 and were monitored on three occasions between 2009 and 2010. Biannual monitoring for the parameters specified in the Schedule C of the licence began in 2012.

The monitoring results are presented in Tables 4.1 to 4.4, which includes the Interim Guideline Values (IGV) for Irish groundwater published by the Agency and the Threshold Values (TV) from the European Community Environmental Objectives (Groundwater) Regulations 2010.

From the start of the monitoring programme the ammonia levels in MW-1, MW-2 and MW-3 have exceeded the TV, while the level in MW-4 has been generally below the TV, with only occasional exceedances. Nitrates have not been detected, and sulphate is only consistently recorded in MW-4. The chloride level in MW-4, while initially similar to that in the other wells has increased over time, with occasional spikes.

In September 2016 KWD commissioned Southern Scientific Services Ltd to collect five samples from BH-3 over a four hour period, measure the dissolved oxygen level and check the redox potential in the field and conduct laboratory analysis for ammonia, COD, nitrate, nitrite, ferrous and ferric ions and sulphide. The laboratory report is in Appendix 4 and the results are in Table 4.2.

**Table 4.1 MW-1**

| Field Readings | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-1 Top of Well Pipe 91.792m (mAOD) | Units | Ground Water Regs SI No 9 of 2010 | EPA Interim Guidline Values | Sep-09 | Nov-09 | May-10 | Mar-12 | Jul-12 | Feb-13 | Sep-13 | Jan-14 | Jul-14 | Nov-14 | Jan-15 | Jul-15 | Jan-16 | Jun-16 | Aug-16 | Nov-16 | Jan-17 |
| Total Depth | m | - | - | 18 | 18 | 18 | | | | | | | | | | | | | | |
| Depth to Water Level | m | - | - | 0.02 | 0.01 | 0.2 | ND | ND | ND | | ND | ND | ND | ND | ND | ND | 0 | 0 | 0.35 | 0.35 |
| Water Level (mAOD) | m | - | - | 91.772 | 91.782 | 91.592 | – | – | – | | – | – | – | – | – | – | 91.792 | 91.792 | 91.442 | 91.442 |
| Temperature | °C | - | 25 | 10.4 | 10.4 | 10 | – | – | – | | – | – | – | – | – | – | | | | |
| Conductivity | µS/cm | 800 – 1875 | 1000 | 618 | 649 | 663 | 626 | 627 | 637 | 639 | 639 | 640 | 635 | 647 | 633 | 650 | 641 | 661 | 651 | 645 |
| pH | pH Units | - | 6.5 - 9.5 | 7.04 | 7.04 | 6.67 | – | – | – | | | – | – | – | – | – | – | – | – | – |
| **Laboratory Results** | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids | mg/l | NE | 1000 | 325 | 325 | 336 | – | – | – | | – | – | – | – | – | – | | | | – |
| Ammonia (as N) | mg/l | 0.05 –0.136 | 0.12 | 1.77 | 1 | 0.9 | 1.78 | 2.46 | 1.81 | 0.97 | 1.84 | 2.07 | 1.64 | 1.85 | 1.11 | 1.85 | 0.99 | 1.06 | 1.79 | 1.99 |
| Chloride | mg/l | 187.5 | 30 | 22.4 | 23.6 | 21.6 | 24.9 | 24.6 | 23.7 | 23.7 | 22.1 | 23.6 | 24.1 | 22.6 | 24.3 | 24.9 | 24.1 | 23.5 | 23.8 | 24.2 |
| Sulphate | mg/l | 187.5 | 200 | <3 | <3 | <3 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 0.79 | <0.5 | <0.5 | <0.5 | <0.5 |
| Nitrate as $NO_3$ | mg/l | 37.5 | 25 | <0.06 | <0.06 | <0.06 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 |
| Diesel Range Organics | ug/l | 10 | 10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 110 | <10 |
| Orthophosphate | mg/l | 0.03 | 0.03 | | | | | | | | | | | | | | | | | 0.03 |
| Total Hardness | mg/l | 200 | 200 | | | | | | | | | | | | | | | | | 363 |
| Alkalinity | mg/l | NAC | NAC | | | | | | | | | | | | | | | | | 368 |
| Iron Dissolved | mg/l | 0.2 | 0.2 | | | | | | | | | | | | | | | | | 2.01 |
| Manganese Dissolved | mg/l | 0.05 | 0.05 | | | | | | | | | | | | | | | | | 0.1 |
| Dissolved Oxygen | mg/l | NE | NE | | | | | | | | | | | | | | | | | 1.55 |
| Redox Potential | | NE | NE | | | | | | | | | | | | | | | | | -86 |
| Coliforms | MPN | 0 | 0 | | | | | | | | | | | | | | | | | <1 |
| Faecal Coliforms | MPN | 0 | 0 | | | | | | | | | | | | | | | | | <1 |
| NE: Not Established | | | | | | | | | | | | | | | | | | | | |
| NAC No Abnormal Change | | | | | | | | | | | | | | | | | | | | |

**Table 4.2 MW-2**

| BH-2 Top of Well Pipe 92.814m (mAOD) | Units | Ground Water Regs SI No 9 of 2010 | EPA Interim Guidline Values | Apr-09 | Nov-09 | May-10 | Mar-12 | Jul-12 | Feb-13 | Sep-13 | Jan-14 | Jul-14 | Nov-14 | Jan-15 | Jul-15 | Jan-16 | Jun-16 | Aug-16 | Nov-16 | Jan-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Field Readings** | | | | | | | | | | | | | | | | | | | | |
| Total Depth | m | - | | 19.32 | 19.32 | 19.32 | | | | | | | | | | | | | | |
| Depth to Water Level | m | - | | 0.54 | 0.43 | 0.98 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | 0.6 | 0.35 | 0.32 | 0.08 |
| Water Level (mAOD) | m | | | 92.274 | 92.384 | 91.834 | – | – | – | – | – | – | – | | – | | 92.214 | 92.464 | 92.494 | 92.736 |
| Temperature | °C | - | 25 | 10.4 | 10.4 | 10.5 | – | – | – | – | – | – | – | | – | | | | | |
| Conductivity | µS/cm | 800 – 1875 | 1000 | 772 | 772 | 828 | 748 | 746 | 747 | 776 | 758 | 787 | 760 | 764 | 769 | 760 | 776 | 796 | 766 | 751 |
| pH | pH Units | NE | 6.5 - 9.5 | 7.08 | 7.08 | 6.9 | – | – | – | – | – | – | – | | – | – | – | – | 7.2 | 7.2 |
| **Laboratory Results** | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids | mg/l | NE | 1000 | 385 | 385 | 412 | – | – | – | – | – | – | – | | – | | | | | – |
| Ammonia (as N) | mg/l | 0.05 –0.136 | 0.12 | 2.83 | 1.86 | 0.578 | 1.84 | 2.11 | 1.84 | 1.19 | 2.07 | 1.47 | 1.23 | 1.16 | 0.65 | 1.7 | 0.53 | 0.73 | 1.42 | 1.76 |
| Chloride | mg/l | 187.5 | 30 | 24.2 | 24.7 | 21.4 | 24.8 | 24.1 | 23.3 | 22.5 | 23.1 | 21.6 | 23.1 | 22.1 | 22.1 | 24.3 | 21.9 | 22.3 | 22.8 | 23.3 |
| Sulphate | mg/l | 187.5 | 200 | <3 | <3 | <3 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 0.51 | <0.5 | <0.5 | <0.5 | <0.5 |
| Nitrate as $NO_3$ | mg/l | 37.5 | 25 | <0.06 | <0.06 | 0.0799 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 |
| Diesel Range Organics | ug/l | 10 | 10 | <10 | <10 | <46 | <10 | <10 | <10 | 28 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 149 | <10 |
| Orthophosphate | mg/l | 0.03 | 0.03 | | | | | | | | | | | | | | | | | 0.01 |
| Total Hardness | mg/l | 200 | 200 | | | | | | | | | | | | | | | | | 421 |
| Alkalinity | mg/l | NAC | NAC | | | | | | | | | | | | | | | | | 440 |
| Iron Dissolved | mg/l | 0.2 | 0.2 | | | | | | | | | | | | | | | | | 4.19 |
| Manganese Dissolved | mg/l | 0.05 | 0.05 | | | | | | | | | | | | | | | | | 0.15 |
| Dissolved Oxygen | mg/l | NE | | | | | | | | | | | | | | | | | | 3.35 |
| Redox Potential | | NE | | | | | | | | | | | | | | | | | | -119 |
| Coliforms | MPN | 0 | 0 | | | | | | | | | | | | | | | | | <1 |
| Faecal Coliforms | MPN | 0 | 0 | | | | | | | | | | | | | | | | | <1 |
| NE: Not Established | | | | | | | | | | | | | | | | | | | | |
| NAC No Abnormal Change | | | | | | | | | | | | | | | | | | | | |

**Table 4.3 MW-3**

| Field Readings | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-3 Top of Well Pipe 93.645m (mAOD) | Units | Ground Water Regs SI No 9 of 2010 | EPA Interim Guidline Values | Apr-09 | Nov-09 | May-10 | Mar-12 | Jul-12 | Feb-13 | Sep-13 | Jan-14 | Jul-14 | Nov-14 | Jan-15 | Jul-15 | Jan-16 | Jun-16 | Aug-16 | Nov-16 | Jan-17 |
| Total Depth | m | - | | 18.16 | 18.16 | 18.16 | | | | | | | | | | | | | | |
| Depth to Water Level | m | - | | 1.49 | 1.44 | 1.71 | ND | ND | ND | ND | ND | ND | ND | ND | ND | | 1.9 | 1.4 | 1.6 | 1.7 |
| Water Level (mAOD) | m | | | 92.155 | 92.205 | 91.935 | – | – | – | – | – | – | – | | | | 91.745 | 92.245 | 92.045 | 91.116 |
| Temperature | °C | - | 25 | 10.3 | 10.5 | 11 | – | – | – | – | – | – | – | | | | | | | |
| Conductivity | µS/cm | 800 – 1875 | 1000 | 544 | 556 | 583 | 508 | 515 | 516 | 525 | 516 | 531 | 527 | 528 | 529 | 541 | 539 | 558 | 573 | 548 |
| pH | pH Units | NE | 6.5 - 9.5 | 7.01 | 6.81 | 6.64 | – | – | – | – | – | – | – | | | – | – | – | 7.2 | 7.1 |
| **Laboratory Results** | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids | mg/l | NE | 1000 | 272 | 278 | 286 | – | – | – | – | – | – | – | | | | | | | – |
| Ammonia (as N) | mg/l | 0.05 –0.136 | 0.12 | 2.86 | 1.32 | 2.54 | 2.99 | 3.08 | 2.91 | 3.16 | 3.47 | 3.21 | 3.03 | 3.2 | 3.2 | 3.13 | 2.81 | 3.35 | 3.25 | 2.8 |
| Chloride | mg/l | 187.5 | 30 | 20.6 | 21.6 | 19.6 | 22.8 | 21.4 | 22.4 | 21.6 | 21.1 | 21.1 | 21.4 | 20.4 | 22.5 | 22.4 | 22.5 | 21.4 | 21.8 | 22.7 |
| Sulphate | mg/l | 187.5 | 200 | <3 | <3 | 4.4 | <0.5 | 1.38 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 0.71 | <0.5 | <0.5 | <0.5 | <0.5 |
| Nitrate as $NO_3$ | mg/l | 37.5 | 25 | <0.06 | <0.06 | <0.06 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 |
| Diesel Range Organics | ug/l | 10 | 10 | <10 | <10 | <46 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Orthophosphate | mg/l | 0.03 | 0.03 | | | | | | | | | | | | | | | | | 0.03 |
| Total Hardness | mg/l | 200 | 200 | | | | | | | | | | | | | | | | | 289 |
| Alkalinity | mg/l | NAC | NAC | | | | | | | | | | | | | | | | | 311 |
| Iron Dissolved | mg/l | 0.2 | 0.2 | | | | | | | | | | | | | | | | | 3.64 |
| Manganese Dissolved | mg/l | 0.05 | 0.05 | | | | | | | | | | | | | | | | | 0.13 |
| Dissolved Oxygen | mg/l | NE | | | | | | | | | | | | | | | | | | 3 |
| Redox Potential | | NE | | | | | | | | | | | | | | | | | | -79.6 |
| Coliforms | MPN | 0 | 0 | | | | | | | | | | | | | | | | | 11 |
| Faecal Coliforms | MPN | 0 | 0 | | | | | | | | | | | | | | | | | 1 |
| NE: Not Established | | | | | | | | | | | | | | | | | | | | |
| NAC No Abnormal Change | | | | | | | | | | | | | | | | | | | | |

## Table 4.4 MW-4

| Field Readings | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-4 Top of Well Pipe 92.816m (mAOD) | Units | Ground Water Regs SI No 9 of 2010 | EPA Interim Guidline Values | Apr-09 | Nov-09 | May-10 | Mar-12 | Jul-12 | Feb-13 | Sep-13 | Jan-14 | Jul-14 | Nov-14 | Jan-15 | Jul-15 | Jan-16 | Jun-16 | Aug-16 | Nov-16 | Jan-17 |
| Total Depth | m | - | | 19.9 | 19.9 | 19.9 | | | | | | | | | | | | | | |
| Depth to Water Level | m | - | | 0.49 | 0.1 | 0.27 | ND | ND | ND | ND | ND | ND | ND | ND | ND | 0.6 | 0 | 1 | 1 | 1 |
| Water Level (mAOD) | m | | | 92.326 | 92.716 | 92.546 | – | – | – | – | – | – | – | | | | 92.816 | 91.816 | 91.816 | 91.816 |
| Temperature | °C | - | 25 | 10.9 | 10.9 | 11.2 | – | – | – | – | – | – | – | | | | | | | |
| Conductivity | µS/cm | 800 – 1875 | 1000 | 400 | 407 | 410 | 380 | 389 | 378 | 388 | 392 | 392 | 387 | 397 | 398 | 398 | 396 | 407 | 404 | 405 |
| pH | pH Units | NE | 6.5 - 9.5 | 6.86 | 6.86 | 6.28 | – | – | – | – | – | – | – | | | – | – | – | | 7.2 |
| Laboratory Results | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids | mg/l | NE | 1000 | 203 | 203 | 203 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Ammonium (as N) | mg/l | 0.065-0.175 | 0.12 | <0.2 | <0.2 | <0.2 | <0.02 | 0.03 | 0.03 | 0.06 | <0.02 | 0.04 | <0.02 | 0.08 | <0.02 | <0.02 | 0.24 | 0.03 | <0.02 | 0.06 |
| Chloride | mg/l | 187.5 | 30 | 24.1 | 24.8 | 22.4 | 27 | 34.6 | 30.1 | 26.6 | 29.9 | 87.8 | 32.3 | 60.3 | 27 | 28.3 | 51 | 33.4 | 41 | 67.8 |
| Sulphate | mg/l | 187.5 | 200 | <3 | <3 | 21.9 | 20.2 | 34 | 20 | 22.3 | 28.2 | 70.4 | 27 | 48.3 | 45.7 | 21.6 | <0.5 | 31.4 | 33.6 | 63.9 |
| Nitrate as $NO_3$ | mg/l | 37.5 | 25 | <0.06 | <0.06 | <0.06 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 |
| Diesel Range Organics | ug/l | - | 10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Orthophosphate | mg/l | 0.035 | 0.03 | | | | | | | | | | | | | | | | | 0.01 |
| Total Hardness | mg/l | NE | 200 | | | | | | | | | | | | | | | | | 190 |
| Alkalinity | mg/l | NE | NAC | | | | | | | | | | | | | | | | | 1405 |
| Iron Dissolved | mg/l | NE | 0.2 | | | | | | | | | | | | | | | | | 0.13 |
| Manganese Dissolved | mg/l | NE | 0.05 | | | | | | | | | | | | | | | | | 0.07 |
| Dissolved Oxygen | mg/l | NE | NE | | | | | | | | | | | | | | | | | 2.7 |
| Redox Potential | | NE | NE | | | | | | | | | | | | | | | | | -41.6 |
| Coliforms | MPN | NE | 0 | | | | | | | | | | | | | | | | | 2 |
| Faecal Coliforms | MPN | NE | 0 | | | | | | | | | | | | | | | | | 64 |
| NE: Not Established | | | | | | | | | | | | | | | | | | | | |
| NAC No Abnormal Change | | | | | | | | | | | | | | | | | | | | |

Although the dissolved oxygen was >1.0 mg/l, the redox potential readings (-78 mV to -132.8mV) indicated reducing conditions. Ferrous and ferric ions were present, nitrate and sulphide were not detected and the COD (<10mg/l) was low. The ammonia levels were consistent with those previously measured.

**Table 4.2 Water Quality MW-3 September 2016**

| Parameter | Units | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 |
|---|---|---|---|---|---|---|
| Dissolved Oxygen* | mg/l | 1.5 | 2.1 | 2.9 | 2.9 | 3.4 |
| Redox Potential (Eh)* | mV | -132.8 | -78 | -93.5 | -115.9 | -106.4 |
| Ammonia | mg/l | 3.04 | 3.13 | 3.22 | 3.28 | 3.28 |
| COD | mg/l | <10 | <10 | <10 | <10 | <10 |
| Nitrate | mg/l | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 |
| Nitrite | mg/l | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| Ferrous ions | mg/l | 4.18 | 4.60 | 5.17 | 5.32 | 5.29 |
| Ferric ions | mg/l | 4.77 | 4.94 | 4.26 | 4.20 | 4.20 |
| Sulphide | ug/l | <5 | <5 | <5 | <5 | <5 |

*Field Measurements

In January 2017, KWD requested Southern Scientific Ltd to include dissolved oxygen, redox potential, alkalinity, hardness, orthophosphate, dissolved iron, dissolved manganese, total and faecal coliforms in the range of parameters tested. The laboratory report is in Appendix 4 and the results are in Table 4.3.



**Table 4.3 Water Quality MW-1 to MW-4 January 2017**

| Parameter | Units | MW-1 | MW-2 | MW-3 | MW-4 |
|---|---|---|---|---|---|
| Dissolved Oxygen* | mg/l | 1.55 | 3.35 | 3.0 | 2.7 |
| Redox Potential (Eh)* | mV | -86 | -119.1 | -79.6 | -41.6 |
| pH | pH Units | | | | |
| Orthophosphate | mg/l | 0.03 | 0.01 | 0.03 | 0.01 |
| Nitrate | mg/l | <0.25 | <0.25 | <0.25 | <0.25 |
| Total Hardness | mg/l | 363 | 321 | 289 | 190 |
| Alkalinity | mg/l | 369 | 440 | 311 | 1405 |
| Chloride | mg/l | 24.2 | 23.3 | 22.7 | 67.8 |
| Sulphate | mg/l | <0.5 | <0.5 | <0.5 | 63.9 |
| Iron** | mg/l | 2.01 | 4.19 | 3.64 | 0.13 |
| Manganese** | mg/l | 0.10 | 0.15 | 0.13 | 0.07 |
| DRO | ug/l | <10 | <10 | <10 | <10 |
| Coliforms | MPN | <1 | <1 | 11 | 2 |
| Faecal Coliforms | MPN | <1 | <1 | 1 | 64 |

* Field measurement
** Dissolved

While the dissolved oxygen levels are >1mg/l, the redox reading indicates reducing conditions. Dissolved iron was detected in all wells, with the lowest level in MW-4. The sulphate level in MW-4 were significantly higher than previously recorded, while the levels in the other wells were consistent with previous results. The alkalinity in MW-4 was very high and is probably anomalous as the hardness

was lower than those in the other wells. Total and faecal coliforms were not detected in MW-1 and MW-2, but were detected in MW-3 and MW-4, with the highest levels in MW-4.

### 4.3 Discussion

The results of the monitoring from 2009 to January 2017 indicate that hydro chemical signature of MW-4 differs from that of MW-1, MW-2 and MW-3. The average electrical conductivity, ammonia, sulphate, chloride, hardness, and dissolved iron levels recorded in each of the wells are in Table 4.3.

**Table 4.3 Mean of Indicator Parameters (2009-2017)**

| Parameter | Units | MW-1 | MW-2 | MW-3 | MW-4 |
|---|---|---|---|---|---|
| Electrical* Conductivity | uS/cm | 643 | 769 | 537 | 395 |
| Ammonia* | mg/l | 1.57 | 1.47 | 2.96 | 0.07 |
| Chloride* | mg/l | 23.7 | 23 | 21 | 39 |
| Sulphate* | mg/l | 0.79 | 0.51 | 2.16 | 34.8 |
| Hardness | mg/l | 363 | 421 | 289 | 190 |
| Dissolved Iron | mg/l | 2.01 | 4.19 | 3.64 | 0.13 |

* Average level 2009 to 2017



The ammonia levels have been persistently elevated in MW-1, MW-2 and MW-3 over the monitoring period. While elevated ammonia levels can be indicative of contamination by an organic waste source(s) (e.g. animal slurries, sanitary waste water, leachate), the levels of other indicator parameters (chloride, nitrate, orthophosphate and, in the case of MW-3, COD) are not consistent with an organic waste source.

The historical monitoring data indicate the presence of reducing conditions in the aquifer. The redox potential measurements in MW-3 in September 2016, and in all of the wells in January 2017, in conjunction with the dissolved iron levels in January 2017 and the ferric oxide staining and iron bacteria slime on the headworks at MW-1[1] observed by OCM in October 2016, confirm the presence of reducing conditions.

The reduction-oxidation (redox) state of a groundwater body controls the mobilisation or sequestration of naturally occurring metals; the biodegradation or preservation of anthropogenic contaminants such as nitrates and volatile organic compounds , and the generation of compounds and organisms that affect water quality (dissolved iron and manganese, iron bacteria and hydrogen sulphide).

The redox state is the outcome of a set of electron transfer reactions facilitated by microorganisms that control the transfer of electrons from electron donors (e.g. organic matter, pyrite etc.) and electron acceptors (dissolved oxygen, nitrate, iron etc.)

Reducing conditions start with the take up of the dissolved oxygen by oxygen reducing microorganisms. This continues until all of the available dissolved oxygen is depleted, following which the next most easily exploited electron acceptor (nitrate) becomes available. The pattern of reaction preferences for inorganic compounds are:

[1] Soluble ferrous hydroxide is oxidised to ferric hydroxide when the dissolved oxygen levels increase at the top of the well pipe.

**$O2 > NO_3 > Mn (iv) > Fe (iii) > SO4 > CO_2$**

Groundwater redox conditions are influenced by factors such as recharge rates, local groundwater flow rates and the presence of contaminants, which means that different redox conditions can occur at varying depths, or zones, in the aquifer.

Where a well is exclusively screened in one redox state zone, the redox conditions are stable. Where a well screen straddles a number of different zones, for example when water enters the well pipe from both deep in the aquifer, where reducing conditions predominate, and from higher up where oxidising conditions are prevalent, the groundwater in the well pipe will display a mixed redox character.

This means it is possible for a groundwater sample to have indicators of both oxidising (e.g. dissolved oxygen > 1mg/l) and reducing conditions (ammonia, dissolved iron, negative Eh and low levels of nitrate and sulphate), which is the case in the MW-1, MW-2 and MW-3) and low Eh and low nitrate, ammonia and dissolved iron in MW-4. A complicating factor at MW-4 is the potential for surface water run-off to enter the well pipe, which is likely the source of the faecal coliform contamination and the elevated chloride.

As referred to above, a controlling factor on the redox state is the electron donor, which usually is organic matter. The sources of organic matter can either be naturally occurring (e.g. peatland) or anthropogenic (wastewater treatment systems, agricultural wastes, landfills, oil.).

At the KWD site the soils within and adjoining the site comprise peat, which is a natural source of organic matter. Potential on-site organic matter contamination sources include sanitary wastewater, leachate, contaminated yard run-off and oil. The only potential off-site sources are the wastewater treatment systems serving the houses to the south of the installation and possibly land spreading of farm animal slurry and manure.



If the waste activities were the source of the organic matter chemical indicator parameters (chloride, electrical conductivity and nitrate) should be elevated, but they are not. Faecal coliforms, which are an indicators of sanitary waste water and farm animal waste contamination, were detected in the two upgradient wells (MW-3 and MW-4) but not in the downgradient ones (MW-1 and MW-2).

Given that the headworks on both MW-3 and MW-4 are damaged, there are no well caps and MW-4 is approximately 0.5 m below ground level, the likely source of the coliforms is faecal contamination by birds or small mammals and not off-site sources.

# 5. IMPACT ON RECEPTORS

## 5.1 Surface Water

A biological water quality assessment carried out as part of the preparation of the 2005 EIS established that the drain was seriously polluted at the point where it enters the KWD site and that it was moderately or slightly polluted c.200m upstream of the site. Physio-chemical monitoring established elevated levels of COD, Biochemical Oxygen Demand (BOD), iron and manganese upstream of the site and elevated levels of ammonia, iron, manganese and conductivity downstream of the site. Given the confined conditions in the aquifer groundwater beneath the site does not provide baseflow into the drain and therefore is not the source of the elevated ammonia.

The licence requires annual monitoring of the drain up and downstream of the site bi-annually for pH, electrical conductivity and ammonia. The results of the monitoring conducted in 2016 are in Table 5.1. The Table includes for comparison purposes the 'average' Environmental Quality Standards (EQS) from the Surface Water Regulations 2009 for 'Good Status' waters.

Table 5.1 Surface Water Quality KWD Monitoring

| Parameter | Units | 16/11/2016 Upstream | 16/11/2016 Downstream | 16/12/2016 Upstream | 16/12/2016 Downstream | EQS |
|---|---|---|---|---|---|---|
| Conductivity | uS/cm | 266 | 261 | 268 | 312 | |
| pH | pH Units | 6.9 | 7.3 | 6.7 | 7.1 | 6-9 |
| Ammonia | mg/l | 0.07 | 0.06 | 0.18 | 0.27 | 0.065-0.140 |
| BOD | | | | 2.3 | 1.2 | <1.5 (Mean) |
| COD | | | | 136 | 52 | |



In February and March 2016 the Agency monitored the quality in the drain up and downstream of the site and the results are in Table 5.2.

| Parameter | Units | 16/02/2016 Upstream | 16/02/2016 Downstream | 07/03/2016 Upstream | 07/03/2016 Downstream | EQS |
|---|---|---|---|---|---|---|
| Conductivity | uS/cm | - | - | 218 | 306 | - |
| pH | pH Units | - | - | 6.7 | 7.1 | 6-9 |
| Suspended Solids | mg/l | 9 | 8 | <4 | 4 | - |
| Ammonia | mg/l | 0.038 | 0.51 | 0.18 | 0.27 | 0.065-0.140 |
| Chloride | mg/l | 30.4 | 37.8 | 30.1 | 32 | |
| Orthophosphate | mg/l | 0.047 | | 0.029 | 0.022 | |
| Nitrite | mg/l | - | - | 0.0183 | 0.0056 | |
| BOD | mg/l | - | - | <1 | 1 | <1.5 (Mean) |
| COD | mg/l | 78 | 45 | 57 | 46 | |
| TON | mg/l | <0.2 | 0.49 | 0.49 | 0.34 | |
| Coliforms | MPN | - | - | - | 687 | |
| Faecal Coliforms | MPN | - | - | - | 261 | |

While faecal coliforms were detected in the downstream sample, in the absence of any results for the upstream sample it is not possible to comment on the significance of this. The results of the chemical tests indicate that facility operations are not impacting on the water quality in the drain.

## 5.2 Groundwater

There is no evidence that waste activities are impacting on groundwater beneath the site. The condition of the well heads and MW-3 and MW-4 means there is the potential for contaminants from the ground surface to enter the well pipes.

## 6. CONCLUSIONS & RECOMMENDATIONS

### 6.1 Conclusions

Monitoring wells MW-4 is up gradient and MW-3 is side gradient of waste activities and MW-1 and MW-2 are down gradient.

Since monitoring began in 2009, elevated ammonia has been detected in MW-1, MW-2 and MW-3. Nitrate has never been detected in any of the wells and sulphate, while present in MW-4, has only very occasionally been detected at very low levels in the other wells. The redox potential in all of the wells, in conjunction with the low nitrate and presence of dissolved iron, indicates reducing conditions.

The wastes activities are a potential source of organic matter that typically is required to allow reducing conditions to develop; however the physiochemical data does not indicate this is the case, as the electrical conductivity, chloride and orthophosphate levels in MW-1, MW-2 and MW-3 are typical of uncontaminated groundwater. The peat, which underlies the site, is a recognised source of organic matter, which is a controlling factor in a redox state.

Faecal coliforms were detected in up gradient wells MW-3 and MW-4. The headworks on MW-3 and MW-4 wells are damaged and there are no well caps making both wells vulnerable to faecal contamination by birds and small mammals and in the case of MW-4, where the well pipe is below ground level, the entry of surface water run-off.

The source of the ammonia detected in MW-1, MW-2 and MW-3 is the naturally occurring reducing conditions in the bedrock aquifer.



### 6.2 Recommendations

It is recommended that the headworks at MW-3 be repaired and a well cap provided. At MW-4, the well pipe should be extended above ground-level, fitted with a well cap and a steel headworks installed. Following the repairs both wells should be disinfected.

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# HYDROGEOLOGICAL SURVEY REPORT

## KILLARNEY WASTE DISPOSAL LTD

## AUGHACURREEN

## WASTE LICENCE NO. W0217-01



**Prepared For: -**

Killarney Waste Disposal Ltd,
Aughcureen,
Killarney,
County Kerry.

**Prepared By: -**

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**February 2017**

| Project | Groundwater Quality Assessment | | | |
|---|---|---|---|---|
| Client<br>Licence | Killarney Waste Disposal Ltd<br>W0217-01 | | | |
| Report No | Date | Status | Prepared By | Reviewed By |
| 1602330201 | 14/07/2017 | Draft Client Review | Jim O'Callaghan MSc, CEnv, MCIWM, IEMA | Sean Moran MSc, PGeol, Euro Geol MCIWEM |
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## EXECUTIVE SUMMARY

Killarney Waste Disposal Ltd (KWD) operates its facility at Aughacureen under Waste Licence Reg. No. W0217-01. In 2008 KWD commissioned OES to carry out a Hydrogeological Survey of the site in compliance with Condition 3.21 of the licence. The survey included the installation of four on-site groundwater wells (MW-1, MW-2, MW-3 and MW-4) and the collection and analysis of groundwater samples. Elevated ammonia levels were detected in three of the wells (MW-1, MW-2 and MW-3) and OES concluded that the source was off site agricultural and forestry land use.

The Agency, based on the continued detection of elevated ammonia levels in a number of the wells, requested KWD to submit an up-to-date hydrogeological investigation report that examined the reasons for the high concentrations. KWD commissioned O'Callaghan Moran & Associates (OCM) to update the OES report.

The facility encompasses 2.2 hectares (ha) and consists of a material recovery building (3,223m$^2$), concrete yards, weighbridge and administration building. Ancillary infrastructure includes fuel storage, storm water drainage system and reed bed, and a sanitary effluent treatment system.

The soils and subsoils at the site comprise peat overlying till and the combined thickness ranges from 3m in the east to the site to 5m in the west. The underlying bedrock is shale and sandstone, the upper 3 to 5m of which is weathered. The bedrock is classified as a locally important aquifer, which is moderately productive only in local zones. It is not used locally as a water supply source. The aquifer vulnerability to pollution from the ground surface ranges from Moderate to High. The direction of groundwater flows is from the south-west to north-east.

During the installation of the monitoring wells water strikes were encountered between 10 and 20m below ground level. Subsequently the water levels in all of the wells rose above the top of the weathered bedrock, indicating confined conditions. This is confirmed by the water level data recorded during the routine monitoring and OCM field observations of artesian conditions in one of the wells.

The on-site potential sources of groundwater contamination are a leachate sump inside the materials recovery building; a sump at the timber and metal storage area; an oil storage tank, oil interceptor; the reed beds and percolation area, and the percolation area associated with the 'puraflo' sanitary waste treatment system installed in 2016. The sumps, oil interceptor and oil tank bund are subjected to routine integrity tests. The most recent were completed in 2016 and confirmed the structures were fit for purpose. Testing of the treated sanitary effluent has confirmed that the 'puraflo' system is functioning properly.

Past operational practices, including the discharge of surface water run-off from the bin washing area and compost bay to the reed beds; the original septic tank, and the discharge of water from the sumps at the timber storage area and at the weighbridge had the potential to cause groundwater contamination.

The site is in a rural area and the surrounding land use is primarily agricultural, with some forestry. There are approximately twenty (20) residences within 500m of the facility, the majority of which are in a 'ribbon development' along the local road to the north of the site. It is understood that the houses are served by septic tanks.

Monitoring wells MW-3 and MW-4 are up gradient of waste activities and MW-1 and MW-2 are down gradient. All of the wells are exclusively screened in the bedrock, however at MW-2 and MW-4 the screen extends into the weathered zone.

Since monitoring began in 2009, elevated ammonia has been detected in MW-1, MW-2 and MW-3. Nitrate has never been detected in any of the wells and sulphate, while present in MW-4, has only very occasionally been detected at very low levels in the other wells. The redox potential in all of the wells, in conjunction with the low nitrate and presence of dissolved iron, indicates reducing conditions, which is consistent with confined aquifer conditions.

While the wastes activities are a potential source of organic matter that typically is required to allow reducing conditions to develop, the monitoring data does not indicate this is the case, as the electrical conductivity, chloride and Chemical Oxygen Demand (COD) levels are consistent with uncontaminated groundwater.

Faecal coliforms were detected in MW-3 and MW-4 in January 2017. The headworks of both wells are damaged and there are no well caps, meaning the wells are susceptible to faecal contamination by birds and small mammals, and, in the case of MW-4, the entry of surface water run-off.

The elevated ammonia detected in MW-1, MW-2 and MW-3 is due to naturally occurring reducing conditions in the aquifer. The condition of the well heads at MW-3 and MW-4 means they are vulnerable to contamination from the ground surface and it is recommended that they be repaired and the wells disinfected.

# 1. INTRODUCTION

## 1.1 General Introduction

KWD operates its Materials Recovery Facility at Aughacureen under Waste Licence Reg. No. W0217-01 issued by the Environmental Protection Agency (Agency). In 2008 KWD commissioned OES to carry out a Hydrogeological Survey of the site in compliance with Condition 3.21 of the licence. The survey included the installation of on-site groundwater wells and the collection and analysis of groundwater samples in 2009 and 2019. Elevated ammonia levels were detected in a number of the wells and OES concluded that based on the direction of groundwater flow the sources were off-site.

Bi-annual groundwater monitoring began in 2012. The Agency, based on elevated ammonia levels persistently detected in a number of the wells requested KWD to submit an up-to-date hydrological investigation report that examined the reasons for the high concentrations. KWD commissioned O'Callaghan Moran & Associates (OCM) to update the OES report.

The revised report is based on information in the Environmental Impact Statement (EIS) prepared in 2005, the OES report, databases maintained by Teagasc and the Geological Survey of Ireland (GSI) and the results of the groundwater monitoring carried out by KWD.



## 1.2 Objective and Background Information

The objectives of the updated report were at a minimum to clarify the precise groundwater flow direction contours around the site based on datum levels of water within the wells; provide analysis results for the total and faecal coliforms from the well; provide integrity test results for all sumps, lagoons and underground pipelines handling effluent or sanitary waste and clarify the presence and use of any private groundwater abstraction wells at residential properties within 200m of the facility.

*Site History*

The site was developed as a waste management facility in 1987 on lands that had previously been used for agricultural purposes. It operated under a series of Waste Permits issued by Kerry County Council that authorised the acceptance and processing of 16,500 tonnes/annum of non-hazardous waste. In 2005 the Agency granted a Waste Licence that authorised the acceptance and processing of 40,000 tonnes of non-hazardous waste.

## 1.3 Summary of Previous Assessments

OES submitted the proposed scope of the hydrological survey to the Agency and, following receipt of approval, completed the assessment. It comprised a desk study of geological and hydrogeological databases maintained by the GSI the installation of four groundwater monitoring wells (MW-1, MW-2, MW-3 and MW-4); the collection and analysis of groundwater samples on three occasions and an assessment of potential on and off-site contaminant sources. A copy of the report is in Appendix 1.

OES established that the underlying bedrock is a Locally Important aquifer, bedrock which is moderately productive only in Local Zones (**Ll**) and that secondary permeability is dominant. The nearest groundwater well to the site was more than 1km upgradient, with the closest down gradient well 2.7km away.

Two of the monitoring wells (MW-1 and MW-2) were positioned to the south and down topographic gradient of the operational area, with MW-3 and MW-4 being to the north and up gradient. The wells were installed using an air rotary rig.

The borehole logs indicate the soils and subsoils comprise peat overlying 'mottled clay'. The peat was up to 2m thick and the clay was between 1 and 3m thick. The underlying bedrock is described as a weathered black shale.

The borings extended to between 18 and 24 m below ground level and water strikes were encountered in the bedrock at depths ranging from 11 to 20m below ground level (bgl). The water levels recorded in the wells during subsequent groundwater sample collection ranged from 0.1 m below the top of the well pipe in MW-1, to 1.71m in MW-3; however OES did not survey the wells to datum level. More detail on the well construction is provided in Section 4.

OES conducted groundwater quality monitoring on three occasions (04/09/2009, 26/11/2009 and 27/05/2010) for pH, electrical conductivity, total dissolved solids, ammonia, chloride, nitrate, sulphate and extractable petroleum hydrocarbons (EPH).

Elevated ammonia levels were detected in MW-1, MW-2 and MW-3 on all three occasions, with the levels in the up-gradient well (MW-3) ranging from 1.32 to 2.86 mg/l. Ammonia was not detected in the other upgradient well (MW-4). The maximum levels in the down gradient wells were 1.71 mg/l in MW-1 and 2.83 mg/l in MW-2. Nitrate and sulphate were not detected in MW-1, MW-2 and MW-3, but sulphate was detected in MW-4 on one occasion. The electrical conductivity and total dissolved solids levels in MW-4 were significantly lower than in the other wells.

OES identified two potential on-site contaminant sources for the elevated ammonia, which were the leachate holding tank in the materials recovery building and the reed beds. Off-site potential sources included septic tanks, the land application of farm animal slurry and forestry. OES concluded that the leachate tank and reed beds were not the sources of the elevated ammonia and, given its detection in the up gradient well, the source was outside the site boundary.

## 2. ENVIRONMENTAL SETTING

### 2.1 Site Location & Description

The facility is located at Aughacurren approximately 4km km to the north-west of Killarney (Figure 2.1). The site layout is shown on Drawing No. 01 Rev A. It encompasses 2.2 hectares (ha) and consists of a material recovery building (3,223m$^2$), concrete yards, weighbridge and administration building. Ancillary infrastructure includes fuel storage, storm water drainage system and reed bed, and a sanitary effluent treatment system.

### 2.2 Waste Activities

#### *2.2.1 Surface Water Drainage*

There are three separate surface water drainage systems. The first collected rainwater run-off from the roof of the materials recovery building and discharges it to a drain that runs through the site.

Rainwater run-off from the operational yards, where there is the potential for contamination to occur (bin washing area and compost bay), is directed to holding tanks where it is stored pending removal from the site for off-site treatment in the Irish Water Wastewater Treatment Plant (WWTP) in Killarney.

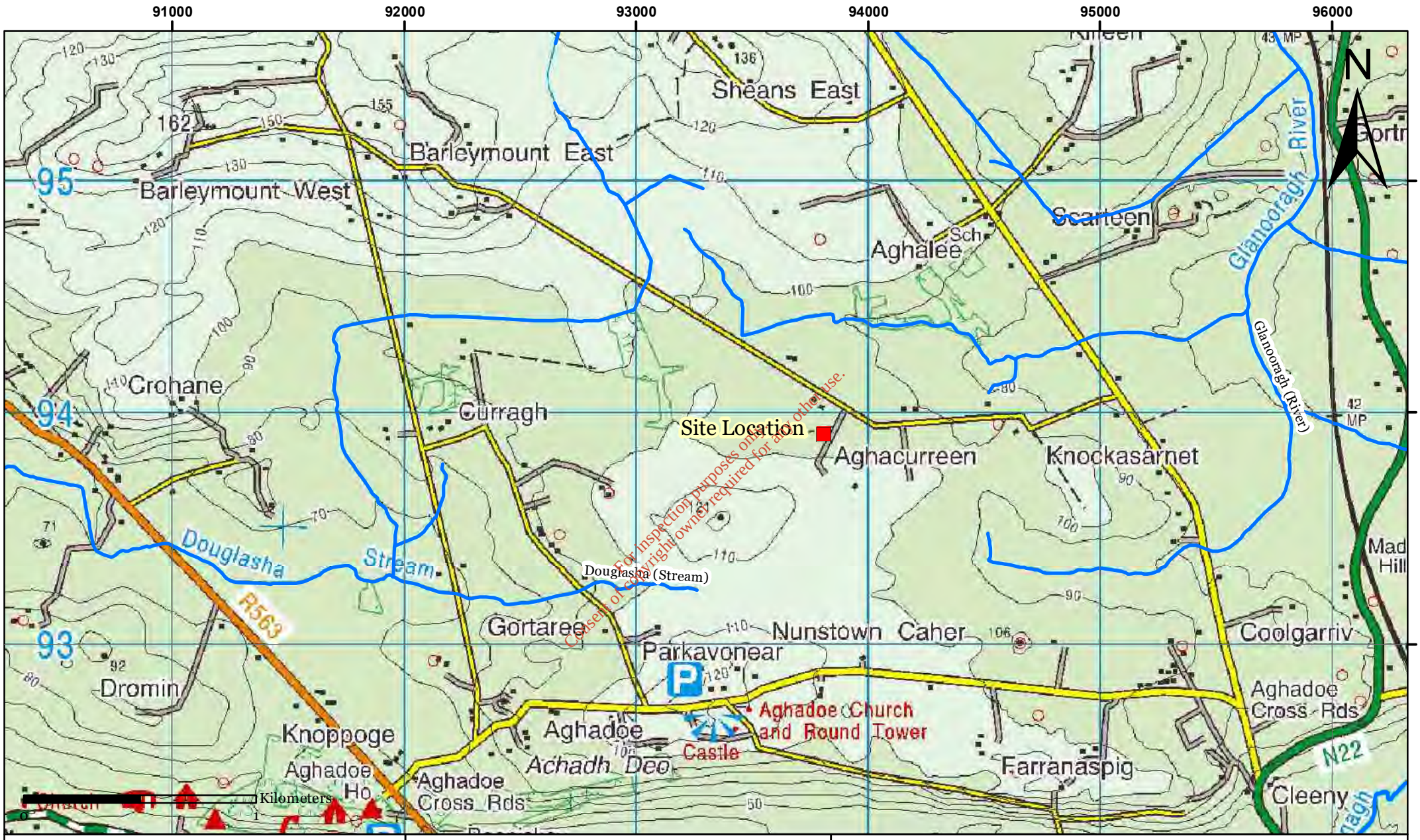
Rainwater run-off from the yards where the risk of contamination is low, including the area around the office and the timber storage area, is collected and directed via a Class 1 Oil Interceptor and three settlement tanks to the on-site reed beds. The reed beds comprise an initial 'glass' bed followed by a 'lagoon' bed. The outflow from the 'lagoon' bed is to an on-site percolation area in the north-west of the site.



#### *2.2.2 Foul Water Drainage*

Liquid seeps from the waste handled inside the materials recovery building is collected in an underground effluent holding tank (6,92m$^3$). The tank is made of pre-cast concrete and sits in a second underground concrete tank that provides secondary containment (bund). The wastewater accumulating in the tank is removed for treatment at the Irish Water WWTP.

Sanitary wastewater is treated in an on-site proprietary wastewater treatment system (puraflo) located close to the northern site boundary, with the treated effluent pumped to an on-site percolation area located to the north of the reed bed percolation area. The system was installed and certified in 2016 to replace a former septic tank located to the north-west of the weighbridge that has now been decommissioned.

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CLIENT
Killarney Waste Disposal

TITLE
Site Location

Details:
Site Location

Figure 2.1

NOTES:

THIS DRAWING IS COPYRIGHT ©

DO NOT SCALE FROM THIS DRAWING.
WORK ONLY FROM FIGURED DIMENSIONS.
ALL ERRORS AND OMMISIONS TO BE REPORTED TO THE ARCHITECT.

N

Site Area = 2.202 HA

New Pump Main From Puraflo System To Wastewater Treatment Area. Of 4No. Pods On A Polishing Filter.

R 2 & SW 2 drain to external land drain

Glass Reed Bed

Existing Storm Water Settling Tanks x3No.

New Wastewater Treatment Area. Of 4No. Pods On A Polishing Filter.

SEE Drawing K-W-D-04-2016-Rev-A SEW (SPECIFIED ENGINEERING WORKS)

SEE Drawing K-W-D-03-2016-Rev-A SEW (SPECIFIED ENGINEERING WORKS)

Post and Wire Fence

Lagoon Reed Bed 0.5m Freeboard

Solids Separator

stream

New Puraflo System

Existing Septic Tank No Longer In Use

Area of Paving served by Reed Bed = 2550 sq. m

SW 2

SW 1

Storm water (SW 1) drains to percolation ditch

SEE Drawing K-W-D-03-2016-Rev-A SEW (SPECIFIED ENGINEERING WORKS)

Existing Metal Shearing Yard

100mm pipe

ESB Pole

Proposed Borehole 1

SEE Drawing K-W-D-02-2016-Rev-A SEW (SPECIFIED ENGINEERING WORKS)

Baled Plastic Shed

Water drains from wooded area to 400mm land drain

Timber Shredding Yard

Proposed Borehole 2

Proposed new holding tanks

750mm Pipe under track

Weigh Bridge

Entrance

Roof Water Discharges to drain.

Proposed Gulley

Heat Exchangers

Proposed Offices

Proposed Gulley

Dryer

Two Air Compressors

New effluent holding tank

Concrete Pad

Baling Shed

Private access road

MRF Building

R1

Roof stormwater(R1) discharges to roadside drain

Diesel Generator

4.55 cubic metre holding tank

Foul Sewer Pipe

Storm Drainage off Roc

Yard Drainage Pipe

750mm Proposed Drainag

Proposed New Building

Designated Parking Are

Concrete Area

Existing Material Recov

| REV | DATE | REVISION INFO. |
|---|---|---|
| A | 03/10/16 | INFORMATION. |

CLIENT: KWD RECYCLING LTD MRF FACILITY AT AUGHACUREEN.

PROJECT: SEW (SPECIFIED ENGINEERING WORKS)

DRAWING: SITE LAYOUT PLAN.

SCALE: 1:500 | DATE: 03.10.2016

DWG No. : 01

DONAL MOYNIHAN
B.E, C.Eng., M. IEI.
CHARTERED ENGINEER

## 2.3 Surrounding Land Use

The facility is located in a rural area and the surrounding land use is primarily agricultural, with some forestry (Figure 2.2). There are approximately twenty (20) residences within 500m of the facility, the majority of which are in a 'ribbon development' along the local road to the north of the site. These residences obtain their water supply from the Irish Water mains.

## 2.4 Hydrology

There is a local high point (121mOD) approximately 500 m to the south-west of the site, from where the ground falls away in all directions (Figure 2.3). This high point forms a watershed between tributaries of the Glanooragh River to the north of the site and the Douglasha Stream to the west. Both watercourses are tributaries of the River Laune. The site is in the catchment of the Glanooragh River, which is a tributary of the Gweestin River.

A surface water drain flows through the site in a south-west to north-east direction. At the north-eastern boundary, the drain changes direction to flow south-east along the boundary to the access road, where it turns in a north-easterly direction and joins a tributary of the Glanooragh River, approximately 250m from the site.

## 2.5 Geology

### *2.5.1 Subsoils*

The Teagasc maps (Figure 2.4) indicate that the subsoils are till derived from Namurian shales and sandstones. The logs of the boreholes installed by OES (refer to Appendix 1) indicate the soils comprise peat overlying tills. The combined thickness ranges from 3m in the east of the site to 5m in the west.



### *2.5.2 Bedrock*

The GSI bedrock map (Figure 2.5) indicates the site is underlain by Namurian shales and sandstones. The OES borehole logs indicate the bedrock comprises a black shale, the upper 3 to 5m of which is weathered.

## 2.6 Hydrogeology

### *2.6.1 Aquifer Classification*

The subsoils are not significantly water bearing. The underlying bedrock is characterised by the GSI as a Locally Important aquifer, which is moderately productive only in Local Zones (**Ll**) (Figure 2.6). Permeability in the bedrock is highest in the upper few metres but generally decreases rapidly with depth. In general, groundwater flow is concentrated in the upper 15 m of the aquifer, although deeper inflows from along fault zones or connected fractures can be encountered.

The OES borehole logs show water strikes at between 11 and 20m below ground level. The water levels recorded by OES in the wells in 2009 and 2010 were all significantly above the top of the bedrock, indicating confined conditions.




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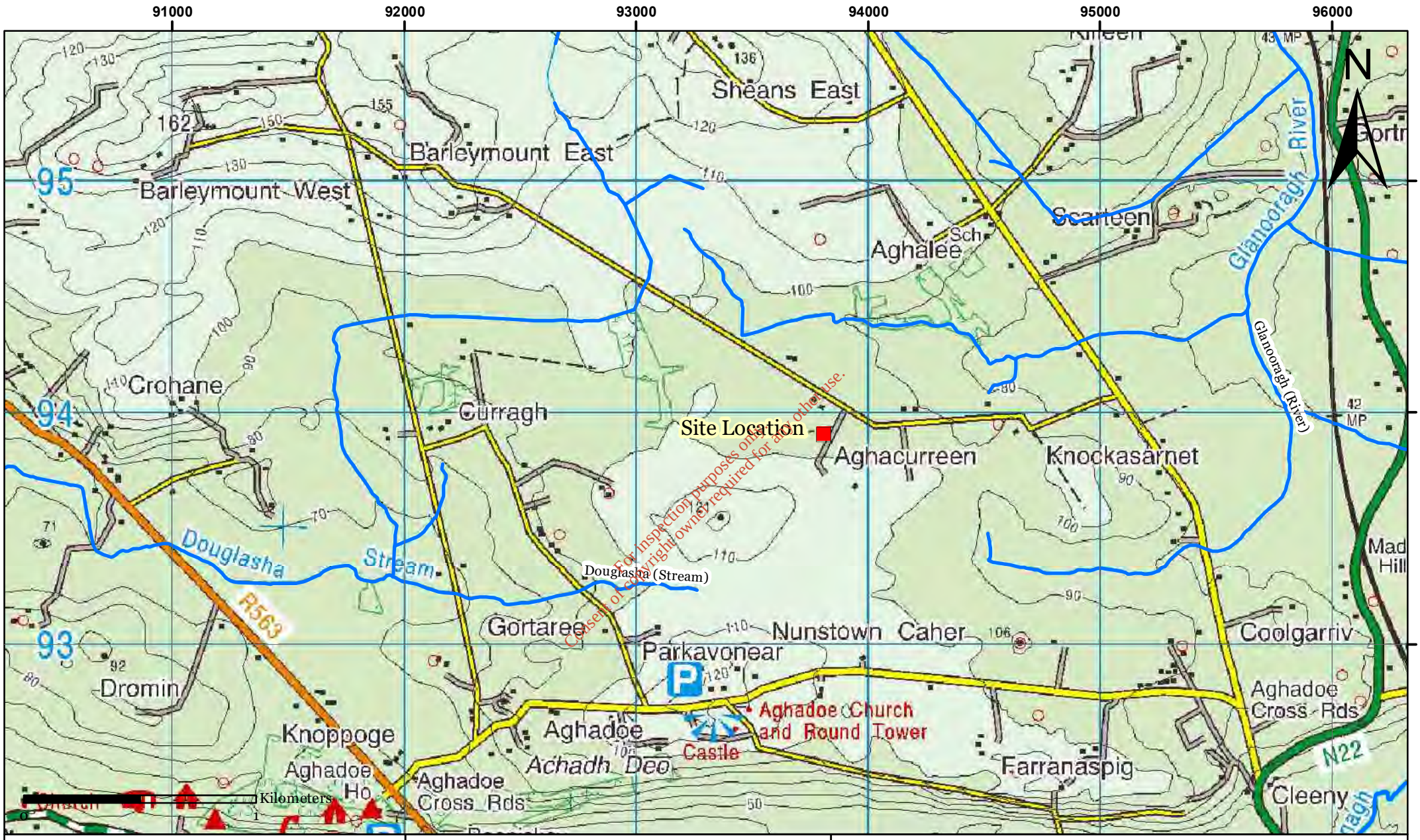
CLIENT
Killarney Waste Disposal

TITLE
Surrounding Land Use

Details:
Site Location

Figure 2.2

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CLIENT
Killarney Waste Disposal

TITLE
Hydrology

Details:
- Site Location
- Rivers

Figure 2.3


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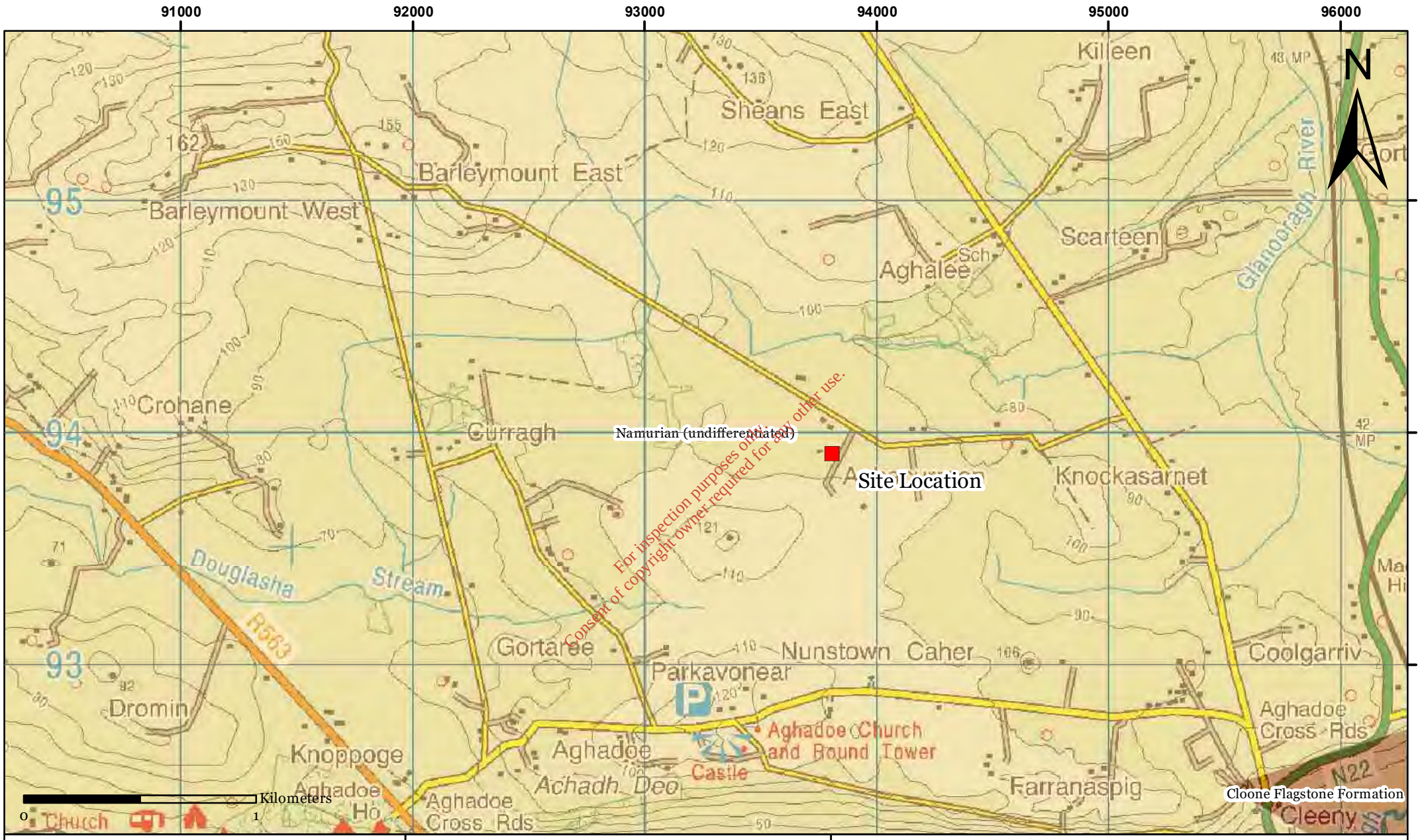
CLIENT
Killarney Waste Disposal

TITLE
Subsoils

Details:
- Site Location
- A - Alluvium undifferentiated
- BktPt - Blanket peat
- Made - Made Ground
- Rck - Bedrock at surface
- TDSs - Sandstone till (Devonian)
- TNSSs - Shales and sandstones till (Namurian)

Figure 2.4

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CLIENT
Killarney Waste Disposal

TITLE
Bedrock Geology

Details:
- Site Location
- Cloone Flagstone Formation-Greywacke,Siltstone & Shale
- Namurian (undifferentiated)-Shale & Sandstone

Figure 2.5

Significant yields can sometimes be obtained from this formation type where boreholes are drilled into known fault zones; however, the yields are not necessarily sustainable, as the fracture networks are generally not extensive or well connected, but primarily concentrated in the vicinity of the fault zones.

The aquifer is part of the Scartaglin Groundwater Body. The GSI's initial characterisation of this water body (Appendix 2) states that the sandstone beds in the bedrock formation have a slightly higher permeability than the shales due to their greater ability to fracture and that there are a number of artesian supplies where the sandstone beds are confined by the shales and mudstones.

### *2.6.2 Aquifer Vulnerability*

Vulnerability is defined as the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. Vulnerability categories range from Extreme (rock close to surface) to **Extreme** to **High** to **Moderate** to **Low** and are dependent on the nature and thickness of subsoils above the water table.

The Namurian till has a low permeability and although in some areas it has a stony matrix there is still generally a high clay content due to the weathering of shale clasts. The GSI Vulnerability Map (Figure 2.7) indicates that the vulnerability across the site is **Low** however the borehole logs describe the soil and subsoil (peat and till) thickness as ranging from 3 to 5m, indicating the vulnerability ranges from **Extreme to High**.

### *2.6.3 Groundwater Flow Paths and Direction*

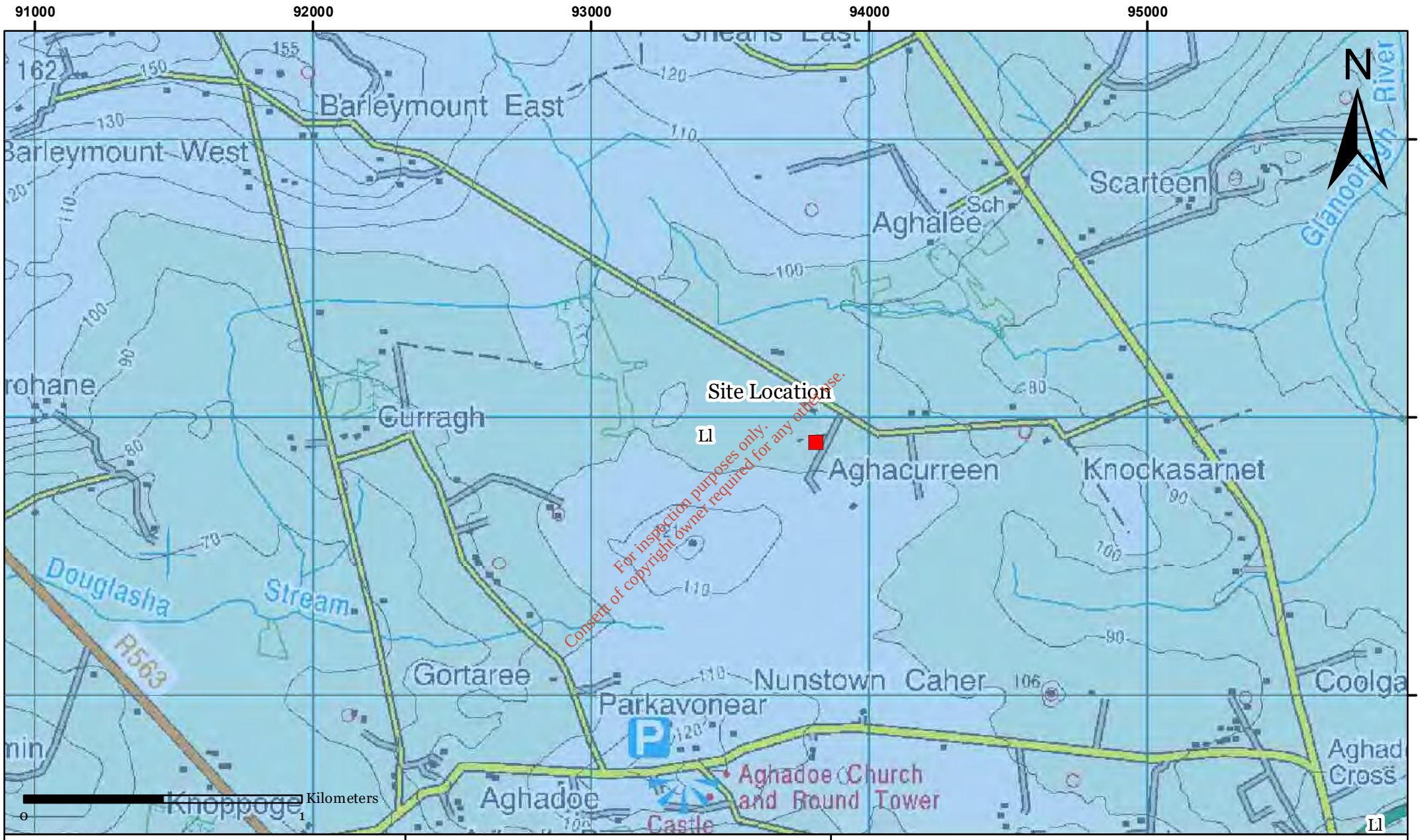
Groundwater flow paths in the bedrock beneath the site are generally short, typically 30-300 m, with groundwater typically discharging to small springs, or to the streams and rivers that traverse the aquifer. Flow directions are expected to mirror the local surface water catchments. The local direction of groundwater flow is likely to be influenced by the topography and be the north-east, towards the tributary of the Glanooragh Stream.



OES recorded the groundwater levels on three occasions in 2009 and 2010; however they did not survey the wells to a datum level and therefore they estimated the direction of groundwater flow as being to the north-east based on the local topography. In October 2016 KWD surveyed the wells to Ordnance Datum (OD) and the level of the top of the casing at each of the wells is shown in Table 2.1.

**Figure 2.1 Monitoring Well Levels**

| Well | Easting | Northing | OD Top of Casing (m) |
|---|---|---|---|
| MW-1 | 493661 | 594052 | 91.792 |
| MW-2 | 493612 | 594086 | 92.814 |
| MW-3 | 493519 | 593989 | 93.645 |
| MW-4 | 493570 | 593933 | 92.816 |

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CLIENT
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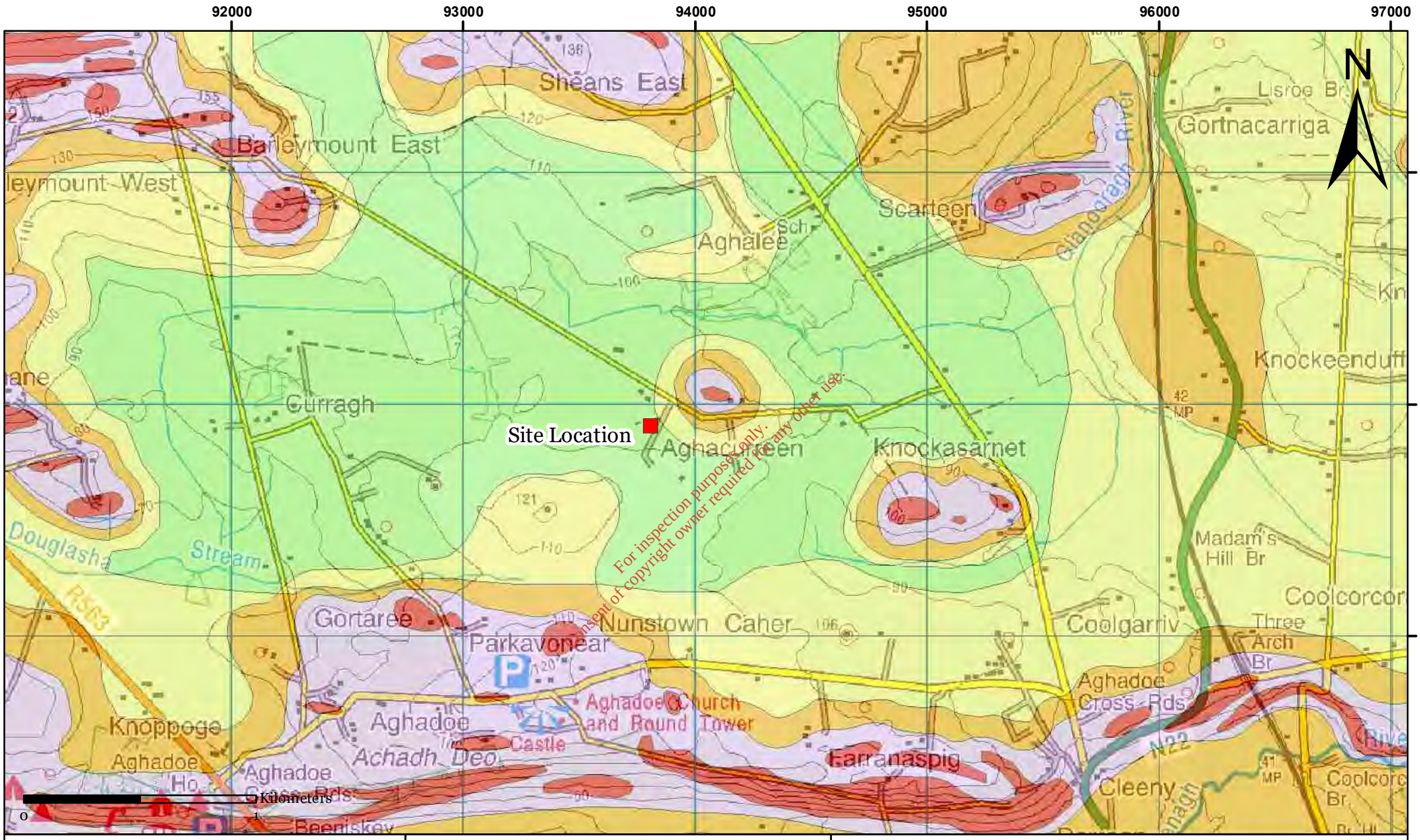
TITLE
Aquifer Classification

Details:
- Site Location
- Ll-Bedrock which is moderately productive only in Local Zones

Figure 2.6

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CLIENT
Killarney Waste Disposal

TITLE
Groundwater Vulnerability

Details:

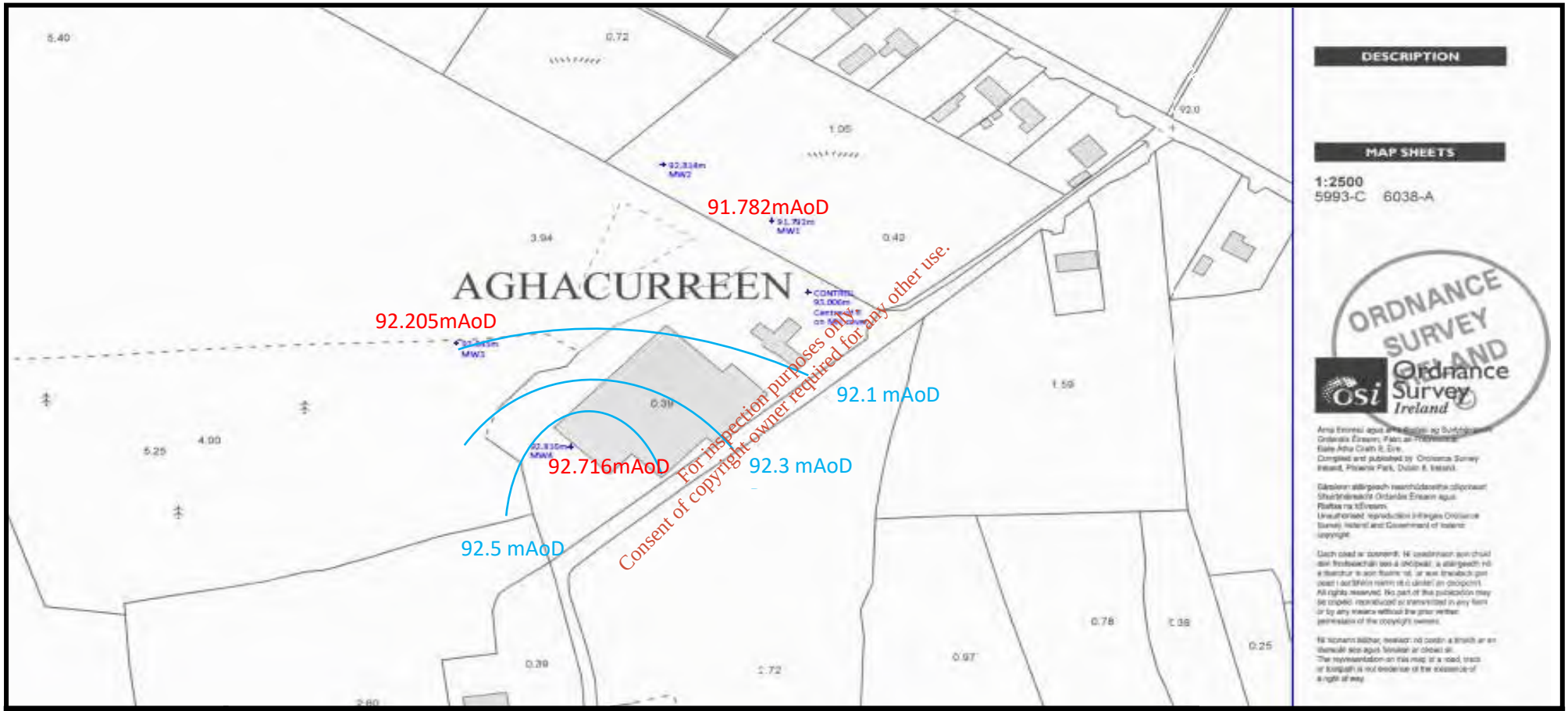
- Site Location
- Bedrock near Surface
- Extreme
- High
- Moderate
- Low

Figure 2.7

Although the groundwater wells have been routinely monitored since 2012 groundwater level data has only been recorded since June 2016. OCM used the water levels recorded in wells MW-1, MW-3 and MW-4 in November 2009 and June 2016 to calculate the groundwater flow direction to compare with the OES estimated direction of flow and the current position and these are shown on Figures 2.8 and 2.9. The flow is from south to north, meaning that wells MW-4 is up gradient and MW-3 Is side gradient of the operational area, while wells MW-1 and MW-2 are downgradient.

### *2.6.4 Groundwater Abstraction Wells*

KWD informed OCM that the private residences to the north of the site obtain their water supplies from the Irish Water mains. A review of the GSI water well database did not identify any additional wells to those described in the OES and the nearest recorded well is 1km up gradient of the site, with the closest down gradient well 2.7km away (Figure 2.10).

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**Title:**

## Figure 2.8

## Groundwater Contours November 2009

**Legend**

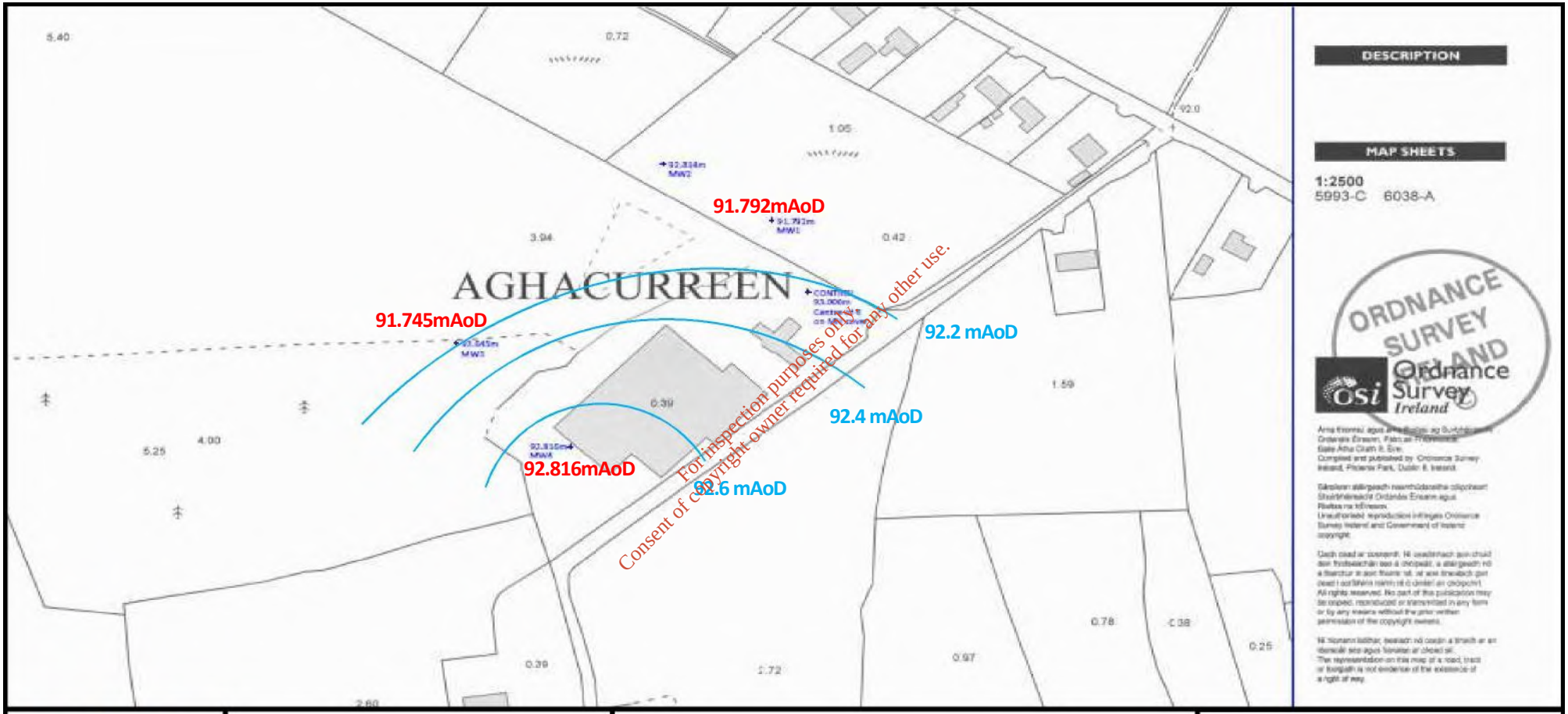
= Groundwater Contour

92.214mAoD= Dip Levels



**Client:**

**Killarney Waste Disposal Ltd.**

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**Title:**

**Figure 2.9**

**Groundwater Contours June 2016**

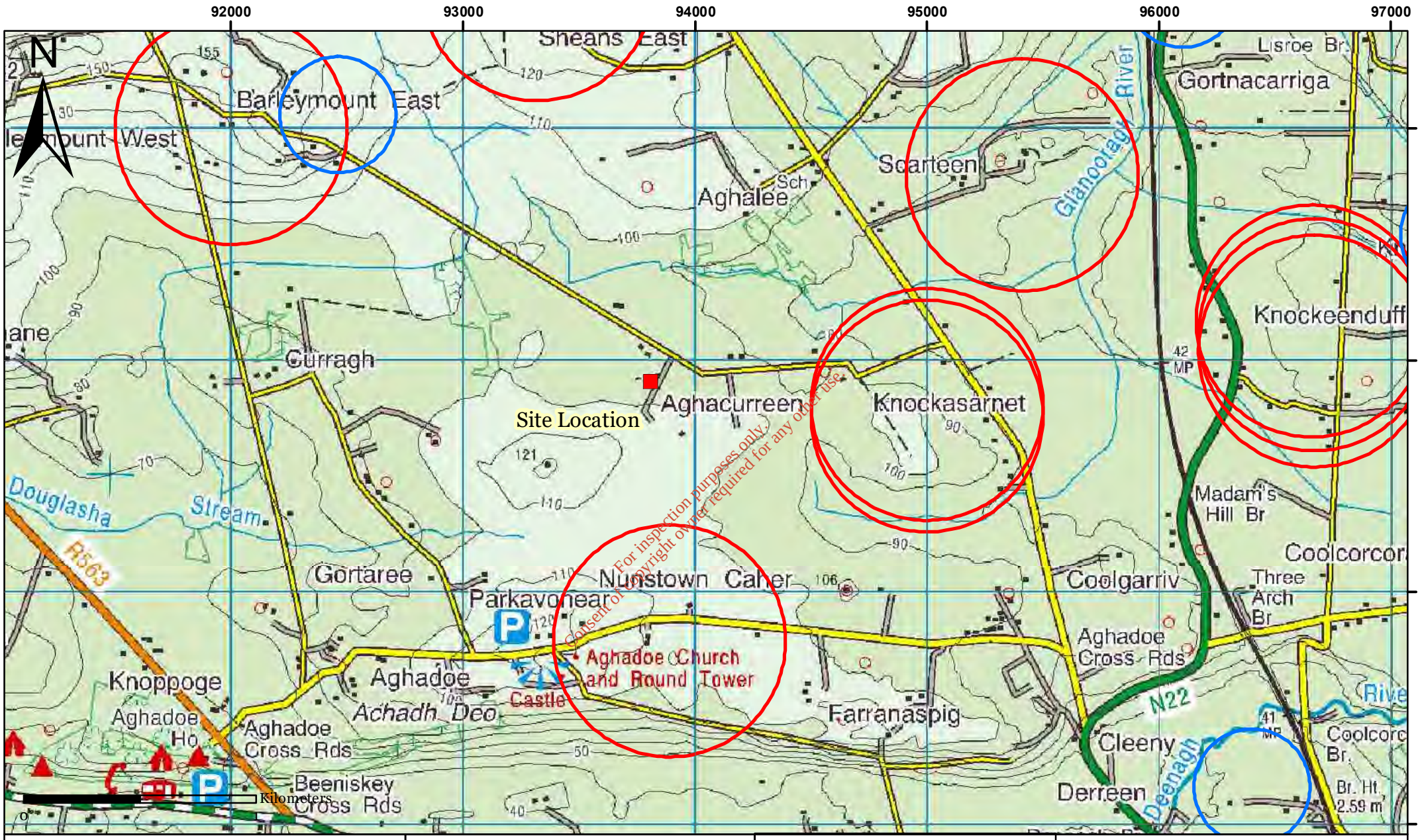
**Legend**

= Groundwater Contour

92.214mAoD= Dip Levels

**Client:**

**Killarney Waste Disposal Ltd.**

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CLIENT
Killarney Waste Disposal

TITLE
GSI Well Location Data

Details:
Unfortunately many of the borehole logs in the GSI database do not contain accurate location information. The size of the circles shown above is inversely proportional to the accuracy of the well location (i.e. small circles represent high accuracy, where relatively larger circles represent lower accuracy).

- Site Location
- 250m-500m
- 500m-1km

Figure 2.10

## 3. CONCEPTUAL SITE MODEL

A Conceptual Site Model (CSM) is shown on Figure 3.1. The site is underlain by a peat and low permeability till that range in thickness from 3 in the east to 5m in the west of the site. The subsoils are not significantly water bearing and the underlying bedrock is classified as a 'Locally Important aquifer, bedrock which is moderately productive only in Local Zones'.

In MW-1, MW-3 and MW-4 the depth to water ranges from 0.35 to 1.9m below the top of the well casing, with discernible seasonal variation in MW-3. There are artesian conditions in MW-1, with water overflowing the top of the well pipe in the winter. The water levels indicate that bedrock aquifer is confined, with the piezometric head above the top of the weathered bedrock. The direction of groundwater flow is from the south-west to the north east.

The operational area is entirely covered by buildings or concrete paving, but the reminder of the site is unpaved. There are two reed beds in the northern unpaved area that treat rainwater run-off from clean paved areas, with the treated water discharging to an on-site percolation area. Sanitary wastewater is treated in the 'puraflo' system and the treated effluent discharges to ground.



### 3.1 Contaminant Sources

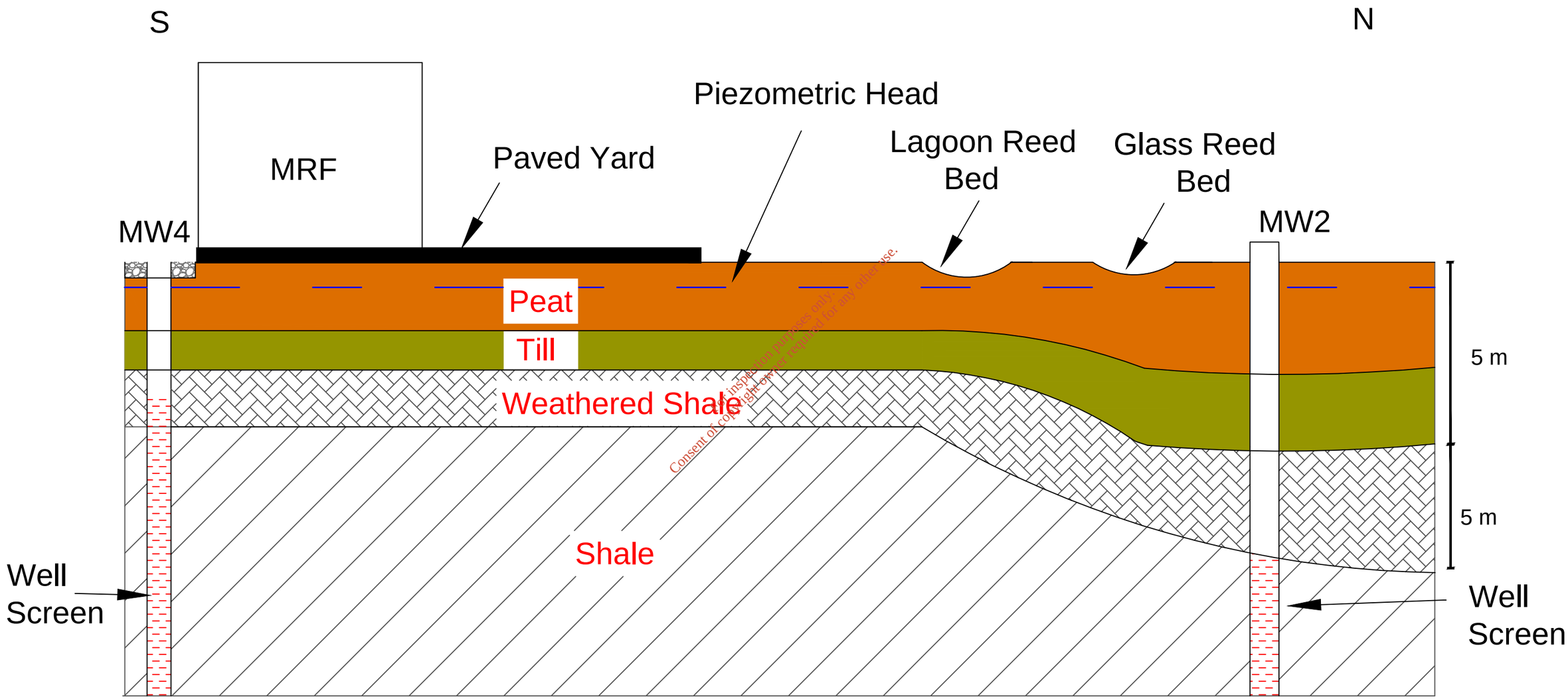
Waste Activities

All wastes other than timber and metal are off loaded and processed/transferred inside the materials recovery building. Liquid seeps from the waste is collected in an underground effluent holding tank (6,92m$^3$). The tank is made of pre-cast concrete and sits in a second underground concrete tank that provides secondary containment (bund). The wastewater is removed for treatment at the Irish Water WWTP.

Metal and timber wastes were handled in open paved areas where the timber was shredded and the metal cut. Rainwater run-off from the area is collected in an underground sump. In 2016 KWD ceased the external processing of the timber and metal, but the external storage of the timber and metal continues.

Originally rainwater run-off from all the paved open yard areas discharged via an oil interceptor and settling tanks to the on-site reed beds. The outfall from the 'lagoon' reed bed discharges to ground. In 2016 the run-off from the operational yards, where there was the potential for rainwater run-off to become contaminated (including the bin washing area and compost bay), was diverted from the reed beds and into a holding tank, where it is stored pending removal for off-site treatment.

Sanitary wastewater was previously discharged to an on-site septic tank and associated percolation area located in the north-west of the site. In 2016 the 'puraflo' system and a new percolation area were installed and the original septic tank was decommissioned. Testing of treated effluent before it enters the percolation area is carried out and the results confirm that system is operating satisfactorily and meeting the performance standards set in the Agency's Code of Practice: Wastewater Treatment and Disposal Systems Serving Single Houses.



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environmental management for business



CLIENT: Killarney Waste Disposal

FIGURE No.: 3.1

TITLE: Conceptual Site Model

SCALE: NTS

REV.: A

Due to high groundwater levels in the vicinity of the weighbridge, which were attributed to a spring, KWD installed a sump from which groundwater was pumped to the drain that runs along the north-eastern site boundary. Following concerns raised by the Agency on the quality of the water, the discharge was stopped.

Rainwater accumulating in the sump beneath the weighbridge use to overflow to the drain along the north-eastern boundary. In 2016 this overflow was sealed and the water is now removed from the tank using a vacuum tanker and stored in the wastewater tank in the materials recovery building.

All underground sumps, the oil tank bund and the oil interceptor are subject to regular integrity tests, as required by the licence conditions. The foul water pipe network was surveyed in 2014 and no defects were found. The most recent tests on the sumps, bund and interceptor were completed in 2016 and all of the structures were found to be fit for purpose. Copies of the underground line survey and sump test report are in Appendix 3.

Off-Site Sources

The facility is located in a rural area and the land use in the vicinity of the site is primarily agricultural, with some forestry. There are approximately twenty (20) residences within 500m of the facility, the majority of which are in a 'ribbon development' along the local road to the north of the site. It is understood that the houses are served by septic tanks.



### 3.2 Pathways

The operational areas where wastes are handled are either paved with concrete or covered with buildings, which prevents the direct infiltration of rainfall on the site to the subsoils and eliminates the pathway by which any contaminants at the ground surface can move towards the bedrock.

The north-western part of the licensed area is not paved and contains the reed beds and associated percolation area and the percolation area for the recently installed 'puraflo' system. The reed beds and percolation areas provide pathways for rain-water run-off from the yards and the treated sanitary wastewater effluent to the bedrock aquifer. However the confined conditions means there is an upward groundwater pressure head, which would inhibit the entry of contaminants into the aquifer.

The confined conditions in the aquifer means that groundwater does not provide baseflow to the drain and with the exception of MW-1 which is artesian, there are no pathways between the groundwater beneath the site and the drain that runs through the site.

### 3.3 Receptors

The known receptors that could potentially be impacted by on-site contamination sources are the groundwater in the bedrock aquifer and the surface water drain that flows through the site. However, as referred to above the confined conditions inhibit the entry of contaminants into the aquifer. The houses to the north of the site obtain their water supply from the Irish Water mains, and there is no record of any abstraction well within 1km of the site.

## 4. GROUNDWATER QUALITY ASSESSMENT

### 4.1 Groundwater Monitoring Wells

The description of the wells is based on the borehole logs in Attachment A of the OES Report. At MW-1 there is 2m of peat which is underlain by 3m of till. The top 2m of the bedrock is weathered and the total depth of the well is 18m. A water strike was encountered at 10m bgl. Slotted well pipe extends from the bottom of the hole to the base of the weathered bedrock, with plain pipe extending from there to above ground level. There is a bentonite seal from ground level to the base of the weathered bedrock. The well construction details indicate the well is screened exclusively in the competent bedrock.

The well is located in a wooded area to the north of the drain that flows along the north-eastern boundary. The headworks are intact (Photograph 1) but there is evidence of artesian conditions.



**Photograph 1 MW-1**

At MW-2 there is approximately 1.8m of peat, which is underlain by 1.2 m of till. The top 3m of the bedrock is weathered and the total depth of the well is 24m. A water strike was encountered at 20m below ground level. Slotted well pipe extends from the bottom of the hole to the base of the weathered bedrock, with plain pipe extending from there to above ground level. There is a bentonite seal from ground level to the base of the weathered bedrock. The well construction details indicate the well is screened exclusively in the competent bedrock.

The well is located in a wooded area to the north of the drain that flows along the north-eastern boundary. The headworks are intact.



**Photograph 2 MW-2**

At MW-3 there is approximately 1.8m of peat which is underlain by almost 3m of till. The top 3.5m of the bedrock is weathered and the total depth of the well is 18m. A water strike was encountered at 11m below ground level. Slotted well pipe extends from the bottom of the hole into the weathered bedrock, with plain pipe extending from there to above ground level. There is a bentonite seal from ground level to the middle of the weathered bedrock. The well construction details indicate it is possible for water in the weathered zone and the competent rock to enter the well pipe.

The well is located in the south-west of the site. The on the top of the steel casing has been removed and there is no cap on the top of the well pipe.

**Photograph 3 MW-3**



At MW-4 there is approximately 1.8m of peat, underlain by almost 1.2m of till. The top 5m of the bedrock is weathered and the total depth of the well was 18m. A water strike was encountered at 11m below ground level. Slotted well pipe extends from the bottom of the hole into the weathered bedrock, with plain pipe extending from there to above ground level. There is a bentonite seal from ground level to the middle of the weathered bedrock. The well construction details indicate it is possible for water in the weathered zone and the competent rock to enter the well pipe.

MW-4 is located in the south-east of the site close to the rear wall of the materials recovery building. The top of the well pipe is approximately 1m below ground level as a result of the raising of the access road to the rear of the building.

The well was protected by placing a large diameter plastic pipe on the ground and backfilling around it. However the lid on top of the casing has been remove and there is no well cap. OCM observed water had accumulated in the base of the protective pipe and the level was just below the top of the well pipe and there were leaves and litter around the well pipes. It was not possible to determine if the water in the base was overtopping groundwater or surface water.

**Photograph 4 MW-4**



### 4.2 Water Quality Data

The wells were installed in 2009 and were monitored on three occasions between 2009 and 2010. Biannual monitoring for the parameters specified in the Schedule C of the licence began in 2012.

The monitoring results are presented in Tables 4.1 to 4.4, which includes the Interim Guideline Values (IGV) for Irish groundwater published by the Agency and the Threshold Values (TV) from the European Community Environmental Objectives (Groundwater) Regulations 2010.

From the start of the monitoring programme the ammonia levels in MW-1, MW-2 and MW-3 have exceeded the TV, while the level in MW-4 has been generally below the TV, with only occasional exceedances. Nitrates have not been detected, and sulphate is only consistently recorded in MW-4. The chloride level in MW-4, while initially similar to that in the other wells has increased over time, with occasional spikes.

In September 2016 KWD commissioned Southern Scientific Services Ltd to collect five samples from BH-3 over a four hour period, measure the dissolved oxygen level and check the redox potential in the field and conduct laboratory analysis for ammonia, COD, nitrate, nitrite, ferrous and ferric ions and sulphide. The laboratory report is in Appendix 4 and the results are in Table 4.2.

**Table 4.1 MW-1**

| Field Readings | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-1 Top of Well Pipe 91.792m (mAOD) | Units | Ground Water Regs SI No 9 of 2010 | EPA Interim Guidline Values | Sep-09 | Nov-09 | May-10 | Mar-12 | Jul-12 | Feb-13 | Sep-13 | Jan-14 | Jul-14 | Nov-14 | Jan-15 | Jul-15 | Jan-16 | Jun-16 | Aug-16 | Nov-16 | Jan-17 |
| Total Depth | m | - | - | 18 | 18 | 18 | | | | | | | | | | | | | | |
| Depth to Water Level | m | - | - | 0.02 | 0.01 | 0.2 | ND | ND | ND | | ND | ND | ND | ND | ND | ND | 0 | 0 | 0.35 | 0.35 |
| Water Level (mAOD) | m | - | - | 91.772 | 91.782 | 91.592 | – | – | – | | – | – | – | – | – | – | 91.792 | 91.792 | 91.442 | 91.442 |
| Temperature | °C | - | 25 | 10.4 | 10.4 | 10 | – | – | – | | – | – | – | – | – | – | | | | |
| Conductivity | µS/cm | 800 – 1875 | 1000 | 618 | 649 | 663 | 626 | 627 | 637 | 639 | 639 | 640 | 635 | 647 | 633 | 650 | 641 | 661 | 651 | 645 |
| pH | pH Units | - | 6.5 - 9.5 | 7.04 | 7.04 | 6.67 | – | – | – | | | – | – | – | – | – | – | – | – | – |
| **Laboratory Results** | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids | mg/l | NE | 1000 | 325 | 325 | 336 | – | – | – | | – | – | – | – | – | – | | | | – |
| Ammonia (as N) | mg/l | 0.05 –0.136 | 0.12 | 1.77 | 1 | 0.9 | 1.78 | 2.46 | 1.81 | 0.97 | 1.84 | 2.07 | 1.64 | 1.85 | 1.11 | 1.85 | 0.99 | 1.06 | 1.79 | 1.99 |
| Chloride | mg/l | 187.5 | 30 | 22.4 | 23.6 | 21.6 | 24.9 | 24.6 | 23.7 | 23.7 | 22.1 | 23.6 | 24.1 | 22.6 | 24.3 | 24.9 | 24.1 | 23.5 | 23.8 | 24.2 |
| Sulphate | mg/l | 187.5 | 200 | <3 | <3 | <3 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 0.79 | <0.5 | <0.5 | <0.5 | <0.5 |
| Nitrate as $NO_3$ | mg/l | 37.5 | 25 | <0.06 | <0.06 | <0.06 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 |
| Diesel Range Organics | ug/l | 10 | 10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 110 | <10 |
| Orthophosphate | mg/l | 0.03 | 0.03 | | | | | | | | | | | | | | | | | 0.03 |
| Total Hardness | mg/l | 200 | 200 | | | | | | | | | | | | | | | | | 363 |
| Alkalinity | mg/l | NAC | NAC | | | | | | | | | | | | | | | | | 368 |
| Iron Dissolved | mg/l | 0.2 | 0.2 | | | | | | | | | | | | | | | | | 2.01 |
| Manganese Dissolved | mg/l | 0.05 | 0.05 | | | | | | | | | | | | | | | | | 0.1 |
| Dissolved Oxygen | mg/l | NE | NE | | | | | | | | | | | | | | | | | 1.55 |
| Redox Potential | | NE | NE | | | | | | | | | | | | | | | | | -86 |
| Coliforms | MPN | 0 | 0 | | | | | | | | | | | | | | | | | <1 |
| Faecal Coliforms | MPN | 0 | 0 | | | | | | | | | | | | | | | | | <1 |
| NE: Not Established | | | | | | | | | | | | | | | | | | | | |
| NAC No Abnormal Change | | | | | | | | | | | | | | | | | | | | |

**Table 4.2 MW-2**

| Field Readings | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-2 Top of Well Pipe 92.814m (mAOD) | Units | Ground Water Regs SI No 9 of 2010 | EPA Interim Guidline Values | Apr-09 | Nov-09 | May-10 | Mar-12 | Jul-12 | Feb-13 | Sep-13 | Jan-14 | Jul-14 | Nov-14 | Jan-15 | Jul-15 | Jan-16 | Jun-16 | Aug-16 | Nov-16 | Jan-17 |
| Total Depth | m | - | | 19.32 | 19.32 | 19.32 | | | | | | | | | | | | | | |
| Depth to Water Level | m | - | | 0.54 | 0.43 | 0.98 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | 0.6 | 0.35 | 0.32 | 0.08 |
| Water Level (mAOD) | m | | | 92.274 | 92.384 | 91.834 | – | – | – | – | – | – | – | | – | | 92.214 | 92.464 | 92.494 | 92.736 |
| Temperature | °C | - | 25 | 10.4 | 10.4 | 10.5 | – | – | – | – | – | – | – | | – | | | | | |
| Conductivity | µS/cm | 800 – 1875 | 1000 | 772 | 772 | 828 | 748 | 746 | 747 | 776 | 758 | 787 | 760 | 764 | 769 | 760 | 776 | 796 | 766 | 751 |
| pH | pH Units | NE | 6.5 - 9.5 | 7.08 | 7.08 | 6.9 | – | – | – | – | – | – | – | | – | – | – | – | 7.2 | 7.2 |
| **Laboratory Results** | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids | mg/l | NE | 1000 | 385 | 385 | 412 | – | – | – | – | – | – | – | | – | | | | | – |
| Ammonia (as N) | mg/l | 0.05 –0.136 | 0.12 | 2.83 | 1.86 | 0.578 | 1.84 | 2.11 | 1.84 | 1.19 | 2.07 | 1.47 | 1.23 | 1.16 | 0.65 | 1.7 | 0.53 | 0.73 | 1.42 | 1.76 |
| Chloride | mg/l | 187.5 | 30 | 24.2 | 24.7 | 21.4 | 24.8 | 24.1 | 23.3 | 22.5 | 23.1 | 21.6 | 23.1 | 22.1 | 22.1 | 24.3 | 21.9 | 22.3 | 22.8 | 23.3 |
| Sulphate | mg/l | 187.5 | 200 | <3 | <3 | <3 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 0.51 | <0.5 | <0.5 | <0.5 | <0.5 |
| Nitrate as $NO_3$ | mg/l | 37.5 | 25 | <0.06 | <0.06 | 0.0799 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 |
| Diesel Range Organics | ug/l | 10 | 10 | <10 | <10 | <46 | <10 | <10 | <10 | 28 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | 149 | <10 |
| Orthophosphate | mg/l | 0.03 | 0.03 | | | | | | | | | | | | | | | | | 0.01 |
| Total Hardness | mg/l | 200 | 200 | | | | | | | | | | | | | | | | | 421 |
| Alkalinity | mg/l | NAC | NAC | | | | | | | | | | | | | | | | | 440 |
| Iron Dissolved | mg/l | 0.2 | 0.2 | | | | | | | | | | | | | | | | | 4.19 |
| Manganese Dissolved | mg/l | 0.05 | 0.05 | | | | | | | | | | | | | | | | | 0.15 |
| Dissolved Oxygen | mg/l | NE | | | | | | | | | | | | | | | | | | 3.35 |
| Redox Potential | | NE | | | | | | | | | | | | | | | | | | -119 |
| Coliforms | MPN | 0 | 0 | | | | | | | | | | | | | | | | | <1 |
| Faecal Coliforms | MPN | 0 | 0 | | | | | | | | | | | | | | | | | <1 |
| NE: Not Established | | | | | | | | | | | | | | | | | | | | |
| NAC No Abnormal Change | | | | | | | | | | | | | | | | | | | | |

**Table 4.3 MW-3**

| Field Readings | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-3 Top of Well Pipe 93.645m (mAOD) | Units | Ground Water Regs SI No 9 of 2010 | EPA Interim Guidline Values | Apr-09 | Nov-09 | May-10 | Mar-12 | Jul-12 | Feb-13 | Sep-13 | Jan-14 | Jul-14 | Nov-14 | Jan-15 | Jul-15 | Jan-16 | Jun-16 | Aug-16 | Nov-16 | Jan-17 |
| Total Depth | m | - | | 18.16 | 18.16 | 18.16 | | | | | | | | | | | | | | |
| Depth to Water Level | m | - | | 1.49 | 1.44 | 1.71 | ND | ND | ND | ND | ND | ND | ND | ND | ND | | 1.9 | 1.4 | 1.6 | 1.7 |
| Water Level (mAOD) | m | | | 92.155 | 92.205 | 91.935 | – | – | – | – | – | – | – | | | | 91.745 | 92.245 | 92.045 | 91.116 |
| Temperature | °C | - | 25 | 10.3 | 10.5 | 11 | – | – | – | – | – | – | – | | | | | | | |
| Conductivity | µS/cm | 800 – 1875 | 1000 | 544 | 556 | 583 | 508 | 515 | 516 | 525 | 516 | 531 | 527 | 528 | 529 | 541 | 539 | 558 | 573 | 548 |
| pH | pH Units | NE | 6.5 - 9.5 | 7.01 | 6.81 | 6.64 | – | – | – | – | – | – | – | | | – | – | – | 7.2 | 7.1 |
| **Laboratory Results** | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids | mg/l | NE | 1000 | 272 | 278 | 286 | – | – | – | | – | – | – | | | | | | | – |
| Ammonia (as N) | mg/l | 0.05 –0.136 | 0.12 | 2.86 | 1.32 | 2.54 | 2.99 | 3.08 | 2.91 | 3.16 | 3.47 | 3.21 | 3.03 | 3.2 | 3.2 | 3.13 | 2.81 | 3.35 | 3.25 | 2.8 |
| Chloride | mg/l | 187.5 | 30 | 20.6 | 21.6 | 19.6 | 22.8 | 21.4 | 22.4 | 21.6 | 21.1 | 21.1 | 21.4 | 20.4 | 22.5 | 22.4 | 22.5 | 21.4 | 21.8 | 22.7 |
| Sulphate | mg/l | 187.5 | 200 | <3 | <3 | 4.4 | <0.5 | 1.38 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 0.71 | <0.5 | <0.5 | <0.5 | <0.5 |
| Nitrate as $NO_3$ | mg/l | 37.5 | 25 | <0.06 | <0.06 | <0.06 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 |
| Diesel Range Organics | ug/l | 10 | 10 | <10 | <10 | <46 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Orthophosphate | mg/l | 0.03 | 0.03 | | | | | | | | | | | | | | | | | 0.03 |
| Total Hardness | mg/l | 200 | 200 | | | | | | | | | | | | | | | | | 289 |
| Alkalinity | mg/l | NAC | NAC | | | | | | | | | | | | | | | | | 311 |
| Iron Dissolved | mg/l | 0.2 | 0.2 | | | | | | | | | | | | | | | | | 3.64 |
| Manganese Dissolved | mg/l | 0.05 | 0.05 | | | | | | | | | | | | | | | | | 0.13 |
| Dissolved Oxygen | mg/l | NE | | | | | | | | | | | | | | | | | | 3 |
| Redox Potential | | NE | | | | | | | | | | | | | | | | | | -79.6 |
| Coliforms | MPN | 0 | 0 | | | | | | | | | | | | | | | | | 11 |
| Faecal Coliforms | MPN | 0 | 0 | | | | | | | | | | | | | | | | | 1 |
| NE: Not Established | | | | | | | | | | | | | | | | | | | | |
| NAC No Abnormal Change | | | | | | | | | | | | | | | | | | | | |

## Table 4.4 MW-4

| Field Readings | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH-4 Top of Well Pipe 92.816m (mAOD) | Units | Ground Water Regs SI No 9 of 2010 | EPA Interim Guidline Values | Apr-09 | Nov-09 | May-10 | Mar-12 | Jul-12 | Feb-13 | Sep-13 | Jan-14 | Jul-14 | Nov-14 | Jan-15 | Jul-15 | Jan-16 | Jun-16 | Aug-16 | Nov-16 | Jan-17 |
| Total Depth | m | - | | 19.9 | 19.9 | 19.9 | | | | | | | | | | | | | | |
| Depth to Water Level | m | - | | 0.49 | 0.1 | 0.27 | ND | ND | ND | ND | ND | ND | ND | ND | ND | 0.6 | 0 | 1 | 1 | 1 |
| Water Level (mAOD) | m | | | 92.326 | 92.716 | 92.546 | – | – | – | – | – | – | – | | | | 92.816 | 91.816 | 91.816 | 91.816 |
| Temperature | °C | - | 25 | 10.9 | 10.9 | 11.2 | – | – | – | – | – | – | – | | | | | | | |
| Conductivity | µS/cm | 800 – 1875 | 1000 | 400 | 407 | 410 | 380 | 389 | 378 | 388 | 392 | 392 | 387 | 397 | 398 | 398 | 396 | 407 | 404 | 405 |
| pH | pH Units | NE | 6.5 - 9.5 | 6.86 | 6.86 | 6.28 | – | – | – | – | – | – | – | | | – | – | – | | 7.2 |
| **Laboratory Results** | | | | | | | | | | | | | | | | | | | | |
| Total Dissolved Solids | mg/l | NE | 1000 | 203 | 203 | 203 | – | – | – | | – | – | – | – | – | – | – | – | – | – |
| Ammonium (as N) | mg/l | 0.065-0.175 | 0.12 | <0.2 | <0.2 | <0.2 | <0.02 | 0.03 | 0.03 | 0.06 | <0.02 | 0.04 | <0.02 | 0.08 | <0.02 | <0.02 | 0.24 | 0.03 | <0.02 | 0.06 |
| Chloride | mg/l | 187.5 | 30 | 24.1 | 24.8 | 22.4 | 27 | 34.6 | 30.1 | 26.6 | 29.9 | 87.8 | 32.3 | 60.3 | 27 | 28.3 | 51 | 33.4 | 41 | 67.8 |
| Sulphate | mg/l | 187.5 | 200 | <3 | <3 | 21.9 | 20.2 | 34 | 20 | 22.3 | 28.2 | 70.4 | 27 | 48.3 | 45.7 | 21.6 | <0.5 | 31.4 | 33.6 | 63.9 |
| Nitrate as $NO_3$ | mg/l | 37.5 | 25 | <0.06 | <0.06 | <0.06 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 |
| Diesel Range Organics | ug/l | - | 10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Orthophosphate | mg/l | 0.035 | 0.03 | | | | | | | | | | | | | | | | | 0.01 |
| Total Hardness | mg/l | NE | 200 | | | | | | | | | | | | | | | | | 190 |
| Alkalinity | mg/l | NE | NAC | | | | | | | | | | | | | | | | | 1405 |
| Iron Dissolved | mg/l | NE | 0.2 | | | | | | | | | | | | | | | | | 0.13 |
| Manganese Dissolved | mg/l | NE | 0.05 | | | | | | | | | | | | | | | | | 0.07 |
| Dissolved Oxygen | mg/l | NE | NE | | | | | | | | | | | | | | | | | 2.7 |
| Redox Potential | | NE | NE | | | | | | | | | | | | | | | | | -41.6 |
| Coliforms | MPN | NE | 0 | | | | | | | | | | | | | | | | | 2 |
| Faecal Coliforms | MPN | NE | 0 | | | | | | | | | | | | | | | | | 64 |
| NE: Not Established | | | | | | | | | | | | | | | | | | | | |
| NAC No Abnormal Change | | | | | | | | | | | | | | | | | | | | |

Although the dissolved oxygen was >1.0 mg/l, the redox potential readings (-78 mV to -132.8mV) indicated reducing conditions. Ferrous and ferric ions were present, nitrate and sulphide were not detected and the COD (<10mg/l) was low. The ammonia levels were consistent with those previously measured.

**Table 4.2 Water Quality MW-3 September 2016**

| Parameter | Units | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 |
|---|---|---|---|---|---|---|
| Dissolved Oxygen* | mg/l | 1.5 | 2.1 | 2.9 | 2.9 | 3.4 |
| Redox Potential (Eh)* | mV | -132.8 | -78 | -93.5 | -115.9 | -106.4 |
| Ammonia | mg/l | 3.04 | 3.13 | 3.22 | 3.28 | 3.28 |
| COD | mg/l | <10 | <10 | <10 | <10 | <10 |
| Nitrate | mg/l | <0.25 | <0.25 | <0.25 | <0.25 | <0.25 |
| Nitrite | mg/l | <0.005 | <0.005 | <0.005 | <0.005 | <0.005 |
| Ferrous ions | mg/l | 4.18 | 4.60 | 5.17 | 5.32 | 5.29 |
| Ferric ions | mg/l | 4.77 | 4.94 | 4.26 | 4.20 | 4.20 |
| Sulphide | ug/l | <5 | <5 | <5 | <5 | <5 |

*Field Measurements

In January 2017, KWD requested Southern Scientific Ltd to include dissolved oxygen, redox potential, alkalinity, hardness, orthophosphate, dissolved iron, dissolved manganese, total and faecal coliforms in the range of parameters tested. The laboratory report is in Appendix 4 and the results are in Table 4.3.



**Table 4.3 Water Quality MW-1 to MW-4 January 2017**

| Parameter | Units | MW-1 | MW-2 | MW-3 | MW-4 |
|---|---|---|---|---|---|
| Dissolved Oxygen* | mg/l | 1.55 | 3.35 | 3.0 | 2.7 |
| Redox Potential (Eh)* | mV | -86 | -119.1 | -79.6 | -41.6 |
| pH | pH Units | | | | |
| Orthophosphate | mg/l | 0.03 | 0.01 | 0.03 | 0.01 |
| Nitrate | mg/l | <0.25 | <0.25 | <0.25 | <0.25 |
| Total Hardness | mg/l | 363 | 321 | 289 | 190 |
| Alkalinity | mg/l | 369 | 440 | 311 | 1405 |
| Chloride | mg/l | 24.2 | 23.3 | 22.7 | 67.8 |
| Sulphate | mg/l | <0.5 | <0.5 | <0.5 | 63.9 |
| Iron** | mg/l | 2.01 | 4.19 | 3.64 | 0.13 |
| Manganese** | mg/l | 0.10 | 0.15 | 0.13 | 0.07 |
| DRO | ug/l | <10 | <10 | <10 | <10 |
| Coliforms | MPN | <1 | <1 | 11 | 2 |
| Faecal Coliforms | MPN | <1 | <1 | 1 | 64 |

* Field measurement
** Dissolved

While the dissolved oxygen levels are >1mg/l, the redox reading indicates reducing conditions. Dissolved iron was detected in all wells, with the lowest level in MW-4. The sulphate level in MW-4 were significantly higher than previously recorded, while the levels in the other wells were consistent with previous results. The alkalinity in MW-4 was very high and is probably anomalous as the hardness

was lower than those in the other wells. Total and faecal coliforms were not detected in MW-1 and MW-2, but were detected in MW-3 and MW-4, with the highest levels in MW-4.

### 4.3 Discussion

The results of the monitoring from 2009 to January 2017 indicate that hydro chemical signature of MW-4 differs from that of MW-1, MW-2 and MW-3. The average electrical conductivity, ammonia, sulphate, chloride, hardness, and dissolved iron levels recorded in each of the wells are in Table 4.3.

**Table 4.3 Mean of Indicator Parameters (2009-2017)**

| Parameter | Units | MW-1 | MW-2 | MW-3 | MW-4 |
|---|---|---|---|---|---|
| Electrical* Conductivity | uS/cm | 643 | 769 | 537 | 395 |
| Ammonia* | mg/l | 1.57 | 1.47 | 2.96 | 0.07 |
| Chloride* | mg/l | 23.7 | 23 | 21 | 39 |
| Sulphate* | mg/l | 0.79 | 0.51 | 2.16 | 34.8 |
| Hardness | mg/l | 363 | 421 | 289 | 190 |
| Dissolved Iron | mg/l | 2.01 | 4.19 | 3.64 | 0.13 |

* Average level 2009 to 2017



The ammonia levels have been persistently elevated in MW-1, MW-2 and MW-3 over the monitoring period. While elevated ammonia levels can be indicative of contamination by an organic waste source(s) (e.g. animal slurries, sanitary waste water, leachate), the levels of other indicator parameters (chloride, nitrate, orthophosphate and, in the case of MW-3, COD) are not consistent with an organic waste source.

The historical monitoring data indicate the presence of reducing conditions in the aquifer. The redox potential measurements in MW-3 in September 2016, and in all of the wells in January 2017, in conjunction with the dissolved iron levels in January 2017 and the ferric oxide staining and iron bacteria slime on the headworks at MW-1[1] observed by OCM in October 2016, confirm the presence of reducing conditions.

The reduction-oxidation (redox) state of a groundwater body controls the mobilisation or sequestration of naturally occurring metals; the biodegradation or preservation of anthropogenic contaminants such as nitrates and volatile organic compounds , and the generation of compounds and organisms that affect water quality (dissolved iron and manganese, iron bacteria and hydrogen sulphide).

The redox state is the outcome of a set of electron transfer reactions facilitated by microorganisms that control the transfer of electrons from electron donors (e.g. organic matter, pyrite etc.) and electron acceptors (dissolved oxygen, nitrate, iron etc.)

Reducing conditions start with the take up of the dissolved oxygen by oxygen reducing microorganisms. This continues until all of the available dissolved oxygen is depleted, following which the next most easily exploited electron acceptor (nitrate) becomes available. The pattern of reaction preferences for inorganic compounds are:

[1] Soluble ferrous hydroxide is oxidised to ferric hydroxide when the dissolved oxygen levels increase at the top of the well pipe.

**$O2 > NO_3 > Mn (iv) > Fe (iii) > SO4 > CO_2$**

Groundwater redox conditions are influenced by factors such as recharge rates, local groundwater flow rates and the presence of contaminants, which means that different redox conditions can occur at varying depths, or zones, in the aquifer.

Where a well is exclusively screened in one redox state zone, the redox conditions are stable. Where a well screen straddles a number of different zones, for example when water enters the well pipe from both deep in the aquifer, where reducing conditions predominate, and from higher up where oxidising conditions are prevalent, the groundwater in the well pipe will display a mixed redox character.

This means it is possible for a groundwater sample to have indicators of both oxidising (e.g. dissolved oxygen > 1mg/l) and reducing conditions (ammonia, dissolved iron, negative Eh and low levels of nitrate and sulphate), which is the case in the MW-1, MW-2 and MW-3) and low Eh and low nitrate, ammonia and dissolved iron in MW-4. A complicating factor at MW-4 is the potential for surface water run-off to enter the well pipe, which is likely the source of the faecal coliform contamination and the elevated chloride.

As referred to above, a controlling factor on the redox state is the electron donor, which usually is organic matter. The sources of organic matter can either be naturally occurring (e.g. peatland) or anthropogenic (wastewater treatment systems, agricultural wastes, landfills, oil.).

At the KWD site the soils within and adjoining the site comprise peat, which is a natural source of organic matter. Potential on-site organic matter contamination sources include sanitary wastewater, leachate, contaminated yard run-off and oil. The only potential off-site sources are the wastewater treatment systems serving the houses to the south of the installation and possibly land spreading of farm animal slurry and manure.



If the waste activities were the source of the organic matter chemical indicator parameters (chloride, electrical conductivity and nitrate) should be elevated, but they are not. Faecal coliforms, which are an indicators of sanitary waste water and farm animal waste contamination, were detected in the two upgradient wells (MW-3 and MW-4) but not in the downgradient ones (MW-1 and MW-2).

Given that the headworks on both MW-3 and MW-4 are damaged, there are no well caps and MW-4 is approximately 0.5 m below ground level, the likely source of the coliforms is faecal contamination by birds or small mammals and not off-site sources.

# 5. IMPACT ON RECEPTORS

## 5.1 Surface Water

A biological water quality assessment carried out as part of the preparation of the 2005 EIS established that the drain was seriously polluted at the point where it enters the KWD site and that it was moderately or slightly polluted c.200m upstream of the site. Physio-chemical monitoring established elevated levels of COD, Biochemical Oxygen Demand (BOD), iron and manganese upstream of the site and elevated levels of ammonia, iron, manganese and conductivity downstream of the site. Given the confined conditions in the aquifer groundwater beneath the site does not provide baseflow into the drain and therefore is not the source of the elevated ammonia.

The licence requires annual monitoring of the drain up and downstream of the site bi-annually for pH, electrical conductivity and ammonia. The results of the monitoring conducted in 2016 are in Table 5.1. The Table includes for comparison purposes the 'average' Environmental Quality Standards (EQS) from the Surface Water Regulations 2009 for 'Good Status' waters.

Table 5.1 Surface Water Quality KWD Monitoring

| Parameter | Units | 16/11/2016 Upstream | 16/11/2016 Downstream | 16/12/2016 Upstream | 16/12/2016 Downstream | EQS |
|---|---|---|---|---|---|---|
| Conductivity | uS/cm | 266 | 261 | 268 | 312 | |
| pH | pH Units | 6.9 | 7.3 | 6.7 | 7.1 | 6-9 |
| Ammonia | mg/l | 0.07 | 0.06 | 0.18 | 0.27 | 0.065-0.140 |
| BOD | | | | 2.3 | 1.2 | <1.5 (Mean) |
| COD | | | | 136 | 52 | |



In February and March 2016 the Agency monitored the quality in the drain up and downstream of the site and the results are in Table 5.2.

| Parameter | Units | 16/02/2016 Upstream | 16/02/2016 Downstream | 07/03/2016 Upstream | 07/03/2016 Downstream | EQS |
|---|---|---|---|---|---|---|
| Conductivity | uS/cm | - | - | 218 | 306 | - |
| pH | pH Units | - | - | 6.7 | 7.1 | 6-9 |
| Suspended Solids | mg/l | 9 | 8 | <4 | 4 | - |
| Ammonia | mg/l | 0.038 | 0.51 | 0.18 | 0.27 | 0.065-0.140 |
| Chloride | mg/l | 30.4 | 37.8 | 30.1 | 32 | |
| Orthophosphate | mg/l | 0.047 | | 0.029 | 0.022 | |
| Nitrite | mg/l | - | - | 0.0183 | 0.0056 | |
| BOD | mg/l | - | - | <1 | 1 | <1.5 (Mean) |
| COD | mg/l | 78 | 45 | 57 | 46 | |
| TON | mg/l | <0.2 | 0.49 | 0.49 | 0.34 | |
| Coliforms | MPN | - | - | - | 687 | |
| Faecal Coliforms | MPN | - | - | - | 261 | |

While faecal coliforms were detected in the downstream sample, in the absence of any results for the upstream sample it is not possible to comment on the significance of this. The results of the chemical tests indicate that facility operations are not impacting on the water quality in the drain.

## 5.2 Groundwater

There is no evidence that waste activities are impacting on groundwater beneath the site. The condition of the well heads and MW-3 and MW-4 means there is the potential for contaminants from the ground surface to enter the well pipes.

## 6. CONCLUSIONS & RECOMMENDATIONS

### 6.1 Conclusions

Monitoring wells MW-4 is up gradient and MW-3 is side gradient of waste activities and MW-1 and MW-2 are down gradient.

Since monitoring began in 2009, elevated ammonia has been detected in MW-1, MW-2 and MW-3. Nitrate has never been detected in any of the wells and sulphate, while present in MW-4, has only very occasionally been detected at very low levels in the other wells. The redox potential in all of the wells, in conjunction with the low nitrate and presence of dissolved iron, indicates reducing conditions.

The wastes activities are a potential source of organic matter that typically is required to allow reducing conditions to develop; however the physiochemical data does not indicate this is the case, as the electrical conductivity, chloride and orthophosphate levels in MW-1, MW-2 and MW-3 are typical of uncontaminated groundwater. The peat, which underlies the site, is a recognised source of organic matter, which is a controlling factor in a redox state.

Faecal coliforms were detected in up gradient wells MW-3 and MW-4. The headworks on MW-3 and MW-4 wells are damaged and there are no well caps making both wells vulnerable to faecal contamination by birds and small mammals and in the case of MW-4, where the well pipe is below ground level, the entry of surface water run-off.

The source of the ammonia detected in MW-1, MW-2 and MW-3 is the naturally occurring reducing conditions in the bedrock aquifer.



### 6.2 Recommendations

It is recommended that the headworks at MW-3 be repaired and a well cap provided. At MW-4, the well pipe should be extended above ground-level, fitted with a well cap and a steel headworks installed. Following the repairs both wells should be disinfected.