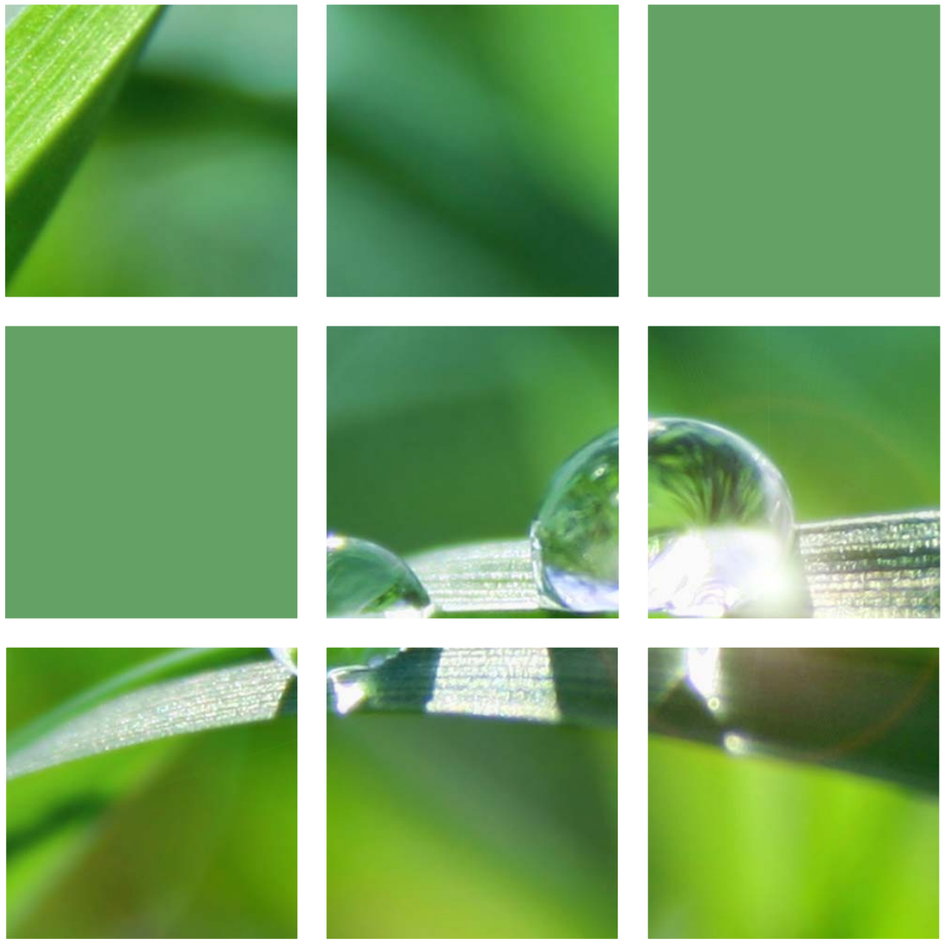
CHERRYWOOD
PLANNING SCHEME

Appendix E: Phase 1 Hydrogeology Assessment of the Cherrywood SDZ

RPS

Cherrywood Hydrogeology

Phase I Hydrogeology Assessment of the Cherrywood SDZ



September 2011

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1 INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

RPS were requested by Dún Laoghaire Rathdown County Council to conduct a Phase 1 Hydrogeological Assessment of the Cherrywood Strategic Development Zone (SDZ) area with a view to identifying potential sensitive groundwater receptors that could be impacted by future development in the area. As part of the ecological studies undertaken for the Cherrywood SDZ area, a number of tuffa spring formations have been identified.

The objectives of this study were to:

- Broaden the understanding of the tuffa springs in the area;
- Highlight potential risks on the tuffa springs; and
- Recommend solutions and mitigation measures that may be needed to avoid negative impacts on the tuffa springs.

1.2 TUFFA FORMATION & PROJECT APPRECIATION

Tuffa is a deposit of calcium carbonate that has deposited at the source of a spring emergence. Groundwater percolating through the soil and aquifer material can dissolve calcium from the parent material and precipitate calcium carbonate where groundwater emerges at the spring source. The chemical reactions are similar to those that cause the formation of stalagmites and stalactites in cave systems.

The significance of tuffa springs formation in relation to the Strategic Development Zone (SDZ) for Cherrywood is that where such springs occur, land development within the catchment area that feeds the tuffa spring can potentially impact these springs. The existing baseline conditions (tuffa spring) are being supported by an existing hydrological cycle whereby rainfall infiltrates the subsoil and discharges at spring emergences. When land developments block or reduce the amount of rainfall that can infiltrate the groundwater system, there can be a direct impact on the amount of groundwater recharge and an indirect down gradient impact on the tuffa springs.

2 METHODOLOGY

In order to provide a preliminary assessment of the tuffa springs and the potential impact of the planned development in the area, RPS conducted a Phase 1 Hydrogeological Assessment of the Cherrywood SDZ using the following methodology:

- Review of the Geological Survey of Ireland (GSI) bedrock, quaternary and groundwater information available;
- Desk top review of soil, geology and water sections of relevant Environmental Impact Statement (EIS) for the area (e.g. LUAS, M50 Scheme);
- Review of relevant and available geotechnical investigations conducted in the area; and
- Preliminary site walkover with the ecology team that had identified the location of the tuffa springs.

3 REVIEW OF EXISTING INFORMATION

3.1 HISTORICAL GEOLOGICAL MAPPING

The Geological Survey of Ireland's (GSI) historical field sheets for the area identify the study area as Limestone Drift with Granite bedrock exposure and drift around Carrickmines and Brennanstown House.

3.2 QUATERNARY & BEDROCK MAPPING

The GSI have identified the bedrock (**Figure 1**) underlying the site as comprising of Granite with a gradation between pale grey fine to coarse grained granite (Stratigraphic code Nt2e) in the west, to Granite with microcline phenocrysts (Stratigraphic code Nt2p) in the east. The bedrock is classified by the GSI to be a Poor Aquifer bedrock (Pl), which is generally unproductive, except for local zones.

The GSI's subsoil Quaternary mapping for the area indicates that Granite Till (TGr) underlies the majority of the study area in the central part of the site with localised areas of bedrock outcrop (Rck) along the M50 and to the west of the M50 (**Figure 2**). Limestone Till (TLs) is mapped in the eastern part of the study area that coincides with the observed locations of tuffa springs (refer to **Section 4.2**) with Alluvium around the Loughlinstown River.

3.3 RELEVANT EIA IN THE STUDY AREA

The LUAS Line B1 Sandyford Industrial Estate to Cherrywood EIS, specifically Area 5 Volume 2 Ballyogan Wood to Bride's Glen, crosses through the study area. The soil and water sections of this EIS refer to a generally low permeability subsoil (descried as glacial till) overlying weathered granite bedrock. The weathered granite bedrock was noted to provide private groundwater abstractions at the time in the Laughanstown area that were due to be replaced by public mains water.

4 WALKOVER OBSERVATIONS

4.1 GENERAL OBSERVATIONS

A site walkover survey was completed on 9 June 2011 in the accompaniment of Mr Paul Scott of Scott Cawley. Weather conditions on the day were dry with sunshine and there was antecedent rainfall on the two days prior to the walkover (3.1mm and 2.7mm recorded at Dublin Airport).

Soil and rock outcrop were observed at several locations during the walkover. Subsoils in the centre of the study area were well exposed from the earth works that have been completed and significant calcareous carbonate source material was evident in the abundant limestone gravel and cobbles observed, which would provide source material to support tuffa spring formation. Granite bedrock was observed at several locations along the river valley running east west to the south of Brennanstown road and granite shallow subsoils were also observed along these locations. Granite parent material in the soil will not provide source material to support tuffa spring formation.

Figure 3 illustrates the locations of the observations made during the site walkover and **Table 1** provides a description of observations made during the walkover.

4.2 TUFFA SPRINGS

Tuffa spring formations were observed at several locations across the study area and can be subdivided into the following broad categories:

Immature recently formed tuffa as the result of recent earthworks exposing shallow perched groundwater tables and spring/seepage along new embankments. Several examples were evident along the northeast - southwest trending embankment to the northwest of the Wyatville Link Road (location 1 on **Figure 3**). Photographs 1 and 2 (**Appendix A**) illustrate this in close up and from a distance.

Mature, high quality tuffa springs with active groundwater flow and calcareous carbonate precipitation with associated plant communities. Two large examples were present on the southwestern flank of the river valley to the southwest of the N11 (location 5 on **Figure 3**) and illustrated in Photographs 3 and 4 (**Appendix A**).

Lower quality tuffa spring formations were located along small drainage channels (with the associated plant communities less dominant). An example occurs at spring seepage to the south of Brennanstown Road on the southern slope of the river valley (location 11 on **Figure 3**) and illustrated in Photograph 5 (**Appendix A**). A rare species of mollusc was also identified by Scott Cawley at location 11.

A complete description of notable field observations is contained in **Table 1** with locations illustrated in **Figure 3**. In summary, a small number of localised high quality tuffa spring formations were observed on the southwestern flank of the river valley to the southwest of the N11 (location 5 on **Figure 3**). The spring flows observed to be feeding one of these deposits was located approximately 1/4 way down the slope embankment, indicating a relatively shallow perched groundwater discharge at this location.

Tuffa spring formations were not widespread across the remainder of the SDZ, with localised recent immature examples present along recently excavated areas (location 1) and lower quality formations at one location in the northwest of the study area (location 11).

The absence of extensive tuffa spring formations along the southwest side of the river valley indicates that the groundwater flow systems supporting these formations are relatively limited in aerial extent. Photograph 6 (Appendix A) illustrates the nature of a well drained slope without any spring emergence 100m to the northwest of the large tuffa springs observed at location 5.

The mature tuffa spring formations observed at location 5 (**Figure 3**) are the only maturely developed tuffa formations within the limits of the SDZ. RPS also understands from Scott Cawley that the tuffa spring formations at location 5 correspond to an EC Habitats Directive Annex I habitat. These factors combined ensure that location 5 will be most important for the proposed SDZ in terms of the impacts of the development on the hydrogeology - ecology interaction of the area.

The more immature tuffa formations identified around the site are insufficiently developed at this time to be considered an issue of high hydrogeological protection, with the exception of location 11. Location 11 has been identified by Scott Cawley as an ecologically sensitive area within the SDZ and as such the hydrogeological impacts of the SDZ development on this site will also be important to consider.

Table 1. Field Observations

Map Location	Observation	Groundwater	Tuffa Spring Sensitivity/Priority Rating
1	Recently formed tuffa springs at base of excavations on the edge of cleared land. Position approximately 4m below natural ground level. Additional tuffa spring formations along sloped embankment created by excavations for development site approximately 2-3m below natural ground level	Seepage and standing water	Moderate
2	Ditch cutting with calcareous and granite source parent material in silty subsoil	Dry	Low
3	Limestone dominated subsoil exposed across development site with dark grey limestone gravel and cobbles within a silty subsoil matrix.	Dry	Low
4	Calcareous moss and orchids at the top of steep sloped bank.	Damp ground	Moderate
5	Large tuffa spring (approx. 15m wide x 2-3m length) with active spring flow and tuffa formation around vegetation. Second suspected tuffa formation heavily overgrown 50-100m north of first formation.	Spring emergence approximately ¼ way from the top of the slope. Saturated soils in the base of the slope.	High
6	Dry grass land slope	Dry	Low
7	Sandy subsoil visible along river floodplain. Adjacent slope embankments dry with no observable spring /seepage discharges	Dry	Low
8	Minor seepage at top of slope, possible marl formation	Seepage	Low
9	Steep embankment to river, dry, with weathered granite bedrock and shallow granite subsoil above bedrock.	Dry	Low
10	Slope with dry soil exposure, granite subsoil.	Dry	Low
11	Spring emergence amongst boulders at top of slope. Concrete water holding tank adjacent. Minor tuffa spring formation along runoff stream from spring 10-15m long by 2-3 m wide. Rare molluscs were identified by Scott Cawley.	Spring	Moderate - High
12	Well drained land, granite subsoil exposed in excavation.	Dry	Low
13	Dry slopes with granite weathered subsoil exposed along base adjacent to river.	Dry	Low

5 PRELIMINARY CONCEPTUAL HYDROGEOLOGICAL MODEL

Based on the information reviewed and the site walkover conducted, the preliminary conceptual hydrogeological model for the site can be described as follows:

- Localised shallow groundwater flow is expected to be within the more permeable zones within the subsoil across the SDZ;
- The limestone parent material (e.g. gravel, cobbles and boulders) with the subsoil is the primary source material for the calcium carbonate to be dissolved by infiltrating rain water;
- Groundwater flow paths are expected to be relatively short (100's m in length) within the subsoil material as evidenced by the relatively high levels of discharge along the embankments of drainage channels and associated tuffa spring formations;
- Groundwater flow within the shallow granite bedrock is not considered to be a critical component supporting tuffa spring formations as groundwater will not be enriched with calcium bicarbonate from the granite rock; and
- Overall groundwater flow directions are expected to follow the local topography with the predominant regional flow direction to the east towards the river valley. Shallower local groundwater flow directions will mirror local variations in the topography and discharge to streams and shallow springs where the geological conditions are favourable (e.g. localised more permeable sand and gravel lenses and bodies within the overburden.

6 POTENTIAL IMPACTS AND MITIGATION

6.1 POTENTIAL IMPACTS FROM THE SDZ

The hydrogeology below the study area has been outlined in **Section 5** of this report. Under current conditions, effective rainfall recharges shallow groundwater in the subsoil and weathered bedrock below the study area. Groundwater within the study area flows towards sloped embankments, where it discharges as a spring or seepage, or to the rivers/streams where it discharges as baseflow. The development of the SDZ has the potential to alter the hydrogeology in several ways that are discussed below:

- The creation of artificial drainage below significant areas of the SDZ has the potential to divert rainwater from groundwater recharge to storm runoff, thereby reducing groundwater recharge. This would reduce the volume of groundwater discharging to the observed tuffa springs and river systems.
- Excavation of soils for landscaping purposes has the potential to reduce the nature of subsoil aquifers below the SDZ lands and create spring discharge of groundwater where excavations proceed below the shallow perched groundwater or the groundwater table.

6.2 MITIGATION MEASURES FOR SDZ DESIGN

Several mitigation measures should be considered during the design stage for sensitive areas within the SDZ in order to minimise the potential impacts to the tuffa springs.

1. A Sustainable Urban Drainage Systems (SUDS) design philosophy should be employed for the SDZ;
2. The construction of hard standing areas should be minimised in the catchments immediately up gradient of the high quality tuffa springs (e.g. location 5) in order to minimise the potential for disruption to recharge in these areas.;
3. Artificial recharge systems should be considered where possible in sensitive areas, specifically up gradient from high quality tuffa spring (e.g. location 5) discharges in order to maintain the overall hydrological balance if development cannot be avoided in these areas; and
4. Landscape proposals should be considered in relation to the position of the groundwater table below the site so as to avoid possible interference with natural groundwater flow directions to sensitive receptors such as the high quality tuffa springs (e.g. location 5).

7 CONCLUSIONS & RECOMMENDATIONS

7.1 CONCLUSIONS

In summary, localised areas of tuffa spring formation have been observed within the SDZ. These appear to be supported by relatively shallow groundwater flow systems within permeable zones of the subsoil. The limestone parent material within the subsoil is acting as the source of the calcium carbonate. Tuffa spring formation is limited to where this is present and where there is a groundwater flow and discharge such as at localised slope banks. As these are relatively high up the embankments it suggests the presence of shallow perched groundwater flow systems that are not laterally extensive. The catchment areas feeding these tuffa springs are sensitive to future land changes that create impermeable surfaces, which will reduce groundwater recharge and ultimately discharge to these localised tuffa springs.

The most significant of these tuffa spring formations has been located to the southwest of the N11 on the south-western flank of the river valley, (location 5 on **Figure 3**). A low quality tuffa spring formation which is ecologically significant was also observed high on the northwest sloping boundary of the SDZ. (location 11 on **Figure 3**). These two tuffa spring formations will be dealt with in the recommendations below.

7.2 RECOMMENDATIONS

A number of high level recommendations have been made in relation to potential mitigation principles for the SDZ design (e.g. avoidance of sensitive areas, use of SUDS systems and possible use of artificial recharge). In line with the avoidance principle two spereate protection zones have been developed to encompass the tuffa spring formations at location 5 and location 11 and the most likely catchment areas that feed the individual tuffa formations.

The protection zone (**Figure 4)** relevant to location 5 extends to the southwest and upgradient of the tuffa formation to where the land rises again out of a topographical dip approximately 25m/30m in that southwesterly direction. To the northwest the protection zone extends to the boundary line of neighbouring agricultural land where a drainage ditch has been dug. The southeast boundary of the protection zone is the previously developed land. The proposed protection zone covers an area of 380m by 230m. With further field investigations the protection zone may be refined and more accurately delineated.

The protection zone (**Figure 4**) relevant to location 11 coincides largely with the 50m buffer zone recommended by Scott Cawley. The protection zone has been extended 50m past the recommended buffer zone to the west of the tuffa spring formation, giving a 100m protection zone in this direction to allow for a conservative estimate in the length of the flow path to the tuffa spring. Topographic contours suggest that flows from the east are unlikely to be contributing to the tuffa spring at location 11.

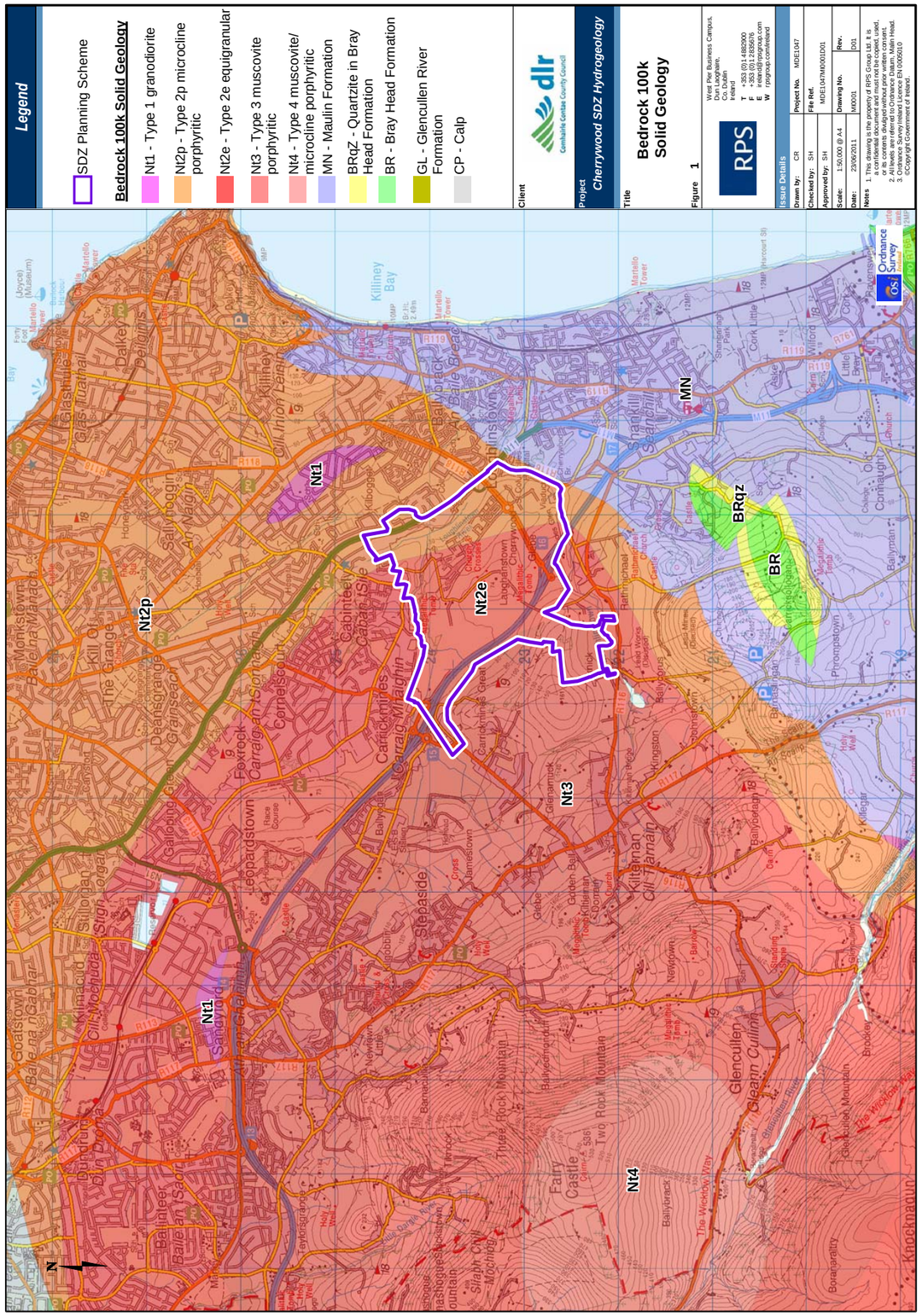
If avoidance of the sensitive catchment at location 5 is not possible, a targeted hydrogeological site investigation is recommended so that the hydrogeological system can be more completely evaluated and a baseline monitoring programme can be established on which to predict potential development impacts more completely. A targeted hydrogeological investigation would also help to refine the extent of the protection zone. Ideally this should include:

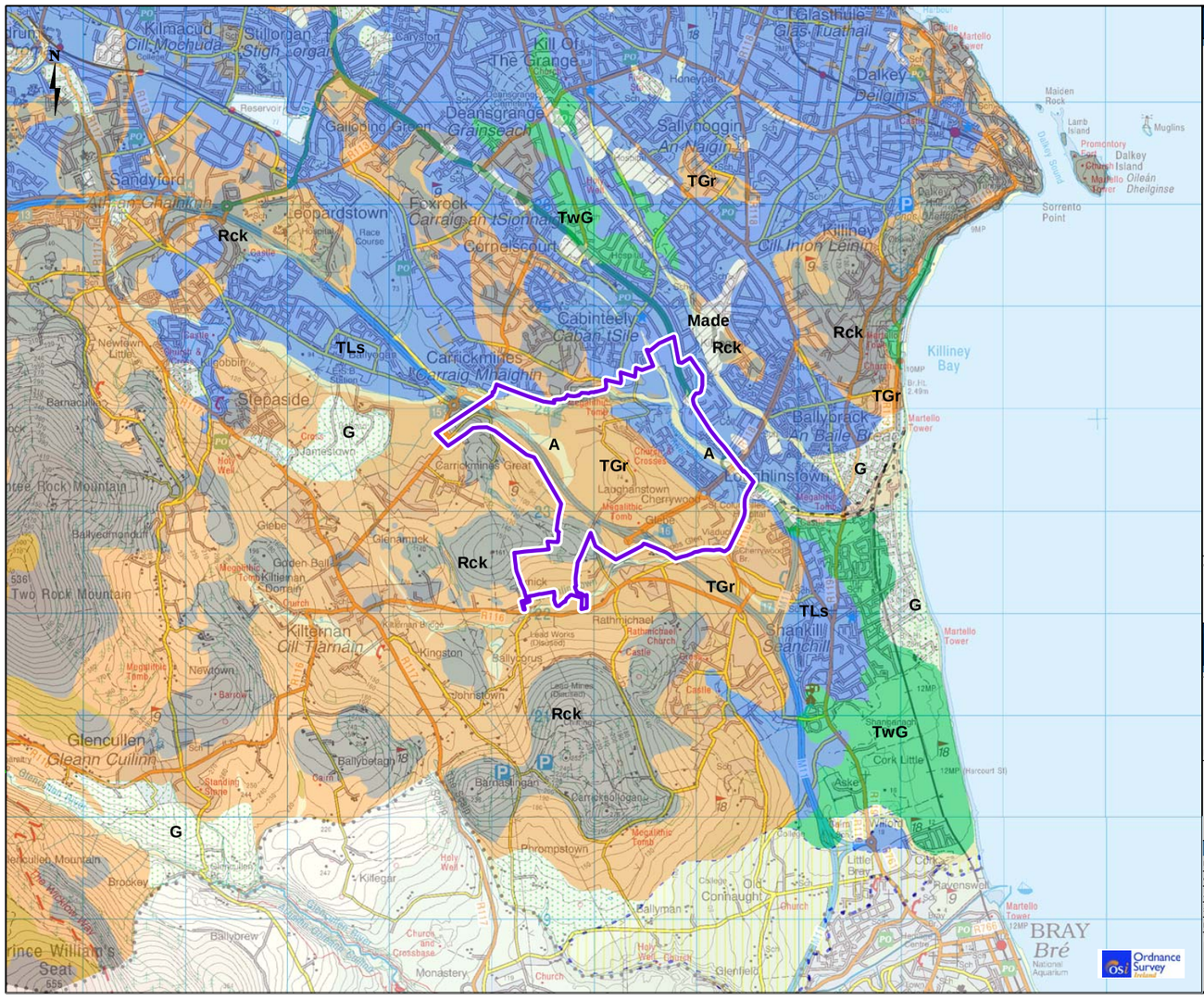
- Trial pit excavation to a nominal depth of 2.5m – 3m at approximately 15 locations across the designated protection area to more accurately assess subsoil geology in the catchment.
- Installation of a groundwater monitoring borehole network upslope of the spring emergence. 4 wells minimum, 6/7m deep or to a depth of 3m below the water table, located directly above and to either side of the spring emergence using a shell and auger drilling rig.

- Groundwater levels to be monitored in all boreholes over 12 month period using data loggers.
- Groundwater quality to be assessed in boreholes closest to the tuffa formation and at the spring emergence, (bi-monthly). Samples to be tested for major ions. – Ca, Na, CO_3, Cl, Mg, N
- Calculation of the mass water balance for the sensitive catchments above the tuffa springs to assess the overall impacts from future land use development changes in the catchment area.

APPENDIX A

PROJECT FIGURES

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Kill Of The Grange
Deansgrange
Sandyford
Leopardstown
Foxrock
Cornelscourt
Dalkey
Killiney
Sallynoggin
Glasthule
Cabinteely
Carrickmines
Stepaside
Ballybrack
Loughlinstown
Killiney Bay
Two Rock Mountain
Kilternan
Glencullen
Johnstown
Cherrywood
Rathmichael
Shankill
Ballycorus
Newtown
Ballyedmonduff
Glenamuck
Golden Ball
Jamestown
Laughanstown
Carrickmines Great
Sorrento Point
Maiden Rock
Dalkey Island
Muglins
Martello Tower
Megalithic Tomb
Holy Well
Church & Crosses
Viaduct
Cherrywood Br
Lead Works (Disused)
Castle
Barnaslingan
Carrickgollogan
Phrompstown
Killegar
Brookey
Ballybrew
Ballyman
Old Conaught
Cork Little
Ravenswell
Aske
Monastery
Glenfield
BRAY
Bré
National Aquarium
Ordnance Survey Ireland
Legend
SDZ Planning Scheme
Quarternary Geology
Ag - Alluvium (sandy)
As - Alluvium (silty)
G- Sands & Gravels (undifferentiated)
GLs- Limestone Sands & Gravels (undifferentiated)
Made - Made Ground
Mbs - Beach Sand
Pt - Peat
Rck - Bedrock at surface
TGr - Granite Till
TLs - Limestone Till (carboniferous)
TwG - Till with gravel (undifferentiated)
W - Water
Client
dlr
Comhairle Contae County Council
Project
Cherrywood SDZ Hydrogeology
Title
Quarternary Geology
Figure 2
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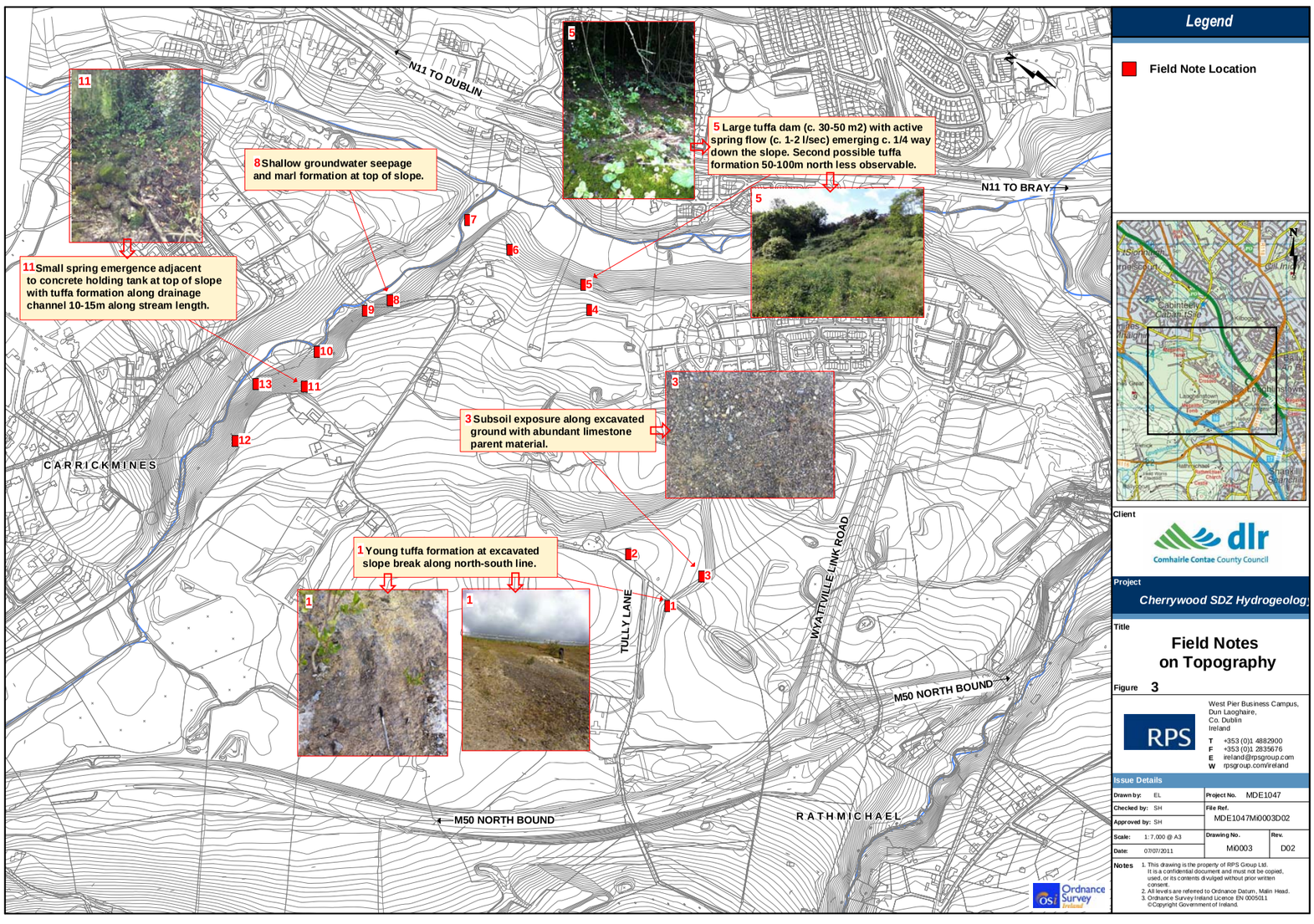
11
11 Small spring emergence adjacent to concrete holding tank at top of slope with tuffa formation along drainage channel 10-15m along stream length.
8 Shallow groundwater seepage and marl formation at top of slope.
5
5 Large tuffa dam (c. 30-50 m2) with active spring flow (c. 1-2 l/sec) emerging c. 1/4 way down the slope. Second possible tuffa formation 50-100m north less observable.
5
3
3 Subsoil exposure along excavated ground with abundant limestone parent material.
1 Young tuffa formation at excavated slope break along north-south line.
1
1
N11 TO DUBLIN
N11 TO BRAY
M50 NORTH BOUND
M50 NORTH BOUND
CARRICKMINES
RATHMICHAEL
TULLY LANE
WYATTVILLE LINK ROAD
11
10
13
12
9
8
7
6
5
4
3
2
1
Legend
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Comhairle Contae County Council
Project
Cherrywood SDZ Hydrogeology
Title
Field Notes on Topography
Figure 3
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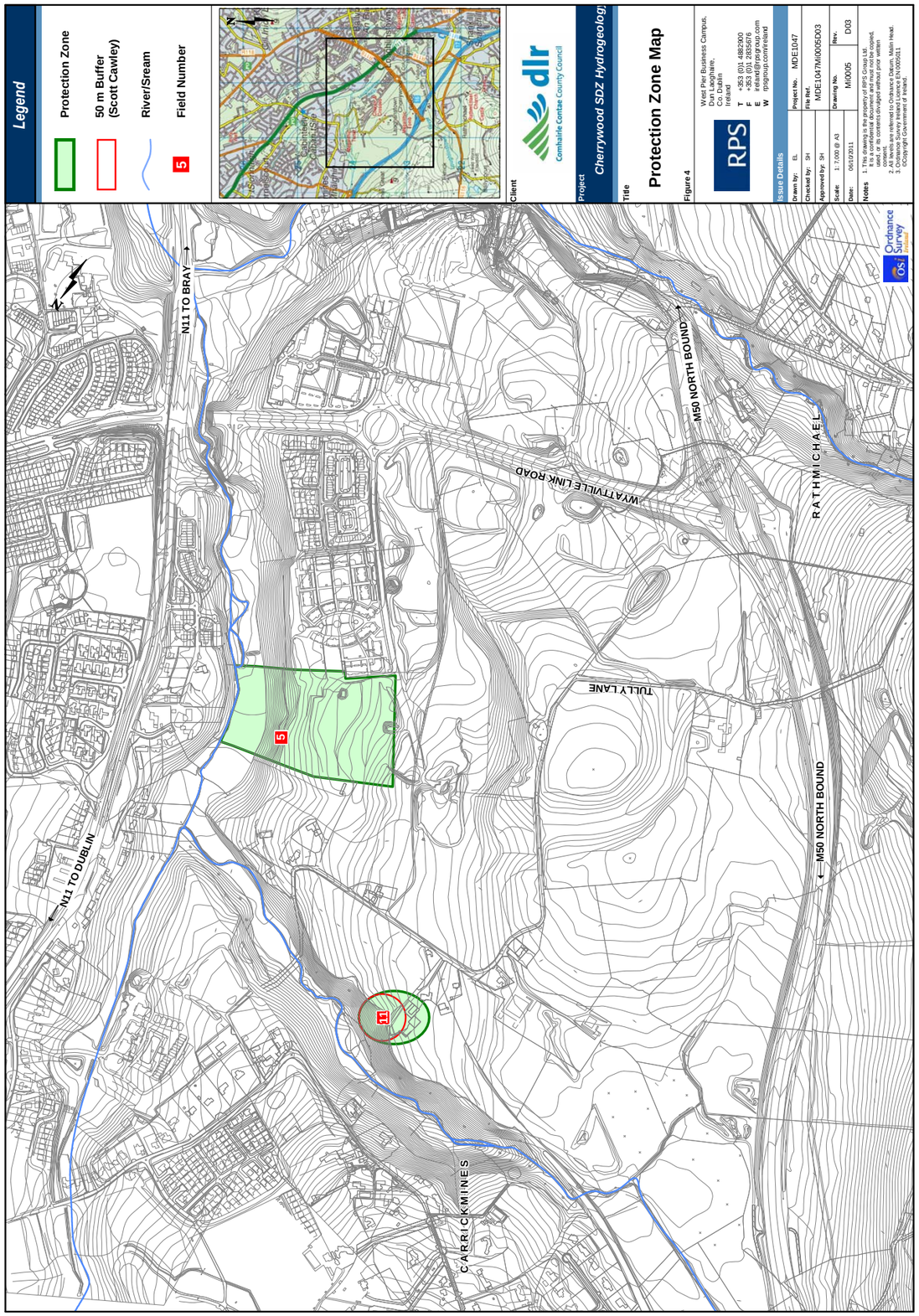

APPENDIX B

PROJECT PHOTOGRAPHS

Photograph 1 – Close up view of new tuffa formation observed along slope break (ref Location 1 on Figure 3).

Photograph 2 – View of new tuffa formation (where person is standing) observed from a distance along slope break (ref Location 1 on Figure 3).

Photograph 3 – Close up of tuffa (orange material surrounded by moss) and spring located along southwest bank of valley at location 5 (refer to Figure 3).

Photograph 4 – Distant view of tuffa spring (heavily overgrown area to the left of trees) located along southwest bank of valley at location 5 (refer to Figure 3).

Photograph 5 –Tuffa formation along drainage stream from spring emergence at location 11. Concrete water holding tank visible at top left corner of image.

Photograph 6 – Dry well drained land without spring or tuffa emergence along western bank of River valley, refer to location 6 on Figure 3.