Limerick City & County Council in partnership with Limerick Twenty Thirty DAC

Cleeves Riverside Quarter

Flood Risk Assessment

Reference: CRQMP-ARUP-ZZ-ZZ-RP-CF-0001

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Contents

Tables

Figures

Executive Summary

This Flood Risk Assessment report has been prepared by Arup for the proposed Cleeves Riverside Quarter development comprising residential spaces, commercial offices, community, and cultural uses to support the final Masterplan through planning. The development is being progressed in nine distinct but overlapping stages. This document considers the flood risks both at the final completion stage and throughout the works. Flood mitigation measures will be constructed in earlier stages for areas in Flood Zones A and B before any parts of the Proposed Development in these areas are occupied. The development site is located at the old Cleeves factory site in Limerick.

The purpose of the report is to identify and assess the risk of flooding to and from the development site and to propose mitigation measures to manage flood risk throughout the lifetime of the development, taking the potential effects of climate change into account (see Chapter 4 for further details).

The key findings of the report are summarised in the table below.

Item	Description	Findings
Flood Risk to the Site	Tidal	The main risk of flooding to the site is tidal (high tides and tidal surges) from the River Shannon. Part of the site lies in areas of high to moderate risk of flooding (Flood Zones A or B). The Shipyard site and part of the Flaxmill site (Infiltration Galleries) are at high risk of tidal flooding (0.5% Annual Exceedance Probability AEP), parts of the Quarry site are at moderate risk of flooding (0.1% AEP) and the rest (the majority) of the site is at low risk (<0.1% AEP). These areas correspond to Flood Zones A, B and C (i.e. high, moderate, and low risk respectively).
	Fluvial	The site is at low risk of fluvial flooding from the River Shannon in the absence of a high tidal boundary level.
	Surface water/Pluvial	The Stonetown Terrace, Salesian and Quarry sites could receive shallow overland flows originating from the adjacent residential developments to the north.
	Groundwater	Groundwater levels within the site generally exhibit no substantive correlation with the tidal signal nor the water levels in the reservoir (which themselves are correlated to the tidal signal). The exception to this is at a well location within made ground in very close proximity to the reservoir at the Quarry site, where the testing results showed that the groundwater levels are more closely related to the water levels in the reservoir (and by default, correlated to the tidal signal, noting the reservoir levels do exhibit a tidal influence, albeit a muted correlation i.e. as these levels are still well below the corresponding tide levels). Overall the risk of groundwater flooding is deemed low, particularly once the connectivity of the reservoir to the river is mitigated.
	Reservoir	Survey investigations have indicated that the reservoir within the Quarry site discharges to the River Shannon. Further confirmatory investigation and analysis will deepen the understanding of the subsurface pipe network and its hydraulic connectivity to the river. It is evident from surveys completed thus far that the flow and volumes passing through the network and reservoir are

Item	Description	Findings
		low and the tidal signal is muted, which in itself mitigates the risk from tidal flooding. Upon completion of the network assessment, measures will be implemented to prevent backflow through the system. This will include the strategic installation of non-return valves and the decommissioning of redundant pipework.
Mitigation Measures (see also Chapter 4 for more detailed information)	Sequential Approach	Highly vulnerable uses such as residential properties will be in areas at low risk of flooding or raised upper levels. Residential areas have been located at Salesian site, Stonetown Terrace, and the Quarry site. Residential plots are also proposed at the upper levels at the O'Callaghan Strand site. A justification test is included in Chapter 5 of this report which contains detailed information in this regard.
	Flood Protection Level	Development to be protected against the 1 in 200-year tidal event with allowance for climate change and a suitable freeboard.
	Climate Change Allowance	+500mm for less vulnerable uses and +1000mm for highly vulnerable
	Freeboard Allowance	+500mm
	Minimum Recommended Finished Floor Levels	Lower threshold (commercial uses): 5.7m AOD Higher threshold (residential/habitable spaces): 6.2m AOD
	Safe Access and Egress	Safe access and egress to be provided from all buildings for emergency vehicles. The Master Plan proposes that North Circular Road (NCR) be raised above 5.7m AOD to provide safe access and egress to/from the site.
	Intercepting Overland Flows	There is a relatively minor risk of shallow overland flows entering the Salesians, Quarry and Stonetown Terrace sites from the north during a significant rainfall event. A new perimeter drainage system (open or piped) will intercept any offsite overland flows from adjacent properties to the north of the site to safely divert the flow away from the properties.

1. Introduction

1.1 Project Background

This Flood Risk Assessment has been prepared by Arup on behalf of Limerick City & County Council in partnership with Limerick Twenty Thirty DAC (LTT) as part of a planning application for the proposed Cleeves Riverside Quarter Development.

Limerick City and County Council, partnership with Limerick Twenty Thirty DAC, intends to seek the approval of An Coimisiún Pleanála in accordance with Section 175 and 177AE of the Planning and Development Act 2000, as amended, for a mixed-use development that seeks the regeneration and adaptive reuse of a strategic brownfield site, as part of the Limerick City and County Council 'World Class Waterfront revitalisation and transformation project'.

This Flood Risk Assessment (FRA) has been undertaken and prepared in support of the Cleeves Riverside Quarter Stage 2A2 planning application. The FRA is in accordance with the Guidelines for Planning Authorities on 'The Planning System and Flood Risk Management' published in November 2009, jointly by the Office of Public Works (OPW) and the then Department of Environment, Heritage and Local Government (DEHLG).

1.2 Scope of Study

The scope of the study includes the following:

- A review of all relevant available information and data, as detailed in the section below;
- A review of the risk of tidal, fluvial, groundwater and pluvial flooding at the site;
- Preparation of a site-specific FRA Report and Justification Test.

1.3 Summary of data used

The following data was collated and reviewed:

- Strategic Flood Risk Assessment for the Limerick Development Plan 2022-2028, June 2022;
- Consultation with the Limerick County Council regarding the plans for the Limerick City and Environs Flood Relief Scheme, October 2024.
- Catchment Flood Risk Assessment and Management (CFRAM) Programme data accessed through floodinfo.ie in August 2025;
- Topographical data of the site;
- Site visits / walkovers (September 2024, July 2025);
- Architectural drawings of the Proposed Development;
- Aerial photography and mapping from Google Maps;

1.4 Site Description

The Proposed Development comprises Phase II of an overall Masterplan with four phases of development scheduled. Phase II is subsequent to ongoing stabilisation and repair of the Flaxmill protected structure (Phase I). Phase III is intended to comprise an educational campus, inclusive of the adaptive reuse of the Flaxmill Building as part of that development and will be subject to a future separate application. Phase IV comprising the Shipyard site will be the final phase of development.

The Proposed Development provides for the (A) Demolition of a number of structures to facilitate development and (B) Construction and phased delivery of (i) buildings within the site ranging in height from 3 to 7 stories (with screened plant at roof level) including (a) 234 no. residential units; (b) 270 no. student

bedspaces (PBSA) with ancillary resident services at ground floor level; (c) 256sqm of commercial floorspace; and (d) a creche; (ii) extensive public realm works, (iii) riverside canopy and heritage interpretative panels, (iv) 3 no. dedicated bat houses; (v) Mobility Hub with canopy; and (vi) all ancillary site development works including (a) water services, foul and surface water drainage and associated connections across the site and servicing each development zone; (b) attenuation measures; (c) raising the level of North Circular Road; (d) car and bicycle parking; (e) public lighting; (f) telecommunication antennae and (g) all landscaping works. Consent is also sought for use of the PBSA accommodation, outside of student term time, for short-term letting purposes.

The flood risk assessment undertaken as part of this report examines the wider Masterplan area and the associated flood risk to the Proposed Development. Note that with reference to the terminology within this document, the Masterplan encompasses the Proposed Development for Phase II.

The Site is located on the northern bank of the River Shannon at the former Cleeves factory. It is approximately 5ha in area and is bounded by O'Callaghan Strand to the southeast, Condell Road (R527) to the southwest and Stonetown Terrace to the northeast; and Salesian Primary School and the 'Fernhill' residential estate to the northwest and west respectively. North Circular Road (NCR) bisects the site in a southeast to northwest direction. Refer to Figure 1-1. The site is currently a brownfield site, historically used for industrial uses. It is mainly hardstanding. The levels within the site vary significantly, sloping from northwest to southeast towards O'Callaghan Strand and the River Shannon. An old quarry is located at the centre of the site. A reservoir has been formed within the Quarry area. General levels across the site are shown in Table 1-1.

The site is currently occupied by historic structures, some of which are protected (listed) and will be retained, namely the Flax Mill Factory and the Chimney Stack. Additionally, there are several other buildings of historic significance on site which can be retained and converted.

Table 1-1: Existing levels at Cleeves site

Sections/area	Levels (m AOD- Malin datum, OSGM15)
Shipyard	3.5m AOD – 4.4m AOD
Flax Mill	4.4m AOD – 6.2m AOD
Quarry	3.8m AOD – 5.0 m AOD
Salesian	7.7 m AOD – 12.7 m AOD
Stonetown Terrace	9.7 m AOD – 14.0 m AOD

1.5 Proposed Development

The Cleeves Riverside Quarter will deliver a variety of public and private spaces, including residential areas comprising apartment blocks, 3-storey townhouses and student accommodation, a mixed-use apartment block along O'Callaghan Strand, an open public plaza, and provision of public and private spaces. It is split into five sections: the Flax Mill site, the Quarry site, the Shipyard site, the Stonetown Terrace site and the Salesian site as shown in Figure 1-1.

Following completion of the Options Development & Appraisal, the scope of the site has been revised to exclude the Shipyard site and buildings along the NCR. Temporary uses are proposed for these areas. The Shipyard site specifically is proposed to continue being used for car parking, with a new walkway proposed to connect Condell Road with the NCR along the north part of the Shipyard site.

The development of the site will occur over the course of nine distinct but overlapping stages to allow for the raising of the North Circular Road, a key component of the flood emergency access and egress routes, before

the introduction of highly vulnerable development within areas requiring mitigation. The CRQ project team and LTT have been coordinating closely with LCCC to ensure an integrated approach to flood protection along the Shannon is achieved, and, in particular, at the junction of Stonetown Terrace and O'Callaghan Strand. For more information on this junction location, please see Section 4.3, and for more information on the Flood Protection Level, please see Section 4.2. Based on market conditions and delivery mechanisms, some stages will progress more quickly or ahead of others. The anticipated sequence of the stages is outlined as follows. More detail on the phased approach can be found within Atkins Realis CEMP, Section 2.5.1 'Construction Phasing and Duration' (Table 2-2), but which are also summarised below:

- Stage 1: Construction of Bat Houses – 3 months allocated with no overlapping construction activity to allow for the bats to adjust
- Stage 2: Site Demolition and Enabling Works: - 12-15 months allocated for demolition of identified buildings and structures and to install enabling drainage infrastructure across the Flaxmill area. Temporary surface treatments applied to support access to the upper-level sites (Salesians and Stonetown Terrace).
- Stage 3: Flood Protection Works – 15 months concurrent with Stage 2 allocated for the raising of the North Circular Road and implementation of other flood protection measures.
- Stage 4: Salesians Zone Development – 18-24 months to begin midway through Stage 2 for construction of apartments and townhouses along with public realm and communal open spaces.
- Stage 5: Stonetown Terrace Zone Development – 15-18 months concurrent with Stage 4.
- Stage 6: O'Callaghan Strand Zone Development – 15 months for construction of apartments in the zone. To begin midway through Stage 5.
- Stage 7: Quarry Zone PBSA and Public Realm: 24 months for construction of Purpose-built Student Accommodation (PBSA) and associated amenities, as well as public realm improvements around the reservoir.
- Stage 8: Flaxmill Plaza and Riverside Public Realm – 15 months for the delivery of Flaxmill Plaza and riverside canopy works.
- Stage 9: Shipyard Mobility Hub – 6 months for the final stage involving the construction of the Mobility Hub on the Shipyard site, along with associated site works.

Figure 1-1 Site location (Background image: Google Satellite)

2. Planning Context

2.1 Introduction

The following planning policy documents are relevant to the assessment of this Masterplan of the Cleeves Riverside Quarter:

- The national planning guidelines published by the OPW and the DEHLG in November 2009 entitled 'The Planning System and Flood Risk Management: Guidelines for Planning Authorities'
- Limerick City and County Council Development Plan 2022-2028 and Strategic Flood Risk Assessment (SFRA).

2.2 The Planning System and Flood Risk Management: Guidelines for Planning Authorities

In November 2009, the DEHLG and the OPW jointly published a Guidance Document for Planning Authorities entitled "The Planning System and Flood Risk Management". This is referred herein as the Guidelines.

The Guidelines are issued under Section 28 of the Planning and Development Act 2000 and Planning Authorities. Therefore, An Bord Pleanála are required to implement these Guidelines in carrying out their functions under the Planning Acts.

The aim of the Guidelines is to ensure that flood risk is neither created nor increased by inappropriate development.

The Guidelines require the planning system to avoid development in areas at risk of flooding, unless they can be justified on wider sustainability grounds, where the risk can be reduced or managed to an acceptable level.

They require the adoption of a sequential approach to flood risk management following the steps of avoidance of flood risk, substitution with less vulnerable uses, justification, and mitigation of flood risk. The Guidelines require the incorporation of Flood Risk Assessment (FRA) into the process of making decisions on planning applications and planning appeals.

Fundamental to the Guidelines is the introduction of flood risk zoning and the classification of different types of development having regard to their vulnerability to flooding.

The management of flood risk is now a key element of any development proposal in an area of potential flood risk and should therefore be addressed as early as possible in the site master planning stage.

2.2.1 Flood Zones

There are three types of flood zones defined in the Guidelines and replicated in Table 2-1.

Table 2-1: Definition of Flood Zone Categories

Zone Category	Probability	Definition
Flood Zone A	High probability	Probability of flooding from rivers and the sea is highest (greater than 1% annual exceedance probability (AEP) or 1 in 100 for river flooding or 0.5% AEP or 1 in 200 for coastal flooding).
Flood Zone B	Moderate probability	Probability of flooding from rivers and the sea is moderate (between 0.1% or 1 in 1000 and 1% AEP or 1 in 100 for river flooding and between 0.1% AEP or 1 in 1000 and 0.5% or 1 in 200 for coastal flooding); and
Flood Zone C	Low probability	Probability of flooding from rivers and the sea is low (less than 0.1% AEP or 1 in 1000 for both river and coastal flooding). Flood Zone C covers all areas of the plan which are not in zones A or B.

2.2.2 Flood Risk Vulnerability

The Guidelines classify different land uses and types of development as highly vulnerable, less vulnerable, and water-compatible to flooding. The vulnerability classification is influenced primarily by the ability to manage the safety of people in flood events and the long-term implications for recovery of the function and structure of buildings. Table 2-2 summarises the vulnerability classes defined in the Guidelines and provides a sample of the most common type of development applicable to each class.

The Proposed Development uses at Cleeves site are residential (*highly vulnerable*), commercial offices and cultural/visitor attractions (*less vulnerable*).

Table 2-2:Definition of vulnerability classes

Vulnerability Class	Land uses and types of development which include
Highly Vulnerable Development	Includes Garda, ambulance and fire stations, hospitals, schools, residential dwellings, residential institutions, essential infrastructure, such as primary transport and utilities distribution and SEVESO and IPPC sites, etc.
Less Vulnerable Development	Includes retail, leisure, warehousing, commercial, industrial, and non-residential institutions, etc.
Water Compatible Development	Includes Flood Control Infrastructure, docks, marinas, wharves, navigation facilities, water-based recreation facilities, amenity open spaces and outdoor sport and recreation facilities

2.2.3 Sequential approach and Justification Test

The Guidelines outline the sequential approach that is to be applied to all levels of the planning process. This approach should also be used in the design and layout of a development and the broad philosophy is shown in Figure 2-1. In general, development in areas with a high risk of flooding should be avoided as per the sequential approach.

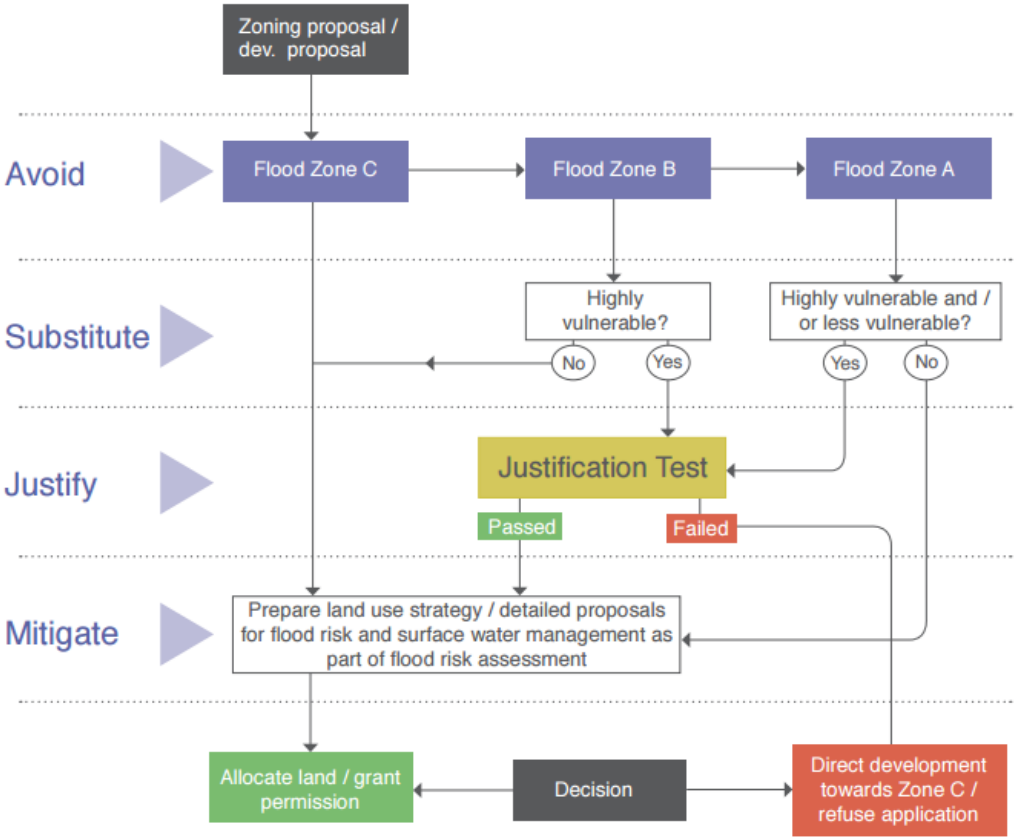

Figure 2-1:Sequential approach (reproduced from the Guidelines)

The Justification Test has been designed to rigorously assess the appropriateness, or otherwise, of developments that are being considered in areas of moderate or high flood risk. The test comprises the following two processes.

- The first is the Plan-making Justification Test and is used at the plan preparation and adoption stage where it is intended to zone or otherwise designate land which is at moderate or high risk of flooding.
- The second is the Development Management Justification Test and is used at the planning application stage where it is intended to develop land at moderate or high risk of flooding for uses or development vulnerable to flooding that would generally be inappropriate for that land.

Table 2-3 illustrates the different types of Vulnerability Classes appropriate to each zone and indicates where the Justification Test is required.

Table 2-3:Vulnerability class appropriateness in flood zones

Vulnerability class	Flood Zone A	Flood Zone B	Flood Zone C
Highly Vulnerable	Justification Test	Justification Test	Appropriate
Less Vulnerable	Justification Test	Appropriate	Appropriate
Water Compatible	Appropriate	Appropriate	Appropriate

2.3 Limerick City & County Council Development Plan 2022-2028

The Limerick City & County Council Development Plan 2022-2028 was adopted in June 2022. It sets the core strategy for Limerick City and County which is implemented through a set of policies and objectives. Policy **CAF P5 - Managing Flood Risk** aims to *protect Flood Zones A and B from inappropriate development and direct land uses into the appropriate lands, as per the Guidelines. Where a development* ***is***

proposed that is inappropriate within the Flood Zone, but that has passed the Plan Making Justification Test, then the development proposal will need to be accompanied by a Development Management Justification Test and Site-Specific Flood Risk Assessment In Flood Zone C, the developer should satisfy themselves that the probability of flooding is appropriate to the development being proposed and should consider other sources of flooding, residual risks and the implications of climate change.

Objective CAF020 was set by the council as part of the plan and are relevant to the development:

It is an objective of the Council to require a Site-Specific Flood Risk Assessment (FRA) for all planning applications in Flood Zones A and B and consider all sources of flooding (for example coastal/tidal, fluvial, pluvial or groundwater), where deemed necessary. The detail of these Site-Specific FRAs (or commensurate assessments of flood risk for minor developments) will depend on the level of risk and scale of development. The FRA will be prepared taking into account the requirements laid out in the SFRA, and in particular in the Plan Making Justification Tests as appropriate to the particular development site. A detailed Site-Specific FRA should quantify the risks, the effects of selected mitigation and the management of any residual risks. The assessments shall consider and provide information on the implications of climate change with regard to flood risk in relevant locations.

2.3.1 LCCC Development Plan 2022-2028 Strategic Flood Risk Assessment

A Strategic Flood Risk Assessment (SFRA) was developed to accompany the development plan. It included a two stage assessment of flood risk to first identify risk, and where settlements were identified as requiring the Justification Test were carried through to Stage 2, a more detailed assessment of flood risk. The SFRA also provides guidelines for development within areas at potential risk of flooding.

The report includes guidelines on development in Flood Zones A and B, and recommended allowances for climate change and freeboard when setting finished floor levels. These are included below.

Table 5-2: Climate change allowances by vulnerability and flood source

Development vulnerability	Fluvial climate change allowance (increase in flows)	Tidal climate change allowance (increase in sea level)	Storm water / surface water
Less vulnerable	20%	0.5m (MRFS) + 50mm for land movement	The Surface water management plan including details of climate change allowances is under preparation
Highly vulnerable	20%	0.5m (MRFS) + 50mm for land movement	
Critical or extremely vulnerable (e.g. hospitals, major sub-stations, blue light services)	30%	1.0m (HEFS) + 50mm for land movement	
Note: There will be no discounting of climate change allowances for shorter lifespan developments.			

Table 5-3: Recommended minimum finished floor levels

Scenario	Finished floor level to be based on
Fluvial, undefended	1% AEP flood + climate change (as Table 5-2) + 300mm freeboard.
Tidal, undefended	0.5% AEP flood + climate change (as Table 5-2) + 300mm freeboard (or 500mm where there is risk of storm surge and wave action).
Fluvial, defended	1% AEP flood + 300mm freeboard. Climate change does not need to be included, provided it is included in the defence height or adaption plan for the scheme. Where a breach model has been developed to further understand risks, FFL may be set based on model outputs.
Tidal, defended	0.5% AEP flood + 300mm freeboard (or 500mm where there is risk of storm surge and wave action). Climate change does not need to be included, provided it is included in the defence height or adaption plan for the scheme. Where a breach model has been developed to further understand risks, FFL may be set based on model outputs.

Figure 2-2: LCCC SFRA extracts.

3. Flood Risk Appraisal

3.1 Potential Flood Mechanism

The following potential sources of flood risk were assessed:

- Tidal/Fluvial flood risk from the River Shannon, bounding the site on the southeast;
- Pluvial flood risk from overland flows from adjacent sites;
- Groundwater flood risk; and
- Flood risk from the Quarry reservoir.

3.2 Historic Flooding at the Site

Records of historic fluvial flooding within the development site and neighbouring areas were reviewed from the OPW National Flood Hazard Mapping website (www.floodinfo.ie; accessed August 2025). An extract from the website is included in Figure 3-1.

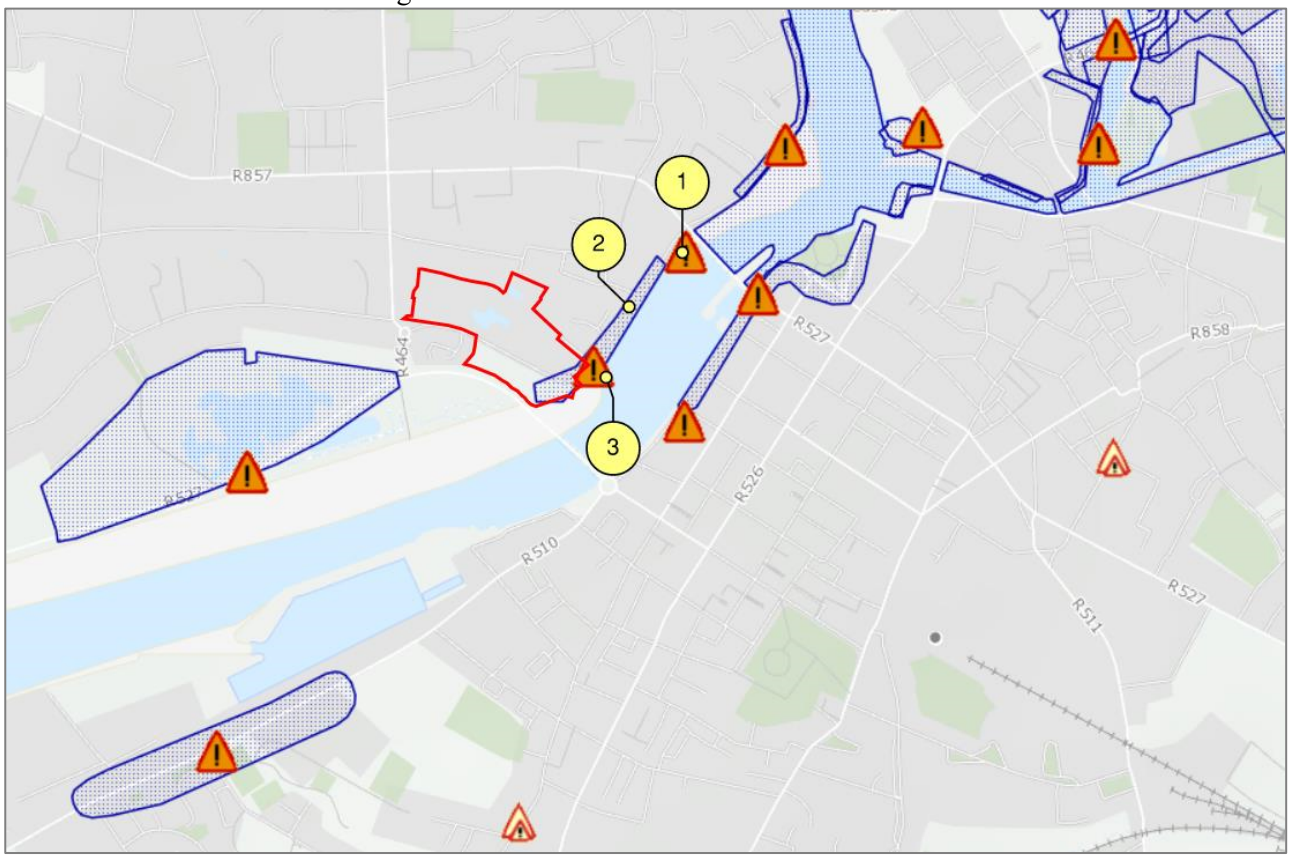

Figure 3-1:Historic flood events (OPW, www.floodinfo.ie)

Information on the events shown is summarised below:

1. On 17th January 1995, flooding occurred on O'Callaghan Strand roadway in front of the Golden Vale (Cleeves' site). 'This was due to the level of the roadway and has happened at this location for as long as I can remember' (information taken from letter to Limerick Corporation City & Environs from Sanitary Services).
2. In December 1999 a combination of spring tides, low atmospheric pressure, strong westerly winds caused increased high tide to 4.1m AOD, as recorded at Limerick Docks. The wave action caused by strong westerly winds increased this height to an effective height of approximately 4.3m AOD. Heavy

rainfall before Christmas resulted in increased flows on the Shannon. O'Callaghan Strand was flooded in the morning of 25th December; the road was impassable for a short period of time however properties were not affected. Flooding coincided with times of high tide and receded as the tide ebbed. Other areas in Limerick were also flooded because of this event: Clancy's Strand, Sir Harry's Mall and Athluknard Street were also affected, with 60 properties in total around Limerick being flooded. (information from Limerick main drainage (City & Environs), Report on flooding – December 1999)

3. On the morning of 11th February 2002, Limerick City experienced its highest tide since 1961, with a tide level of 4.27m AOD. This was caused by a combination of heavy rain, low atmospheric pressure, westerly winds, and a spring tide. Flooding can also be contributed to by the release of water from the E.S.B. power station at Ardnacrusha. The flooding on O'Callaghan Strand was restricted to the 300m of the strand where the quay wall finishes at road level (information from Limerick City flooding – February 2002).

Since the OPW created the above database in 2014, several other events have occurred that might have caused flooding to the site. Most notable are the events occurring in February 2014, January 2018, and February 2016, when water levels at Baals Bridge river level gauge reached 4.48m AOD, 4.37m AOD and 4.27m AOD. These events along with events occurring in 2017 and 2020 have recorded higher flood levels than the February 2002 flood event recorded by OPW and are considered more extreme.

3.3 Limerick City & Environs Flood Relief Scheme Tidal/Fluvial Flood Risk from the River Shannon

The site is bounded on the southeast by the River Shannon. The risk of flooding from the River Shannon has been assessed as part of the Shannon CFRAM study (2016). A joint probability analysis of the coincidence of fluvial flood flows and coastal flood levels was carried out as part of the study, which indicated that the upper reach of the model extent is not affected by tidal levels and the lower reach not affected by fluvial levels. Due to the insensitivity to the boundary condition, it was therefore decided that the tidal flood modelling will be mapped for the tidally affected reach only and the fluvial flooding mapped for the fluvial reach only. An overlapping area at Kings Island was mapped for both.

The Shannon is tidal at the site location, with the most critical flood event occurring due to tidal flooding (high tides and tidal surges) rather than fluvial (high river flows). The risk of fluvial flooding to the site is considered low (less than 0.1%AEP).

3.3.1 Tidal flood risk and flood zones

The risk of tidal flooding and designated flood zones around the site can be seen in Figure 3-2. Note that the darker green shows areas at risk of flooding during the 1 in 10-year event (10% Annual Exceedance Probability – AEP).

Areas at relatively low probability of flooding (less than 1 in 1000 year event, <0.1% AEP) are shown transparent (i.e. where no flood extent is shown on the image).

Most of the site lies in areas at low risk of flooding (<0.1%AEP), which is defined by the Guidelines as Flood Zone C.

The Shipyard site and Infiltration Galleries lie in an area at high risk of flooding, during the 1 in 200 year flood event (0.5% AEP), defined as Flood Zone A. The Quarry lies within an area at moderate risk of flooding, defined as Flood Zone B, which sits between Flood Zone A and C (i.e. between the 1 in 200 (0.5% AEP) flood extent and the 1 in 1000 year (0.5% AEP) flood extent respectively).

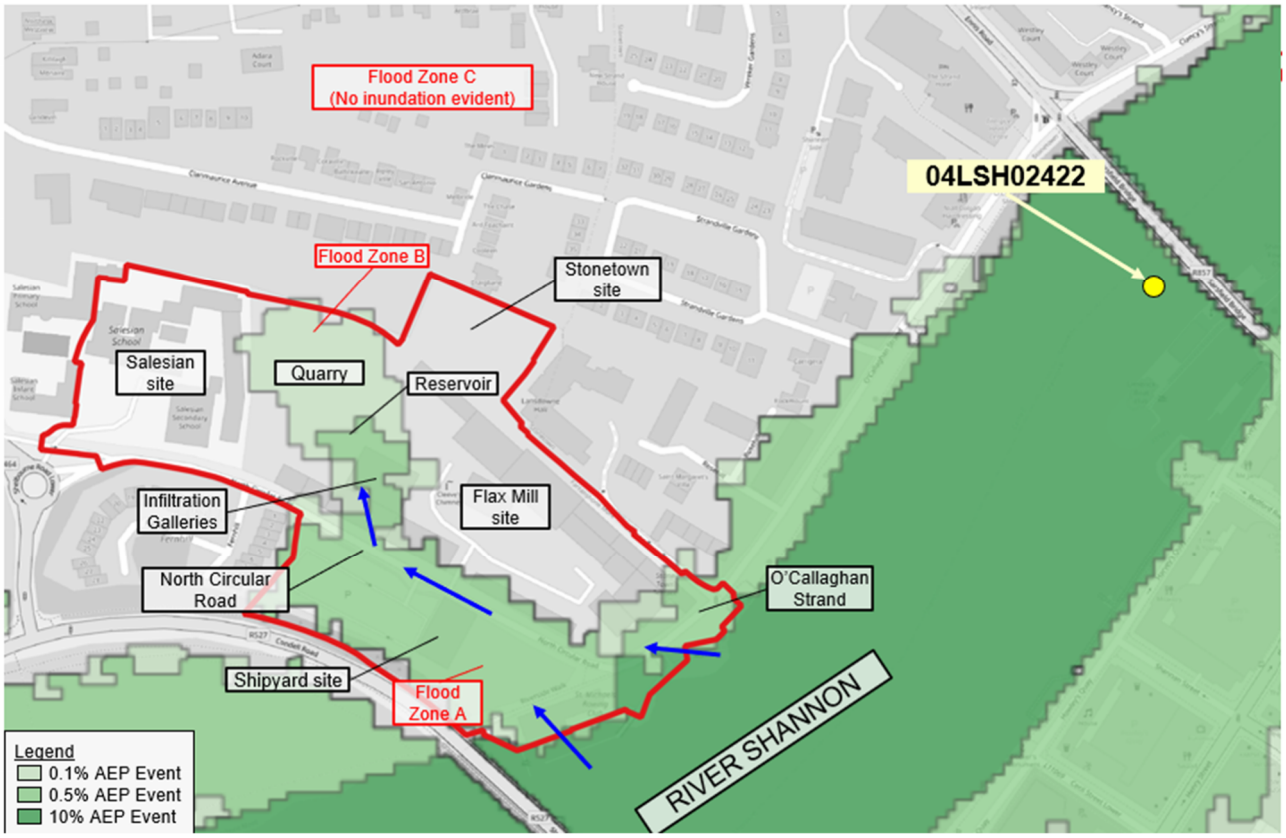

Figure 3-2 Tidal flooding (CFRAM study) and flow paths (shown in blue). Site boundary shown in thin red line.

3.3.2 Predicted Flood Levels

The predicted flood levels at the closest upstream modelled node downstream of Sarsfield Bridge (04LSH02422, see Figure 3-2) as estimated by the CFRAM study are shown in Table 3-1. Note that the CFRAM modelled levels are transformed[1] to OSGM15, which is the geoid model recommended to be used nationally by Ordnance Surveys Ireland (OSI).

Table 3-1:Modelled flood levels downstream Sarsfield Bridge (Shannon CFRAM study, 2016)

Flood event	Level (OSGM02 – m AOD)	Level (OSGM15 – m AOD)
1 in 10 year (10% AEP)	3.99	3.92
1 in 200 year (0.5% AEP)	4.72	**4.65**
1 in 1000 year (0.1% AEP)	5.16	5.09

3.3.3 Flooding Mechanism

According to the Shannon CFRAM study, the predicted flood level at the site during the 1 in 200-year tidal flood event is 4.65m AOD (OSGM15, Malin Head). Some parts of the site lie below this predicted extreme flood level. During such an event, water from River Shannon will overtop its banks and flood O'Callaghan Strand, St Michael's Rowing Club, and the Shipyard/lower North Circular Road. As the flood levels rise, a

[1] In August 2016, the OSGM02 geoid model used in Ireland to report elevation data changed to an improved OSGM15. While both geoids use Malin Head datum, there are differences between the two. At the subject site, the difference is 0.069m (OSGM02 higher than OSGM15). While the CFRAM modelling and studies were done in OSGM02, all surveys since August 2016 are generally in OSGM15.

flood pathway is created along North Circular Road, shown to enter the Infiltration Galleries causing flooding to the Quarry area.

It should be noted that the ground floor levels in the Infiltration Galleries are set at 5.6m AOD, which is above the modelled 1 in 1,000 year flood level. It is believed that the building floor level was modelled incorrectly during the CFRAM study, possibly set only a small height above the surrounding road levels as captured by LiDAR surveys. In the absence of threshold survey data, this is a common and acceptable approach for the CFRAMS. However, underestimating the levels in the Infiltration Galleries allows the creation of a flood flow path through the building to the Quarry site that possibly is not there in reality.

The internal floor level of one of the buildings northwest of the Infiltration Galleries has a level of 5.6mOD. Furthermore, the ground finished floor levels will be raised to a minimum of 5.7m AOD to block any flood flows from the Shipyard site to the Quarry site as part of the developed scenario, along with the raising of the North Circular Road. Accordingly, this issue (as is evident in the CFRAMS mapping) is of no consequence to the site as all flowpaths into the site will be cut off owing to the proposed design and design levels (see Section 4).

3.3.3.1 Future Flooding – Climate Change Allowance and Land Movement

The effects of climate change are likely to result in an increase in sea levels and subsequent increased flood levels and frequency of flood events. OPW guidelines recommend consideration of two possible future scenarios where, mean sea level could increase by 0.5m in the Mid-Range Future Scenario (MRFS) and 1m in the High-End Future Scenario (HEFS). This is to help minimise vulnerability and provide resilience to flooding in the future. This is a critical part of any assessment of flood risk and assessment of design and mitigation measures.

An allowance of 0.5mm/year shall also be allowed for isostatic land movement of the south part of Ireland, including Limerick. This has been accounted as 50mm in total, assuming a 100-year design life.

The future 1 in 200-year flood level could therefore increase to between 5.2m and 5.7m AOD.

This increased future flood level would result in an increase in flood extents and depths, resulting in future flood risk to some parts of the Flax Mill site.

3.3.4 Pluvial Flood Risk

Pluvial flooding occurs when the capacity of the local urban drainage network is exceeded during periods of intense rainfall.

At these times, rainfall runoff cannot infiltrate into the ground or drain away and can collect at low points in the topography, causing flooding.

The Salesian site (northwest of the Masterplan area) lies between 11.0m -13.0m OD, sloping from north to south. The Quarry is immediately to the east of the site and is excavated to an average level of 4.0m OD. The Quarry face acts as retaining wall of approximately 8.0m in height along the west and north of the Quarry. This area forms a significant depression in the topography that is prone to pluvial ponding.

The Salesian, Quarry and Stone Town terrace sites are bounded to the north by the back gardens of residential housing on Clanmaurice Avenue, sloping from 13.0m OD adjacent to Salesian site to 15.8m OD at the road level to the north. As such, there is a risk of overland flows from these higher grounds entering the Salesian, Quarry, and Stone Town terrace sites from the north during a heavy rainfall event.

3.3.5 Groundwater flooding

Groundwater flooding occurs when the groundwater table rises above ground level, leading to ponding at local low points and causing flooding. It typically occurs following lengthy periods of rainfall, typically over several days, usually late winter/ early spring when the groundwater table is already high. Groundwater can also impose risk of flooding to basements and underground services.

Verde Environmental Consultants (Verde) have undertaken water level monitoring at a series of groundwater wells within the Cleeves site. Automatic groundwater level dataloggers were installed from 20 January 2021 through to 24 February 2021 in three bedrock wells and three wells installed in made ground. An additional

datalogger was placed in the Quarry reservoir, refer to Figure 3-3. The following information is taken from the Factual Report on Hydrographic and Hydrogeological Assessments (Verde, March 2021). This is included in Appendix A.

The findings from the groundwater monitoring are summarised below:

Made ground – Perched groundwater levels:

- Direct hydraulic connectivity between perched groundwater at MW102 (Quarry site, near reservoir) and the reservoir levels.
- Tidal influence on the perched groundwater in the made ground at MW102.
- No obvious tidal influence at MW104 and MW107 located to the southeast of the site at Flax Mills site, despite located near the Shannon.

Overall, the tidal influence on the site in the shallow perched groundwater is related to the hydraulic connection between the reservoir and the permeable made ground deposits that surround this feature (Verde, March 2021).

Bedrock groundwater levels:

- No significant tidal influence.
- The main influence in groundwater levels in bedrock related to rainfall recharge.
- A bedrock groundwater contour map was created and is shown in Figure 3-3.

Rainfall measurements and groundwater level charts that support the above observations are included in Verde's report in Appendix A.

There is no evidence of strong tidal influence from the river on the groundwater levels. The risk of groundwater flooding to the development is considered low.

3.4 Flood Risk from Quarry Reservoir

A depression within the Quarry, referred to here as the Quarry Reservoir, is observed to permanently hold water. A bathymetric survey and water level monitoring have been undertaken by Irish Hydrodata Ltd in February 2021. The water level monitoring was undertaken between 20th January and 12th February 2021. The report produced by Irish Hydrodata Ltd. is included in Appendix A.

It was found that the water levels in the Quarry reservoir vary semi-diurnally and with the spring-neap tidal cycle. Recorded values ranged from 1.2m AOD- 2.15m AOD, while the tidal levels ranged from -1.5m AOD to 3.0m AOD.

An inlet flap valve was located under the Infiltration Gallery. Water was observed to enter and exit the lagoon through this structure during the bathymetric survey (Irish Hydrodata Ltd., March 2021).

Survey investigations have confirmed that the reservoir within the Quarry site discharges to the River Shannon. Confirmatory investigations and analysis will further the understanding of the subsurface pipe network and its hydraulic connectivity to the river. Note however that the flow and volumes that are passing through the network into and out of the reservoir appear low – this is evident in a muted tidal signal within the reservoir which matches neither the peak nor the ebb of the river's tidal signal (see the ranges quoted above in the second paragraph of this section). This in itself is a mitigating factor with regard to flood risk. Upon completion of the confirmatory investigations, measures will be implemented to prevent backflow through the system. This will include the strategic installation of non-return valves and the decommissioning of redundant pipework.

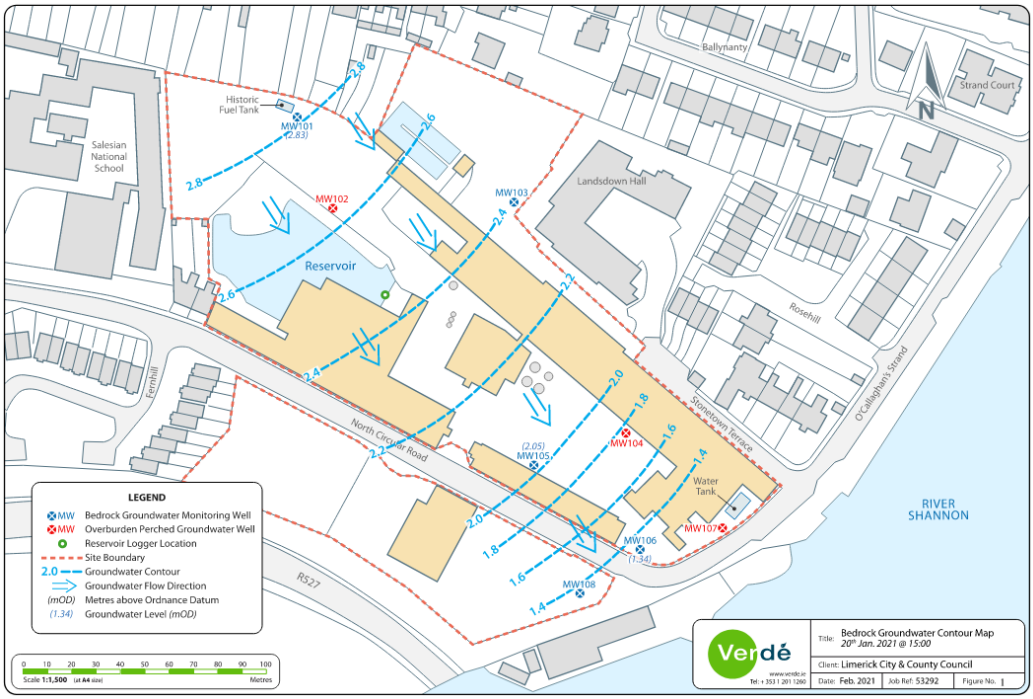

Figure 3-3: Location of groundwater level monitoring wells and groundwater contours, Verde (March 2021)

3.5 Summary of Flood Risk

The main risk of flooding to the site is tidal from the River Shannon. The site lies in areas at high, moderate, or low risk of flooding (Flood Zones A, B and C, respectively). The Shipyard Site and part of the Infiltration Galleries lie in Flood Zone A (high risk), parts of the Quarry Site lie in Flood Zone B (moderate risk) and the rest (the majority) of the site lies in Flood Zone C (low risk).

The Stonetown Terrace, Salesian and Quarry Site could be at risk of receiving shallow overland flow originating from the adjacent residential development to the north.

Due to proximity of the site to the Shannon River, there is risk of groundwater flooding to basements or underground services. Based on groundwater level monitoring within the site, there is no evidence of a strong tidal influence on the groundwater levels.

An inlet valve has been identified under the Infiltration Gallery. The inlet allows water ingress from the Shannon to the Quarry Reservoir on a rising tide, and vice versa on a falling tide. When the river levels are very high, there could be a slight risk of flooding to areas around the reservoir if no mitigation measures were implemented. Note however that even then, the flow and volumes passing through the network into and out of the reservoir appear low, which in itself is a mitigating factor – this is evident in a muted tidal signal within the reservoir which matches neither the peak nor the ebb of the river's tidal signal. Confirmatory investigations and analysis will be completed to understand the connectivity of the underground piping at the site. Any residual flood risk will be mitigated following these confirmatory investigations and analysis, via the installation of non-return valves and the decommissioning of redundant pipework.

4. Managing and Reducing Flood Risk

4.1 Approach to Flood Risk Management

According to the Guidelines, most forms of development should be avoided in areas of flood risk where possible. Where development cannot be avoided, proposals for less vulnerable uses should be substituted.

The Guidelines also recognise that in some instances such as existing brownfield sites in large urban areas, it may be appropriate to allow development where it can be illustrated that there is a wider strategic justification for such development and that the flood risk can be managed to an acceptable level. However,

where a change of use from less vulnerable to highly vulnerable development is proposed in areas of flood risk, a Justification Test will be required.

Given the location of the site and its designation as a key regeneration site within the current development plan, the site will pass the Justification Test provided the Masterplan mitigates the flood risk to an acceptable level for highly vulnerable development (i.e. as per the site-specific mitigation measures outlined in this document).

While the planning guidance requires that flood risk should be managed to an appropriate level for the design life of the development, it should be done in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.

The following measures to flood risk management will ensure flood risk is managed to an acceptable level:

- Flood risk areas are avoided where possible,
- Highly vulnerable uses such as residential development are in areas at lower risk (Flood Zone C) or raised to a higher level when located in Flood Zones A or B. Residential uses are primarily proposed within the Salesian and Stonetown Terrace sites. Where residential development is proposed in areas at risk of tidal flooding (O'Callaghan Strand, Quarry site), the development will be raised above flood levels and residences will be located on higher floors,
- Safe access and egress for emergency vehicles are provided to all buildings.
- Finished floor levels are raised above the flood protection level with an allowance for climate change where possible. Raising of levels shall be considered in conjunction with compliance with the Building Regulations for access for all, economics of the development, aesthetics, and practical design.

The above concepts are explained in more detail in the following sections.

Note that modelling has not been conducted for the purposes of this site specific FRA. This acknowledges the key flood mechanism at the site being tidal flooding. Inundation within and around the site is effectively backwater tidal flooding from the River Shannon that extends into the site area / site vicinity. Accordingly, this is a flood-storage area only, particularly so given the flood mechanism. The raising of the NCR or the construction of the embanked walkway in the Shipyard site will therefore have no impact on the surrounding tidal flood levels (implying no risk of adverse flood level increases to adjacent properties or land). Of note, the proposed mitigation measures do not impact on flow conveyance (for all the reasons outlined above) hence flood modelling not being required.

4.2 Flood Protection Level

The Guidelines recommend a minimum standard of protection for new development level of the 1 in 200-year flood event plus an appropriate allowance for climate change and a suitable freeboard.

Freeboard allowances are made to account for uncertainties in data collection, assessment, and modelling, as well as allowances for physical interference / effects such as wave action.

As the River Shannon near the site is tidal on an estuary subject to some wave action, it is recommended that an allowance of 500mm freeboard be used in addition to the design flood levels. This is in line with the recommendations included in the LCCC SFRA (included in Figure 2-2).

The SFRA requires developments to be protected from flooding with allowances for climate change depending on the vulnerability classification of the Proposed Development. The final SFRA required that for both the less vulnerable development (commercial uses) and highly vulnerable uses (residential uses) the MRFS allowance of 0.5m shall be considered.

A more conservative approach has been followed when proposing flood protection levels across the site. The HEFS allowance of 1m has been applied to highly vulnerable development.

Please refer to Table 4-1 for the variation in flood protection levels, depending on the climate change allowances adopted.

Table 4-1 Flood protection level range for Cleeve Riverside Quarter

Parameter	Lower allowance (Commercial uses)	Higher allowance (Residential uses)
1 in 200-year flood level	4.65m AOD	
Mean Sea Level Rise	+500mm (Mid-Range Future Scenario)	+1000mm (High End Future Scenario)
Land movement	50mm	50mm
Freeboard	500mm	500mm
Flood protection level	5.7m OD	6.2m OD

Flood protection on site will be achieved by raising floor levels. As the risk of flooding to the site is primarily tidal (from the sea) and not fluvial, the land raising within the site is expected to have negligible impact on flood risk to other sites upstream or downstream of the site. The requirement to provide flood compensation storage within the site is not anticipated to be required owing to the fact that the critical flood mechanism is tidal flooding.

Limerick City Council has undertaken detailed hydraulic modelling of the River Shannon as a part of the Limerick FRS. The modelling has produced updated flood levels compared to CFRAMs as shown in Table 4-2:

Table 4-2 Comparison of Flood Defence Levels Between CFRAMS and Limerick FRS Modelling

Study	1 in 200-year flood level	Coastal defences level (with 500mm freeboard)	Future defence level (with 1m climate change)
CFRAMS	4.65m AOD		
Limerick FRS	4.97m AOD	5.47m AOD	6.47m AOD

While the baseline 1 in 200-year flood levels have increased by 320mm between CFRAMS and the FRS modelling, it is considered that the proposed level of protection currently being incorporated into the Proposed Development provides adequate protection, noting it to be of a higher standard than the Limerick FRS defences.

The design team discussed lowering the level of defence of the Masterplan to match the flood defence level of the FRS to 5.47m AOD; however, it is considered that this would be a sub-optimal approach recognising it would not cater for any climate change provision. The Masterplan proposed flood protection levels of 5.7m AOD and 6.2m AOD will provide a 230mm and 730mm allowance for climate change, which is deemed a prudent approach. It is also possible that the Limerick FRS might not be able to be adapted in the future to

provide climate change protection to the site location, where hard defences proposed would be expected to be raised by 1m (i.e. above the 5.45m AOD level) to account for climate change. As such, the Design Team concluded, based on best practice guidance, available data, and in their collective professional judgement, that the proposed defence levels are maintained at 5.7mAOD and 6.2mAOD for commercial and residential uses respectively.

4.3 Safe Access and Egress

Emergency services access and egress will be provided to all buildings as part of the Site-specific Flood Risk Assessment Report.

Condell Road runs south of the Shipyard site between 6.5m OD to 8.0m OD northwest to southeast. The road is well above the flood protection level and can provide emergency access and egress for the Shipyard site. Similarly, the exit from Salesian site to North Circular Road (NCR) is at 6.4m AOD, providing safe evacuation towards the northwest. However, NCR is sloping down from 6.4m AOD northwest to 3.97m AOD at the interface with O'Callaghan Strand with an average longitudinal slope of 1:110. Currently, there is no safe access and egress for Flax Mill site, Quarry site or Stonetown Terrace.

A key flood mitigation measure to be considered is therefore the re-grading of NCR. This would allow most of the site to be accessed by the emergency services during the 1 in 200-year flood event, as well as protecting the Quarry and Flax Mill sites from tidal flooding by forming part of the flood defence line.

To provide safe access and egress to the Flax Mill site, Stonetown Terrace and Quarry Site, as well as mitigating the risk of tidal flooding entering the Quarry depression, the NCR will be re-graded and raised to the flood protection level of 5.7m AOD, as shown in Figure 4-1. Raising the road to any higher level than this is not considered practical, considering the levels of the surrounding buildings and roads. From the junction with O'Callaghan Strand, the NCR will rise with a 1:21 slope to 5.7m AOD. The road will be maintained at that level before ramping down again to 5.2m AOD and eventually to 4.85m AOD to tie in with existing road levels in front of existing residential housing west of the Shipyard site. The road naturally rises again to 6.4m AOD at the entrance to Salesians site.

There is a gap in the defence line on the NCR (northwest of the proposed 5.7m AOD crest location) where the road must tie back in with existing road levels of approximately 4.85m AOD. As part of the original Masterplan, the Shipyard site was proposed to be raised to the flood protection levels and provide the defence line against flows coming from the south through the site. Without this being done, floodwater reaching levels approaching 5.7m AOD could inundate the Shipyard site, flood onto the NCR north-west of the proposed mitigation crest / raising of the NCR, and then enter the site via pathways / flow-paths leading into the development.

Under the current proposal, the Shipyard site is proposed to have temporary uses, until the site is developed to a mixed-use development (note that flood protection works for any such future mixed-use development have not been taken into account as part of this assessment).

The temporary uses currently considered include the current car parking facilities, landscaping and access to St Michael's boat club in the south and a new pedestrian connection running between the NCR at 5.7m AOD and Condell Road at 6.78m AOD. The site may also serve as a potential zone for the construction compound. This new pedestrian embankment will provide interim flood protection to the NCR and the rest of the development, until the Shipyard site development is completed. The Shipyard site itself during the temporary use phase is not proposed to be protected and will be allowed to flood as per existing conditions, apart from a situation where it is being used as a construction compound. Safe access and egress routes are demonstrated in Figure 4-2.

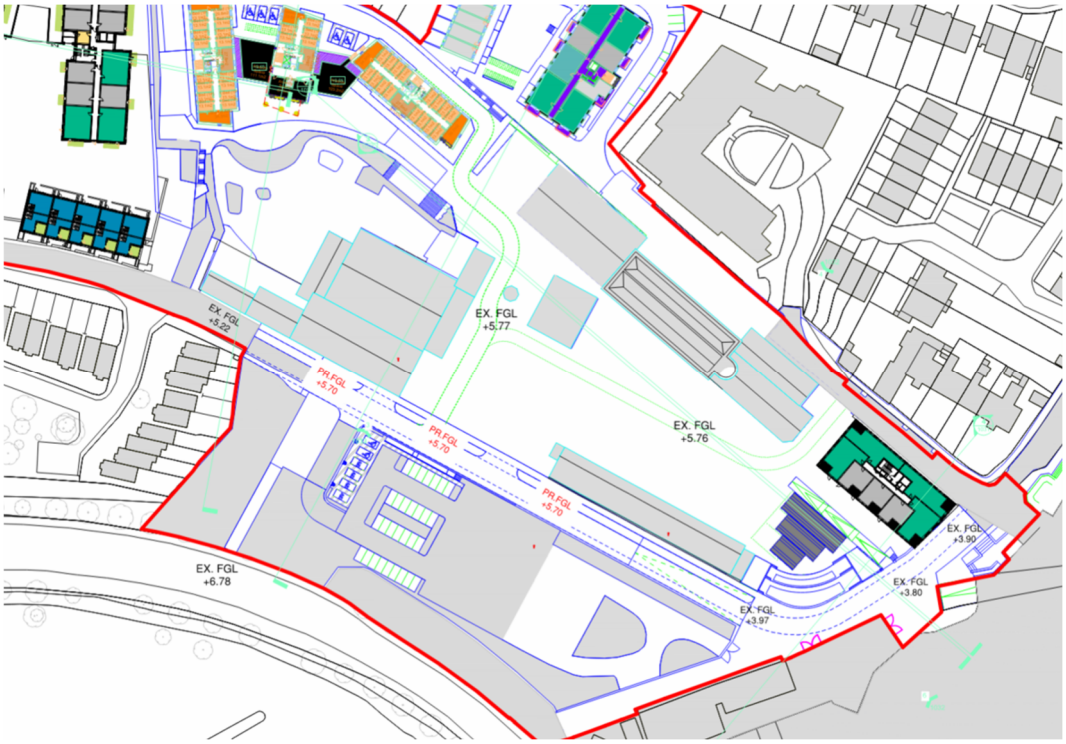

Figure 4-1 Proposed NCR land raising for flood protection.

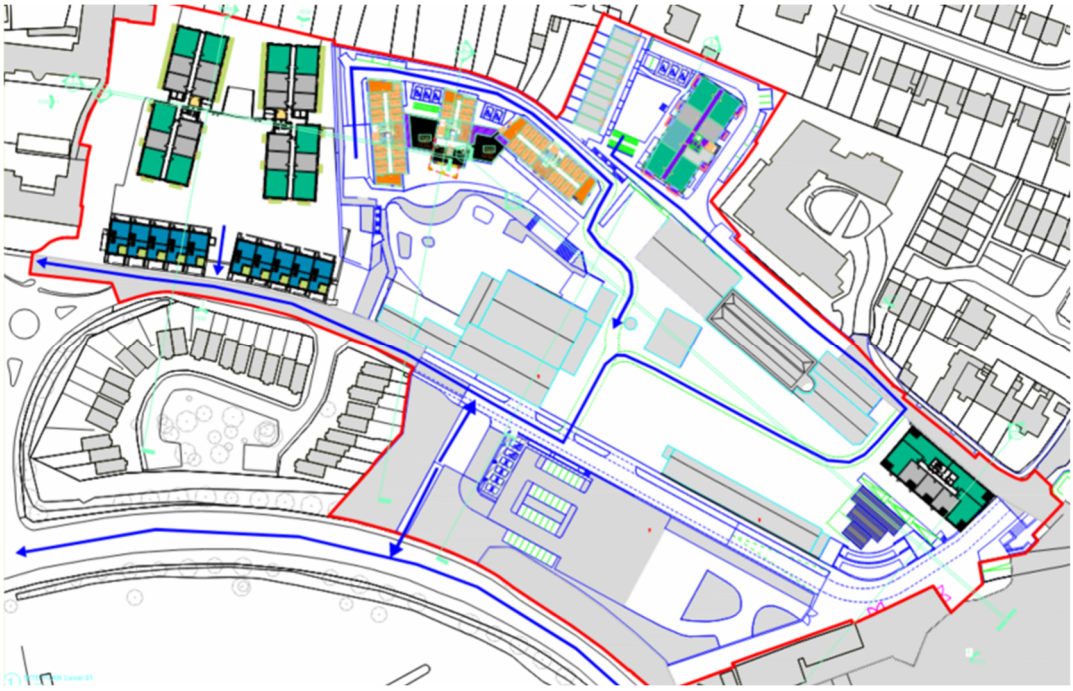

Figure 4-2: Safe access and egress.

Note also that at the junction of Stonetown Terrace and O'Callaghan Strand, flood protection measures are proposed that will protect existing residential buildings along O'Callaghan Strand from inundation during tidal floods that exceed bank-full level at this location. The protection of these buildings is principally achieved through design work being commissioned by LCCC as part of the Limerick (River Shannon) Flood Relief Scheme (FRS). However the CRQ project team and LTT have been coordinating closely with LCCC to ensure an integrated approach to flood protection along the Shannon, and – in particular – at the junction of Stonetown Terrace and O'Callaghan Strand.

As part of the Limerick (River Shannon) FRS, both projects will interface to provide a holistic design solution that will protect the aforementioned buildings along O'Callaghan Strand against tidal flood inundation. While not final as yet, this design will likely comprise a close-able flood gate near the junction of O'Callaghan Strand and Stonetown Terrace, which will work in tandem with the wider, more extensive flood defence measures along the Shannon in this area (i.e. flood defence walls / barriers). This collaborative design solution is currently being developed, but is shown indicatively in the Landscape Plan (drawing number CRQMP-MLA-ZZ-XX-DR-L-1003-OCS).

4.4 Intercepting Overland Flows

The northern boundary of the site is at a relatively minor risk of receiving overland flow from external / off-site catchments without any mitigation measures being implemented (Salesian site, the Quarry, and Stonetown Terrace site). Accordingly a new perimeter drainage system (open or piped) will be installed to intercept the offsite flows from the properties to the north and divert the surface water runoff to the site drainage system. The perimeter drainage system shall consist of Sustainable Drainage Systems (SuDS) and connect to the Quarry Reservoir.

4.5 Flood Risk Management at Each Site

4.5.1 Flax Mill Site

The Flaxmill building is earmarked for retention during this application for future development for academic use. Flood risk to the building will be considered for access and egress purposes.

The levels within Flax Mill site are proposed to be raised above the flood protection level for less vulnerable uses of 5.7m AOD. Flood mitigation to the standard of protection of 1 in 200 year with climate change is therefore achieved.

The listed Flax Mill Factory and adjacent buildings (Cold Store and Dairy buildings), as well as the Engine House and Water tank building, are currently proposed to be retained due to their historic importance. No works are proposed at this stage to the Infiltration Galleries.

Table 4-3 indicates the approximate existing ground levels of each building.

Table 4-3: Historic buildings to be retained and levels.

Reference	Building	Ground level
A1 & A5	Flax Mill Factory (listed) and extension	5.90m OD
A2	Cold Store	5.94m OD
A3 & A4	Dairy Buildings	5.86m OD
B2-B4	Engine House	5.56m OD
C1	Water Tank building	6.05m OD
C2	Building above Infiltration Galleries	5.60m OD

Where existing buildings are proposed to be retained and are currently below the flood protection level, the ground floor levels can be retained as per existing. Future intended land uses include educational uses, which are the same vulnerability classification as per existing (less vulnerable). Other standard non-structural flood mitigation measures can be retrofitted to these buildings to provide flood resilience.

The building on O'Callaghan Strand is proposed to have sleeping accommodation at the upper levels, above 6.2m AOD. The ground floor level will be raised to 5.7m AOD to ensure safe and dry access and egress for all residents.

Safe access and egress from the Flax Mill site is achieved via the NCR as discussed in Section 4.3.

4.5.2 Quarry Site

The Quarry site is currently located in a depression in the ground and is exposed to flooding during the 1 in 1000-year flood event scenario and the 1 in 200-year future scenario (with climate change). Buildings within the Quarry are proposed to be raised above 5.7m AOD flood protection level. Sleeping accommodation is proposed at upper levels and above the highly vulnerable flood protection level of 6.2m AOD.

Safe access and egress from Quarry site are discussed in Section 4.3.

4.5.3 Salesian Site and Stonetown Terrace

The Salesian site and Stonetown terrace are located above the flood protection level and are therefore outside the risk of tidal flooding. The Salesian site can be accessed safely by emergency vehicle via the higher levels of NCR.

Stonetown Terrace does not currently provide for dry access to the site. Access above the flood protection level of 5.7m AOD to the Stonetown Terrace site is proposed via the raised NCR road through the Flax Mill site.

4.5.4 Shipyard Site

The Shipyard site is currently proposed to be developed for temporary uses, with the mixed-use development proposals to follow as a future phase. The site lies in an area at high risk of tidal flooding (Flood Zone A). It is adjacent to O'Callaghan Strand and the River Shannon and generally lies at low levels (3.5m AOD - 4.4m AOD).

The interim flood protection measures at the Shipyard site (i.e. the embanked pedestrian walkway at the rear of the site) will ensure a continuous flood protection line to tie in with the raised NCR. This is further explained in Section 4.3.

Whatever is ultimately done with the Shipyard site it will be necessary that it is designed such that it protects the NCR from being outflanked by tidal flood levels north-west of the proposed road crest / raising, and to tie in the with the NCR crest level of 5.7m AOD.

5. Application of 'Flood Risk Management Guidelines'

5.1 Flood Zones

The Shipyard site and Infiltration Galleries lie in an area at high risk of flooding, during the 1 in 100 year flood event (1% AEP), defined as Flood Zone A. The Quarry lies within an area at moderate risk of flooding, during the 1 in 1000-year flood event (0.1% AEP), defined as Flood Zone B.

The rest of the site lies within Flood Zone C (outside the 0.1% AEP extents).

5.2 Vulnerability Classification

The Proposed Development includes residential units classified as 'Highly Vulnerable Development' and commercial spaces classified as 'Less Vulnerable Development'.

5.3 Sequential Approach and Requirement for Justification Test

Figure 5-1 illustrates the Sequential Approach to be adopted under the 'Planning System and Flood Risk Management' guidelines. The site partially lies within Flood Zone A and is classified as 'Highly and/or Less Vulnerable Development'; therefore, a Justification Test is required.

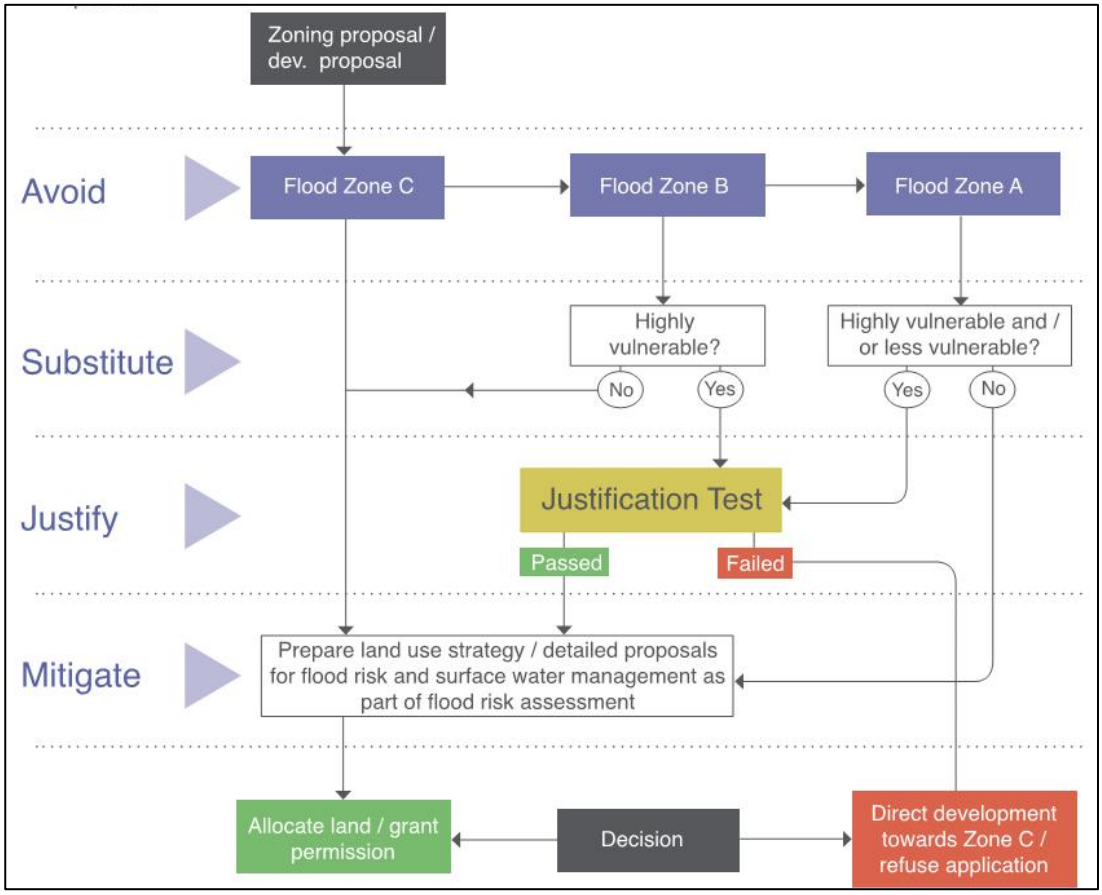

Figure 5-1 Sequential approach justification test.

5.4 Application of the Justification Test

5.4.1 Overview

The Development Plan Justification Test has been undertaken as a part of the Strategic Flood Risk Assessment for the Limerick Development Plan 2022-2028. The development is within an area which constitutes brownfield under-utilised lands within the centre of the city in addition to being part of the city core. The Justification Test was passed and allows for development proposals supported by an appropriately detailed FRA.

5.4.2 Development Management Justification Test

The Development Management Justification Test is undertaken when developments vulnerable to flooding are proposed in areas at moderate or high risk of flooding (Flood Zones A and B). Prior to granting permission for the development, the planning authority must be satisfied that the development meets the criteria set out in the Development Management Justification Test described in Section 5 of The Planning Guidelines. These criteria are included in Table 5-1. It is demonstrated that the Proposed Development satisfies the criteria of the Development Management Justification Test.

Table 5-1 Justification Test for Development Management

Justification Test Criteria	Response based on findings of FRA
1. The subject lands have been zoned or otherwise designated for the particular use or form of development in an operative development plan, which has been adopted or varied taking account of these Guidelines.	The Limerick Development Plan 2022-2028 has zoned the area within the site boundary as 'city centre' and 'existing residential'. The objectives of the city centre zoning including protection, consolidation, and facilitation of commercial, retail, education, leisure, residential social and community uses/facilities. The objective of existing residential zoning is to provide for and protect existing residential amenities. The development proposal includes 270 beds within the proposed student accommodation and 234 homes within proposed residential areas as well as commercial, educational, and childcare facilities. These all align with the recommendations of the urban centre. Therefore, it is considered that the Masterplan satisfies the criteria of Part 1 of the development management Justification Test.
2. The proposal has been subject to an appropriate flood risk assessment that demonstrates:	
i. The development proposed will not increase flood risk elsewhere and, if practicable, will reduce overall flood risk;	In terms of assessing whether the development would increase flood risk elsewhere, the Proposed Development will be constructed largely on existing building footprints. Flow pathways throughout the site have been investigated to ensure no new flow pathways are created. To ensure safe access and egress, the NCR will be raised to 5.7m AOD sloping away from O'Callaghan Strand before sloping back down to 4.85m AOD to match existing road levels in front of existing residences west of the Shipyard site. A gap is created during this lowering of the NCR back down to the residences which could allow for water to pass through the Shipyard site. A pedestrian embankment is proposed as an interim measure to protect the NCR and the rest of the development until the Shipyard is developed in a future proposal. The nature of the flooding at the site is tidal, and therefore the development and mitigation works will not impact on flood levels associated with fluvial / conveyance-dominated flood events.
ii. The development proposal includes measures to minimise flood risk to people, property, the economy and the environment as far as reasonably possible;	The development minimises flood risk by setting levels above the 1-in-200 year flooding event and including provisions for climate change (500mm for lower allowance and 1000mm for higher allowance) in addition to freeboard and land movement allowances. These levels are higher than the SOP proposed for the Limerick FRS, providing a high standard of protection for the lifetime of the Masterplan.
iii. The development proposed includes measures to ensure that residual risks to the area and/or development can be managed to an acceptable level as regards the adequacy of existing flood protection measures or the design, implementation and funding of any future flood risk management measures and provision for emergency services access;	Because the flood mechanism is tidal, raising the finished floor levels is not expected to cause residual risks. The flood mitigation measures proposed ensure all of the site areas have adequate emergency access and egress in the event of flooding along O'Callaghan Strand. It is noted that the Shipyard site is not protected in this proposal, but provision has been made for an interim pedestrian embankment to serve as a barrier for the flow path through the site. A permanent defence should be designed for should the Shipyard development not occur. The development proposal is in line with the options considered for the Limerick FRS and the site is protected with or without the scheme through the raising of finished floor levels.
iv. The development proposed addresses the above in a manner that is also compatible with the achievement of wider planning objectives in relation to development of good urban design and vibrant and active streetscapes.	The Proposed Development supports the development of a vibrant and active city centre and the objective for increasing housing provision; therefore, it is in line with wider planning objectives. It is considered that the Proposed Development satisfies the criteria of Part 2(iv) of the development management Justification Test.

6. Conclusion

The Cleeves site is currently at risk of flooding from the following sources:

- Tidal flood risk: The Shipyard Site and Quarry Site are at risk of flooding during the 1 in 200-year flood event, Flax Mill site could be at risk of flooding in the future, when climate change allowances for sea level rise are considered.
- Pluvial flood risk: The Quarry site, Salesian Site and Stonetown Terrace could be at relatively minor risk from receiving overland flows from external catchment areas.
- Groundwater flood risk: The risk of groundwater flooding is deemed low.
- Reservoir flood risk: An inlet flap valve has been identified with a potential to allow water ingress from the river to the Quarry Site. Confirmatory investigations and analysis will be completed to understand the underground pipe network so as to mitigate this risk.

A variety of flood mitigation measures have been proposed and are presented in this Flood Risk Assessment. These include:

- raising building floor levels to between 5.7m AOD and 6.2m AOD
- raising the NCR to 5.7m AOD thereby providing safe access and egress to/from the site, and;
- construction of a new pedestrian connection at the northern end of the Shipyard site to run between Condell Road and the NCR set between 6.78m AOD and 5.7m AOD. This will provide flood mitigation for the development by completing the flood defence line in the interim until the Shipyard site is fully developed.

Appendix A

Factual Report on Hydrographic and Hydrogeological Assessments, Verde, March 2021

Verde Environmental Consultants

Factual Report on Hydrographic and Hydrogeological Assessments

Cleeves Factory Site, North Circular Road, Limerick

March 2021

TABLE OF CONTENTS

FIGURES

GRPAHS

APPENDICES

DOCUMENT CONTROL

Project Title:	Factual Report on Hydrographic and Hydrogeological Assessments
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Created By	Donal Hogan		3rd Mar 2021	Senior Hydrogeologist
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Approved by	Kevin Cleary		3rd Mar 2021	Operations Director

LIMITATIONS

This report represents the results of the inspection and site survey works conducted at the above referenced site. Best practice was followed at all times and within the limitations stated. This report is the property of Verde Environmental Consultants Limited and cannot be used, copied or given to any third party without the explicit prior approval or agreement of Verde Environmental Consultants Limited.

Verde makes no other representations whatsoever, including those concerning the legal significance of its findings or as to other legal matters touched on in this report, including, but not limited to ownership of any property or the application of any law to the facts set forth herein.

1 Factual Survey Report Findings

1.1 Project Contractual Basis & Parties Involved

Verde Environmental Consultants (Verde) was commissioned by Rogerson Reddan on behalf Limerick Twenty Thirty (LTT) to provide baseline characterisation data to support the soil and water chapters of an Environmental Impact Assessment Report (EIAR) in relation to Redevelopment of the Cleeves Site in Limerick. The factual report includes the following initial survey findings with recommendations in relation to proposed further assessment works.

1.2 Water Level Monitoring

In 2017 Verde carried out an environmental due diligence assessment of the Cleeves site involving soil and groundwater assessments. As part of this assessment a series of groundwater monitoring wells were installed in the overburden and bedrock aquifer underlying the site.

On 20th January 2021, Verde located the existing groundwater monitoring wells and installed automatic groundwater level dataloggers in three bedrock wells and three well installed in the made ground/subsoils. In addition a datalogger was placed in the surface water reservoir on-site to observe any comparison with this tidally influenced water feature, as outlined in Table 1. Site survey levels were provided from a topographic survey undertaken on-site.

Table 1: Water Level Logging Locations on-site and Survey Levels

Cleeves Reservoir & Groundwater Level Monitoring					
Well ID	**Geology**	**Survey Level (mOD)**	**Water Level (mOD) 20/01/21 @15:00**	**Neap Tidal Range (m)**	**Spring Tidal Range (m)**
MW101	Bedrock	4.47	2.83		
MW102	Made Ground	4.77	1.4	0.05	0.44
MW104	Made Ground	5.43	3.61		
MW105	Bedrock	5.7	2.05		
MW106	Bedrock	5.05	1.34		
MW107	Made Ground/ Clay	4.7	2.54		
Reservoir		2.99	1.35	0.1	0.65

A graph of the shallow perched groundwater level monitoring in the shallow wells installed in the made ground/subsoils is presented in Graph 1 with the bedrock aquifer groundwater level monitoring wells in Graph 2. Surface water levels in the reservoir show a tidal influence of approximately 0.1m range during neap tides and 0.65m range during spring tides in the monitoring period of 20th January to 24th February 2021.

1.2.1 Perched Groundwater Levels

It can be seen there is direct hydraulic connection between the perched groundwater in MW102 and the adjacent reservoir water level. There is tidal influence on the perched groundwater in the made ground in MW102 of approximately 0.05m during neap tides and 0.44m during spring tides.

In MW104 and MW107 located to the south east of the site, there is no obvious tidal influence on the perched groundwater in these locations, although closer to the River Shannon. The fluctuations seen in the perched groundwater in MW104 and MW107 are seen to be related to responses to rainfall recharge. This indicative daily rainfall data for the site was obtained from the Shannon Airport weather station.

Overall the tidal influence on the site in the shallow perched groundwater is related to the hydraulic connection between the reservoir and the permeable made ground deposits that surround this feature.

1.2.2 Bedrock Groundwater Levels

The groundwater levels in the bedrock monitoring wells are not seen to have any significant tidal influence. In MW101 located within 40m of the reservoir there was no noticeable tidal influence.

In bedrock wells MW105 and MW106 located in the south eastern region of the site and closer to the River Shannon there was some minor tidal influence of <0.04m.

The main influence on groundwater levels in the bedrock aquifer is related to rainfall recharge as presented in Graph 2. Overall the reservoir tidal influence does not impact on the nearby limestone bedrock aquifer groundwater levels.

Using the survey levels and groundwater levels taken at 15:00 on 21st January 2021 a bedrock groundwater contour map was created, as presented in Figure 1. It can be seen the groundwater flow in the bedrock aquifer underlying the site is in a south easterly flow direction towards the River Shannon.

1.3 Reservoir Water Quality

The automatic water level datalogger installed in the surface water reservoir also recorded electrical conductivity (EC) to assess if the water quality is fresh or influenced by brackish/saline water from the River Shannon. The EC readings from the datalogger at the location presented in Figure 1 ranged from 205µS/cm to 248µS/cm, as presented in Graph 3. These low EC readings recorded at the south eastern corner of the reservoir indicate fresh water with no brackish water influence over this period of measurement from 20th January to 24th February 2021.

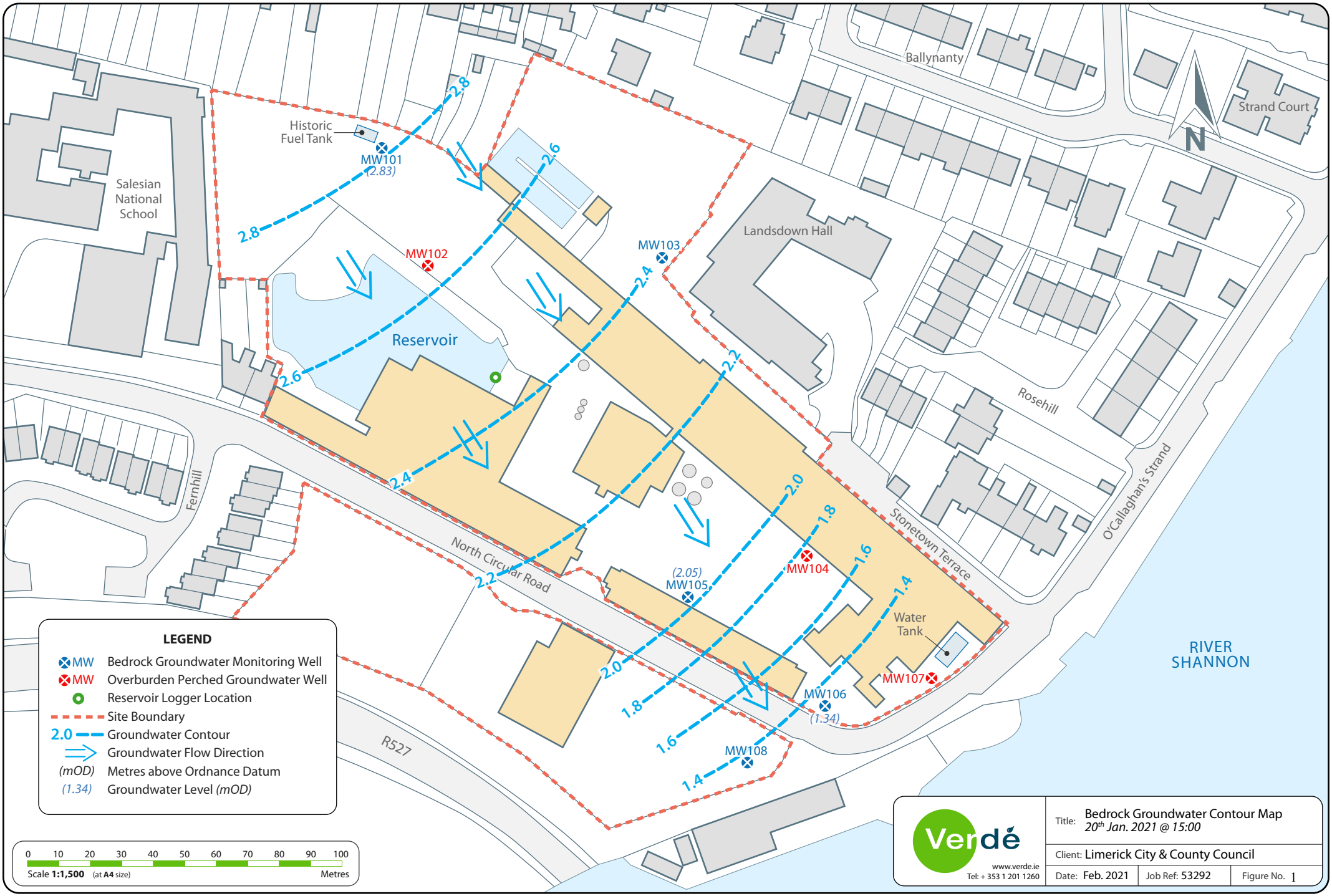
This corresponds with the low EC readings (263µS/cm) recorded from the reservoir when sampled in the 2015 investigation.

1.4 Bathymetric Survey

The Bathymetric Survey prepared by Irish Hydrodata Ltd is presented in Appendix A.

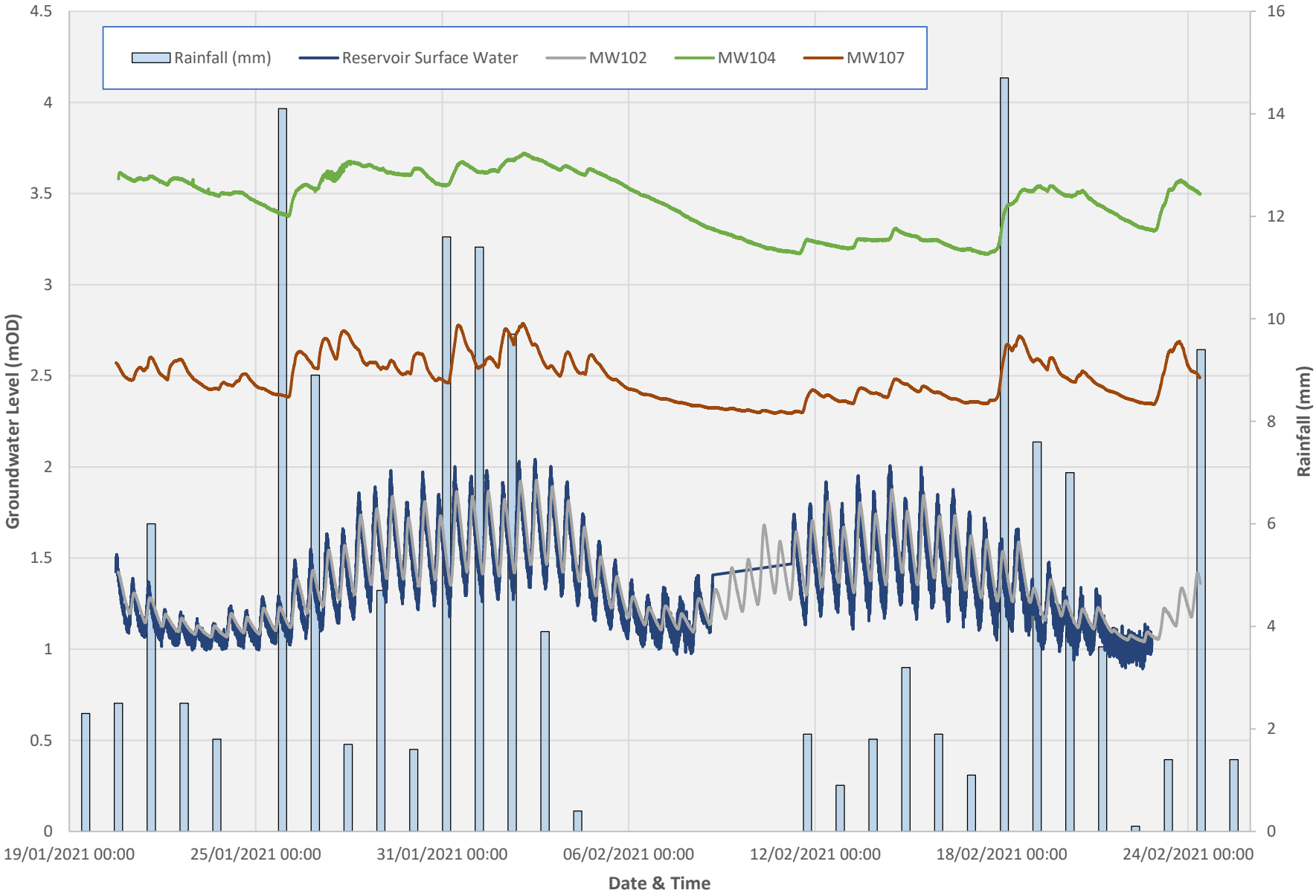
Figure 1

Groundwater Contour Map for Limestone Bedrock Monitoring Wells


Ballynanty
Strand Court
N
Historic Fuel Tank
MW101
(2.83)
Salesian National School
MW102
MW103
Landsdown Hall
Reservoir
Rosehill
Fernhill
North Circular Road
Stonetown Terrace
O'Callaghan's Strand
(2.05)
MW105
MW104
Water Tank
MW107
MW106
(1.34)
MW108
R527
RIVER SHANNON
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
LEGEND
MW Bedrock Groundwater Monitoring Well
MW Overburden Perched Groundwater Well
Reservoir Logger Location
Site Boundary
2.0 Groundwater Contour
Groundwater Flow Direction
(mOD) Metres above Ordnance Datum
(1.34) Groundwater Level (mOD)
0 10 20 30 40 50 60 70 80 90 100
Scale 1:1,500 (at A4 size)
Metres
Verdé
www.verde.ie
Tel: + 353 1 201 1260
Title: Bedrock Groundwater Contour Map
20th Jan. 2021 @ 15:00
Client: Limerick City & County Council
Date: Feb. 2021
Job Ref: 53292
Figure No. 1

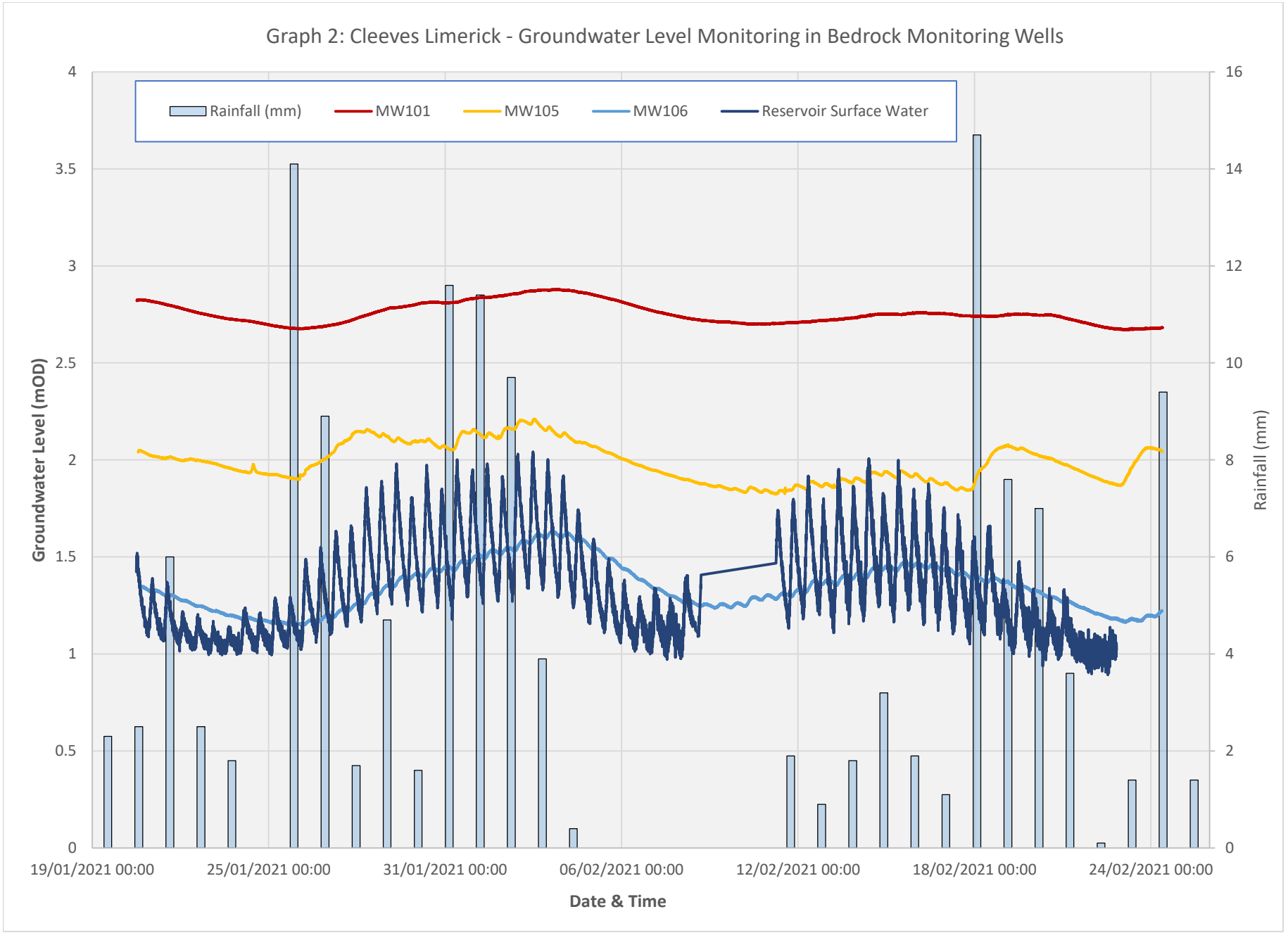
Graph 1: Perched Groundwater Level in Made Ground/Subsoils

Graph 1: Cleeves Limerick - Perched Groundwater Level Monitoring in Wells installed in Made ground/Suboils



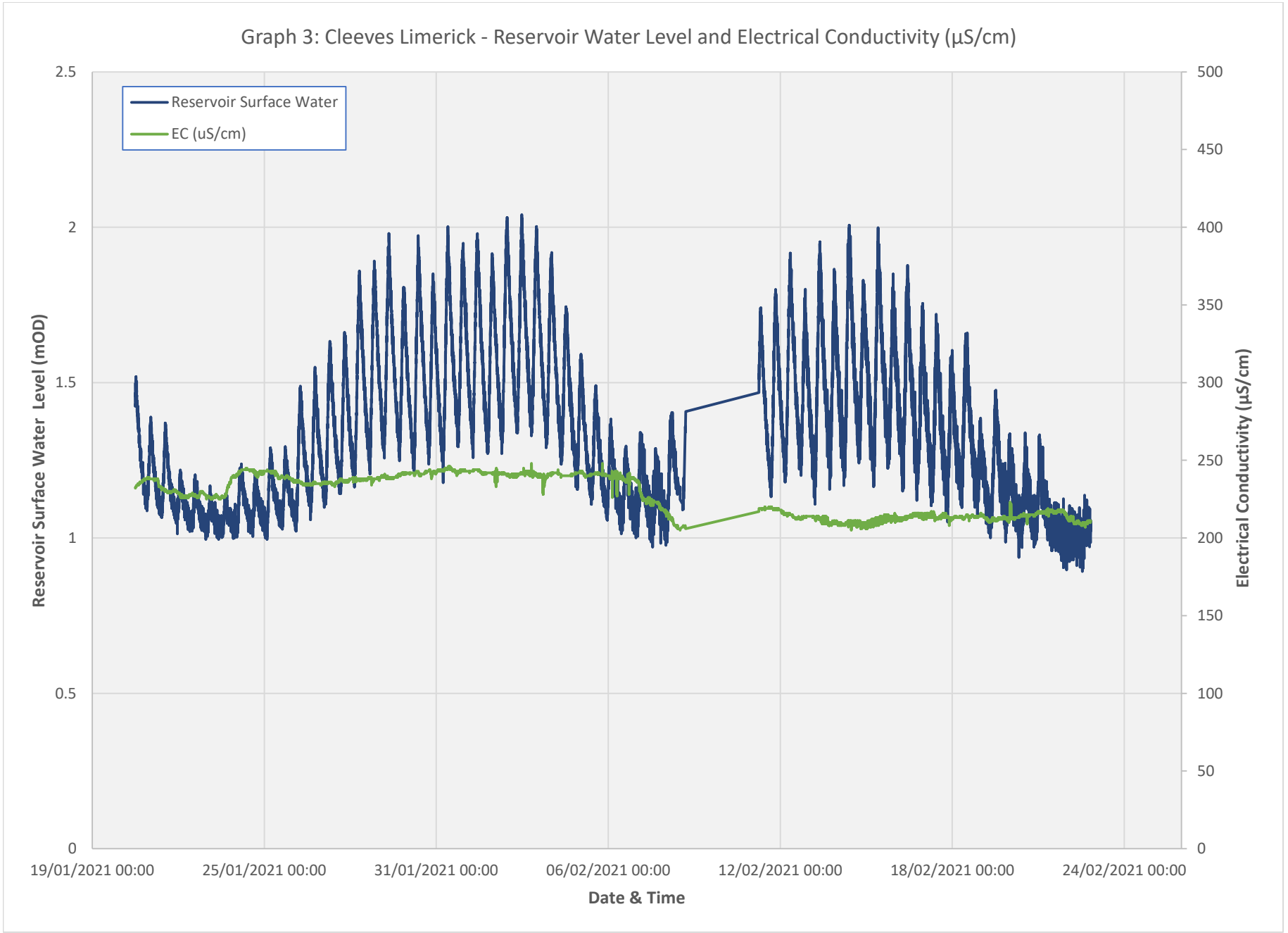
Graph 2:

Groundwater Levels in Limestone Bedrock


Graph 2: Cleeves Limerick - Groundwater Level Monitoring in Bedrock Monitoring Wells
Rainfall (mm)
MW101
MW105
MW106
Reservoir Surface Water
Groundwater Level (mOD)
Rainfall (mm)
4
3.5
3
2.5
2
1.5
1
0.5
0
16
14
12
10
8
6
4
2
0
19/01/2021 00:00
25/01/2021 00:00
31/01/2021 00:00
06/02/2021 00:00
12/02/2021 00:00
18/02/2021 00:00
24/02/2021 00:00
Date & Time

Graph 3:

Reservoir Water Level and Electrical Conductivity


Graph 3: Cleeves Limerick - Reservoir Water Level and Electrical Conductivity (µS/cm)
Reservoir Surface Water
EC (uS/cm)
Reservoir Surface Water Level (mOD)
Electrical Conductivity (µS/cm)
Date & Time
2.5
2
1.5
1
0.5
0
500
450
400
350
300
250
200
150
100
50
0
19/01/2021 00:00
25/01/2021 00:00
31/01/2021 00:00
06/02/2021 00:00
12/02/2021 00:00
18/02/2021 00:00
24/02/2021 00:00

Appendix A

Bathymetric Survey

Cleeves Site, Limerick

Bathymetric Survey

12th February 2021

Prepared by:	***Prepared for:***
IRISH HYDRODATA Ltd. Rathmacullig West, Ballygarvan, Co. Cork	***Verde Environmental Consultants on behalf of Rogerson Reddan and Limerick Twenty Thirty (LTT)*** Park House, Arthurs Quay, Limerick.

March 3rd 2021

Contents

1.0 INTRODUCTION

Irish Hydrodata Ltd. (IHD) was commissioned by Verde Environmental Consultants (Verde) on behalf of Rogerson Reddan and Limerick Twenty Thirty to carry survey works in the lagoon area of the Cleeves Site in Limerick City (Figures 1a-d).

The survey works comprised:

- Bathymetric survey of the open area of the lagoon;
- Preliminary reconnaissance survey under building;
- Preliminary dye test within lagoon.

A preliminary site visit was made on 20th January 2021, the survey works were completed on 12th February 2021.

2.0 SURVEY RESULTS

Water Level Measurements

A water level recorder was deployed at the site on 20th January. This remained in place until 12th Feb, logging data at 5 minute intervals. Data was reduced to Ordnance Datum Malin Head (ODM) based on level data supplied by Geodata Surveys. The observed lagoon water levels together with tidal data from Limerick Docks are presented in Figure 2. An expanded plot for the survey date is shown in Figure 3. Water levels in the lagoon vary semi-diurnally and also with the spring – neap tidal cycle. Recorded values ranged from a minimum level of 1.2m ODM to 2.15m ODM over the duration of the measurement period.

Bathymetric Survey Results

The open water area was surveyed by boat using an echo sounder and DGPS. The survey data were reduced to Malin datum. Data is presented in the accompanying survey chart and in Figure 4. The typical bed level is between 0.6 to 0.8m ODM with local areas dropping to a level of about 0.0m ODM.

The water level during the bathy survey ranged from about 1.6 to 1.7m ODM. The lagoon water surface area at this level is about 2200sqm (including the area under the building).

Speed of sound profiling indicated that the lagoon waters were substantially fresh and well mixed.

The lagoon bed was found to be composed of very soft mud. Hand probing easily achieved penetrations of about 1m. Various underwater obstructions and debris were encountered. These have been included on the survey chart in their approximate locations.

Under-building Survey Results

The area under the old building adjacent to and above the lagoon was examined by boat. The building is supported on cross walls which run in a NE-SW direction (Figure 5). These walls have three or four arch openings running the length of the building. The under-building area is about 35m long by an average of 26m wide. At the outer NW end, Bay 9, the width dimension is 34m while at the opposite end, Bay 1, it reduces to approximately 18m.

The arch dimensions are typically as shown in Figure 6. Not all arches were measured and some of the arches appear visually smaller.

An inlet flap is located in Bay 1 at the SE end of the building as shown in Figure 7 and in Photo 1. This comprises a timber gate (0.6m wide) with a top hinge recessed in an arch passage. The arch structure has a base cill level of +0.3m ODM. The state of the timber gate could not be determined. On the day of the survey waters were exiting and entering the lagoon through this structure.

Partition walls were evident at a number of locations. Only some of these were recorded due to the difficulty of manouvering in the confined areas. The top levels of these observed ranged from +1.4 to +1.7m ODM. The presence of these walls and associated pipe nozzle and gate valves suggests that the area was used in the past for liquid impoundment. The wall and gate valve in Bay 6 has a top level of +1.4m suggesting that in the past the lagoon water level must have been kept below +1.4m for these to be effective.

Bed probing indicated very soft mud in the area under the building. Various observed features are recorded in the attached photographs.

Preliminary Dye Test

Small quantities of tracer dye were released in the south eastern part of the lagoon and under the building to help identify water movements. Weather conditions on the day were not ideal with strong winds inducing surface circulations. The only significant water movement observed was in the vicinity of the inlet flap valve structure where waters exiting on the ebb tide. A more thorough survey would be required to identify and locate the outlet structure if one exists.

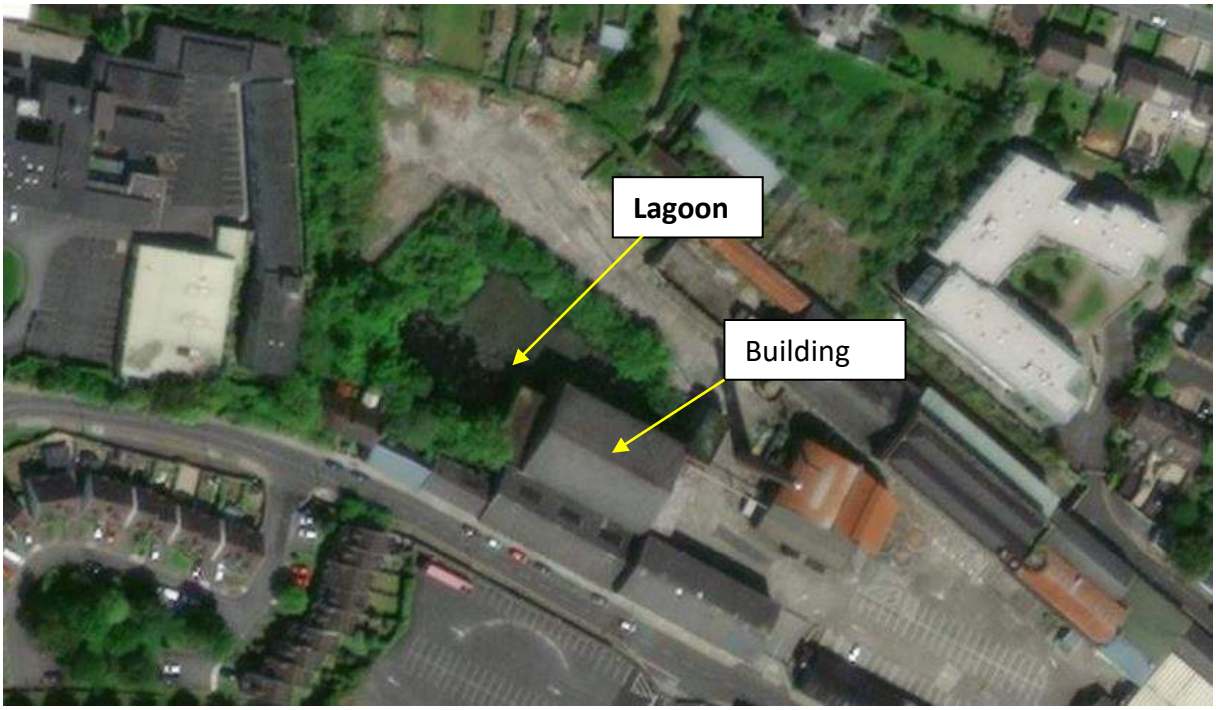


Figure 1a – Lagoon in Cleeve's site

Figure 1b – Lagoon in Cleeve's site

Figure 1c – Lagoon in Cleeve's site

Figure 1d – Lagoon in Cleeve's site

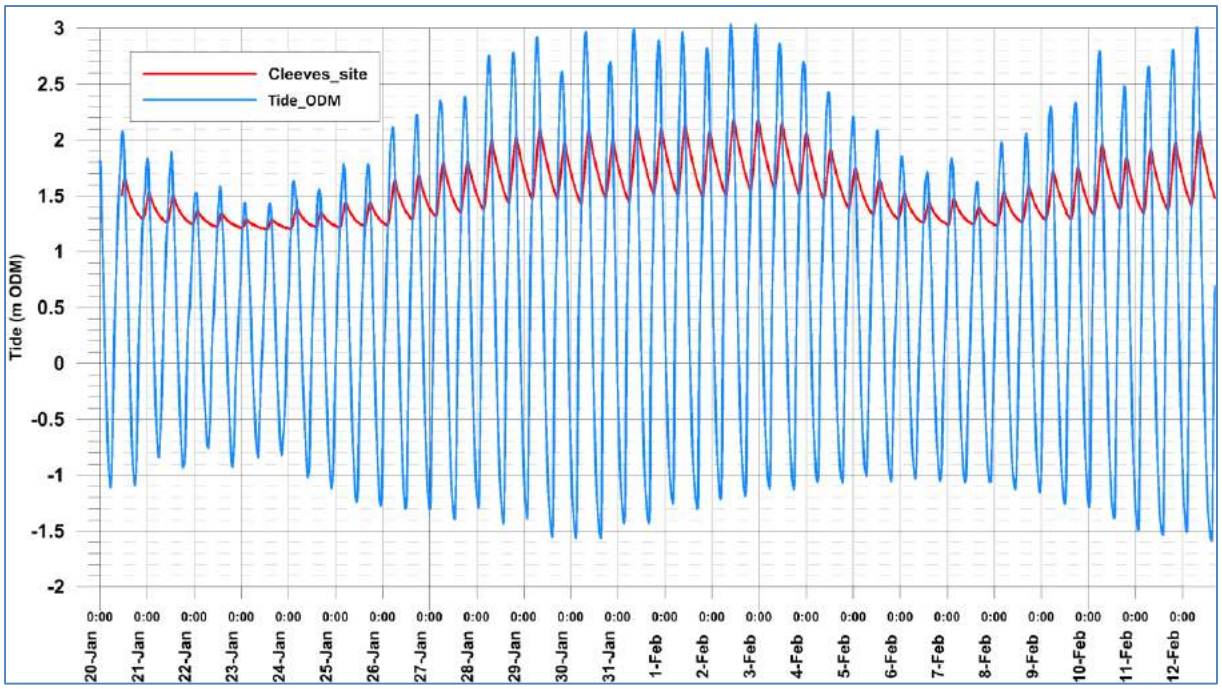


Figure 2 – Water level variations in the lagoon and Limerick Docks over the period 20th Jan to 12th Feb.

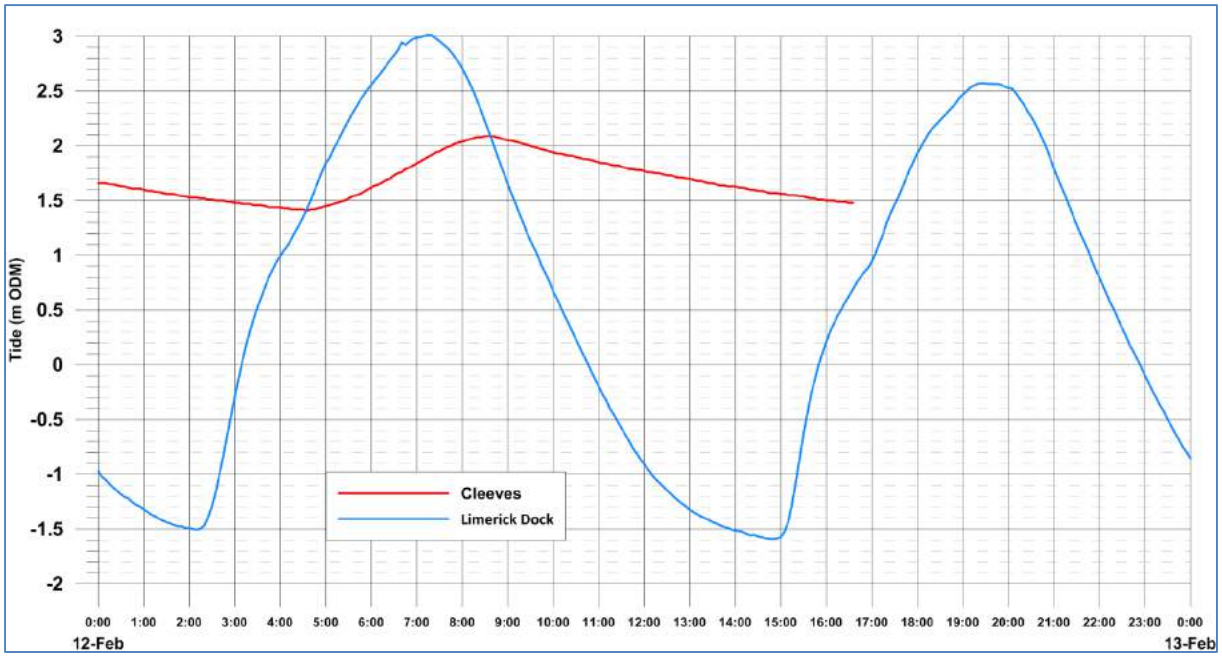


Figure 3 – Water level variations in the Cleeves lagoon and at Limerick Docks during the survey works on 12th Feb.

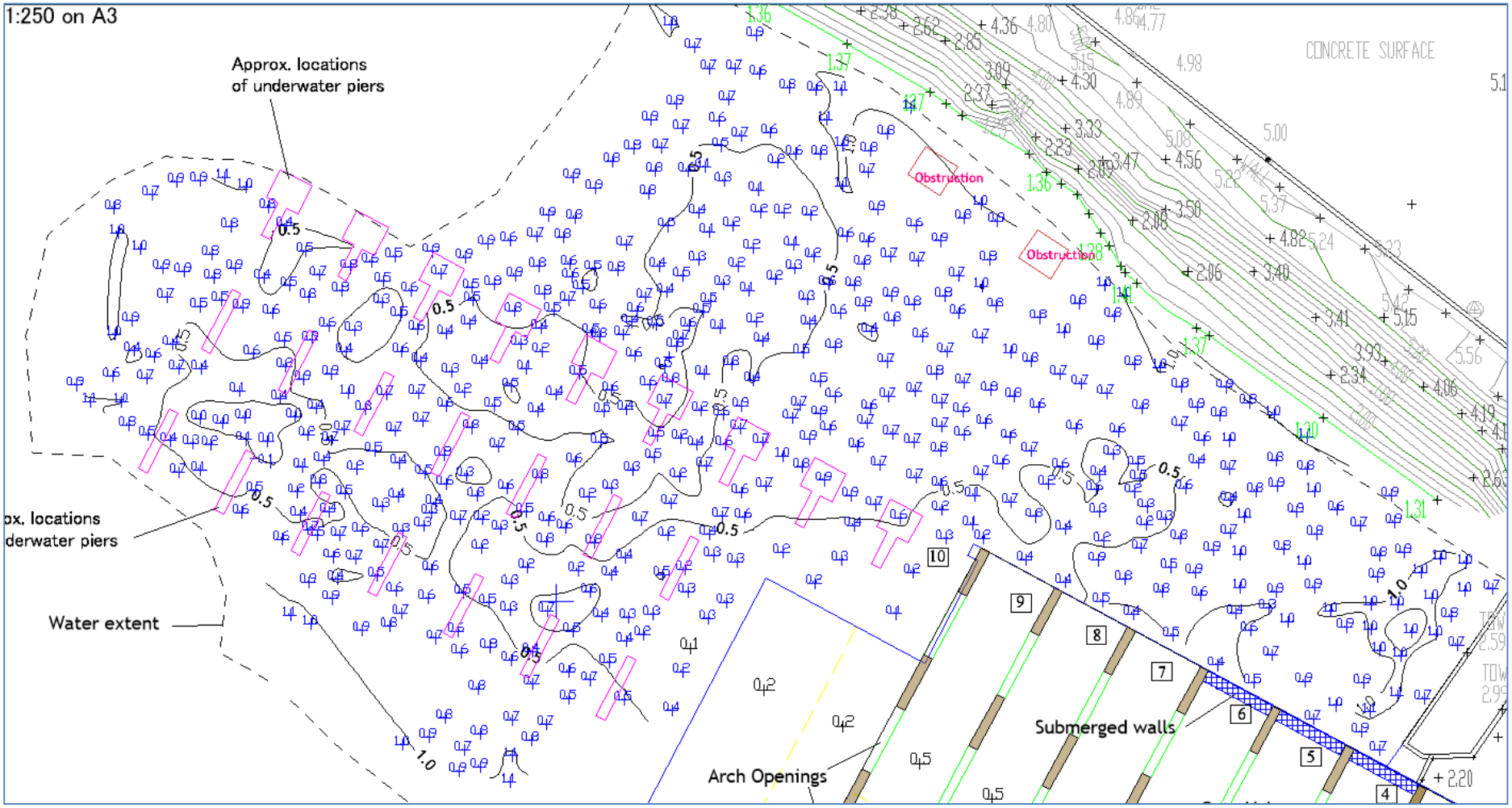


Figure 4 - Open water bathymetric survey area

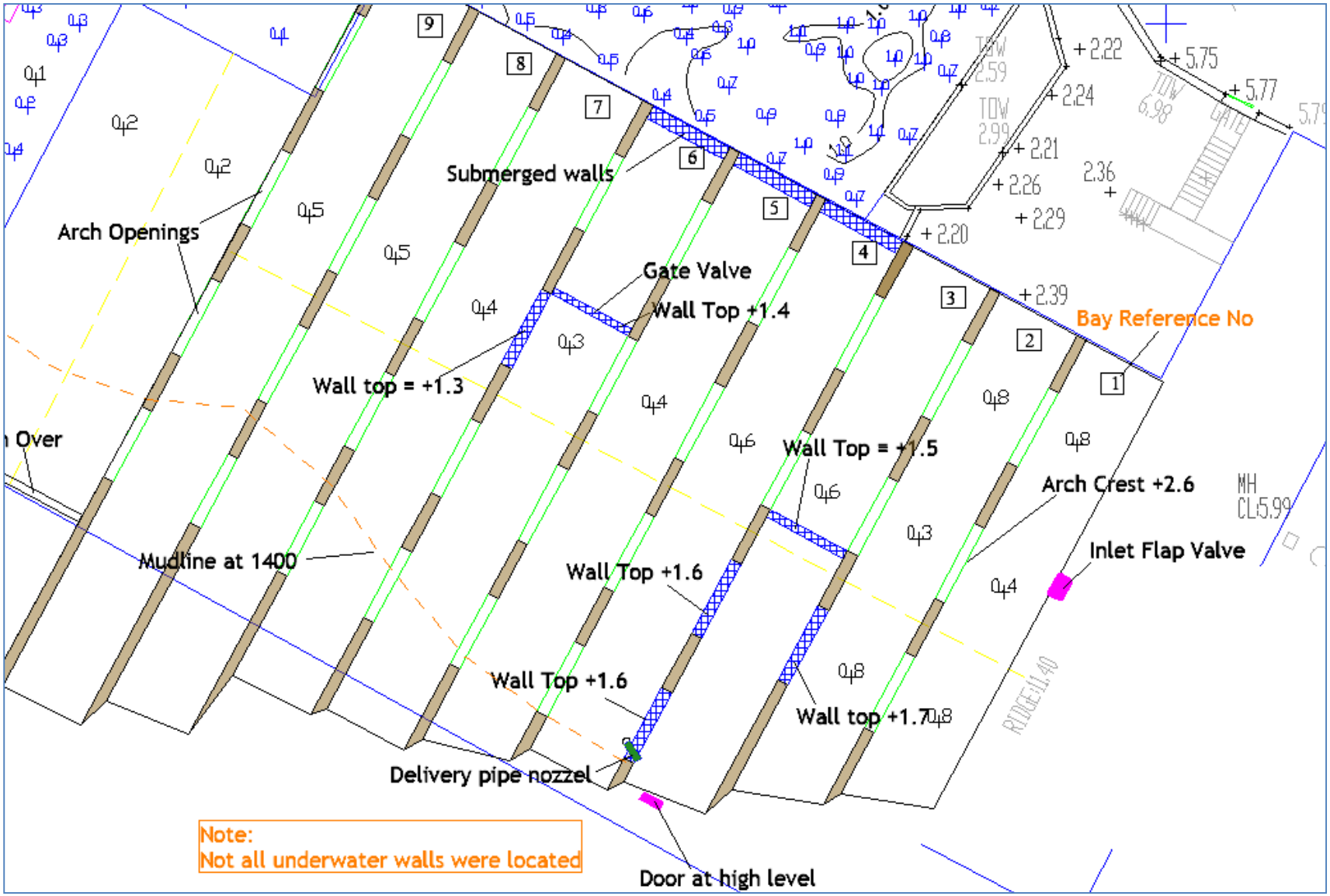


Figure 5 – Area under building

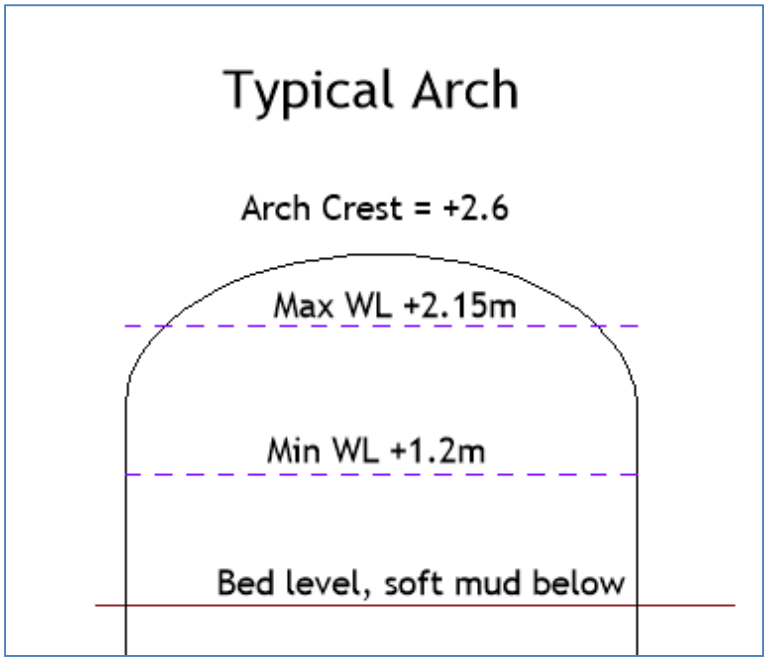


Figure 6 – Typical under-building arch dimensions (Max and min water levels are based on Figure 1)

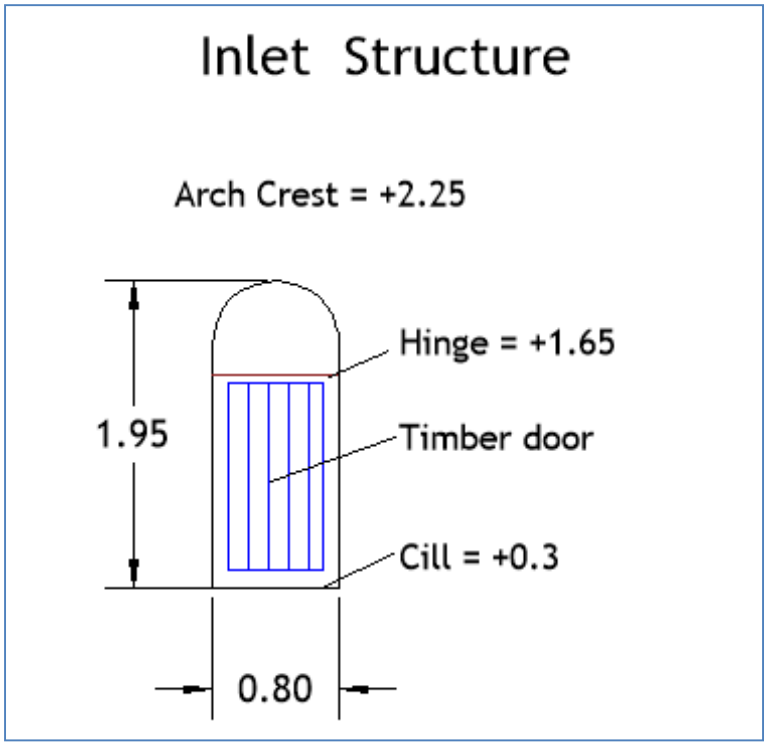


Figure 7 – Inlet water structure dimensions (waters were observed to be flowing in and out at this location during the survey, the underwater condition of the door is not known)

Photo 1 – Inlet flap valve located in recessed arch on south eastern wall in Bay 1

Photo 2 – End wall of Bay 1 constructed on limestone rock

Photo 3 – End wall of Bay 3 showing arched passage way above limestone rock

Photo 4 – Delivery pipe nozzle in Bay 4, pointed into Bay 3, submerged wall visible

Photo 5 – Gate valve in Bay 6, rectangular ope below

Photo 6 – Bay 10

Scale 1:250 on A3

Approx. locations of underwater piers

Approx. locations of underwater piers

Water extent

Obstruction

Obstruction

CONCRETE SURFACE

CONCRETE SURFACE

TARMAC SURFACE

Arch Openings

Submerged walls

Gate Valve

Wall Top +1.4

Wall top = +1.3

Arch Over

Wall Top = +1.5

Arch Crest +2.6

Bay Reference No

Inlet Flap Valve

Mudline at 1400

Wall Top +1.6

Wall Top +1.6

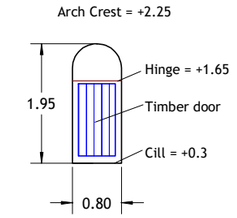
Wall top +1.7

Delivery pipe nozzel

Door at high level

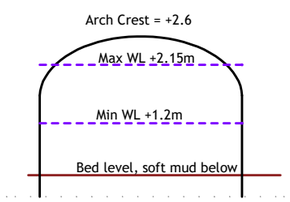
Note:
Not all underwater walls were located

Inlet Structure



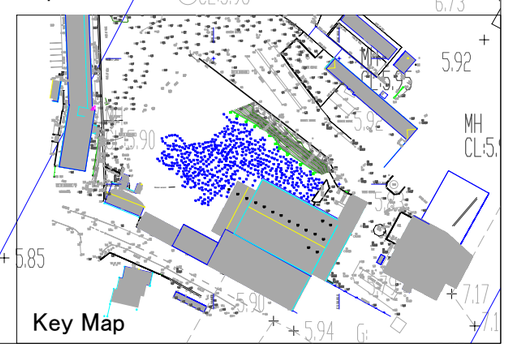
Scale 1:100

Typical Arch



Scale 1:100

N 657,200



No.	Revision	Drg. by	Chk. by
0	First issue	TFB	JFW

Grid: ITM | Vertical Datum: OSGM15

0m 5m 10m 15m 20m 25m

Scale: 1 : 250

Client:

Rogerson Reddan,
Park House,
Arthurs Quay,
Limerick

Drg by: TFB | Chk by: JFW | App. by: JFW

Scale 1:500 (A3) | Survey Date: February 12th 2021

Drawing No. 1374-01

Revision 0

Surveyed by:

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www.hydrodata.ie
T +353 (021) 4311255

Project:

Cleeve's site, Limerick City

Title:

Reservoir Survey

Notes:

1. Levels are in metres and decimetres.
2. Position of levels in reservoir are at decimal point in number.
3. Survey is mapped to Irish Transverse Mercator (ITM).
5. Levels are referred to OSGM15.
6. Water Level data from gauge on site.