	• Monitoring and maintenance of stored plants; • Direct transfer of removed material to other ditch/es, as may be agreed with NPWS; • Transfer of stored material to suitable habitat, as may be agreed with NPWS; • Monitoring, maintenance of transferred plants; • Management of habitat for the species; • In-filling of ditch following rescue translocation of protected species. Others actions, as may be agreed with NPWS	

Dated 25th July 2019

For the Minister for Culture, Heritage and the Gaeltacht

National Parks & Wildlife Services LICENCE

Conditions

1) All conservation work connected with *Groenlandia densa* and its habitat to follow and implement the strategies, methods and actions described in the report "*Section 21 Application.* Groenlandia densa *Methods Statement. March 2019*. Unpublished report to NPWS, in support of Section 21 Licence application prepared by Denyer Ecology" its two appendices A&B and the finalised detailed translocation plan (see condition 2), below) and any subsequent modifications to these as may be proposed and agreed with the National Parks and Wildlife Service of the Department of Culture, Heritage and the Gaeltacht (NPWS).
2) The detailed translocation plan noted in sections 2.3.1 and 2.3.3 of the above report to be finalised in agreement with NPWS and incorporated with a finalised *Methods Statement* report into a *Conservation Management Plan* for the species at the site, in advance of commencement of any of the works covered by this licence – this plan to include finalised details of actions to be undertaken and the order and timeline for these.
3) Reports detailing progress, the results of surveys/monitoring/maintenance/management as well as recommendations for additional or modified management/remedial measures as may be required to ensure the survival of the species, to be provided to NPWS 6-monthly in the first two years following commencement of the works and annually for the three years post translocation.
4) All work directly on *Groenlandia densa* to be carried out by a qualified botanist with expertise in rare vascular plants and familiarity with the protected species and the site.

5) On expiry of this licence a return should be sent to Wildlife Licensing Unit, National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, 90 North King Street, Smithfield, Dublin 7, DO7 N7CV, whether or not this licence was used.
6) This licence shall be produced for inspection in a request being made in that behalf by a member of An Garda Síochána or any person appointed by the Minister for Culture, Heritage and the Gaeltacht, under Section 72 of the Wildlife Acts 1976 to 2018, to be an authorised person for the purposes of the Acts.
7) Any query in relation to this licence should be made to Wildlife Licensing Unit, National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, 90 North King Street, Smithfield, Dublin 7, DO7 N7CV. Telephone: 01 8883298.

Note: This permission does not confer right of access to any lands – permission from landowners should be sought prior to carrying out work

Wildlife Licensing Unit,
National Parks and Wildlife Service,
Department of Culture, Heritage and the Gaeltacht,
90 North King Street,
Dublin 7

Section 23 (7)(iv) Application - Badger *Meles meles*

Our Ref:2015s3353 - Section 23 (7)(iv) Application v0.1

2nd August 2019

Application of Licence to Interfere with or Destroy the Breeding Places of Any Wild Animals

1 BACKGROUND

Ms. Jean Hamilton (Senior Ecologist with JBA Consulting) is applying for a 'Licence to Interfere with or Destroy the Breeding Places of Any Wild Animals' under Section 23 (7)(iv) of the Wildlife Act 1976 as amended in relation to Badger *Meles meles* on King's Island, Limerick City.

1.1 Project

King's Island is historically susceptible to both tidal and fluvial flood risk. The island and surrounding area were badly flooded in early 2014 when an extremely high tide overtopped the embankments around the Island and caused them to fail in one location. Further flooding was experienced in 2016 as a result of another storm surge event in the Shannon Estuary. This flooding was confined to Merchants Quay, as the sandbags around the island contained the tidal surge.

A major improvement on the existing temporary flood defences is required to reduce the frequency of extreme events which inundate the island, which is why King's Island Flood Relief Scheme, led by Limerick City and County Council is proposed. This scheme will be designed to provide protection to properties in the study area from the 1 in 200-year tidal flood event (0.5% AEP event).

1.2 Badger records within the site

A mammal survey was carried out by Ecologists Jean Hamilton, BSc MSc MCIEEM and Hannah Mulcahy BSc MSc on 1st May and the 15th May 2019; this is outside the optimal season for badger surveys, but there were no major constraints. During a survey conducted on the 1st May 2019, several mammal burrows were found along the southern boundary of the marsh habitat on King's Island, north side of the football pitches, directly adjacent to the drainage ditch (Figure 1). The site was resurveyed by Jean and Hannah on the 15th May and several mammal burrows were noted on this bank.

A trail camera was deployed at the site for a week, and a badger was recorded on the camera on the 8th June 2019.

It is of note that this site is liable to flooding, which can be seen in attached photos from the survey in January 2017. This indicates that the badger sett is used only on a temporary, seasonal basis.

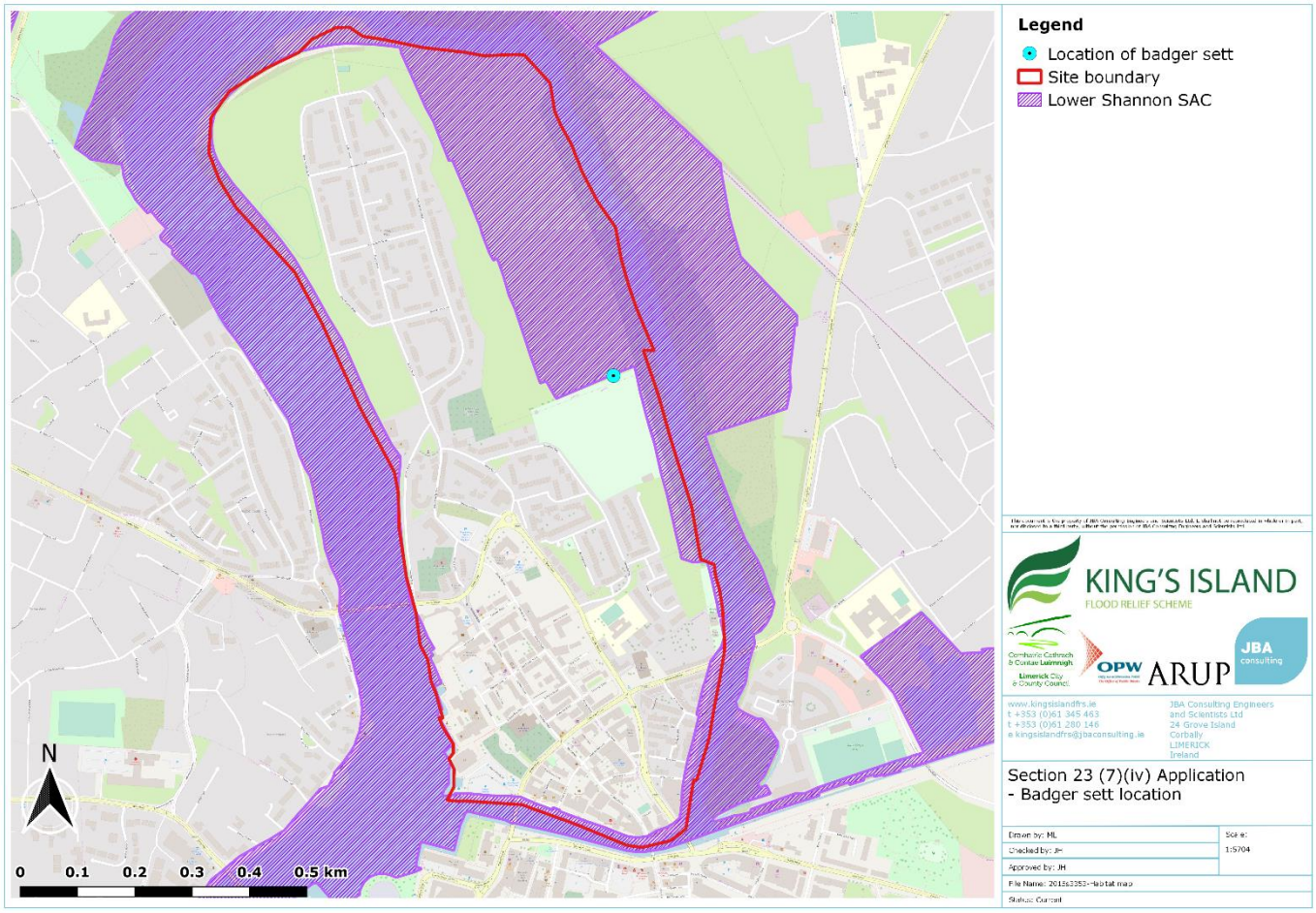

Figure 1: Location of badger sett on King's Island

Figure 2: Mammal holes are located along treeline above ditch

Figure 3: Mammal holes.

Figure 4: Mammal holes from survey in May 2019. Sticks being placed in entrance to monitor activity.

1.3 Disturbance to Badgers

Construction of new embankment to the south of marsh habitat may result in damage to the badger sett, which could have an effect on the badger population in this area.

1.4 Relevant experience

Jean Hamilton is a senior ecologist, with over twelve years' experience in environmental consultancy and has been a full member of the Chartered Institute of Ecology and Environmental Management (CIEEM) since 2014. Since 2007, Jean has worked on major infrastructural developments such as road schemes, which involved surveying over large areas to identify the presence of protected mammal species such as badgers and otters. She is highly skilled in the identification of field signs of badger, otter and other protected mammal species, and is competent in the use of trail cameras to monitor activity. She has also worked on the design and implementation of mammal mitigation on major infrastructural developments, including sett exclusions, supervision of sett destruction and construction of artificial badger setts.

2 PURPOSE OF LICENCE

A licence is applied for in order to undertake exclusion and destruction of a badger sett which is within the works area of the flood relief scheme. The sett lies in an area where a flood bund is being constructed and the works may result in collapse of tunnels which may result in badger injuries or mortalities if it is not excluded prior to the commencement of works.

2.1 Sett exclusion

Sett exclusion will be carried out during the period July 2019 - November 2020. Sett entrances will first be monitored for activity using sticks, sand pads or trails cameras, or a combination of methods. If sett entrances have not been in use for five days, they will be soft-blocked using vegetation and a light application of soil, and left for a further five days to confirm that the sett is unoccupied. If all entrances remain undisturbed for five days, the sett will be destroyed immediately, under the supervision of the named ecologist on the licence.

If the sett entrances are showing signs of current use, it will be assumed that badgers are present in the sett and they will have to be excluded prior to sett destruction. Badgers will be excluded from the sett by installing one-way gates and exclusion fencing at the entrances, to allow badgers to exit the sett but not re-enter. Following installation, the gates will be tied open for three days before they are set to exclude. The gates will then be left in place for a minimum of 21 days before the sett is deemed unoccupied. Regular visits will be carried out to check that the gates haven't been interfered with; if the sett exclusion shows signs of interference, the exclusion gates/fencing will be repaired, and the 21-day monitoring period will begin again.

2.2 Sett destruction

Provided there is no sign of current occupation, the sett will be destroyed under the supervision of the named ecologist on the licence immediately following the 21-day exclusion period.

Sett destruction will be carried out using a tracked 12-25 tonne digger. As the sett entrances open out into a drain to the north of the sett, it will not be feasible to work from the outside in. Therefore, the work will be carried out from the eastern side and/or the western side, starting from c. 25m from the outermost hole, working inwards towards the core of the sett. Once it is ensured that badgers are not present in the sett, the core will then be destroyed and the area back-filled.

If the supervising ecologist sees a badger at any time, the works will be stopped immediately and NPWS will be informed.

2.3 Other mitigation

The sett is a small outlier; it is in an area prone to flooding and so would only be used seasonally and is not presumed to be used during the breeding season. After the works have been completed, the bank will remain and this may be used for sett digging.

Therefore, the loss of the sett is not expected to have a significant effect on the local badger population, and so it is not considered necessary to construct an artificial sett.

3 POST-CONSTRUCTION

3.1 Reporting

Following the completion of works, a report will be prepared outlining the works carried out. This will include photos of the sett exclusion and destruction. The report will be sent to NPWS.

Yours faithfully,

Jean Hamilton
For and on behalf of JBA Consulting Engineers & Scientists Limited

BSc (Hons) MSc MCIEEM
Senior Ecologist
Jean.hamilton@jbaconsulting.ie

Encs.

An Roinn Cultúir,
Oidhreachta agus Gaeltachta
Department of Culture,
Heritage and the Gaeltacht

Jean Hamilton (Senior Ecologist with JBA Consulting)
JBA Consulting Engineers and Scientists Ltd.
24 Grove Island
Corbally
Limerick
Jean.Hamilton@jbaconsulting.ie

16/08/2019

Re: application to interfere with the breeding and resting places of badger *Meles Meles* under Section 23(5)(D) of the Wildlife Acts 1976 to 2012 for **King's Island Flood Relief Scheme**.

Dear Mr Ms agent

Further to application of **Limerick City and County Council** to destroy / disturb badger setts within the area proposed for works at **King's Island**, the Department of Culture, Heritage and the Gaeltacht (National Parks and Wildlife Service), does not oppose the works needed provided that:

1. No active setts (in any category) can be interfered with or disturbed during the badger breeding season (December to June inclusive).

2. Any badgers injured as a result of the works (either at the sett or during construction) must be reported to the local NPWS Conservation Ranger, **Ciara Powell, ciara.powell@chg.gov.ie .**

3. A report detailing any relevant issues must be submitted to the NPWS following completion of the works.

4. In order to minimize disturbance to badgers in the vicinity of the proposed works the mitigation (**Section (7)(iv) Application – Badger *Meles meles*, 2. Purpose of Licence, pp 5-6**) must be adhered to in full.

5. The works will be supervised by a qualified scientific agent(s): **Jean Hamilton BSc MSc MCIEEM, JBA Consulting.**

6. All works are to be undertaken in accordance with the Guidelines for the Treatment of Badgers prior to the Construction of National Road Schemes (http://www.tii.ie/tii-library/environment/construction-guidelines/Guidelines-for-the-Treatment-of-Badgers-prior-to-the-Construction-of-a-National-Road-Scheme.pdf).

7. The licensee shall, within 14 days of completion of the actions which this licence authorises, submit a written report to the address below, describing the activities carried out in pursuance of works requested.

8. NPWS Conservation Ranger, **Ciara Powell** must be contacted giving one week's notice before works commenced with the vicinity of the badger setts.

If you have any queries about this letter, please contact **Pádraig Shortt**, padraig.shortt@chg.gov.ie, 01-8883256.

Yours sincerely

Gabriel Staunton
Wildlife Licencing Unit

An Roinn Cultúir, Oidhreachta agus Gaeltachta
Department of Culture, Heritage and the Gaeltacht
An tSeirbhís Páirceanna Náisiúnta agus Fiadhúlra
National Parks and Wildlife Service
90 Sráid an Rí Thuaidh, Margadh na Feirme, Baile Átha Cliath 7, D07 N7CV
90 King Street North, Smithfield, Dublin 7, D07 N7CV

T +353 (0)1 888 3253| www.npws.ie

Roinn Cumarsáide, Gníomhaithe
ar son na hAeráide & Comhshaoil
Department of Communications,
Climate Action & Environment

DEPARTMENT OF COMMUNICATIONS, CLIMATE ACTION AND ENVIRONMENT

CERTIFICATE OF AUTHORISATION UNDER SECTION 14 OF THE FISHERIES (CONSOLIDATION) ACT, 1959 AS SUBSTITUTED BY SECTION 4 OF THE FISHERIES (AMENDMENT) ACT, 1962.

The Minister for Communications, Climate Action and Environment in exercise of the powers conferred on him by Section 14 of the Fisheries (Consolidation) Act, 1959 as substituted by Section 4 of the Fisheries (Amendment) Act, 1962 hereby authorises: Ross Macklin, Senior Ecologist & Fisheries Scientist, Triturus Environmental Services, 42 Norwood Court, Rochestown, Cork (and or person(s) nominated by him to undertake a depletion survey at four locations at King's Island, Limerick City for the King's Island Flood Relief Scheme.

This authorisation is granted subject to the following conditions:

1. **This authorisation shall not confer on the holder thereof, independently of the conditions therein;**

   (a) **any rights or title which the holder would not have had if this authorisation had not been given, or;**

   (b) **any authority in any way to interfere with or infringe the lawful rights of any other person.**

2. **This authorisation is issued to and valid for use by Ross Macklin and or person(s) nominated by him.**

3. **This authorisation is valid to 30 September 2019.**

Teach Leamháin, Bóthar Ghleann an Iarla, An Cabhán, H12 A8H7
Elm House, Earlsvale Road, Cavan, H12 A8H7
T +353 1 678 2000 | 1890 44 99 00
www.dccae.gov.ie

4. Electro-fishing should be carried out between July 1st and September 30th when juvenile salmonids (if present) are of a sufficiently large size to be caught by electric fishing, to minimize damage and for them to be distinguished from similar species (refer to CEN (2001) and CFB (2008) 'Electric Fishing in Wadeable Reaches' manual).

5. The consultant should be mindful of other listed species that might be encountered during the electrical fishing exercise. The planned work is to take place within an SAC. If not already done so, it would be prudent to contact NPWS to inform them of the proposed survey and to seek their permission.

6. The applicant is aware of biosecurity concerns and must adhere to the Biosecurity Protocol for Field Survey Work, whereby equipment must be disinfected prior to and after use to prevent the spread of disease, parasites or invasive species (http://www.fisheriesireland.ie/Biosecurity/biosecurity-protocol-for-field-survey-work.html) and as directed by an officer of IFI.

7. The consultants should be mindful of the potential occurrence of invasive alien species, either in the watercourse being surveyed or in the adjoining riparian zone. Extra care should be taken to ensure that plant fragments and seeds of invasive balsam and knotweed species are not inadvertently transported on clothing, footware or equipment. It would be very helpful if the consultant could record presence of such species, along with geo-reference and indication of extent of occurrence, in report material submitted to IFI. If possible, surveying should commence at the uppermost site and proceed sequentially downstream.

8. The applicant and agents should desist, to the greatest extent possible, from walking in the general instream area and to avoid walking on instream gravelled areas if present, thereby limiting adverse impact to intra-gravel life stages of salmonids and other species.

9. The electro-fishing must be carried out only by nominated personnel with training and experience in such operations. All electric fishing equipment must be available for inspection by an IFI officer during each survey

10. The Director of the Shannon River Basin District and the appropriate Fisheries Inspector should be informed of exact date, location and scope of the planned survey, five working days prior to survey start. Contact details are as follows:

    Ms Amanda Mooney, Shannon River Basin District, Ashbourne Business Park, Dock Road, Limerick, V94 NPE0 Phone: 061 300238; Fax: +353 (0)61 300308

    Email: Limerick@fisheriesireland.ie / amanda.mooney@fisheriesireland.ie

11. All equipment must be available for inspection by an IFI officer during the survey.

12. In the event that the proposed survey is cancelled the relevant IFI office should be notified, initially by telephone and subsequently by e-mail. An indication of the proposed re-commencement date of the survey operation should also be advised.

13. The applicant should seek permission from fishery owners and informs local angling clubs of their plans for the surveys where relevant. The applicant must also seek permission from landowners to cross land, where relevant.

14. Electric fishing operations must be carried out during suitable weather and flow conditions.

15. No fish of any species should be sacrificed during the surveys. The number of fish killed (if any) is to be kept to an absolute minimum and IFI Limerick and Citywest are to be informed of any fish mortalities immediately after the survey. Details including the county, site number, river name, townland, Irish grid reference, and the species and numbers killed shall be communicated to IFI Limerick by telephone and a subsequent e-mail, for the attention of Michael Fitzsimons, Senior Environmental Officer.

16. A standard template for reporting survey data to IFI is attached. A survey report and qualitative/quantitative data (in the attached standard IFI format) must be provided, within 30 days of completion of the survey, in electronic format to Sandra Doyle (Sandra.Doyle@fisheriesireland.ie). These data will not be made publically available, for a period of 3 years, without the permission of the applicant.

17. When doing anything pursuant to this authorisation, the holder shall, if requested by any person affected, produce this authorisation to that person.

18. Failure to comply with any of the conditions of this authorisation may result in revocation of this authorisation.

19. The holder of this authorisation shall indemnify and keep indemnified the State, the Minister for Communications, Climate Action and Environment and the Minister for Finance against any claims, arising in any manner whatsoever in connection with the user of the fishing gear or in the exercise of the permission hereby granted.

20. Notwithstanding the foregoing, this authorisation may be revoked or amended by the Minister for Communications, Climate Action and Environment without the payment of compensation to the holder on giving one week's notice in writing to the holder if he considers it necessary in the public interest to do so.

Dated this 05 September 2019

For the Minister for Communications, Climate Action & Environment

Gerry Clerkin
An officer authorised on that behalf by the said Minister

IFI Biosecurity Protocol for Field Survey Work

December 2010

Iascach Intíre Éireann
Inland Fisheries Ireland

Biosecurity Protocol for Field Survey Work

Invasive species are an ever present threat in our aquatic and riparian systems and it is imperative that none of our field operations exacerbate the risks to the environment and to the economy that are posed by these species. Fish parasites, pathogens and diseases also represent a significant threat to the health status of our watercourses. The introduction or transfer of such pathogens or diseases has the potential to wipe out large populations of fish in affected waters or catchments. Vigilance is required if we are to stop the spread of invasive species and fish diseases, and it is imperative that we in IFI lead by example in the ongoing struggle against these significant threats to our fishery watercourses.

The need for basic biosecurity in our fisheries operations must become ingrained in the psyche of our staff if we are to do our part to stop the spread of hazardous invasive species and fish pathogens. Much to do with biosecurity involves awareness, common sense and agreed procedures. Listed below are some basic procedures that must be implemented when conducting field survey work.

Each field vehicle must carry a 'disinfection box'. This should contain Virkon Aquatic or another proprietary disinfectant, a spray bottle, cloths or sponges, a scrubbing brush and protective gloves.

On completion of any field operation, all equipment used must be treated according to the procedures listed below. Equipment in this respect includes the following:
boats, trailers, outboard motors, anchors and rope, weights, tanks, buckets and bins, all PPE (including boots, wellingtons, waders, wetsuits, dry suits, waterproof clothing, life jackets, diving apparatus, etc.) and any technical or sampling apparatus used as part of the survey. Protective gloves must be worn when using any disinfectant solution in any of the procedures listed below.

- Visually inspect all equipment that has come into contact with the water for evidence of attached plant or animal material, or adherent mud or debris. This should be done before leaving the site.

- Remove any attached or adherent material (fish, fish scales, vegetation and debris) before leaving the site of operation.

- Ensure that all water is drained from boats, live wells and other water retaining compartments, outboard motors, tanks and other equipment before transportation elsewhere.

- High-pressure steam cleaning, with water > 40 degrees C, is recommended for boats (including oars, row locks, attachment ropes, anchors and buoys), trailers and outboard motors that are being moved from one watercourse to another. Many roadside garages provide these facilities. If it is not possible to steam clean the equipment, a normal power hose must be used. After cleaning visually inspect the equipment to ensure that all adherent material and debris has been removed.

- It is recommended to apply disinfectant, using the spray bottle from the 'disinfection box', to the undercarriage and wheels of the vehicle and trailer after steam cleaning or power hosing.

- Wet or live wells and other water retaining compartments in survey boats must be cleaned, rinsed or flushed with a 1% solution of Virkon Aquatic or another proprietary disinfection product. Alternatively, a 5% solution (100 ml / 20 litre solution) of chlorine bleach should be used. Rinse thoroughly with clean water.

- Tanks that are used to stock or transfer live fish should be thoroughly washed with a 1% solution of Virkon Aquatic or another proprietary disinfection product. Alternatively, a 5% solution (100 ml / 20 litre solution) of chlorine bleach should be used. All disinfected equipment must be thoroughly rinsed with clean water.

- Outboard motors should be flushed with a 1% solution of Virkon Aquatic or another proprietary disinfection product, or with water > 40 degrees C. Alternatively, a 5% solution (100 ml / 20 litre solution) of chlorine bleach should be used. Facilities will be provided at IFI stores countrywide to accommodate this operation.

- Nets (to include monofilament and braided gill nets, fyke nets and seine nets) must be cleaned of all vegetation and debris before returning to base. The clean nets must then be placed in a freezer for a period of four days (3 days will suffice for monofilament nets). Following this treatment the nets must be soaked in a 1% solution of Virkon Aquatic or a proprietary disinfectant for a period of not less than 15 minutes and thoroughly rinsed thereafter. Where these proprietary disinfectants are not available the nets must be soaked in a 5% solution (100 ml / 20 litre solution) of chlorine bleach for 1 hour and thoroughly rinsed after.
  An SOP on 'Management and Disinfection of Survey Nets' is available on request from IFI Swords.

- Footwear should be dipped in or scrubbed with a disinfectant solution (e.g. 1% solution of Virkon Aquatic or another proprietary disinfection product) and thoroughly dried afterwards.

- All PPE should be visually inspected and any attached vegetation or debris removed. Where appropriate, the gear should be wiped down with a cloth soaked in 1% solution of Virkon Aquatic or another proprietary disinfection product. Alternatively, a 5% solution (100 ml / 20 litre solution) of chlorine bleach should be used. Rubber gloves must be worn when undertaking this procedure.

- Sampling equipment (e.g. electrofishing electrodes and cable, grab samplers, meter sticks, buckets and bins, etc.) must be cleaned, rinsed or wiped down with or dipped in a suitable disinfectant solution.

- Landing nets and hand nets must be dipped in disinfectant solution and rinsed in clean water.

- All field equipment must be suitably disinfected before being returned to the IFI Swords warehouse for storage. Staff will be requested to sign a prepared form detailing the nature of the disinfection process carried out and the date on which this was conducted.

Note
Disinfectants must be used with care and in strict accordance with the manufacturer's instructions. They must be disposed of safely and never in close proximity to open waters,

For additional information, please contact:

Dr Joe Caffrey
Senior Research Officer

Inland Fisheries Ireland, Swords.
01 8842600

Inland Fisheries Ireland
Swords Business Campus,
Swords,
Co. Dublin,
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Tel: +353 1 8842 600
Fax: +353 1 8360 060

D Surface and Groundwater

D1 Hydrogeological Summary

D2 Groundwater Testing Results

King's Island Site Investigation
Groundwater testing results

Chemtest Job No.:					16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	S.I. No. 9
Client Sample ID.:					BH106	SW01	BH114	BH105	BH107	BH113	BH111	Overall
Sample Type:					WATER	WATER	WATER	WATER	WATER	WATER	WATER	Threshold
Date Sampled					22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	Values
Determinand	Accred.	SOP	Units	LOD								
pH	U	1010	N/A		7.7	8.3	7.7	7.9	7.5	7.7	7.7	-
Electrical Conductivity	U	1020	µS/cm	1	630	410	1000	570	920	630	580	800-1875
Suspended Solids at 105C	U	1030	mg/l	5	7200	130	25000	47	4600	860	400	-
Total Dissolved Solids	N	1040	mg/l	1	380	250	600	340	550	380	350	-
Biochemical Oxygen Demand Low Level	N	1090	mg O2/l	1	[B] 4.0	[B] 1.0	[B] 2.0	[B] 1.0	[B] 1.0	[B] -.0	[B] -.0	-
Chemical Oxygen Demand	U	1100	mg O2/l	10	-	29	18	13	12	12	10	-
Dissolved Oxygen	N	1150	mg O2/l	0.5	8.1	8.1	6.7	9.1	7.6	7.7	7.4	-
Dissolved Oxygen	N	0.5	% saturation	0.5	89	89	74	100	84	85	81	-
Redox Potential	N	1170	mV	N/A	530	520	510	600	580	610	620	-
Alkalinity (Total)	U	1220	mg CaCO3/l	10	240	200	420	250	300	240	240	-
Chloride	U	1220	mg/l	1	20	23	28	22	39	20	21	24-187.5
Ammoniacal Nitrogen	U	1220	mg/l	0.01	0.51	0.14	0.93	0.23	0.39	0.33	0.64	-
Nitrate	U	1220	µg/l	500	-	2700	-	6400	-	-	-	-
Nitrate	U	1220	mg/l	0.5	-	2.7	-	6.4	-	-	-	37.5
Phosphate	U	1220	µg/l	50	-	-	-	-	-	-	-	-
Phosphate	U	1220	mg/l	0.05	-	-	-	-	-	-	-	-
Sulphate	U	1220	mg/l	1	19	13	120	18	110	19	16	187.5
Calcium	U	1415	mg/l	5	72	72	52	90	130	85	81	-
Potassium	U	1415	mg/l	0.5	1.1	1.7	3.4	1.5	5.5	1.1	0.73	-
Magnesium	U	1415	mg/l	0.5	21	7.3	9.1	25	30	24	20	-
Sodium	U	1415	µg/l	500	13000	9100	180000	16000	24000	13000	13000	-
Sodium	U	1415	mg/l	0.5	13	9.1	180	16	24	13	13	150
Arsenic (Dissolved)	U	1450	µg/l	1	5.3	-	4.1	-	2.3	2.9	2.2	7.5
Barium (Dissolved)	U	1450	µg/l	5	400	45	47	77	72	170	280	-
Cadmium (Dissolved)	U	1450	µg/l	0.08	-	-	-	-	-	-	0.13	3.75
Chromium (Dissolved)	U	1450	µg/l	1	1.5	-	2.6	6.6	2	-	1.7	37.5
Copper (Dissolved)	U	1450	µg/l	1	-	1.2	2.1	-	-	-	-	1500
Iron (Dissolved)	N	1480	µg/l	20	300	230	180	250	480	270	290	-
Manganese (Dissolved)	U	1450	µg/l	1	630	6.9	140	2.9	1800	160	600	-
Molybdenum (Dissolved)	U	1450	µg/l	1	1.2	-	4.5	-	1.5	3.3	1.9	-
Nickel (Dissolved)	U	1450	µg/l	1	1.3	1.2	2.9	-	2.3	2.8	1.7	15
Lead (Dissolved)	U	1450	µg/l	1	-	-	-	-	-	-	-	18.75
Antimony (Dissolved)	U	1450	µg/l	1	-	-	-	-	-	1.7	-	-
Selenium (Dissolved)	U	1450	µg/l	1	-	-	16	4.1	2.3	1.3	-	-
Vanadium (Dissolved)	U	1450	µg/l	1	-	-	9	-	-	-	-	-
Zinc (Dissolved)	U	1450	µg/l	1	3.7	2.9	4.6	2	5	2.1	2.1	-
Mercury Low Level	U	1460	µg/l	0.01	-	-	-	-	-	-	-	0.75
Chromium (Hexavalent)	U	1490	µg/l	20	-	-	-	-	-	-	-	-
TPH >C6-C10	N	1670	µg/l	0.1	-	-	-	-	-	-	-	-
TPH >C10-C21	N	1670	µg/l	0.1	-	-	-	-	-	-	-	-
TPH >C21-C40	N	1670	µg/l	0.1	-	-	-	-	-	-	-	-
Total TPH >C6-C40	U	1670	µg/l	10	-	-	-	-	-	-	-	-
Dichlorodifluoromethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Chloromethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Vinyl Chloride	N	1760	µg/l	1	-	-	-	-	-	-	-	-

King's Island Site Investigation
Groundwater testing results

Chemtest Job No.:					16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	S.I. No. 9
Client Sample ID.:					BH106	SW01	BH114	BH105	BH107	BH113	BH111	Overall
Sample Type:					WATER	WATER	WATER	WATER	WATER	WATER	WATER	Threshold
Date Sampled					22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	Values
Determinand	Accred.	SOP	Units	LOD								
Bromomethane	U	1760	µg/l	5	-	-	-	-	-	-	-	-
Chloroethane	U	1760	µg/l	2	-	-	-	-	-	-	-	-
Trichlorofluoromethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,1-Dichloroethene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Trans 1,2-Dichloroethene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,1-Dichloroethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
cis 1,2-Dichloroethene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Bromochloromethane	U	1760	µg/l	5	-	-	-	-	-	-	-	-
Trichloromethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,1,1-Trichloroethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Tetrachloromethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,1-Dichloropropene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Benzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2-Dichloroethane	U	1760	µg/l	2	-	-	-	-	-	-	-	-
Trichloroethene	N	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2-Dichloropropane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Dibromomethane	U	1760	µg/l	10	-	-	-	-	-	-	-	-
Bromodichloromethane	U	1760	µg/l	5	-	-	-	-	-	-	-	-
cis-1,3-Dichloropropene	N	1760	µg/l	10	-	-	-	-	-	-	-	-
Toluene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Trans-1,3-Dichloropropene	N	1760	µg/l	10	-	-	-	-	-	-	-	-
1,1,2-Trichloroethane	U	1760	µg/l	10	-	-	-	-	-	-	-	-
Tetrachloroethene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,3-Dichloropropane	U	1760	µg/l	2	-	-	-	-	-	-	-	-
Dibromochloromethane	U	1760	µg/l	10	-	-	-	-	-	-	-	-
1,2-Dibromoethane	U	1760	µg/l	5	-	-	-	-	-	-	-	-
Chlorobenzene	N	1760	µg/l	1	-	-	-	-	-	-	-	-
1,1,1,2-Tetrachloroethane	U	1760	µg/l	2	-	-	-	-	-	-	-	-
Ethylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
m & p-Xylene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
o-Xylene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Styrene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Tribromomethane	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Isopropylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Bromobenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2,3-Trichloropropane	N	1760	µg/l	50	-	-	-	-	-	-	-	-
N-Propylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
2-Chlorotoluene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,3,5-Trimethylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
4-Chlorotoluene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Tert-Butylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2,4-Trimethylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Sec-Butylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene	N	1760	µg/l	1	-	-	-	-	-	-	-	-
4-Isopropyltoluene	U	1760	µg/l	1	-	-	-	-	-	-	-	-

King's Island Site Investigation
Groundwater testing results

Chemtest Job No.:					16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	S.I. No. 9
Client Sample ID.:					BH106	SW01	BH114	BH105	BH107	BH113	BH111	Overall
Sample Type:					WATER	WATER	WATER	WATER	WATER	WATER	WATER	Threshold
Date Sampled					22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	Values
Determinand	Accred.	SOP	Units	LOD								
1,4-Dichlorobenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
N-Butylbenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2-Dibromo-3-Chloropropane	U	1760	µg/l	50	-	-	-	-	-	-	-	-
1,2,4-Trichlorobenzene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
Hexachlorobutadiene	U	1760	µg/l	1	-	-	-	-	-	-	-	-
1,2,3-Trichlorobenzene	U	1760	µg/l	2	-	-	-	-	-	-	-	-
Methyl Tert-Butyl Ether	N	1760	µg/l	1	-	-	-	-	-	-	-	-
N-Nitrosodimethylamine	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Phenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Chlorophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Bis-(2-Chloroethyl)Ether	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Methylphenol (o-Cresol)	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Bis(2-Chloroisopropyl)Ether	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Hexachloroethane	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
N-Nitrosodi-n-propylamine	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
4-Methylphenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Nitrobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Isophorone	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Nitrophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2,4-Dimethylphenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Bis(2-Chloroethoxy)Methane	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2,4-Dichlorophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
1,2,4-Trichlorobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Naphthalene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
4-Chloroaniline	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Hexachlorobutadiene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
4-Chloro-3-Methylphenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Methylnaphthalene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Hexachlorocyclopentadiene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2,4,6-Trichlorophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2,4,5-Trichlorophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Chloronaphthalene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Nitroaniline	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Acenaphthylene	N	1790	µg/l	0.5	0.9	-	-	-	-	-	-	-
Dimethylphthalate	N	1790	µg/l	0.5	0.5	-	-	-	-	-	-	-
2,6-Dinitrotoluene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Acenaphthene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
3-Nitroaniline	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Dibenzofuran	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
4-Chlorophenylphenylether	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2,4-Dinitrotoluene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-

King's Island Site Investigation
Groundwater testing results

Chemtest Job No.:					16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	16-20516	S.I. No. 9
Client Sample ID.:					BH106	SW01	BH114	BH105	BH107	BH113	BH111	Overall
Sample Type:					WATER	WATER	WATER	WATER	WATER	WATER	WATER	Threshold
Date Sampled					22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	22-Aug-16	Values
Determinand	Accred.	SOP	Units	LOD								
Fluorene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Diethyl Phthalate	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
4-Nitroaniline	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
2-Methyl-4,6-Dinitrophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Azobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
4-Bromophenylphenyl Ether	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Hexachlorobenzene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Pentachlorophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Phenanthrene	N	1790	µg/l	0.5	0.7	-	-	-	-	-	-	-
Anthracene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Carbazole	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Di-N-Butyl Phthalate	N	1790	µg/l	0.5	1	-	-	-	-	-	-	-
Fluoranthene	N	1790	µg/l	0.5	1	-	-	-	-	-	-	-
Pyrene	N	1790	µg/l	0.5	1	-	-	-	-	-	-	-
Butylbenzyl Phthalate	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Benzo[a]anthracene	N	1790	µg/l	0.5	1	-	-	-	-	-	-	-
Chrysene	N	1790	µg/l	0.5	0.6	-	-	-	-	-	-	-
Bis(2-Ethylhexyl)Phthalate	N	1790	µg/l	0.5	3	-	-	-	-	-	-	-
Di-N-Octyl Phthalate	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Benzo[b]fluoranthene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Benzo[k]fluoranthene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Benzo[a]pyrene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)Pyrene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Dibenz(a,h)Anthracene	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
Benzo[g,h,i]perylene	N	1790	µg/l	0.5	1	-	-	-	-	-	-	-
4-Nitrophenol	N	1790	µg/l	0.5	-	-	-	-	-	-	-	-
"-" indicates test result was below Limit of Detection (LOD)												

A number of geological cross sections have been produced for Kings Island in GINT, which are based on the additional information obtained in the ground investigation. The locations of these are shown on Figure 1 and the sections are presented as Sections A – D (Figures 2 – 5).

Automatic data loggers have been installed in groundwater locations around the site. These data loggers record groundwater levels at set intervals and have been moved around the site on a monthly basis to establish the relationship between surface water and groundwater in the various lithologies.

Further site survey data received has identified an outfall pipe on the eastern side of the SAC.

1.1 Summary of groundwater and surface water level data

The geology of the site comprises of overburden multi layered clay, gravel and made ground all overlying overlying limestone. Monitoring wells are designed for monitoring groundwater levels in either the subsoil or bedrock. A total of eight (8 No.) monitoring wells are set into subsoils and three monitoring wells are set in limestone (3 No.) bedrock. These water level data was recorded between May and June 2016, with between 2 and 8 records for each monitoring well (Table 1).

Monitoring well ID	**Response zone depth (mBGL)**	**Lithology**	**Depth to water (mBGL)**		**Depth to water (mOD)**	
			Average	Max	Average	Max
BH105	17 – 20	Limestone	-0.1	-0.1	2.21	2.21
BH106	5.5 – 6.5	Clay	0	0	2.16	2.16
BH107	3 – 4	Clay	0.24	0	1.88	2.12
BH108	1.5 – 2.5	Clay	2.01	1.67	1.83	2.17
BH109	4.9 – 6.1	Gravel and cobbles	0.33	0.2	2.23	2.35
BH110	7.7 – 8.7	Cobbles	1.80	1.61	2.08	2.27
BH111	5.3 – 6.3	Gravel and cobbles	0.03	0	1.85	1.88
BH113	5.5 – 6.3	Limestone	0.10	0	2.57	2.67
BH114	3.5 – 4.5	Clay	0.40	0	2.20	2.59
BH115A	7.3 – 8.3	Clay	2.19	1.86	1.59	1.92
BH115RC	16.9 – 19.9	Limestone	1.72	1.72	2.06	2.06

Table 1 Groundwater levels

Groundwater levels in the gravel and cobbles is highest in BH109 and BH110 located to the north of BH111. The hydraulic gradient extends from the north towards the south. Rising head tests in the gravel and cobbles unit indicate a permeability of between $1.3x10^{-6}$m/s and $3.5x10^{-6}$m/s.

The limestone groundwater level in the northern part of the site (BH105) is artesian and the aquifer unconfined beneath the clay. Groundwater levels in RC115A and BH113 are also confined beneath the clay as groundwater levels are lower in the adjacent clay boreholes. Groundwater levels in the limestone are higher in BH113 located further inland and to the south compared to BH105 and

BH115RC. This suggests a hydraulic gradient from the centre of the island towards the river. Groundwater levels in BH105 on both monitoring occasions were the same suggesting little fluctuation, however between three monitoring occasions in BH113 there was fluctuation. Due to the limited number of sampling occasions it is not possible to determine the influence of the tidal effect on the bedrock groundwater. Rising head tests in the bedrock at RC113 and RC115A suggest permeabilities of $1.8x10^{-6}$m/s and $9.8x10^{-5}$m/s.

Surface water levels were monitored in the Abby River, Kings Island in February 2016 (Figure 6). It is noted that the Abby River is tidal but also that these data are upstream of a weir located just before the Abbey re-joins the Shannon. Surface water data is not available for period of time between May and June 2016 (when the groundwater data was recorded).

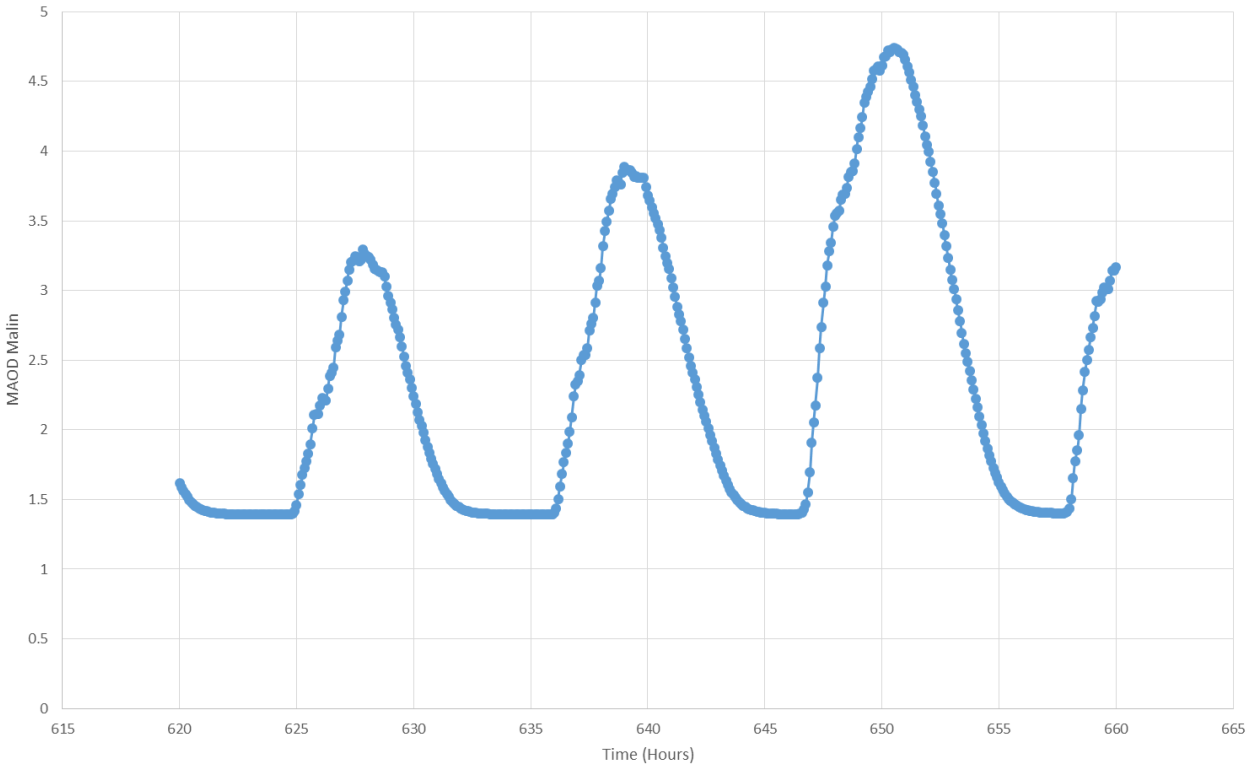

Figure 6. Hydrograph from the Abbey River, King's Island, Limerick (low tide 1.4m OD). (February 2016 data provided by JBA).

1.2 Outstanding information

Groundwater level loggers were installed in monitoring wells across the site. The data is still outstanding, as to date the compensated data has not been provided by the contractor.

2 Updated CSM

The updated conceptual site model (CSM) based on the additional information obtained during the GI is summarised below:

- The geology of Kings Island is composed of made ground and alluvial deposits (Silt, clay, sand, gravel) overlying limestone. According to geophysical profiles carried out across the site the clay and silt overlying the gravels is consistent across the site. The borehole logs and geophysical profiles suggest the clay and silt unit is by approximately 2m to over 15m thick. The gravel unit is not consistent across the site but is absent where the clay and silt directly overlies the limestone bedrock.
- The thickness and composition of the made ground is variable. Contaminated soils are likely to be present in St Marys Park (the site of an unregulated landfill).
- The depth of limestone is variable across the site. Ground investigation information shows rock head at approximately 10mbgl in the north of the site and approximately 4mbgl in the south of the site. The GSI groundwater vulnerability mapping notes an area of extreme vulnerability along the western walkway in the north west of the site indicating that rock may be present at or near the surface in this area, however the ground investigation indicated that this is not correct and that rock is up to 8mbgl in this area (BH121).
- Limited groundwater levels are available for the site at the time of this report, however, these data indicate there is a strong connection between river and groundwater level as indicated from groundwater logger data in RC01A at Verdant Place.
- Groundwater flow in the subsoils (in particular the gravels and cobbles) at Kings Island is from north to south, in the same direction as the flow of the river.
- The groundwater level data and King's River stage data show that the river and subsoils are hydraulically connected.
- There is likely to be an epikarstic layer at the top of the limestone that interconnects with groundwater flow through the subsoil. Groundwater flow will be generally be in the top 30m of the rock
- Groundwater in the limestone beneath the site is locally confined beneath the clay and highest in the centre of the site (BH113). The available data (three points) indicate that groundwater flow is likely to be radial from the centre outwards with surging effect close to the river reflecting tidal cycles.
- The upper layers of the subsoil comprise of peat, clay and silt. These low permeability subsoils will recharge to the underlying gravels and cobbles. It is suggested that water table in the underlying sands and gravels at Kings Island is a consequence of their connectivity to the surrounding rivers
- The recommended flood protection level is 5.8mOD Malin.

The SAC is of significant ecological importance. Additional commentary, specifically related to the SAC, is summarised below:

- Part of the SAC lies within the site boundaries. In the vicinity of the SAC, the site investigation illustrates that the peat / soil material is underlain by silt and clay. These in turn overlie sand / gravel and cobbles which overlie the bedrock.
- Made ground in the SAC is described as having 'tar inclusions' indicating that there may be minor contamination due to the presence of Made ground.
- Groundwater monitoring wells were installed in the limestone and the overburden to determine the interaction between these units. Available data indicates that one well (BH105) with a response zone beneath the clay (in limestone) is artesian or at ground indicating that the clay is acting as a confining unit. Shallower wells show water levels at or below ground level further illustrating this.
- The SAC is receiving recharge from rainfall which is likely to be limited from infiltrating into the underlying gravels due to the low permeability clay covering the site. Surface runoff flows towards drains which flow towards the eastern boundary of the site.
- A pipe located on the eastern side of the SAC has an invert level of 1.14 m. The water level at the time of the survey was 1.35 m. According to the survey drawing the area around the pipe is flooded and the flooding extends to the north and south adjacent to the embankment within the SAC, although the flooding to the south covers a larger area. The invert level of the flooded area generally increase to the south (from 0.39 up to 0.75 m). This suggests that the water is flowing to the lower area in the south. The hydrograph from the Abbey River shows that the river fluctuates between approx. 1.5 mOD and 4.8 mOD. As this is above the invert level of the pipe this suggests that the pipe is contributing surface water to the SAC. Once the water flows to the south, drainage is prevented by the underlying clay and the embankment resulting in the localised flooding. Removing or cutting off this pipe is likely to significantly affect the water balance of the SAC.
- During flooding events, the rate at which the groundwater levels in all the geological units will rise will be determined by the level of the flooding, the position in the tidal cycle, how saturated the deposits are and the permeability of the material.

3 Seepage analysis

The seepage assessment examines the likelihood of groundwater flooding occurring during flood levels in the River Shannon and Abbey River at the north east of the site. The existing bank conditions at the site comprise of an embankment which runs along the northern and eastern boundaries of the site and separates the river from the SAC. The model was run to determine seepage into and from the northern and eastern bank conditions of King's Island. The methodology for the seepage calculations are provided below and the results from these calculations follow.

The calculations on seepage were undertaken using Darcy's Law (Ref: Equation 1) and calculation of rate at which groundwater rises in a porous medium (Ref: Equation 2). These calculations are intended for guidance only and should not be taken as definitive.

The parameters used in the calculations are deliberately conservative.

Equation 1

$$Q = K.x.y.\left(\frac{h_1 - h_2}{L}\right)$$

Q is the calculated flow rate through the aquifer (m3/s)

K is the hydraulic conductivity of aquifer (m/day)

x is the width of the aquifer (m)

y is the thickness of the aquifer (m)

h_1 is the river flood level above the base of the aquifer (m)

h_2 is a groundwater level above the base of the aquifer (m)

L is the horizontal distance between h_1 and h_2 (m)

Equation 2

$$t = \frac{Z.x.2L.n}{Q}$$

Z is the distance between the ground level and initial groundwater level (m)

Q is the volumetric flow rate through the gravel (m3/s)

x is the width of the aquifer normal to the river (m)

2L is the width of the aquifer behind the flood defence (m)

n is the porosity of the gravel (m3/m3)

t is time (s)

The numerical modelling was undertaken using equations 1 and 2 in a spreadsheet format. Seepage is calculated as inflow from the river to groundwater when the river rises to the recommended flood protection level of 4.99mOD.

The calculations require input for aquifer parameters on hydraulic gradient, hydraulic conductivity, groundwater head and specific yield. These data were estimated from observations made in the field but also using approximations using guideline values made from literature and from experience. Hydraulic conductivity is based upon Kruseman & de Ridder Analysis and Evaluation of Pumping Test Data (2nd Ed) (1970).

Parameter		Unit	Number
Hydraulic conductivity	K	m/s	1.16×10^{-8}
River flood elevation	h	m	5.8
Groundwater elevation	h	m	2.1
Distance aquifer extends inland from flood defence	L	m	100
Specific Yield	N	ratio	0.3

Table 2. Parameters using in numerical model

The data presented in Table 1 is considered to represent a conservative representation of the values. In particular hydraulic conductivity is considered to represent the highest likely value for clay containing sand and gravel mixes. This calculation also assumes that the embankment material consists of very low permeability material and the principle flow pathway is through the clay. Furthermore, the calculations assume that the embankment height is greater than the flood height and as such overtopping is not considered.

Considering the conservative parameters chosen the seepage rate from the river to the land per m section. At this rate it would take 15 hours consistently at the flood level of 5.8 mOD for the water to breech through the clay layer on land side of embankment.

The calculation indicates that the existing embankment to the north of the SAC is sufficient to prevent flooding of the SAC.

Groundwater flooding may occur where there is a breech in the clay layer. It is unclear from the site investigations carried out to date if the clay is consistent within the central part of the SAC and beneath the houses to the west of the SAC. A cut off wall is proposed to the west of the SAC, between the houses and the SAC. This may prevent groundwater seepage through areas where the clay may be very thin of absent.

4 Summary

- The site located in the north east of Kings Island consists of clay, which is likely to be consistent across the site based on the SI information to date, over gravel overlying limestone bedrock. The low permeability clay layer will limit groundwater seepage.
- Gravel underlies the upper clay subsoils which is approximately 2 – 15m thick. The overlying clay prevents the gravel from receiving recharge. The gravels, whilst in hydraulic connectivity with the river, are hydraulically separate and disconnected with the SAC. The SAC is likely to be fed by incident rainfall and surface water via an existing pipe but not from groundwater.
- The analysis in the northern part of the island at BH105 indicates the seepage beneath the embankment would be circa 2 l/hr per m section.
- Based on the seepage calculations a cut off wall along the river bank is unlikely to provide significant additional protection from flooding to the SAC.
- There is an existing pipe in the eastern part of the SAC which appears to connect the SAC to the river and allow the river to contribute surface water to the SAC. Cutting off this connection is likely to influence the water balance of the SAC negatively.

E Soil and Geology

E1 Summary of Soil Testing Results

E2 Summary of Soil WAC Results

King's Island Site Investigation
Soil Testing Results

Client Sample Ref.:					BH125	BH125	BH125	FIP111	FIP111	FIP111	FIP109	FIP109	FIP109	FIP103	FIP103	FIP103
Client Sample ID.:					ES1	ES2	ES3	ES1	ES2	ES3	ES1	ES2	ES3	ES1	ES2	ES3
Sample Type:					SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Top Depth (m)					0.5	2.0	3.0	0.6	1.0	2.0	0.5	1.5	3.5	1.5	2.0	2.5
Date Sampled					20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16
Determinand	Accred.	SOP	Units	LOD												
Moisture	N	2030	%	0.02	8.6	10	8.8	26	21	20	12	12	17	7	12	11
pH	U	2010	-	-	8.9	8.9	8.9	8.3	8.4	8.8	8.9	9	8.9	9	8.9	8.8
Arsenic	U	2450	mg/kg	1	16	16	14	12	9	11	17	21	14	20	10	13
Barium	U	2450	mg/kg	10	39	31	33	190	150	93	79	45	42	45	70	50
Cadmium	U	2450	mg/kg	0.1	-	0.12	0.15	0.3	0.39	0.34	0.21	0.22	0.18	0.2	0.15	0.15
Chromium	U	2450	mg/kg	1	11	13	7.2	20	16	17	8.4	6.4	6.7	18	21	17
Copper	U	2450	mg/kg	0.5	18	14	11	36	30	92	18	11	12	16	21	25
Mercury	U	2450	mg/kg	0.1	0.32	0.17	0.17	0.36	0.19	0.59	0.43	0.2	0.17	0.28	0.16	0.18
Molybdenum	U	2450	mg/kg	2	-	-	-	-	-	-	-	-	-	-	-	-
Nickel	U	2450	mg/kg	0.5	19	24	10	26	20	25	14	10	9.2	20	36	31
Lead	U	2450	mg/kg	0.5	460	32	21	90	45	140	150	72	78	38	43	24
Antimony	N	2450	mg/kg	2	-	-	-	-	-	-	-	-	-	-	-	-
Selenium	U	2450	mg/kg	0.2	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	U	2450	mg/kg	0.5	26	25	19	64	200	210	71	31	25	37	58	61
Chromium (Hexavalent)	N	2490	mg/kg	0.5	-	-	-	-	-	-	-	-	-	-	-	-
LOI	U	2610	%	0.1	0.64	1.1	1.1	7.2	4.3	2.5	2.1	1.4	1.2	1.1	1.6	1.5
Total Organic Carbon	U	2625	%	0.2	0.76	1.1	1.9	2.5	2.6	1	1.6	0.56	0.89	0.95	0.63	0.63
Mineral Oil	N	2670	mg/kg	10	-	59	-	-	-	-	-	-	-	24	-	-
Aliphatic TPH >C5-C6	N	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C6-C8	N	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C8-C10	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C10-C12	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C12-C16	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C16-C21	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	2.5	-	-
Aliphatic TPH >C21-C35	U	2680	mg/kg	1	-	58	-	-	-	-	-	-	-	21	-	-
Aliphatic TPH >C35-C44	N	2680	mg/kg	1	-	1.4	-	-	-	-	-	-	-	-	-	-
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5	-	59	-	-	-	-	-	-	-	24	-	-
Aromatic TPH >C5-C7	N	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C7-C8	N	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C8-C10	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C10-C12	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C12-C16	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C16-C21	U	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	79	-	-
Aromatic TPH >C21-C35	N	2680	mg/kg	1	-	16	-	-	-	-	-	-	-	580	-	-
Aromatic TPH >C35-C44	N	2680	mg/kg	1	-	-	-	-	-	-	-	-	-	7.4	-	-
Total Aromatic Hydrocarbons	N	2680	mg/kg	5	-	16	-	-	-	-	-	-	-	670	-	-
Total Petroleum Hydrocarbons	N	2680	mg/kg	10	-	75	-	-	-	-	-	-	-	690	-	-
Benzene	U	2760	µg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	U	2760	µg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	U	2760	µg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
m & p-Xylene	U	2760	µg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
o-Xylene	U	2760	µg/kg	1	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	U	2800	mg/kg	0.1	-	-	-	-	-	0.12	0.16	-	-	-	-	-
Acenaphthylene	N	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Acenaphthene	U	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Fluorene	U	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.49	-	-	-	-	-
Anthracene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.13	-	-	-	-	-
Fluoranthene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.83	-	-	-	-	-
Pyrene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.69	-	-	-	-	-
Benzo[a]anthracene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.23	-	-	-	-	-
Chrysene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.21	-	-	-	-	-
Benzo[b]fluoranthene	N	2800	mg/kg	0.1	-	-	-	-	-	-	0.27	-	-	-	-	-

King's Island Site Investigation
Soil Testing Results

Client Sample Ref.:					BH125	BH125	BH125	FIP111	FIP111	FIP111	FIP109	FIP109	FIP109	FIP103	FIP103	FIP103
Client Sample ID.:					ES1	ES2	ES3	ES1	ES2	ES3	ES1	ES2	ES3	ES1	ES2	ES3
Sample Type:					SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Top Depth (m)					0.5	2.0	3.0	0.6	1.0	2.0	0.5	1.5	3.5	1.5	2.0	2.5
Date Sampled					20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16
Benzo[k]fluoranthene	U	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Benzo[a]pyrene	U	2800	mg/kg	0.1	-	-	-	-	-	-	0.19	-	-	-	-	-
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Benzo[g,h,i]perylene	U	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Coronene	N	2800	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Total Of 17 PAH's	N	2800	mg/kg	2	-	-	-	-	-	-	-	-	-	-	-	-
PCB 28	U	2810	mg/kg	0.01	-	-	-	-	-	-	-	-	-	-	-	-
PCB 52	U	2815	mg/kg	0.01	-	-	-	-	-	-	-	-	-	-	-	-
PCB 101	U	2815	mg/kg	0.01	-	-	-	-	-	-	-	-	-	-	-	-
PCB 118	U	2815	mg/kg	0.01	-	-	-	-	-	-	-	-	0.024	-	-	-
PCB 153	U	2815	mg/kg	0.01	-	-	-	-	-	-	-	-	-	-	-	-
PCB 138	U	2815	mg/kg	0.01	-	-	-	-	-	-	-	-	-	-	-	-
PCB 180	U	2810	mg/kg	0.01	-	-	-	-	-	-	-	-	-	-	-	-
Total PCBs (7 Congeners)	N	2815	mg/kg	0.1	-	-	-	-	-	-	-	-	-	-	-	-

"-" indicates that test result was below the Limit of Detection (LOD)

King's Island Site Investigation
Soil Testing Results

Client Sample Ref.:	FIP104	FIP104	FIP104	FIP106	FIP106	FIP102	FIP102	FIP101	FIP101	FIP101	BH109	BH109	BH109a	BH109a	BH113	BH113
Client Sample ID.:	ES1	ES2	ES3	ES1	ES2	ES1	ES2	ES1	ES2	ES3	ES1	ES1	ES2	ES3	ES1	ES2
Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Top Depth (m)	1.0	2.0	4.0	0.8	1.5	0.8	1.5	0.5	2.0	2.5	0.5	1.0	1.7	2.7	0.5	1.0
Date Sampled	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16
Determinand																
Moisture	17	19	15	8.8	12	19	26	5.9	24	30	18	29	23	19	15	28
pH	9.3	9.3	9	11.4	9.1	8.6	8.2	9	8.3	8.3	8.1	7.8	8.4	8.4	8	7.8
Arsenic	14	18	9.7	13	9.4	12	6.2	15	9	8.1	16	20	27	15	14	25
Barium	66	85	38	75	35	100	85	73	75	91	190	300	310	210	190	460
Cadmium	0.1	-	-	0.13	-	0.21	0.18	0.19	0.13	0.22	0.53	0.62	0.59	0.33	0.62	0.89
Chromium	9.6	13	13	14	8.6	21	17	25	17	18	22	34	30	21	23	32
Copper	38	85	26	28	23	43	17	51	16	14	66	79	36	41	57	16
Mercury	0.39	0.65	0.31	0.2	0.24	0.27	-	0.23	-	-	0.29	0.24	0.12	0.13	0.4	0.18
Molybdenum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.7
Nickel	14	19	15	25	14	30	24	37	26	24	36	34	59	42	33	43
Lead	82	180	39	45	71	51	27	37	20	22	120	110	92	40	150	64
Antimony	-	11	2.2	-	-	-	-	-	-	-	2.2	2.6	-	-	2.2	-
Selenium	-	-	-	-	-	-	-	-	-	-	-	0.31	-	-	-	0.77
Zinc	43	58	25	36	23	62	46	100	46	43	220	180	97	60	170	52
Chromium (Hexavalent)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LOI	2.8	2.6	2.3	1.3	3.6	3.2	8.9	1.7	3.6	3.8	7.6	8	3.3	2.2	9.5	9.4
Total Organic Carbon	1.5	1.1	1.1	0.91	1.6	1.1	1.4	1.4	2	1.6	11	5.1	0.65	0.3	5	1.1
Mineral Oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C5-C6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C6-C8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C8-C10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C10-C12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C12-C16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C16-C21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C21-C35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatic TPH >C35-C44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Aliphatic Hydrocarbons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C5-C7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C7-C8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C8-C10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C10-C12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C12-C16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C16-C21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C21-C35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatic TPH >C35-C44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Aromatic Hydrocarbons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Petroleum Hydrocarbons	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Toluene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
m & p-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
o-Xylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	-	-	-	-	-	-	-	0.34	-	-	-	-	-
Acenaphthylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acenaphthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluorene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	-	-	-	-	-	-	-	-	-	-	0.62	-	-	-	0.23	1.23
Anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluoranthene	-	-	-	-	-	-	-	-	-	-	0.58	-	-	-	0.46	0.46
Pyrene	-	-	-	-	-	-	-	-	-	-	0.46	-	-	-	0.48	0.48
Benzo[a]anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	0.11
Chrysene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13	0.13
Benzo[b]fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18	0.18

King's Island Site Investigation
Soil Testing Results

Client Sample Ref.:	FIP104	FIP104	FIP104	FIP106	FIP106	FIP102	FIP102	FIP101	FIP101	FIP101	BH109	BH109	BH109a	BH109a	BH113	BH113
Client Sample ID.:	ES1	ES2	ES3	ES1	ES2	ES1	ES2	ES1	ES2	ES3	ES1	ES1	ES2	ES3	ES1	ES2
Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
Top Depth (m)	1.0	2.0	4.0	0.8	1.5	0.8	1.5	0.5	2.0	2.5	0.5	1.0	1.7	2.7	0.5	1.0
Date Sampled	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16
Benzo[k]fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo[a]pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)Pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)Anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo[g,h,i]perylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coronene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Of 17 PAH's	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 118	0.024	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 153	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 138	0.048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCB 180	-	-	-	-	-	-	-	-	-	0.21	-	-	-	-	-	-
Total PCBs (7 Congeners)	-	-	-	-	-	-	-	-	-	0.21	-	-	-	-	-	-

"-" indicates that test result was below t

King's Island Site Investigation
Soil Testing Results

Client Sample Ref.:	BH113	TP116	TP116	TP117	TP117
Client Sample ID.:	ES3	ES1	ES2	ES1	ES2
Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL
Top Depth (m)	1.5	0.5	1.2	0.5	1.2
Date Sampled	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16
Determinand					
Moisture	27	18	20	17	27
pH	8.1	7.9	8.1	8.6	7.7
Arsenic	21	19	8	18	9.5
Barium	410	240	210	190	270
Cadmium	0.54	0.75	0.14	0.6	0.18
Chromium	27	24	22	19	27
Copper	16	93	21	71	16
Mercury	0.18	0.37	-	0.27	0.14
Molybdenum	2.5	2.1	-	-	-
Nickel	37	43	31	34	27
Lead	63	220	46	120	58
Antimony	-	5	-	2.7	-
Selenium	0.24	-	-	-	0.37
Zinc	56	300	74	270	80
Chromium (Hexavalent)	-	-	-	-	-
LOI	5.6	6.2	3.4	6.9	5.6
Total Organic Carbon	0.97	4	1	5	0.77
Mineral Oil	-	210	-	-	-
Aliphatic TPH >C5-C6	-	-	-	-	-
Aliphatic TPH >C6-C8	-	-	-	-	-
Aliphatic TPH >C8-C10	-	1.8	-	-	-
Aliphatic TPH >C10-C12	-	5.2	-	-	-
Aliphatic TPH >C12-C16	-	5	-	-	-
Aliphatic TPH >C16-C21	-	40	-	-	-
Aliphatic TPH >C21-C35	-	160	-	-	-
Aliphatic TPH >C35-C44	-	-	-	-	-
Total Aliphatic Hydrocarbons	-	210	-	-	-
Aromatic TPH >C5-C7	-	-	-	-	-
Aromatic TPH >C7-C8	-	-	-	-	-
Aromatic TPH >C8-C10	-	4	-	-	-
Aromatic TPH >C10-C12	-	-	-	-	-
Aromatic TPH >C12-C16	-	8.9	-	-	-
Aromatic TPH >C16-C21	-	4.2	-	2.9	-
Aromatic TPH >C21-C35	-	120	-	-	-
Aromatic TPH >C35-C44	-	-	-	-	-
Total Aromatic Hydrocarbons	-	130	-	-	-
Total Petroleum Hydrocarbons	-	340	-	-	-
Benzene	-	-	-	-	-
Toluene	-	-	-	-	-
Ethylbenzene	-	-	-	-	-
m & p-Xylene	-	-	-	-	-
o-Xylene	-	-	-	-	-
Naphthalene	-	0.47	-	-	-
Acenaphthylene	-	-	-	-	-
Acenaphthene	-	-	-	-	-
Fluorene	-	-	-	-	-
Phenanthrene	2.23	0.52	-	0.23	-
Anthracene	< 0.3	0.11	-	-	-
Fluoranthene	0.46	1.1	-	0.36	-
Pyrene	0.48	0.81	-	0.35	-
Benzo[a]anthracene	0.11	0.26	-	-	-
Chrysene	0.13	0.31	-	-	-
Benzo[b]fluoranthene	0.18	0.47	-	-	-

King's Island Site Investigation
Soil Testing Results

Client Sample Ref.:	BH113	TP116	TP116	TP117	TP117
Client Sample ID.:	ES3	ES1	ES2	ES1	ES2
Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL
Top Depth (m)	1.5	0.5	1.2	0.5	1.2
Date Sampled	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16	20-Sep-16
Benzo[k]fluoranthene	-	0.11	-	-	-
Benzo[a]pyrene	-	0.36	-	-	-
Indeno(1,2,3-c,d)Pyrene	-	-	-	-	-
Dibenz(a,h)Anthracene	-	-	-	-	-
Benzo[g,h,i]perylene	-	-	-	-	-
Coronene	-	-	-	-	-
Total Of 17 PAH's	-	4.5	-	-	-
PCB 28	-	-	-	-	-
PCB 52	-	-	-	-	-
PCB 101	-	-	-	-	-
PCB 118	-	-	-	-	-
PCB 153	-	-	-	-	-
PCB 138	-	-	-	-	-
PCB 180	-	-	-	-	-
Total PCBs (7 Congeners)	-	-	-	-	-

"-" indicates that test result was below t

King's Island Site Investigation
Soil WAC Results

Eluates CEN 10:1	Inert Landfill Limits	Non-hazardous Limits	Hazardous Landfill Limits	BH125	BH125	BH125	FIP111	FIP111	FIP111	FIP109	FIP109	FIP109	FIP103	FIP103	FIP103	FIP104	FIP104	FIP104	FIP106	FIP106	FIP102
Depth (mbgl)	-	-	-	0.50	2.00	3.00	0.60	1.00	2.00	0.50	1.50	3.50	1.50	2.00	2.50	1.00	2.00	4.00	0.80	1.50	0.80
Arsenic	0.5	2	25	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.066	<0.050	0.082	0.066	0.091	<0.050	<0.050	<0.050
Barium	20	100	300	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.400	<0.5	<0.5
Cadmium	0.04	1	5	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chromium	0.5	10	70	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.085	<0.050	<0.050	0.200	<0.050	<0.050
Copper	2	50	100	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.084	<0.050	0.066	0.180	<0.050	<0.050
Mercury	0.01	0.2	2	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.019	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Molybdenum	0.5	10	30	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.082	0.110	0.140	<0.050	<0.050	<0.050	0.510	0.083	0.150
Nickel	0.4	10	40	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lead	0.5	10	50	<0.010	<0.010	<0.010	<0.010	<0.010	0.013	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.021	<0.010	0.011	0.015	<0.010	<0.010
Antimony	0.06	0.7	50.1	0.013	0.015	0.026	<0.010	<0.010	0.011	<0.010	<0.010	<0.010	<0.010	0.034	0.021	0.027	0.032	0.038	<0.010	0.028	0.072
Selenium	0.1	0.5	7	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.018	<0.010	<0.010
Zinc	4	50	200	<0.50	<0.50	<0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Chloride	800	15000	25000	27	14	29	24	19	17	18	14	12	19	15	11	14	16	18	31	19	21
Fluoride	10	150	500	2.7	1.9	2.1	2.6	2.6	2.1	1.6	1.5	1.5	2.3	1.6	1.6	1.7	1.9	1.8	3.2	1.5	1.6
Sulphate	1000	20000	50000	79	110	100	61	63	97	69	70	55	120	240	190	240	300	200	86	170	440
Total Dissolved Solids	4000	60000	100000	740	870	840	910	810	870	700	690	740	710	490	950	880	1000	790	12000	880	910
Dissolved Organic Carbon	500	800	1000	150	< 50	< 50	< 50	50	54	59	< 50	< 50	< 50	< 50	< 50	72	55	50	93	< 50	< 50

King's Island Site Investigation
Soil WAC Results

Eluates CEN 10:1	Inert Landfill Limits	Non-hazardous Limits	Hazardous Landfill Limits	FIP102	FIP101	FIP101	FIP101	BH109	BH109	BH109a	BH109a	BH113	BH113	BH113	TP116	TP116	TP117	TP117
Depth (mbgl)	-	-	-	1.50	0.50	2.00	2.50	0.50	1.00	1.70	2.70	0.50	1.00	1.50	0.50	1.20	0.50	1.20
Arsenic	0.5	2	25	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Barium	20	100	300	0.600	<0.5	0.750	0.740	0.630	0.800	<0.5	0.940	0.630	<0.5	<0.5	0.730	0.640	<0.5	0.610
Cadmium	0.04	1	5	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chromium	0.5	10	70	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Copper	2	50	100	<0.050	0.055	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Mercury	0.01	0.2	2	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Molybdenum	0.5	10	30	0.056	0.058	<0.050	0.061	0.220	0.290	<0.050	<0.050	0.160	<0.050	<0.050	2.200	<0.050	0.083	0.054
Nickel	0.4	10	40	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lead	0.5	10	50	<0.010	<0.010	<0.010	<0.010	<0.010	0.025	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Antimony	0.06	0.7	50.1	0.080	0.015	0.043	0.062	0.120	0.180	0.042	0.073	0.150	<0.010	<0.010	0.110	0.017	<0.010	0.057
Selenium	0.1	0.5	7	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.012	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Zinc	4	50	200	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Chloride	800	15000	25000	17	38	24	25	46	74	35	65	28	31	20	34	33	25	21
Fluoride	10	150	500	1.4	2.4	1.7	1.4	2.1	1.7	3.8	3.4	1.9	5.4	6.3	2.1	4.9	1.9	2.4
Sulphate	1000	20000	50000	460	330	380	380	1700	1100	180	320	910	130	160	1500	130	490	440
Total Dissolved Solids	4000	60000	100000	1300	1000	1200	1800	2600	420	610	600	2500	580	560	3400	550	2000	800
Dissolved Organic Carbon	500	800	1000	50	55	59	78	92	130	68	< 50	97	55	< 50	83	< 50	68	110

F LVIA Receptor Tables

F1 Visual Receptor Tables

Appendix F1 Landscape Character and Visual Amenity Impacts

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
Impact on Landscape Character Areas						
Area A1	Temporary to Short Term, Slight, Negative	Pedestrian pathway route kept open and storage of materials and plant in construction compound.	Temporary to Short Term, Imperceptible, Negative	Permanent, Slight, Negative	Painting the light colour coping a darker shade of grey	Permanent, Imperceptible, Positive
Area A2	Temporary to Short Term, Slight, Negative	Pedestrian diversion routes maintained; regulation of construction traffic; and storage of materials and plant in construction compound.	Temporary to Short Term, Imperceptible, Negative	Permanent, Slight, Negative	Raising ground level to maintain a wall height of 1.2m above ground level to allow river edge views, painting the coping a lighter shade of grey, lighting along upgraded footpath will be controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Positive
Area A3	Temporary to Short Term, Moderate, Negative	Pedestrian diversion routes maintained; regulation of construction traffic and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Moderate, Negative	Profiling of the embankment around St Mary's Park; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties; connecting access paths from residential areas onto the embankment	Permanent, Slight, Negative
Area A4	Temporary to Short Term, Moderate, Negative	Pedestrian diversion routes maintained; regulation of construction traffic and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Moderate, Negative	Profiling of the embankment where possible (north and south); seeding embankment with meadow grass to ensure natural appearance, lighting controlled by motion sensors to mitigate light overspill to residential properties; semi mature trees to filter visibility into the rear of properties, connecting access paths from residential areas onto the embankment	Permanent, Slight, Negative
Area A5	Temporary to Short Term, Moderate, Negative	Scheduling the works during summer (out of football season); pedestrian diversion routes maintained; regulation of construction traffic and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Moderate, Negative	Profiling of the embankment opposite Assumpta Park and Abbey View; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties; connecting access paths from residential areas onto the embankment	Permanent, Slight, Negative

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
Area A6	Temporary to Short Term, Moderate, Negative	Pedestrian diversion routes maintained; regulation of construction traffic; and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Slight, Negative	New concrete wall 2.7m in height along the length of the Athlunkard Boat Club, Stone finish to dry side with random rubble with rough rack coping.	Permanent, Imperceptible, Positive
Area A7	Temporary to Short Term, Moderate, Negative	Pedestrian diversion routes maintained; regulation of construction traffic; and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Slight, Negative	Stone finish to existing flood wall raised in height in a random rubble finish, laid to courses with a flat stone coping to match the existing wall along this extent. Footpath raised to maintain river edge views	Permanent, Imperceptible, Positive
Area A8	Temporary to Short Term, Slight, Negative	Pedestrian pathway route kept open and storage of materials and plant in construction compound.	Temporary to Short Term, Imperceptible, Negative	Permanent, Slight, Negative	None necessary	Permanent, Imperceptible, Positive
Area A9	Temporary to Short Term, Moderate, Negative	Pedestrian diversion routes maintained; use of jack-up rig to avoid construction traffic; and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Slight, Negative	Stone finish with rough-hewn stone in sneck pattern with double chamfered rectangular stone coping. Impact remain as wall will be 1.4m in height and visibility of river edge will be lost to a minority of walkers (based on average eye level of 1.5m in height)	Permanent, Imperceptible, Negative
Area A10	Temporary to Short Term, Moderate, Negative	Pedestrian diversion routes maintained; regulation of construction traffic; and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Slight, Negative	Stone finish: eastern portion will be rough-hewn stone in sneck pattern with double chamfered rectangular stone coping, western portion will be faced to match existing, intermediate pier will define the change. Two replacement trees planted.	Permanent, Imperceptible, Negative
Area B1	Temporary to Short Term, Moderate, Negative	Pedestrian and vehicular diversion routes maintained; regulation of construction traffic; and storage of materials and plant in construction compound. Trees to be stabilised and protected	Temporary to Short Term, Slight, Negative	Permanent, Moderate, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Slight, Negative

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
Area B2	Temporary to Short Term, Moderate, Negative	Pedestrian and vehicular diversion routes maintained; regulation of construction traffic; and storage of materials and plant in construction compound. Trees to be stabilised and protected	Temporary to Short Term, Slight, Negative	Permanent, Moderate, Negative	Inclusion of glass panelling to maintain connectivity with river corridor; quay wall cleaned, repaired, grouted and pointed	Permanent, Slight, Negative
Area B3	Temporary to Short Term, Moderate, Negative	Pedestrian and vehicular diversion routes maintained; regulation of construction traffic and storage of materials and plant in construction compound.	Temporary to Short Term, Slight, Negative	Permanent, Moderate, Negative	Glass panelling to maintain connectivity with river corridor; quay wall cleaned, repaired, grouted and pointed	Permanent, Slight, Negative
Impact on Visually Sensitive Receivers						
R1	Temporary to Short Term, Slight, Negative	Pedestrian pathway route kept open and storage of materials and plant in construction compound.	Temporary to Short Term, Imperceptible, Negative	Permanent, Slight, Negative	Painting the light colour coping a darker shade of grey	Permanent, Imperceptible, Positive
R2	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Slight, Negative	Profiling of the embankment around St Mary's Park; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties	Permanent, Imperceptible, Positive
R3	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Moderate, Negative	Profiling of the embankment around St Mary's Park; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Slight, Negative

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
R4	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Moderate, Negative	Profiling of the embankment around St Mary's Park; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Slight, Negative
R5	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Moderate, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties; semi mature trees to filter visibility into the rear of properties.	Permanent, Slight, Negative
R6	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Profiling of the embankment around St Mary's Park and Star Rovers; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties	Permanent, Imperceptible, Negative
R7	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Profiling of the embankment around St Mary's Park and Star Rovers; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties	Permanent, Imperceptible, Negative
R8	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Moderate, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Slight, Negative

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
R9	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties and replacement wall at Athlunkard Boat club with new stone facing and coping detail.	Permanent, Imperceptible, Negative
R10	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Replacement wall at Athlunkard Boat club with new stone facing coping detail	Permanent, Imperceptible, Negative
R11	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Raised wall will be faced with stone to match existing stone pattern and new flat coping all along the stretch of wall to create a continuous stone wall design	Permanent, Slight, Negative
R12	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Raised wall will be faced with stone to match existing stone pattern and new flat coping all along the stretch of wall to create a continuous stone wall design. New raised stepped footpath to allow views over wall towards river.	Permanent, Slight, Positive
R13	Short term, Imperceptible, Negative	None necessary	Short term, Imperceptible,	Permanent, Slight, Negative	Cleaning of wall surface, removal of railings will allow more transparency of heritage landscape	Permanent, Imperceptible, Positive
R14	Short term, Imperceptible, Negative	None necessary	Short term, Imperceptible,	Permanent, Slight, Negative	Painting of light coloured wall coping to a grey less visible tone to reduce visual intrusion in the heritage landscape	Permanent, Imperceptible, Positive
R15	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance which will screen part of the urban back drop of St Mary's Park; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Neutral

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
R16	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance which will screen part of the urban back drop of St Mary's Park; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Neutral
R17	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance which will screen part of the urban back drop of St Mary's Park; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Neutral
C1	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Wall to be faced with roughhewn stone in a sneck pattern and double chamfered rectangular stone coping. Impact remain as short section of wall will be 1.4m in height, visibility of river may be lost to some walkers	Permanent, Slight, Negative
C2	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement. Maintain pedestrian access during construction.	Short term, Imperceptible, Negative I	Permanent, Slight, Negative	Stone finish: eastern portion will be rough-hewn stone in sneck pattern with double chamfered rectangular stone coping, western portion will be faced to match existing, intermediate pier will define the change. Two replacement trees planted.	Permanent, Imperceptible, Positive
C3	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement. Maintain pedestrian access during construction.	Short term, Slight, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible, Positive
C4	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Stone finish: eastern portion will be rough-hewn stone in sneck pattern with double chamfered rectangular stone coping, western portion will be faced to match existing, intermediate pier will define the change. Two replacement trees planted.	Permanent, Imperceptible, Positive

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
C5	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible, Positive
C6	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible, Positive
C7	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement. Maintain pedestrian access during construction.	Short term, Slight, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible, Positive
C8	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement. Maintain pedestrian access during construction.	Short term, Slight, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible, Positive
C9	Temporary to Short Term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement. Maintain pedestrian access during construction.	Temporary to Short Term, Slight, Negative	Permanent, Slight, Negative	Raising ground level to maintain a wall height of 1.2m above ground level to allow river edge views, painting the coping a lighter shade of grey, lighting along upgraded footpath will be controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Positive
C10	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance which will screen part of the urban back drop of St Mary's Park; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Neutral
C11	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement.	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance which will screen part of the urban back drop of St Mary's Park; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Imperceptible, Neutral

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
T1	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials along the river edge	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible, Positive
T2	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials along the river edge	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river.	Permanent, Imperceptible Positive
T3	Temporary to Short Term, Slight, Negative	Pedestrian pathway route kept open and storage of materials and plant in construction compound.	Temporary to Short Term, Imperceptible, Negative	Permanent, Slight, Negative	Painting the light colour coping a darker shade of grey	Permanent, Imperceptible, Positive
T4	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river	Permanent, Imperceptible Positive
T5	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Raising ground level to maintain a wall height of 1.2m above ground level to allow river edge views, painting the coping a lighter shade of grey	Permanent, Imperceptible Positive
OS1	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting from properties	Short term, Slight, Negative	Permanent, Moderate, Negative	Profiling of the embankment around St Mary's Park; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties.	Permanent, Slight, Positive

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
OS2	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties, barrier planting at foot of embankment.	Permanent, Imperceptible, Positive
OS3	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Moderate, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties; semi mature trees to filter visibility into the rear of properties.	Permanent, Slight, Negative
OS4	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Moderate Negative	Profiling of the embankment around St Mary's Park and Star Rovers; seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties	Permanent, Slight, Negative
OS5	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties, barrier planting at foot of embankment.	Permanent, Imperceptible, Positive
OS6	Short term, Moderate, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Slight, Negative	Permanent, Slight, Negative	Seeding embankment with meadow grass to ensure natural appearance; lighting controlled by motion sensors to mitigate light overspill to residential properties, barrier planting at foot of embankment.	Permanent, Imperceptible, Positive

Sensitive receiver	Impact during Construction	Mitigation during Construction	Residual impact during Construction	Impact during Operation	Mitigation during Operation	Residual impact during Operation
V1	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Painting the coping a lighter shade of grey	Permanent, Imperceptible Positive
V2	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Imperceptible Negative	Replacement wall at Athlunkard Boat club with new stone facing coping detail	Permanent, Imperceptible Positive
V3	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Wall to be faced with rough-hewn stone in a sneck pattern and double chamfered rectangular stone coping.	Permanent, Imperceptible Positive
V4	Short term, Slight, Negative	Implementation of site-specific CEMP and TMP to control visibility of dust and traffic movement; screening of plant and materials in compound; directing security lighting away from the residential properties	Short term, Imperceptible, Negative	Permanent, Slight, Negative	Quay wall cleaned, repaired, grouted and pointed, incorporation of transparent panels to allow visual connection with river	Permanent, Imperceptible Positive

G Cultural Heritage

G1 Gazetteer of Archaeological Monuments/Sites

G2 Proposed Archaeological Testing Regime

Appendix G1 - Gazetteer of Archaeological Monuments/Sites close to the KIFRS Works Area

The following gazetteer lists 16 archaeological monuments or sites that are within or close to the KIFRS words area, as indicated by the available designs. Each entry includes the site (SMR) code, class, grid coordinates (ITM), distance and direction from the nearest Area of the works and description of the site where available on the Historic Environment Viewer (HEV) (www.archaeology.ie).

RMP code: LI005-017---- Class: Historic town

Grid coordinates: E 557809, N 657730 (multiple locations)

Location: The historic town area includes the southern part of the works area in Areas A1, A7, A8, A9, A10, B1, B2 and B3.

Description:

The historic city of Limerick was described in the Urban Survey (Bradley et. al. 1989, 241-67) as following; 'The city of Limerick is situated on the river Shannon in the north-east corner of County Limerick. The placename is derived from Luimneach "bare or barren land", a name which originally appears to have been applied to part of the Shannon estuary rather than just the immediate site of the city itself. The handful of prehistoric finds from the city indicates only that the site of the future settlement was occasionally frequented by man in early times. The fact that there are not more is surprising because the presence of the Curragour Falls must have given Limerick a topographical significance even in prehistoric times. There are many artefacts in the collections of the National Museum and elsewhere which were found in the river Shannon "near Limerick" but only two stone axeheads and two bronze dirks can be pinned down to the actual vicinity of the old would seem to have been an into early historic times.

The Hiberno-Scandinavian Town

The first evidence for the presence of Scandinavians occurs in 845 (AFM: 843) when Viking fleets appeared on the Shannon estuary and launched raids into county Limerick. It is unlikely that they settled, however, but there are a few scattered references which may indicate that a base existed at or near Limerick for a short time in the later ninth century. An eleventh century saga states that the Vikings Hona and Tomrir Torra were at Limerick with an army in 860 (Radner 1978, 109); a Viking fleet is known to have raided along the Shannon from Limerick in 866; and the Chronicon Scottorum states that the "foreigners of Limerick" were slaughtered by the Connachtmen in 887. It is hard to know if these three references add up to a permanent settlement at late ninth century Limerick or not but they certainly show that there was Scandinavian activity in the area at this time.

The present city was founded in 922 by the Norse king Tamar mac Ailche (?Thormodr Helgason), "king of an immense fleet" who landed on Inis Sibtond (King's Island) and established a lonqphort there. The site afforded considerable natural advantages. Being an island it was easy to defend, there was immediate access to the open sea along the Shannon estuary and thereby to the lucrative Atlantic trade routes of Europe. The shallows at Curragour Falls formed a natural barrier restricting the flow of river traffic and the situation also afforded an entry into the rich heart of central Ireland along the Shannon basin. Tamar, indeed, lost no time in making his presence felt. His fleet proceeded to devastate the monasteries which could be reached from the Shannon: Terryglass, Lorrha, Clonfert and Clonmacnoise among others (Smyth 1979, 21). At Inis Cealtra, on Lough Derg, the raid was so fierce that two centuries later it was remembered that "they drowned its shrines, relics and its books" (Todd 1867, 38-9). They proceeded into Lough Ree and from there started to raid into Meath and Connacht, all the while presumably sending back the loot of plunder and slaves to the newly founded settlement at Limerick for auction and sale.

The history of Scandinavian Limerick can in fact be divided into four phases: (1) the period of foundation, 922-37; (2) the period of Dublin domination, 937-67; (3) period of Ua Briain domination 967-c.1065; and (4) the period as Ua Briain capital c.1065-c.1195. These periods

can only be briefly glanced at here. The period of foundation, 922-37, witnessed Limerick emerge as an independent Scandinavian settlement struggling to maintain its independence from the kings of Dublin. The events of these years, which witnessed raids by the Limerick Vikings all over central, western and northern Ireland are particularly well recorded in the annals. In 923 they captured Flaithbertach mac Inmainen, the retired king of Munster, from his island retreat at Loch Cré and brought him back to Limerick for ransom. In 924 they again placed a fleet on Lough Ree, this time under the command of Colla mac Bairid (Kolli Baardarson), described in the annals as king of Limerick (AFM: 922; CS: 923). In 924 the Dublin Vikings, worried that the growing number of Limerick raids in central Ireland would diminish their power, sent an army to subdue their Limerick kinsmen but they were defeated and had to retreat back to Dublin (AU). This victory seems to have encouraged the ambitions of Limerick's leaders.

In 928 Tamar mac Ailche put his fleet on Lough Neagh and burnt the islands of that lake (AU: 927). In 929 Limerick vessels are recorded on Lough Corrib and they remained there until the following year (AU: 928; AFM: 927; CS: 930). In 930 a Limerick army encamped in central Ossory, establishing their base at Loch Beathrach, an unidentified lake which appears to have been either on the Nore or its tributary the King's River (Smyth 1979, 25) and was only driven out by the appearance of Gothfrith, king of Dublin, with a rival army in the following year (AFM sa 929; AU sa 929). The year 931 saw a Limerick fleet on Lough Ree (AU: 931; AFM: 929; CS: 930) and the activities of the Limerick Vikings in Connacht and central Ireland between 931 and 937 has led to the suggestion that they must have established a base in Lough Ree (Smyth 1979, 250-1). Indeed Smyth (ibid) has speculated that the famous Hare Island (Co. Westmeath) hoard, the largest known gold find from Viking-age Europe, formed part of the treasure of the Limerick armies.

In 933 a new leader, Olafr Cenncairech ("scabby-head") lead them into Roscommon (AFM:932) and returned there again the following year (CS: 933). In 936 he transported his ships overland from the Shannon to the Erne and raided down into the present-day county of Cavan (AFM: 934; CS: 935; A. Clon., 149). He returned back to Lough Ree on Christmas night of 936 and he remained there for seven months plundering and looting the plains of Connacht (AFM: 934). In August 937 the long-awaited confrontation between the Dublin and Limerick Vikings occurred. Olafr Gothfrithson, king of Dublin, led his army to Lough Ree where he defeated the Limerick vikings, broke up their ships and carried Olafr Cenncairech back to Dublin as his prisoner (AFM: 935; CS: 935; A. Clon. 931).

That the defeat of Olafr Cenncairech marks a stage in Limerick's history is clear from the absence of references to it the succeeding years. Indeed, from what little evidence there is, it appears that the king of Dublin now imposed a member of his own family, Haraldr Sigtryggson (d. 940), king of Limerick (Smyth 1979, 35). The settlers now seem to have become more closely integrated into the local political scene. In 953 Limerick vikings assisted the king of Munster, Cellacháin Caisil, in plundering Clonmacnoise (AFM 951; AU 952). This integration was to reach a head in 967 (AU 966) with the capture of the town by Mathgamain mac Cennetig, who had seized the kingship of Cashel in 963. The Coqadh Gaedhel re Gallaibh, written some two hundred years later states that "the fort and good town (deabali) was burned and reduced ashes" (Todd 1867, 80-1). The booty obtained at the time had all the appearance of oriental origin as Smyth (1977, 165-6) has remarked: "they carried off their jewels and their best property, and their saddles beautiful and foreign; their gold and silver, their beautiful woven cloth of all colours and kinds; their satins and silken cloth, pleasing and variegated, both scarlet and green" (Todd 1867, 78-9). The captives "soft, youthful, bright, matchless girls ..blooming, silk-clad young women, large, active and well-formed boys" were rounded up on the hills of Saingel and "every one that was fit for war was killed and every one of them that was fit for a slave was enslaved" (ibid.,78-81).

The capture of Limerick in 967 marks the beginning of a period of Ua Briain domination that was to last until the coming of the Anglo-Normans. Within this period, however, there is a noticeable break which occurs during the reign of Toirrdelbach ua Briain, king of Munster (1063-86) when makes Limerick his capital (Ó Corráin 1972, 142). This development is all the more noticeable during the reign of his successor Muirchertach Ua Briain (1086-1116) who also spent part of his career as governor of another city, Dublin (Candon 1988). Muirchertach developed extensive overseas contacts and Limerick would appear to have been a busy centre during his

reign. It was at this time also that the town obtained its first bishop and established itself as an episcopal see.

Gilbert, Limerick's first bishop, was consecrated in 1107 and, as papal legate, he presided over the Synod of Rathbresaill in 1111 at which St Mary's was recognised as the diocesan cathedral of Limerick, much to the distress of Mungret nearby. Gilbert's successor, Patrick, was consecrated at Canterbury a fact which also emphasises Limerick's connections with Britain (Gwynn and Hadcock 1970, 90).

The full extent of Limerick's connections with Britain and the Continent in the pre-Norman period can only be guessed at in the absence of archaeological excavation. It is mentioned (once) in the Icelandic sagas (in Landnamabók) Hlymrek and it is to be assumed that it traded with Scandinavia itself. It has been suggested that the Viking finds in west Kerry, such as the runestone and steatite bowl from Beginish Is. and the placename Smerwick, that there was a staging post in this area of Kerry on the route between Limerick and the continent. The exotic description in the Coqadh Gaedhel for the sack of 967 certainly indicates that rich commodities were being imported into the town. The Caithréim Cellacháin Caisil, another twelfth century pseudo-history, mentions that Morann, son of the king of Lewis, fought with the Limerick vikings (Bugge 1905, 65) suggesting contacts with the Hebrides and Western Isles. The Caithréim Cellacháin Caisil also sheds a little light on the appearance of the Hiberno-Scandinavian town and describes it as a fortified stronghold having gates (doirrsi), houses (tighibh) and towers (toraibh) (Bugge, 1905, pp. 9, 66). The Cogadh Gaedhel speaks in similar terms when describing the sack of 967 but it adds the additional piece of information that there were streets and a fort, presumably the royal stronghold (Todd 1867, 79). Neither description sheds light on the appearance of the tenth century settlement, of course, but they do support a picture of Limerick in the twelfth century as a fortified town which had gates and towers on its walls, with streets inside the defences along which houses were probably regularly arranged in the manner which has been evidenced by excavations at Dublin, Wexford and Waterford; in addition there was St Mary's Cathedral and a royal fortress which was probably separated from the town and set within its own defences. From the account of Domhnall Mor Ua Briain's take-over of Limerick in 1176 it is also clear that there was a bridge, probably on the site of Baal's Bridge (Scott and Martin 1978, 167).

Reconciling this picture of the settlement, however, with the remains on the ground poses many problems. The documentary sources are simply not exact enough to provide the sort of detailed information about the size of the town, the course of its defences, the alignment of its streets, and the location of its houses that the archaeologist requires. Some help can be obtained from grants and inquisitions which were made in the years immediately following the Anglo-Norman occupation of the town (c.i195) and which survive, for the most part, in the Black Book of Limerick (MacCaffrey 1907). These make it clear that apart from St Mary's, there were a number of other churches already within the town: St. Munchin's, St. Nicholas', and probably the Augustinian nunnery of St. Peter ("St. Peter's Cell") on King's Island, St. John's in what was later to become Irishtown, and St. Michael's in the estuarine mud just outside Irishtown, St.

Laurence's on the west bank, and the unlocated churches of St. (?St Mark's) and St Brigid. From the distribution of these churches it is clear that settlement concentrated on King's Island but the description of St. John's Church as "within the city of Limerick" as early as 1204-6 suggests that settlement may have also spread to Irishtown in Hiberno-Scandinavian times. From this one may conclude that the axis formed by Nicholas Street and Mary Street was the principal thoroughfare of the pre-Norman town. The outline of the defences is more difficult to determine but the line formed by Dominic St - Bishop St Sheep St seems a likely boundary on the east. Giraldus Cambrensis tells us that the walls were bounded by the river (ab Urbis muralibus que ripe imminebant) Rut whether this coincided with the known line of the walls along the Shannon in the later middle ages or not is unclear (Scott and Martin 1978, 150). It is quite possible, on analogy with the evidence excavated at Waterford, that the defences of the Hiberno-Scandinavian town lay inside the line of the walls of the Anglo-Norman town. The pre-Norman walls, however, do not appear to have risen directly from the water all round the town. From Giraldus" account of its capture it would seem that there was dry ground outside the walls from which the inhabitants threw missiles at the Anglo-Normans endeavouring to cross the river (Scott and Martin 1978, 53). The other contemporary Anglo-Norman source, the Song of Dermot and the Earl adds that there was a fosse, which again implies the presence of some

dry ground: This city was surrounded by a river, a wall, and a dyke, so that no man could pass over without a ship or a bridge, neither in winter nor in summer, except by a difficult ford (Orpen 1892, ii. 3418-23). The exact extent of the area around Limerick which was settled by people of Scandinavian descent is also difficult to guage. The reference to the "cantred of the Ostmen" at Limerick (Sweetman 1875-86, i, no. 146) provides a starting point, however, and this has been identified as the eastern part of the rural deanery of Limerick, comprising land both on the north and south sides of the Shannon. There are also some indications that settlement may have extended over the remainder of the rural deanery and into the cantred of Tradree in Clare (Bradley 1988, 62-4).

The Anglo-Norman Town

Immediately after the submission of Domhnall Ua Briain in 1171 Henry II sent a constable to Limerick (Scott and Martin 1978, 95). The reception which greeted this constable is not recorded not is the duration of his stay. It is evident from the capture of the town in 1175-6 by a host consisting of Anglo-Normans and an army under Ruaidhri Ua Conchobair and that it had not remained loyal to the crown. After this capture an Anglo-Norman garrison was placed in the town and its custody was given to Milo FitzDavid (Orpen 1911-20, i, 349). In 1176 the town was besieged by Domhnall Mór Ua Briain but it was relieved by Raymond le Gros only to be evacuated by him when news came through that Strongbow had died. Domhnall Ua Briain then burnt the town. Giraldus Cambrensis describes the scene: "Just as they [the Anglo-Normans] were leaving, and indeed had scarcely crossed over the far end of the bridge, they suddenly saw that it had been broken down at the other end and this city, so strongly fortified, well furnished with fine buildings, and full to overflowing with provisions gathered in from every quarter, had been set on fire in four different places. It was a sight that grieved them sorely" (Scott and Martin 1978, 167).

In 1177 Henry II granted the kingdom of Limerick, with the exception of the city and the cantred of the Ostmen to Philip de Braose (Orpen 1911-20, ii, 33) but it was not until the closing years of the twelfth century that the Anglo-Normans began to settle the county (Empey 1981). The city of Limerick appears to have been occupied peacefully, by agreement with the Ostmen and Ua Briain (Orpen 1911-20, ii, 156, 158; Scott and Martin 1978, 334: n. 313). In 1196 the Anglo-Norman garrison was expelled by Diarmait Mac Carthaig, king of Desmond, but they were back the following year and thereafter Limerick was to remain in Anglo-Norman hands (Orpen 1911-20, ii, 157). Limerick's earliest charter, in which Prince John granted the inhabitants the same rights as the citizens of Dublin held, was made in 1197 (MacNiocaill 1964 and in the same year burgages within the town were granted to some of the Anglo-Norman colonists (Orpen 1911-20, ii, 157) and about the same time a mint was established (Dolley 1972).

As early as 1200-1 there is evidence that the town was beginning to expand outside its Hiberno-Scandinavian confines. Abstracts of a number of grants by King John survive in which he gave burgages to Anglo-Norman settlers "below the walls" and in the island towards the city, near the bridge" (Lenihan 1866, 48, n. i). From this it would appear that the area which was to develop into Irishtown was being settled although, as we have already seen, the churches of St. Michael and St. John seem to have been in existence before the coming of the Normans. Work commenced on Limerick castle during the first decade of the thirteenth century and part of it seems to have been built on property belonging to the bishop of Limerick (MacCaffrey 1907). The thirteenth century was a period of considerable prosperity which saw not only the expansion of the town but also the construction of new friaries belonging to the Franciscans and Dominicans, as well as considerable work on the town walls.

During the fourteenth and fifteenth centuries the city became increasingly isolated as a result of the Gaelic revival and it was actually stormed and plundered by Mac Con Mara in 1370. The royal records of this time are filled with petitions seeking relaxation of rents and grants in aid of maintaining the city (Tresham 1828, 27: no. 41; 95: no. 176; 100: no. 20). Its loyalty to the crown was never in doubt, however, and it received a series of royal privileges in 1414, 1423, 1433, 1464 and 1489 (Lenihan 1866, 65-8). The town remained an important port although during this period its overseas trade was overshadowed by that of Galway and there were also problems of piracy on the Shannon estuary to contend with (Lenihan 1866, 70).

With the revival of the English government's interest in Ireland during the second half of the sixteenth century the town became one of the principal administrative and provision centres of the Munster plantation. During the Confederate wars of the mid-seventeenth century it initially remained loyal to parliament but after the capture of the castle in 1642 it became one of the Confederate strongholds. The town was besieged by the Cromwellians in 1651 and eventually surrendered to their commander, Ireton. The town's most famous role in military history occurred in 1690-i when it was besieged by the Williamites and held out for almost a year. The story of these events has often been told and they are well covered in the pages of many histories, particularly that of Lenihan (1866, 148-287).

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RMP code: LI005-017001- Class: Bridge

Grid coordinates: E 558054, N 657423

Location: Directly beside Areas B2 and B3.

Description: 19th century Balls (Baals) Bridge (NIAH Reg. No. 21513031) traversing the Abbey River was built on the site of the four arched medieval Baal's Bridge. The medieval bridge was described in the Urban Survey of Limerick (Bradley et. al. 1989, 256) as following; 'The reference to the destruction of a bridge by Domhnall Mor Ua Briain in 1176 indicates that there has been a bridge at Limerick since Viking times. The location of this bridge, however, is not absolutely certain. From the context in which the reference occurs it is most unlikely that it is a bridge which straddles the Shannon but rather a bridge linking King's Island with Irish Town or the mainland probably on the site of the present Baal's Bridge (Scott and Martin 1978, 167). Ball's bridge may retain a medieval core although rebuilt in 1830 (Leask 1941,102). Both Baal's Bridge and Thomond Bridge (LI005-017002-) are shown many times on sixteenth and seventeenth century maps and there can be little doubt but that both are ancient crossing points'.

In 1998 three cuttings were excavated under licence No. 98E0581 on George's Quay and one at Broad Street before construction activity associated with the Limerick Main Drainage Scheme. In addition, a programme of excavation (50 trenches) was initiated in the Abbey River before the first phase of pipe-laying in the riverbed. Phase II of the construction work will see river gravels being investigated for archaeological structures and artefacts at the mouth of the Abbey River at its confluence with the River Shannon and another short programme of land-based excavation in the Potato Market. The summary of these excavations were described by Edmond O'Donovan for Margaret Gowen & Co. Ltd as following; 'Broad Street

Excavations at Broad Street (Cutting 3) uncovered two medieval bridge piers under the junction of Broad Street and Charlotte Quay. These structures formed part of the medieval bridge (on the site of Baal's Bridge) that formed the vital link between the Irishtown and the Englishtown on King's Island. When the Anglo-Normans launched their assault on Limerick in 1175 there was no bridge in the location later occupied by Baal's Bridge. Giraldus Cambrensis records that the attackers found a ford across the Abbey River and he 'hurled himself headlong into the swiftly flowing river...' and managed to cross to the opposite bank. It would appear that the bridge linking King's Island to the mainland to the south, on the site of what is now called Baal's Bridge, was non-existent when the Anglo-Normans arrived in Limerick in 1175.

The excavations at Broad Street indicated a long archaeological sequence commencing in the mid-13th century up to the present day. The cutting measured 35m east-west by between 5m and excavated to a depth of 5m below the street level. Three samples from oak timbers that revetted one of the bridge piers were submitted for dendrochronological dating (David Brown, The Queen's University of Belfast). The results suggested that the bridge piers were constructed in the early 13th century.

Organic deposits were identified abutting the bridge piers. Environmental analysis of macrofossil plant and insect remains (by Eileen Reilly and Penny Johnston of Margaret Gowen & Co.) has demonstrated that the deposits around the bridge piers accumulated slowly as a result of the dumping of organic refuse and the accumulation of river silts. The organic deposits originated from natural silting and contemporary settlement in the medieval city during the 13th and 14th centuries. The excavation revealed evidence for the growth and development of Broad Street, with evidence of house floors dating from the 14th/early 15th century built on top of ground reclaimed from the riverbed. This expansion of the Irishtown towards the Abbey River

is likely to have been associated with renewed town wall building extending into the Abbey River. The uppermost archaeological deposits in the cutting consisted of post-medieval cobbling, drains and culverts. The medieval bridge was demolished in 1830 before the construction of the current Baal's Bridge.

Baal's Bridge

Extensive excavations of the riverbed from Matthew Bridge to Baal's Bridge have been completed. These involved opening a large cutting under Baal's Bridge and fifty smaller trenches upstream and downstream of the ford on which the bridge is sited. The river gravels (c. 1m deep) in these locations are rich in archaeological artefacts. While no in situ structures have been uncovered, a large, important and eclectic collection of archaeological objects was found. The trenches were excavated in situ in the riverbed, and the artefacts were recovered layer by layer.

A preliminary summary of the artefacts found includes objects dating from the prehistoric period (worked flint) to the post-medieval period. To date, no Bronze Age objects have been recovered. Several pre-Viking Age artefacts have been recovered, including a possible Iron Age horse bit, an Early Christian bronze zoomorphic object and a spiral-headed pin. A number of Viking Age stick-pins and a coin (c. 1035), minted in London for King Cnut, were also found. Medieval and post-medieval artefacts include beads, coins, horse equipment, pins, brooches, tools and weapons. A small assemblage of locally manufactured and imported medieval pottery has been recovered from the riverbed. Fifty medieval coins dating from 1200 to 1540 have been recovered; they are largely Irish, although Scottish, French and English coins are also included. An early post-medieval (c. 1600) seal bearing the 'Lymerick Port' coat of arms was also recovered from the riverbed. Objects dating from the Williamite siege of the city, including iron and stone cannon, musket balls of various sizes, gun flints, spurs, fragments of iron mortar bombs, grenades, iron bayonets and coins (Jacobite gun money), have been retrieved.' (www.excavations.ie).

The present 19th century bridge was described by the National Inventory of Architectural Heritage [NIAH] as a, 'Single-arched hump-back limestone bridge, built between 1830-31, linking Mary Street to the north in English Town with Broad Street to the south within Irish Town and spans the Abbey River. Plaque to bridge reads: 'This bridge was erected by virtue of an Act of the XIth of Geo.e the IV. The Rt. Honble. Thos. Spring Rice M.P. for the city of Limerick. Commenced taking down the old bridge Nov. 1830. The new bridge finished Nov. 1831. J.A. & G. R. Pain Architects.' Another plaque reads: 'The ancient bridge of four arches which occupied this site was taken down and this bridge erected at the expense of the new Limerick Navigation Company incorporated 1830 - Chas. Wye Williams Esqr. Chief Director. J.A. & G. R. Pain Architects.' (www.buildingsofireland.ie).

Compiled by: Caimin O'Brien

Date of upload: 14 November 2019

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RMP code: LI005-017002- Class: Bridge

Grid coordinates: E 557575, N 657846

Location: Directly beside Area A1.

Description: The present 19th century Thomond Bridge (NIAH Reg. No. 21508001) crossing the River Shannon overlooked by King John's Castle (LI005-017014-) was described by the National Inventory of Architectural Heritage as a, 'Seven-arch rock-faced limestone road bridge, built in 1836, spanning the River Shannon, with pointed curved breakwaters and short quadrant abutments. Inscription to commemorative plaque, on road side of parapet reads: 'This bridge was built A.D. 1840 at the Expense of the Corporation of the Borough of Limerick. This tablet was placed there by order of the town council A.D. 1843. The Right Worshipful Martin Honan Mayor John F. Raleigh Esq. Town Clerk Francis O'Neil Esq. Treasurer James and G.R. Pain Architects.' The building of a wider and more accessible Thomond Bridge, which was constructed between 1836-1838 to the design of James Pain and George Pain, gave better access to the agricultural districts of Clare. It replaced a series of previous bridges dating to the twelfth or thirteenth century, linking the west side of the River Shannon with King's Island. The previous medieval bridge was of fourteen arches. It is believed to incorporate pier foundations from the bridge which it replaced, as survey drawings dated to 1814, demonstrating the re-use of existing historic fabric by James Pain' (www.buildingsofireland.ie).

Thomond medieval bridge crossing the River Shannon was described in the Urban Survey of Limerick (Bradley et. al. 1989, 256) as following; 'The reference to the destruction of a bridge by Domhnall Mor Ua Briain in 1176 indicates that there has been a bridge at Limerick since Viking times. The location of this bridge, however, is not absolutely certain. From the context in which the reference occurs it is most unlikely that it is a bridge which straddles the Shannon but rather a bridge linking King's Island with Irish Town or the mainland probably on the site of the present Baal's Bridge [LI005-017001-] (Scott and Martin 1978, 167). The bridge across the Shannon appears to have been built in the reign of John [1199-1216]. In 1358 the citizens received a grant to assist them in extending this bridge and adding towers to it in order to repel the Irish (Tresham 1828, 74: no. 82). Both Baal's Bridge and Thomond Bridge are shown many times on sixteenth and seventeenth century maps and there can be little doubt hat both are ancient crossing points'.

Compiled by: Caimin O'Brien

Date of upload: 14 November 2019

References:

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RMP code: LI005-017010- Class: Town defences

Grid coordinates: E 557639, N 657897 (multiple locations)

Location: Beside or at works areas in Areas A1, B1, B2, B3

Description: There is currently no description available for this record on the HEV, however a detailed review of the City Wall is contained in the Limerick City Walls Conservation Management Plan (Collins et al. 2008).

RMP code: LI005-017014- Class: Castle - Anglo-Norman masonry castle

Grid coordinates: E 557689, N657804

Location: Directly beside Area B3

Description: National monument No. 288. The Anglo-Normans first established a presence in Limerick in 1171 when Donal O'Brien, King of Limerick and Thomond, paid homage to King Henry II at Cashel, and afterwards King Henry II sent 'Keepers' to Cork and Limerick (Furnivall 1896, 60). In 1175, Donal O'Brien, King of Limerick, rebelled against the King of England and Raymond le Gros assembled an army of 120 men-at-arms, 300 horse solider and 400 archers on foot and marched on the 1st of October to attack Limerick (Scott and Martin 1978, 149-53). In 1217, King Henry III granted Reginald de Breouse [Braose], 'custody of the castle and city of Limerick, to hold till the K.'s 14th year' (Cal. doc. Ire. No. 787, 118). In this year the King notified the 'knights, free tenants, and others on the lands of William de Breouse in Ireland, that Reginald de Breouse having come to his fealty, the K. restores to him all the lands which belonged to his father ere Meyler Fitz Henry, then justiciary of Ireland, divided them between Munster and Desmond' (Cal. doc. Ire. No. 786, 118). In 1223 King Henry III granted Richard de Burgh the seneschalship of Munster along with the castle of Limerick with the condition that he serve as the king's bailiff under the justiciary (Cal. doc. Ire. No. 1114, 170).

The royal castle of Limerick known as King John's (1199-1216) Castle was described in the Urban Survey (Bradley et. al. 1989, 288-99) as following: 'Work on this castle appears to have commenced in the first decade of the thirteenth century possibly on the site of the "fort" (LI005-017124-) referred to in the Cogadh Gaedhel re Gaillibh (Todd 1867, 81). There was a substantial building here by 1211-12 because the Irish pipe roll of John states that £733 16s. 11d. was needed for repairs to the castle (Davies and Quinn 1941, 69; Sweetman 1980, 1327). Substantial repair works were also carried out in 1327 (Tresham 1828, 35: no. 34) but by 1585 the castle was again in need of considerable repair (Sweetman 1980, 208). Further repairs were carried out in 1608, 1618 and 1624 (ibid.).

The castle is situated on the west perimeter of English Town overlooking the Shannon and Thomond Bridge. It is based on a rough quardangle, measuring 75m north-south by 65m east-west externally. It originally had round towers at each angle and a large twin-towered gatehouse in the centre of the north wall. The buildings have been considerably modified, most of the towers and curtain wall have been lowered and topped with modern parapets. The south-east angle tower is completely missing and was replaced in the early seventeenth century by a rectangular bastion which itself survives only in a fragmentary state. The east curtain wall is entirely missing, while the west curtain wall is not visible above ground internally although much of it is visible externally where ground level is lower. The masonry of all phases consists of coursed limestone rubble. Much of the original masonry displays alternating courses of large blocks and small pinnings while the doors and windows have jambs of red and yellow sandstone.

Gatehouse

The castle is entered through a gatehouse of twin D-shaped towers (overall width 21.5m externally) with, originally, a barrel-vaulted chamber 7.3m wide (externally) behind the entrance passage. The towers are of three floors. The west tower is 17.6m high externally of which the upper 2.1m is modern parapet. The east tower is 15.5m high of which the upper 1.2m is modern parapet. Both have basal batters, 1.5m and 2m high respectively.

On the ground floor is an entrance passage c.2.5m wide leading to a door with a pointed arch and dressed sandstone jambs, which is c.5m high internally but externally is approached by a modern stair rising from street level, 2-3m below. The door was protected by a portcullis and a murder hole, concealed behind a round arch some 12m high between the towers externally. Each of the flanking towers has a round chamber, whose interiors are plastered, making it difficult to distinguish between original and later masonry. The west chamber is entered from the castle yard through an unsplayed doorway with segmental rear arch on the south; three tall splayed loops with dressed sandstone jambs and segmental rear arches, which seem to be of brick, face west, north and east respectively. The east chamber is entered from the castle yard

through a tall pointed doorway whose chamfered sandstone jamb seems to be modern; the pointed rear arch is of brick. Two splayed loops, with sandstone jambs and segmental rear arches face west and north. All that remains of the chamber behind the entrance passage are the north returns of the east and west walls, c.6.5m high with the line of a barrel vault c.6m high in between the south wall of the gatehouse.

It would appear that the only approach to first floor level was from the wall-walk of the curtain wall to the west, unless it was, as it is now, by means of an internal wooden stair within the towers. The two tower chambers are circular, with modern floors supported on ledges in the walls. The west chamber is entered from the curtain wall through a modern round headed door on the west via a short passage with pointed vault in which there are traces of plank centering. This passage overhung the curtain wall to the north. Two splayed loops, with sandstone jambs and pointed rear arches with plank centering face north-west and north-east. On the south east is another modern round-headed door and a passage with pointed vault leading to a balcony occupying the space above the entrance. A portcullis chamber presumably originally occupied this space and perhaps first floor level of the structure behind the entrance. At the E end of the balcony is another passsage with pointed vault entering the east chamber through a pointed door (probably modern) on the south-east. The chamber is lit by a splayed loop with sandstone jambs and segmental rear arch facing north-west and a twin-light rectangular window with chamfered limestone jambs, in a large flat lintelled embrasure with modern window seats facing north-east. On the south-east a round headed doorway leads to a spiral stair giving access to the upper floors, located at the junction of the east side of the tower with the north curtain wall.

The second-floor chambers are circular with modern roofs, flat in the east chamber, domed in the west chamber. This is approached through the mural stairs in the east from which the east chamber is entered through a modern rectangular doorway on the south-east. The chamber is lit by a splayed loop with sandstone jambs and a modern pointed rear arch facing north-west, while on the south-west is a modern rectangular doorway leading to a balcony connecting the east and west towers, which has on its south side a modern open arcade of three round-headed arches.

The west chamber is entered from the balcony through a modern rectangular door on the south-east. It is lit by a modern twin-light rectangular window with chamfered limestone jambs and segmental rear arch facing south (the wall on the south is refaced, if not rebuilt, externally), a modern broad segmental arched window splaying externally and internally with limestone jambs and segmental rear arch facing west and a splayed loop with sandstone jambs and a broad modern segmental arched window with limestone jambs, both set within the same large embrasure with segmental rear arch facing NNW.

The spiral stairs in the east tower rises to roof level, where it terminates in a modern turret c.2.5m high. Both towers are topped by modern parapets above string courses; that on the east tower is low (c. 1m high) and broad, while that on the west tower is taller (c.2.1m high) and has four crenels. Over the entrance is a passage connecting the towers.

NE Tower

A D-shaped tower, at present of one floor, with wall-walk above but originally of at least two floors. It is 13.4m in maximum external width, and c.13m high of which the upper 2m is a modern parapet. There is an external basal batter c.4m high. The main chamber is circular and is entered from the castle yard by a large pointed door with chamfered sandstone jambs (possibly modern) which is c.4m tall; however, the lower 1.8m are blocked, up to the internal floor level, which is modern concrete. The chamber is lit by three splayed loops with sandstone jambs, one facing WNW with pointed rear arch; the latter two are tall, c.l.5m. On the south east is a recess above which is a space apparently for a lintel and which seems to be a blocked fireplace. The chamber is roofed by a domed vault c.6m high in overall height (while the walls of the chamber are 4m high) which is apparently inserted as it seems to block a first floor level embrasure indicated externally by three blocked loops with sandstone jambs, facing NW, NNE and SSE.

The former presence of an upper floor is indicated by a spiral stair located in the south east angle of the tower, at its junction with the east curtain wall. This stair was entered directly from the castle yard through a pointed door with chamfered sandstone jambs, 1.9m tall and set 1.8m above the ground level of the castle yard, leading to a short passage with pointed barrel vault.

The stairs rise only 4-5m above which the stairwell is blocked, while most of the stairs below this are broken; they are lit on the south by a splayed loop with sandstone jambs and flat lintelled rear arch. On the internal south west face of the tower is a straight roof line, apparently of a lean-to building c.5.75m above present ground level of the castle yard.

NW Tower

A three-quarter round tower, at present of one floor with wall-walk above, but of two or more floors originally. It is 12.8m in external diameter and ll.4m high of which the upper section is modern parapet. On the south-west, however, where the tower is directly bordered by the Shannon, the height is c.17-18m above water level. There is an external basal batter, which is up to 4m high and 1.5m wide on the river side but hardly visible above ground level elsewhere.

The main chamber is entered from the castle yard through a modern porch built against the south-east face of the tower; a straight stair in a passage in the tower wall descends to internal floor level, which is 2.3m below ground level of the castle yard. The chamber is circular and is lit by three tall loops with limestone jambs facing south-west, west and north. The latter two have pointed rear arches with traces of plank centering, whereas the former has a round rear arch and is possibly modified. All three have modern window seats inserted. The west and north loops are extremely tall, 3.7m and 3.3m respectively, and are set up to 1.5m below floor level, causing the floors of the embrasures to slope sharply downwards near the loops. The chamber is roofed by a domed vault c.9m high (walls of the chamber c.6.8m high) which is probably inserted. A spiral stairs is located on the east side of the tower, at its junction with the north curtain wall; it is approached by a passage with pointed barrel vault opening off the main entrance passage, and is lit by a splayed loop with limestone jambs and flat lintelled rear arch facing north-east. There may be an intact first floor chamber, but if so, it is inaccessible. It may have been entered through a pointed door with modern arch, having sandstone jambs with heavy roll moulding, in the internal (SE) wall of the tower, now blocked. On the north east is a large embrasure or chamber with pointed vault with traces of plank centering, lit externally by a tall loop with limestone jambs and flat lintelled rear arch, facing ENE, and connected with the spiral stairs by a passage with pointed vault with traces of plank centering; the internal(SW) wall of the large embrasure or chamber is a modern insertion, and may block an entrance to the main first floor chamber.

Above first floor level the spiral stairs continue to rise, and a modernised doorway on the east leads onto the wall-walk of the north curtain wall. Just above this the stairs are abruptly cut off by a modern ceiling. The tower has a (modern?) domed roof with low, c.lm high, broad parapet.

SW Tower

A three-quarter round tower, at present probably of two floors with wall-walk above, but originally probably of at least three floors. It is 12.3m in external diameter and up to 17.3m high on the river side, of which the upper 2m is a modern parapet; there is a strong basal batter up to 3.2m

high. The tower is at present entered, at what appears to be first floor level, from the castle yard through a modern rectangular door in the angle between the west and south curtain walls. The inner wall of the tower is carried over this angle on a round arch c.4m high. Opening off this doorway are, to the south, the main first floor chamber and to the west a spiral stair located at the junction of the tower with the west curtain wall and giving access to the ground and second floors levels. At the base of the stairs is a blocked, pointed doorway, with dressed limestone jambs,which presumably gave access to the ground floor chamber. This chamber is not accessible, but is also evidenced by a small, narrow loop with limestone jambs, facing north-west and visible externally. The first-floor chamber is circular and had at least three embrasures facing east, south-east and west and possibly another facing south-west. The east embrasure has a pointed arch with traces of plank centering, although the inner part has been widened and now has a round arch. Externally a blocked rectangular doorway probably modern date is visible in a buttress-like projection. The south-east embrasure is completely blocked, while the west embrasure is largely blocked, leaving only a rectangular opening 95cm high, 80cm above ground. It has a twin-light round headed window, of which the arch heads, in sandstone are all that survive and a pointed rear arch. The chamber has a domed vault c.5.5m in overall height (walls of the chamber c.3.25m high), again probably inserted. The former existence of a

second-floor chamber is indicated by the presence of a blocked twin-light rectangular window with chamfered limestone jambs facing south-south-west and visible externally. Above first floot level at present, however, there is a flat roof with modern parapet c.2m high approached from the spiral stairs. The stairs are lit by three splayed loops facing north along the west curtain wall; the first between ground and first floor levels has sandstone jambs; the second just above first floor level had limestone jambs and is of uncertain date; the third just below roof-level is modern but beside it is a blocked rectangular opening which presumably gave access to the wall-walk of the west curtain wall.

North Curtain Wall

This wall does not run in a straight line but turns sharply to the south-east just east of the gatehouse. The angle thus formed has dressed sandstone quoins externally, as has a less pronounced angle west of the gatehouse. The wall is up to llm high externally and 3m thick, with basal batter c.3.5m high, east of the gatehouse. West of the gatehouse it is up to 9.9m high, of which the upper 1.1m is modern parapet. West of the gatehouse there is a wall-walk with access at either end from the north-west tower and gatehouse. East of the gatehouse much of the upper part of the wall is missing internally and replaced by modern stairs. Below the stairs, at ground level is a splayed loop with sandstone jambs and pointed rear arch, while three small narrow blocked loops are visible externally at c.7.5m high, two west of the gatehouse and the third east of it.

West Curtain wall

This is almost straight but is angled slightly either side of a projecting rectangular turret near the north end. It does not survive above internal ground level which is c.6.5m high higher than external ground level; thus, it is 6.5m high externally. Wall returns in the north-west and south-west towers, however, indicate that it was originally 10.4m high externally to wall-walk level, above which there was a parapet. South of the turret the wall has a basal batter 90cm high, but north of the turret the batter is much higher (2.5m) and wider (1m). At the junction of the with the north-west tower a garderobe chute in dressed limestone, has been built on. No other features are visible north of the turret, apart from a series of modern gun-loops near the top, in what is probably modern masonry. The turret itself (shown by Philips in 1685) is 5.9m wide, of masonry similar to the curtain wall but without a batter, and featureless apart from a window and gun loop in modern masonry at the top. A modern extension 5m wide, has been built onto the south side. Roughly midway between the turret and the south-west tower is a postern gate with modern arch, but some original sandstone jamb stones survive; it is approached from within the castle by a dog-leg stairs c. 2m wide, with pointed barrell vault above, the other end of which is blocked. North of the postern four rectangular windows with chamfered sandstone jambs occur at a height of c.4m externally and at intervals of c.4m; vaulted embrasures, now inaccessible, are visible inside the windows.

South Curtain Wall

A straight wall up to 7.2m high at the west end externally (but only 5.6m high at the east end, due to rising ground level) of which the upper 1.3m is modern parapet. It is topped by a wall-walk with modern parapets internally and externally. The wall is apparently of two phases. At the west end it is similar, in general features, to the west and north curtain walls, but east of a point 6.9m from the south-west tower it has a much higher (4m) and wider (1.25m) basal batter externally as well as a slight batter internally.

At the east end of the wall are the west and incomplete south walls of a quadrangular bastion which replaced the south-east tower in the early seventeenth century. At present it measures c.8.5m north-south by c.15m east-west, with walls 5.6m high of which the upper 1.3m is modern parapet, having a strong external batter 4m high, and topped by a wall-walk with modern parapets internally and externally. The masonry is of large, roughly dressed limestone blocks, with very large dressed limestone quoins.

Excavations in 1976 revealed the foundations of a thirteenth century hall-like structure and a large quantity of post-medieval pottery (Sweetman 1980)'. Further excavations were carried out in 1989 by Brian Hodkinson, Limerick Corporation, to assess the remains of the east curtain wall (Wiggins 2016, 41). In February 1990, following demolition of row 4 (Nos 22—5) and row 1 (Nos 1—6) of the Corporation terraces, excavation under licence No. E0534, was carried out

by City Archaeologist, Celie O'Rahilly, in the course of which remains of the east curtain wall and the bastion were substantially exposed (ibid.). The overall dimensions of the excavation were c. 46m (north—south), extending between the north-east tower and the standing south wall of the bastion, by c. 24m (east—west). At the beginning of March 1991 a small investigation was carried out near the northern end of the latrine block on the west curtain wall in order to determine the source of water seepage on the outside of the curtain wall. In 1993 further excavations were carried out by Kenneth Wiggins under licence No. 93E0082. Cutting 1 of this phase of the excavations was located at the rear of the gatehouse, where wall stubs indicating the presence of a demolished extension to the gate passage made this area a key one to investigate (Wiggins 2016, 46). Cutting 1 was situated adjacent to the main gate of the castle, at that time not in use for visitor access, along the northern side of the castle. Cutting 2 was established on the western side of the courtyard. Cutting 3 was located outside the south curtain wall. In January/February 1997, three large cuttings were made by mechanical excavator under the supervision of Kenneth Wiggins under licence No. 93E0082. The first two were located at the western end of the site, while cutting 3C was located in the eastern half. Cutting 3A was at the north-western corner of the site, adjacent to the south curtain wall, and measured c. 12m (east—west) by 5m. This area actually corresponded with the proposed location of Castle Lane (Wiggins 2016, 56).

Recent research carried out by Kenneth Wiggins (2016, 38-41) on the castle suggested the following phases in the development of King John's Castle:

Phase 1 (1175—6). Construction of the Anglo-Norman ringwork, an enclosure comprising a clay bank and ditch.

Phase 2 (1195—1216). The first significant masonry work is completed, within the footprint of the ringwork. Section 1 of the east curtain wall is part of this phase. This phase represents the castle as it was during the reign of King John.

Phase 3 (1216—35). The castle expands beyond the limits of the ringwork, by means of a ditch and clay bank. There is no further masonry work at this time.

Phase 4 (1235—80). The stone castle is developed by construction of the north-west tower.

Phase 5 (1280—1608). Substantial time-span, during which the masonry castle is completed. Most of the development is confined to the early years of the phase, including the building of the south-west tower and the great hall (level 1a, c. 1280; level 1b, 1280—97), and substantial improvements to the great hall and the courtyard.

Phase 6 (1608—42). The south-east corner is fortified with the construction of the bastion, and a new ditch is provided. The siege of 1642.

Phase 7 (1642-1750). Evidence for new building in the courtyard and for improved outer defences:

Phase 8 (1751—1922) - The construction of the castle barracks which is the largest building inside the castle courtyard.

Compiled by: Caimin O'Brien

Date of upload: 17 April 2018

References:

1. Anon. 1841 Thomond Bridge and the Castle of Limerick. The Irish Penny Journal 1, No. 39 (Mar. 27, 1841), 305-307.

2. Bradley, J., Halpin, A., and King, H.A. 1989 Urban archaeological survey - county Limerick (3 vols.). Unpublished report commissioned by the Office of Public Works, Dublin.

3. Cal. doc. Ire. - Calendar of documents relating to Ireland 1171-1307, ed. H.S. Sweetman (5 vols., London, 1875-86).

4. Davies, O. and Quinn, D.B. 1941 The Irish pipe roll of 14 John, 1211–1212. Ulster Journal of Archaeology 4, 1–76.

5. Furnivall, F.J. (ed.) 1896 The English conquest of Ireland, A.D. 1166-1185, mainly from the "Expugnatio Hibernica" of Giraldus Cambrensis. Kegan Paul, Trench, Trubner & Co., Limited. London

6. Harbison, P. 1970 (Reprint 1992) Guide to the national monuments in the Republic of Ireland. Dublin. Gill and Macmillan.

7. Leask, H.G. 1941 Irish castles and castellated houses. Dundalk. Dundalgan Press.

8. Scott, A.B. and Martin, F.X. (eds) 1978 Expugnatio Hibernica: the conquest of Ireland by Giraldus Cambrensis. A new history of Ireland, ancillary publications, iii. Dublin. Royal Irish Academy.

9. Shirley, E.P., Dineley, T., O'Brien, R. and Graves, J. 1858-67 Extracts from the Journal of Thomas Dineley, Esquire, giving some account of his visit to Ireland in the reign of Charles II. Journal of the Royal Society of Antiquaries of Ireland 6, 73-91, 176-204, 289-90.

10. Sweetman, P. D. 1980 Archaeological excavations at King John's Castle. Proceedings of the Royal Irish Academy, 80C, 207-29.

11. Todd, J. H. (ed.) 1867 Cogadh Gaedhel re Gallaibh: the war of the Gaedhil with the Gall. London.

12. Tresham, E. 1828 Rotulorum patentium et clausorum cancellariae Hiberniae calendrium Hen II - Hen VII. Dublin.

13. Wiggins, K. 2016 A Place of Great Consequence: Archaeological Excavations at King John's Castle. Wordwell. Dublin.

RMP code: LI005-017069- Class: Mill – unclassified

Grid coordinates: E 557964, N 657464

Location: 8 m north of Area B2

Description: Leask refers to Nicholas Arthur's Mill located 'about the middle of the present George's Quay' (1941, 100), which is shown on a late 16th century map of Limerick City (TCD, MS 1209/57). Also Comyn's Mills, it was demolished in 1763 (O'Flaherty 2010, 30) when George's Quay was built (Hill 1991, 82-3).

Excavations carried out in the Abbey River under licence No. 98E0581 ext. by Ed O'Donovan on behalf of Margaret Gowen & Co. Ltd were summarised as following; 'Over the past year and a half, excavations in advance of construction work associated with the Limerick Main Drainage Scheme have been carried out. The report on the first phase of these excavations (Excavations 1999, 169–71) included brief reports on excavations along George's Quay and at Broad Street. The Phase I excavations also included an account of the various artefacts recovered from the bed of the Abbey River between Matthew Bridge and Baal's Bridge. This year the excavations in the riverbed extended from Matthew Bridge to the mouth of the Abbey River, with its junction with the Shannon at Curragour Point, and from Curragour Point in the Shannon to Sarsfield Lock, and also included a short programme of excavation on George's Quay.

Town wall along George's Quay

Two further sections of the medieval town wall were uncovered along George's Quay (at Manholes E and F). Deep excavation was not required as the construction work was relatively shallow; however, the laying of new pipes along the quay at the junction of Creagh Lane and George's Quay did reveal a substantial wall running parallel to the quay. The preliminary interpretation of the structure suggested that it formed part of a bastion or building standing proud of the line of the town wall. Structures standing proud of the town wall along the Abbey River are illustrated on the early historic maps of the city (Pacata Hibernia map, Hardiman's map and Speed's map). Organic deposits of 16th-century date abutting the structure contained the grain weevil Sitophilus granarius. This insect is a pest of stored grain in particular and is

entirely dependent on humans for its dispersal (Eileen Reilly, pers. comm.). These deposits are possibly related to grain stored around Nicholas Arthur's Mill, depicted on Hardiman's map (c. 1590) (www.excavations.ie). 16th/17th-century weir in the Abbey River

The foundations of an early weir (LI005-017186) were identified in the Abbey River. The structure pre-dates Charlotte's Quay and Bank Place and is thought -to form a head-race for two mills on either side of the river, one under Bank Place (LI005-017098-) and the other at the junction of Creagh Lane and George's Quay. This again may relate to Nicholas Arthur's Mill depicted on Hardiman's map, c. 1590 (O'Donovan et. al. 2003).

Compiled by: Caimin O'Brien

Date of upload: 18 November 2019

References:

1. Leask, H.G. 1941 The ancient walls of Limerick. North Munster Antiquarian Journal 2, 95-108.

2. O'Donovan, E. et. al. 2003 Archaeological excavations on George's Quay and Broad Street: conducted as part of the Limerick Main Drainage Scheme. Unpublished excavation report 98E0581, National Monuments Service, Department of Arts, Heritage and the Gaeltacht, Dublin.

3. O'Flaherty, E. 2010 Irish Historic Towns Atlas, no. 21, Limerick. Dublin. Royal Irish Academy.

4. TCD, MS 1209/57 Trinity College Dublin, Citie of Limrick, per Joanes. Hardiman Atlas. Dublin.

5. Hill, J. 1991 The building of Limerick. Mercier Press

RMP code: LI005-017072- Class: Quay

Grid coordinates: E 557761, N 657536

Location: 25 m north of Area B3

Description: The potato market stands at the junction of Quay Lane [Bridge Street] and Merchant's Quay which was an important harbour or port in medieval Limerick. This merchant's harbour or port protected by a quay wall was described by Leask (1941, 101) as following; 'Where the Potato Market now is there was one of the most interesting features of ancient Limerick — the ship dock or port — enclosed by pier-like arms of the walls terminating in towers. The southern pier or wall, nearly 400 feet [122m] long, started from a tower seemingly three-sided, at the foot of the "Rue du Quay" of the French map: the modern Bridge Street, and formed the south boundary of the port. In 1500, say Fitzgerald and McGregor, "a wall and vault were built on the south side of the Quay. This vault had its entrance by a flight of steps at the end of Quay Lane, and formed a covered way to a six-gun battery at the Pierhead near the flood-gate. This is the south wall and tower shown (the former by a double line) on the French map [Lenihan 1866, 258], which also shows the entrance steps minutely. This south wall of the Quay was repaired in 1640-41, when Wm. Comyn was Mayor, and bore a long inscription to that effect which is given in Ferrar's History, 1st edition, 1767. The tower fell in 1693, the collision of the falling stones detonating the 250 barrels of gunpowder in store there, with most destructive effects: fatal casualties and much injury to persons and property houses were wrecked, many windows broken and roofs stripped. The battery at the pier-head seems to have been a successor to the tower.

The entrance to the port was bounded, on the north side also, by a wall-pier about 100 feet [30m] in length and the same distance from the south wall. It also terminated in a tower. Within the entrance lay the dock itself, an irregular piece of water surrounded by quays and projecting jetties and backed by the quay. The view in Pacata Hibernia shows a sort of half-moon quay, but the French map and that of 1590 [TCD, MS 1209/57] are more precise and detailed and

probably more accurate. The piers and terminal towers—which must have been most interesting and picturesque objects—have quite gone and so also has the whole of the river wall of the town from the dock northwards to the nearest tower of King John's Castle [LI005-017014-]. Its trace passes across the County Court House diagonally at the river end of the building, and in the same way over the yards west of the City Court House'.

Compiled by: Caimin O'Brien

Date of upload: 19 November 2019

References:

1. Ferrar, J. 1787 The history of Limerick. Limerick.

2. Fitzgerald, P. and McGregor, J.J. 1826 The history, topography and antiquities of the county and city of Limerick. Dublin.

3. Leask, H.G. 1941 The ancient walls of Limerick. North Munster Antiquarian Journal 2, 95-108.

4. TCD, MS 1209/57 Trinity College Dublin, Citie of Limrick, per Joanes. Hardiman Atlas. Dublin.

5. Lenihan, M. 1866 Limerick: its history and antiquities.

RMP code: LI005-017073- Class: Battery

Grid coordinates: E 557710, N 657515

Location: At the location of Area B3

Description: A six-gun battery on the S wall of the medieval quay (LI005-017073-) of Limerick described by Leask (1941, 101) as following; 'Where the Potato Market now is there was one of the most interesting features of ancient Limerick — the ship dock or port — enclosed by pier-like arms of the walls terminating in towers. The southern pier or wall, nearly 400 feet [122m] long, started from a tower seemingly three-sided, at the foot of the "Rue du Quay" of the French map: the modern Bridge Street, and formed the south boundary of the port. In 1500, say Fitzgerald and McGregor, "a wall and vault were built on the south side of the Quay. This vault had its entrance by a flight of steps at the end of Quay Lane [Bridge Street], and formed a covered way to a six-gun battery at the Pierhead near the flood-gate. This is the south wall and tower shown (the former by a double line) on the French map [Lenihan 1866, 258], which also shows the entrance steps minutely. This south wall of the Quay was repaired in 1640-41, when Wm. Comyn was Mayor, and bore a long inscription to that effect which is given in Ferrar's History, 1st edition, 1767. The tower fell in 1693, the collision of the falling stones detonating the 250 barrels of gunpowder in store there, with most destructive effects: fatal casualties and much injury to persons and property houses were wrecked, many windows broken and roofs stripped. The battery at the pier-head seems to have been a successor to the tower'.

Compiled by: Caimin O'Brien

Date of upload: 19 November 2019

References:

1. Ferrar, J. 1787 The history of Limerick. Limerick.

2. Leask, H.G. 1941 The ancient walls of Limerick. North Munster Antiquarian Journal 2, 95-108.

3. Lenihan, M. 1866 Limerick: its history and antiquities.

RMP code: LI005-017074- Class: Mill - unclassified

Grid coordinates: E 557688, N 657681

Location: At the location (4 m east) of Area B3

Description: Thomas Arthur's mill, one of a pair of mills (LI005-017075-) located between King John's Castle (LI005-017014-) and the medieval quay (LI005-017072-) (Leask 1941, 101). This is marked as 'Upper Mills' on map in O'Flaherty (2010, 3, Fig. 3) where it is described as 'Newgate Lane, W. end, in Curragour Castle. Mill 14th-15th cent.' (ibid., 30). It is very closely associated with 'Golding Mill' which is also described as 'Newgate Lane, W. end, in Curragour Castle. Mill 14th-15th cent.' (ibid., 30). The two mills were described by Leask (1941, 101) as following; 'At or near the foot of Newgate Lane—the "Rue des Moulins" of the French map [Lenihan 1866, 258] — were two water mills (J on Map). They stood out from the wall [LI005-017010-] just below the Curragower reef. These mills are specifically mentioned in the Civil Survey (Simington 1938, 442-3). There seem to have been two stone houses (36ft. by 30ft. [10.8m x 9.1m] and 45ft, by 27ft. [13.7m x 8.2m]) "with two mills (wheels?) therein seated and a thatched house. The map of 1590 [TCD, MS 1209/57] shows them as "Thos. Arthur's" [LI005-017074-] and the "Queen's Mills," and connected with the city wall (LI005-017010-) by a bridge'.

Both of these probably formed 'the King's Mills' mentioned by Hodkinson (2009, 23) who recorded that 'half of the mill building still exists within the grounds of City Hall, where two stubs of walls can be seen projecting out into the river (ibid.).

Compiled by: Caimin O'Brien

Date of upload: 19 November 2019

References:

1. Hodkinson, B. 2009 The medieval city of Limerick. Matthew Potter, Gearóid Ó Tuathaigh and Liam Irwin (eds.), Limerick history and society: interdisciplinary essays on the history of an Irish county, 17-40. Dublin. Geography Publications.

2. Leask, H.G. 1941 The ancient walls of Limerick. North Munster Antiquarian Journal 2, 95-108.

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4. O'Flaherty, E. 2010 Irish Historic Towns Atlas, no. 21, Limerick. Dublin. Royal Irish Academy.

5. Simington, R.C. (ed.) 1938 The civil survey, AD 1654-1656. Vol. IV: county of Limerick, with a section of Clanmaurice barony Co. Kerry. Dublin. Irish Manuscripts Commission.

6. TCD, MS 1209/57 Trinity College Dublin, Citie of Limrick, per Joanes. Hardiman Atlas. Dublin.

RMP code: LI005-017075- Class: Mill - unclassified

Grid coordinates: E 557699, N 657686

Location: 15 m east of Area B3

Description: Queen's mill, one of a pair of mills (LI005-017074-) located between King John's Castle (LI005-017014-) and the medieval quay (LI005-017072-). The two mills were described by Leask (1941, 101) as following; 'At or near the foot of Newgate Lane—the "Rue des Moulins" of the French map [Lenihan 1866, 258] — were two water mills (J on Map). They stood out from the wall just below the Curragower reef. These mills are specifically mentioned in the Civil Survey (Simington 1938, 442-3). There seem to have been two stone houses (36ft. by 30ft. [10.8m x 9.1m] and 45ft, by 27ft. [13.7m x 8.2m]) "with two mills (wheels?) therein seated and

a thatched house. The map of 1590 [TCD, MS 1209/57] shows them as "Thos. Arthur's" [LI005-017074-] and the "Queen's Mills," and connected with the city wall (LI005-017010-) by a bridge'.

Both of these probably formed 'the King's Mills' mentioned by Hodkinson (2009, 23) who recorded that 'half of the mill building still exists within the grounds of City Hall, where two stubs of walls can be seen projecting out into the river (ibid.).

Compiled by: Caimin O'Brien

Date of upload: 19 November 2019

References:

1. Leask, H.G. 1941 The ancient walls of Limerick. North Munster Antiquarian Journal 2, 95-108.

2. Lenihan, M. 1866 Limerick: its history and antiquities.

3. Simington, R.C. (ed.) 1938 The civil survey, AD 1654-1656. Vol. IV: county of Limerick, with a section of Clanmaurice barony Co. Kerry. Dublin. Irish Manuscripts Commission.

4. TCD, MS 1209/57 Trinity College Dublin, Citie of Limrick, per Joanes. Hardiman Atlas. Dublin.

5. Hodkinson, B. 2009 The medieval city of Limerick. Matthew Potter, Gearóid Ó Tuathaigh and Liam Irwin (eds.), Limerick history and society: interdisciplinary essays on the history of an Irish county, 17-40. Dublin. Geography Publications.

RMP code: LI005-017101- Class: Castle - unclassified

Grid coordinates: E 557694, N 657684

Location: 10 m east of Area B3

Description: Curragower Castle described in the Urban Survey of Limerick (Bradley et. al. 1989, 259) as following; 'In 1657 this was located near the Curragour weir [LI005-110----] parish of St. Nicholas (Westropp 1906-7, 81)'.

Westropp (1906-7, 81) recorded the following details on Curragower Castle; 'The weir [LI005-110----] of Coradoguir is named in 1201 in the Inq. M. f. Henry (B.B.L., p. 15). 1577 The mills [LI005-017074-/075-] of Cordower granted to Hercules Rainsford (Fi. 3027). 1627 W. Creagh f. Martin held the C[astle]. and two mills of Carrowdarrower in the parish of St. Nicholas (Inq. Chan. 50). 1657 Curragowr stone house and C[astle] (C.S., xxviii., p. 64).

Compiled by: Caimin O'Brien

Date of upload: 21 November 2019

References:

1. Bradley, J., Halpin, A., and King, H.A. 1989 Urban archaeological survey - county Limerick (3 vols.). Unpublished report commissioned by the Office of Public Works, Dublin.

2. Simington, R.C. (ed.) 1938 The civil survey, AD 1654-1656. Vol. IV: county of Limerick, with a section of Clanmaurice barony Co. Kerry. Dublin. Irish Manuscripts Commission.

3. Westropp, T.J. 1906-7 The ancient castles of the county of Limerick. Proceedings of the Royal Irish Academy 26, 54-264.

RMP code: LI005-017115- Class: Religious house - Fratres Cruciferi

Grid coordinates: E 558079, N 657465

Location: 10 m north of Area A10

Description: Priory & Hospital of St Mary & St Edward described in the urban Survey (Bradley et. al. 1989,329-30) as following; 'PRIORY & HOSPITAL OF ST MARY & ST EDWARD, alias HOLY CROSS (FRATRES CRUCIFERI) - According to Ware, Simon Minor placed Augustinians in the priory of SS Mary & Edward before 1216. This was, in fact, a house of Augustinian Cruciferi dedicated to SS Mary, Edward and the Holy Cross (Gwynn and Hadcock 1970, 214; Begley 1906, 270-4). Described as "near the bridge" in 1321 (Westropp 1904-5, 360) it is shown on the 1590 map as situated in the angle of the town walls, south of the Franciscan Friary, at Sir Harry's Mall. In 1559 it consisted of the body of the church, a hospital, steeple and a waste garden, barns and close (Westropp 1904-5, 361). Gwynn and Hadcock (1970, 214) have suggested that there were two sets of buildings St Mary and St Edward, and Holy Cross, one the priory the other the hospital. It is possible that the references to the church of "Sancte Marie Rotunda" in the inquisition of 1201-2 (MacCaffrey 1907, 28) relates to this site. It cannot be the same, however, as the church of St Mary Magdalen listed in Bishop Donatus O'Brien's ordinance of 1204-6 (MacCaffrey 1907, 116) because the dedication of the Cruciferi house was clearly to the BVM (Gwynn and Hadcock 1970, 214)'.

Compiled by: Caimin O'Brien

Date of upload: 22 November 2019

References:

1. Bradley, J., Halpin, A., and King, H.A. 1989 Urban archaeological survey - county Limerick (3 vols.). Unpublished report commissioned by the Office of Public Works, Dublin.

2. Begley, J. 1906 The Diocese of Limerick ancient and medieval. Dublin.

3. Gwynn, A. and Hadcock, R.N. 1970 (Reprint 1988) Medieval religious houses of Ireland. Dublin. Irish Academic Press.

4. MacCaffrey, J. 1907 The black book of Limerick. Dublin.

5. Westropp, T.J. 1904-5 A survey of the ancient churches of Co. Limerick. Proceedings of the Royal Irish Academy 25C, 327-479.

RMP code: LI005-017124- Class: Castle – ringwork

Grid coordinates: E 557720, N 657809

Location: At the location of Area B3

Description: Ringwork identified during 1990-1 excavations of King John's Castle (LI005-017014-), the discovery of which was described by Wiggins (2001, 30-3) as following; 'In February 1990 two terraces of corporation houses in the castle were demolished, allowing the development of the castle as a tourist attraction to get under way. Archaeological involvement was commenced by Celie O'Rahilly of Limerick Corporation, who monitored preliminary groundwork activity by the building contractor Brian O'Connell Ltd, which quickly evolved into full-scale excavation under the direction of the writer, until work was completed in September 1991. The purpose of the investigation was to uncover the surviving remains of the eastern curtain wall of the castle, together with the northern flank and eastern face of the bastion, which had been demolished around 1800. The excavated area measured approximately 47.5m north—south, extending from the standing north-eastern tower of the castle to the standing southern wall of the bastion. The width of the excavated area east—west varied between 17m and 30.5m, covering a wide area on both sides of the eastern curtain wall, including the whole interior of the bastion, as well as an area outside the bastion to the east.

In the course of the excavation a good many structural remains other than those of the eastern curtain wall and the bastion emerged. Several features originating in the twelfth century were found, pre-dating the construction of the castle. These included part of the large-scale ringwork enclosure incorporating a stone-revetted bank and broad external ditch, originally constructed by the Anglo-Norman garrison around 1175—6. These early defences were aligned east—west, at right angles to the surviving foundations of the eastern curtain wall. The remains of both the ringwork bank behind the retaining wall and the ditch in front of it were disturbed by the digging of countermines during the siege of 1642'.

Compiled by: Caimin O'Brien

Date of upload: 26 November 2019

References:

1. Wiggins, K. 2001 Anatomy of a siege. King John's Castle, Limerick, 1642. Wordwell. Bray.

RMP code: LI005-017140- Class: House – medieval

Grid coordinates: E 557710, N 657709

Location: 18 m east of Area B3

Description: There is currently no description available for this record on the HEV.

RMP code: LI005-017153- Class: Excavation – miscellaneous

Grid coordinates: E 558058, N 657453

Location: 16 m north of Area A10

Description: This number covers the excavation by Frank Coyne (03E1610) on Mary Street/Sir Harry's Mall, except the burials which have the number LI005-017154-.

RMP code: LI005-017154- Class: Burial ground

Grid coordinates: E 558079, N 657465

Location: 20 m north of Area A10

Description: This is the burial ground represented by the burials uncovered by Frank Coyne in his excavation at Mary Street/Sir Harry's Mall (03E1610ext.) (excavation misc. LI005-017153-) which are probably associated with the nearby abbey (LI005-017115-). Further excavation by Linda G Lynch took place in 2005 uncovering 'a total of 90 human skeletons' (05E0376); see-Lynch, L.G. (2007) 'All shall forgotten lie- Archaeological Excavations at Sir Harry's Mall, Limerick City', NMAJ 47, 11-19.

RMP code: LI005-017177- Class: Burial ground

Grid coordinates: E 558090, N 657475

Location: 22 m north of Area A9

Description: There is currently no description available for this record on the HEV.

RMP code: LI005-018---- Class: Bastioned fort

Grid coordinates: E 557558, N 658574

Location: Outside of the development boundary between Areas A3 and A4.

Description: This fort was located at the northern end of King's Island outside the walled city of Limerick and dates from the period of the Cromwellian war in Ireland (1649-53). In June 1651, the Cromwellian army, under the command of Henry Ireton, came before Limerick and immediately began to invest the city with siege works (see LI005-017183-). Ireton initially set up camp to the north of the city where he erected a large fort (LI005-114----). On 19 June he attempted to storm King's Island by an assault on Thomond Bridge. This was repulsed and four days later he attempted a pre-dawn amphibious attack on the island. A small detachment arrived on the island ahead of the main body and attacked the fort but these were pushed back and a number were killed or drowned as they tried to escape. The remainder of the assault force abandoned the attack and returned to the Clare side of the Shannon. Despite a sustained bombardment Limerick managed to hold out over the following months but eventually surrendered at the end of October 1651. Without doubt the fort on King's Island continued to be garrisoned throughout this siege. The fort is represented on William Webb's map of the siege as a regular square fortification with corner bastions surrounded by a fosse forming an overall star-shaped plan: a single roofed building is shown within the interior. The fort is identified in the map index simply as 'Ye fort in ye island' (O'Flaherty 2010, map 10, no. 65).

It is evident that it was abandoned and allowed to fall into decay but was refortified again during War of the Two Kings, 1688-91. The Jacobite officer, John Stevens, records in his journal that when he arrived at Limerick after the defeat of the Boyne in July 1690 'there were only the ruins of a small fort in the island, the rest being partly a common walk for the citizens and let out for grazing' (Murray 1912, 147). William arrived with his army before Limerick on 9 August 1690 and immediately commenced a siege. At this time the Jacobites were busy strengthening the defences and Stevens remarks in his entry for 12 August that 'The unarmed men were continually kept at work, the chief part whereof was in the King's Island, where was raised a square fort with four bulwarks, on one of them a small platform for three or four guns to play over the branch of the river that makes the island, where it was thought the enemy designed to raise a battery, having made some odd shots from thence.' And again, on 16 August he noted that 'All our unarmed men were continually kept at work, some fortifying the Kings Island' (ibid., 169-70) which included 'an entrenchment or covered way was made about the King's Island to secure it from all attempts, and in the middle of it a Fort Royal with four bastions and a line of communication to the English town.' (ibid., 196). The fort is shown in the schematic panorama included by Story in his 'History' where it identified as 'A new Irish fort' (1693, facing 38; attached). The entrenchments are visible along the northern side of the island but the fort is shown as free-standing without any link to the city. The siege did not go well for William and, after suffering heavy casualties, he eventually abandoned it at the end of August.

Stevens' description of the fort is paralleled by that given by the Williamite, Colonel Michael Richards, who noted in his diary during the second siege in 1691, that it was 'well frized and palisadoed, environed with a handsome counterscarp. Several projects were conceived to attack it, it being first proposed to make a very good battery at the water's edge to cover our passage; but this ground is very low and swampy, which, I apprehend, will put an end to this new design; besides, the fort is so large that all our cannon planted on one battery on this side cannot hinder the enemies from sustaining the said fort with their whole force on the other side, having advantageous ground for it, and a double line of communication to the town' (Gilbert 1892, 288-9). And again, his account is further supported by the Williamite chronicler, George Story, who noted 'great improvements in the King's Island' which had 'a most excellent fort with a double line of communication from thence to the town, mann'd for the most part by the best of their dragoons dismounted' (Story 1693, 213, 277). As depicted on both Story's (ibid., facing 224) and Goubet's maps (O'Flaherty 2010, map 13) it is evident that, besides upgrading the existing fort's earthworks, the most significant undertaking was the addition of a substantial counterscarp and glacis. When Limerick surrendered on 3 October the fortifications were handed over to the Williamites.

The fort is depicted on the map of the city drawn by William Eyres c. 1752 and identified in the map index as the 'Fort in the King's Island; from which the Irish had a communication with the town.' (O'Flaherty 2010, map 16). The map shows that the counterscarp and glacis had been

gradually reclaimed as fields, and a small number of dwellings are depicted near the south-west corner bastion. The fort was further degraded over the ensuing decades and by the time of the OS survey of 1840-1 had been reduced to a four-pointed star with curved sides where it was named '(Site of) Cromwell's Fort'. It continued to be represented as such on subsequent surveys and revisions until it was entirely removed when St Mary's Park housing estate was built on the site by Limerick corporation in the 1930s.

LI005-018----_01 Panorama of the siege of Limerick, 1690, from G. Story, An impartial history of the wars in Ireland with a continuation thereof (1693), facing 38.

LI005-018----_02 Plan of the siege of Limerick, 1691, from G. Story, An impartial history of the wars in Ireland with a continuation thereof (1693), facing 224.

LI005-018----_03 Extract from the plan of the siege of Limerick, 1691, from G. Story, An impartial history of the wars in Ireland with a continuation thereof (1693), facing 224.

Compiled by: Paul Walsh

Date of upload: 6 March 2018

References:

1. Gilbert, J. T. 1892 A Jacobite narrative of the war in Ireland, 1688-1691. Dublin.

2. Murray, R.H. (ed.) 1912 The journal of John Stevens: containing a brief account of the war in Ireland, 1689-1691. Oxford.

3. O'Flaherty, E. 2010 Irish Historic Towns Atlas, no. 21, Limerick. Dublin. Royal Irish Academy.

4. Story, G. 1693 An impartial history of the wars of Ireland, with a continuation thereof. London. Chiswell.

Proposed Testing Regime

In relation to the proposed King's Island Flood Relief Scheme

December 2019

Moore Group

For Arup on behalf of Limerick City and County Council

Contents

Figures

Introduction

A number of archaeologically sensitive areas have been identified in relation to the proposed construction of the King's Island Flood Relief Scheme (KIFRS) in Limerick. It is proposed to undertake archaeological testing in these areas to identify/confirm the nature and extent of archaeological features and/or deposits to clarify the upcoming detailed design phase of the proposed Project. Details of archaeological monuments in relation to the Site Boundary are presented in Appendix 1 Figures 1 and 2.

There are seven areas located in the south west of King's Island where it is proposed to undertake archaeological testing (Appendix 1 3). Proposed constructions work in these areas including flood defences, inter-tidal surface water storage tanks, surface water drainage and a proposed gravity sewer. The works proposed in each area are discussed in more detail below.

It is noted that all of the proposed archaeological testing areas are located within the Record of Monuments and Place Zones of Notification for Limerick City and that much of the work is to take place in the vicinity of the alignment of the City Walls which are designated as National Monuments. The testing in many of the proposed areas is to confirm the presence or absence of the City Walls and, if present, their nature and extent. As such the proposed archaeological testing will take place under Ministerial Consent. Construction of the final designed works will also require Ministerial Consent. Appendix 1 Figure 3 includes the proposed testing Areas overlaid with the alignment of the City Wall from the Limerick City Wall Conservation Management Plan. The alignment of the city wall and its relevant features are discussed in more detail in the relevant sections below.

Archaeological Testing

The definition cited below is that published by the Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs (now the DCHG) in 1999.

'Test excavation is that form of archaeological excavation where the purpose is to establish the nature and extent of archaeological deposits and features present in a location which it is proposed to develop (though not normally to fully investigate those deposits or features) and allow an assessment to be made of the archaeological impact of the proposed development. It may also be referred to as archaeological testing' (DAHGI 1999a, 27).

It is proposed that the applicant machine excavate the trenches using an excavator fitted with a grading bucket to natural subsoil or to the top of archaeological levels if encountered.

Should archaeological material/levels be encountered further cleaning will be carried out by hand in line with best practise and a full photographic and written survey will be completed.

On site recording will be carried out using the single context recording system. Any evident cuts and fills will be recorded using context sheets and if required a mid-excavation plan will be drawn at a scale of 1:10 using a 1m planning grid. Levels will be taken and any cuts photographed. All material will be taken into the curation of the site director and provision will be made for their secure and appropriate treatment. Digital camera equipment will be used and any feature encountered will be recorded three dimensionally using a combination of scale drawings and surveying equipment. A post excavation plan would be drawn at a scale of 1:20 and levels taken and marked onto the plan. The spoil will be metal detected.

Finds Retrieval

Temporary finds storage facilities will be available on-site and more long-term facilities are available in our offices.

All clearing back to investigate potential features will be done by hand and finds from all contexts will be recorded, bagged and numbered in accordance with best practice and in keeping with the special needs and preservation of each find.

All finds and ecofact samples will be kept and submitted to the National Museum as required. If any artefacts require conservation, the relevant licence (Licence to Alter) will be sought from the NMI and professional conservator employed to deal with the material. Osteological remains will be treated per the NMI policy on Human Remains, the Garda Síochána will be notified and an osteoarchaeologist (Linda Lynch) will be available to assist if required. Where a particularly important object is found during testing, the National Museum will be informed immediately.

Environmental Sampling

In the event that sampling is possible without compromising secure contexts, samples for radiocarbon dating would be taken. Advice from environmental specialists would be sought immediately if sensitive bioarchaeological material is encountered (particularly poorly preserved or waterlogged material), to advise on the particular needs of the materials in question. There are no on-site facilities for conservation. Finds or materials requiring conservation would be sent to conservation specialists in that field.

Specialists

No consultations have been undertaken between the applicant and specific specialists, but the following specialists are available for consultation as required.

- Osteologist: Linda Lynch
- Archaeozoologist: Fiona Beglane
- Pottery specialist: Rosanne Meenan
- Conservation specialist: Susannah Kelly.

Additional specialists as required will be contacted.

Reporting

After completion of the testing all records will be indexed, ordered, quantified and checked for consistency. Context, finds, sample and other paper-based records will be transferred to an integrated computer-based system. The drawn record will be digitised in an appropriate format that will permit the output of standard GIS Shapefiles. The Test Excavation Report shall describe the location, nature, date, character, extent, stratigraphy and significance of each archaeological feature or deposit or object discovered or confirmed by Test Excavations. Photographs, plans and sectional drawings of individual trenches, features and deposits (at an appropriate scale) shall be included as appropriate, as well as more general photographs of the work in progress.

Dissemination of the results will take the form of a stratigraphic report and full report to publishable standard lodged with the licensing section (NMS) and the Planning Section (NMS) and the National Museum of Ireland. The report will include the archaeological and historical background of the area, fieldwork procedure, the results of the excavation, the results of the specialist assessment, interpretation and phasing, illustrations (photographs, plans and sections) and assessment, and conclusions.

The final report will comprise an illustrated report on the investigation including all specialist analyses and dating evidence. A summary of the report will also be submitted to the Excavations Bulletin within six weeks of the end of fieldwork. Should results warrant it, wider dissemination in the form of a full publication may be recommended.

Archive and finds deposition

The site archive and any finds will be examined and processed by a professional conservator, pending deposition with the National Museum of Ireland. In the intervening time they would be stored in a safe, secure and suitable location by Moore Group.

Team

The excavation will be conducted by Declan Moore, assisted by Billy Quinn and Willl Anderson. Additional assistance will be available as required.

Summary of Proposed Project

The KIFRS involves the construction of flood defences to protect Kings Island.

There are extensive works proposed in the north of King's Island relating to the construction of an embankment and associated drainage internal to the flood defences. The construction site compound is also proposed in the north of the Island. There is little in the way of known archaeology in the north of King's Island, only a single recoded monument for Cromwell's Fort (SMR No. LI005-018), a bastioned fort dating from c. 1650. The remains of the fort lie beneath what is now St. Mary's Park estate. The nearest works to the fort are approximately 40 m to the west of its associated Zone of Notification. and, following consultation with Sarah McCutcheon (Executive Archaeologist Limerick City and County Council), it is proposed that archaeological mitigation in this area will take the form of archaeological monitoring of topsoil stripping of all greenfield areas that are to be affected by the proposed KIFRS.

Flood defences for the southern half of the Island are more varied, including new concrete flood defence walls, flood defence glass panelling, and new surface water drainage. It is also proposed to lay a new gravity foul sewer pipe from an existing foul sewer pumping station at the rear (north) of Civic Offices to Limerick's Main Drainage manhole on George's Quay. There are two existing foul sewer-pumping stations at the Courthouse and the Civic Offices. It is proposed to decommission these pumping stations and connect directly to this new gravity foul sewer.

There is an intertidal storage tank proposed at the rear of the Civic Offices and a second intertidal storage tank proposed between the Courthouse and the Potato Market at Merchant's Quay. These intertidal storage tanks are designed to cater for 1 in 30-year rainfall event during a high tide event. It is proposed to provide overflows from these intertidal storage tanks to the gravity foul sewer as an emergency overflow, in the event that a high tide and rainfall event greater than the storage volume in the tanks coincide, to prevent surface water ponding at Merchant's Quay.

The greatest threat to archaeology in the south of the Island is dig-out that is required to anchor the proposed flood defences with mass concrete backing to quay walls (Figure 2) and dig-out required to facilitate construction of the gravity sewer.

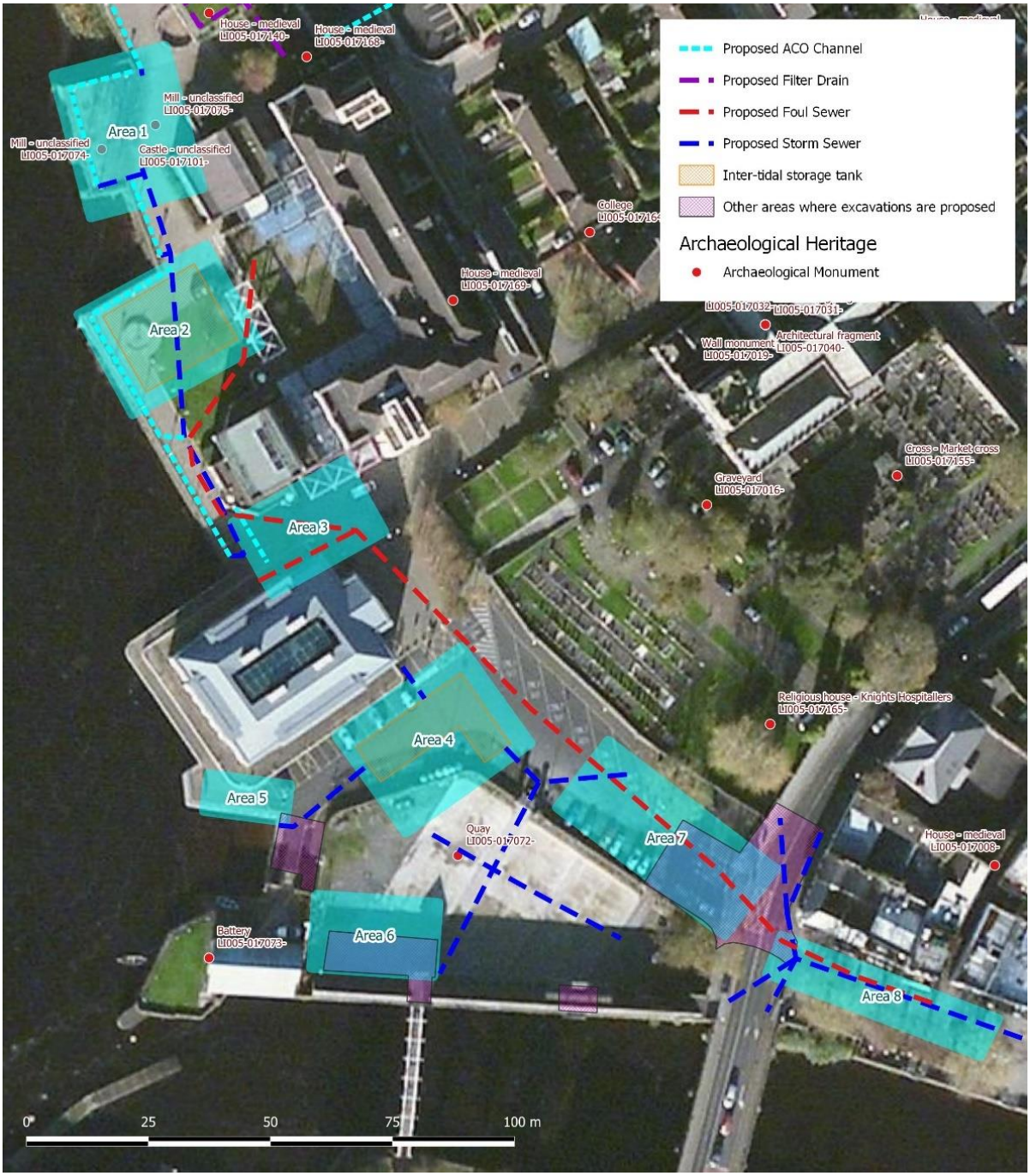

Figure 1. Overview of proposed Project and Archaeological Testing Areas.

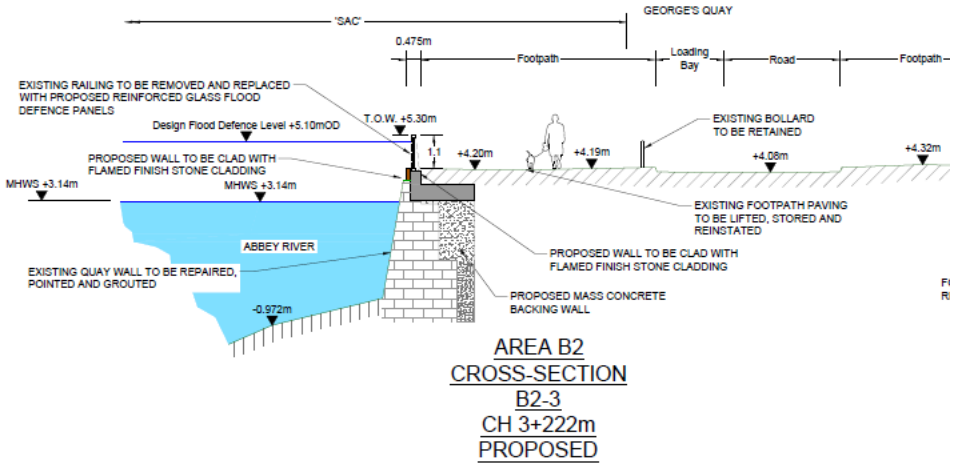

Figure 2. Section showing mass concrete backing to quay wall to support proposed flood defence.

Archaeological Testing Areas

Test trenches will be approximately 1.5 m wide but may be widened to allow for the use of trench boxes or if necessary, for health and safety purposes.

Area 1

Archaeological Potential

The proposed Project design in this area is sensitive to the fact that there are known archaeological deposits in this area that are associated with the City Wall. These include a bridge and the remains of mills, which were accessed through a gate in the City Wall. This is evidenced in numerous historic maps dating from the 16th Century (Figure 3) to the 19th Century, Thomas Phillips' prospect of Limerick from 1685 (Figure 4) and the results of archaeological excavations undertaken by Celie O'Rahilly (1987) (Figure 6) prior to the construction of the Council's Offices. O'Rahilly also noted the presence of a later tunnel which directed water under the western arch of the bridge. Tunnels appear to be indicated in William Eyres' map of 1752 (Figure 5).

Protrusions of stone wall to the west of the quay wall in this area, visible in Figure 6, at the western end of the bridge, would appear to be remnants of one of the mill buildings.

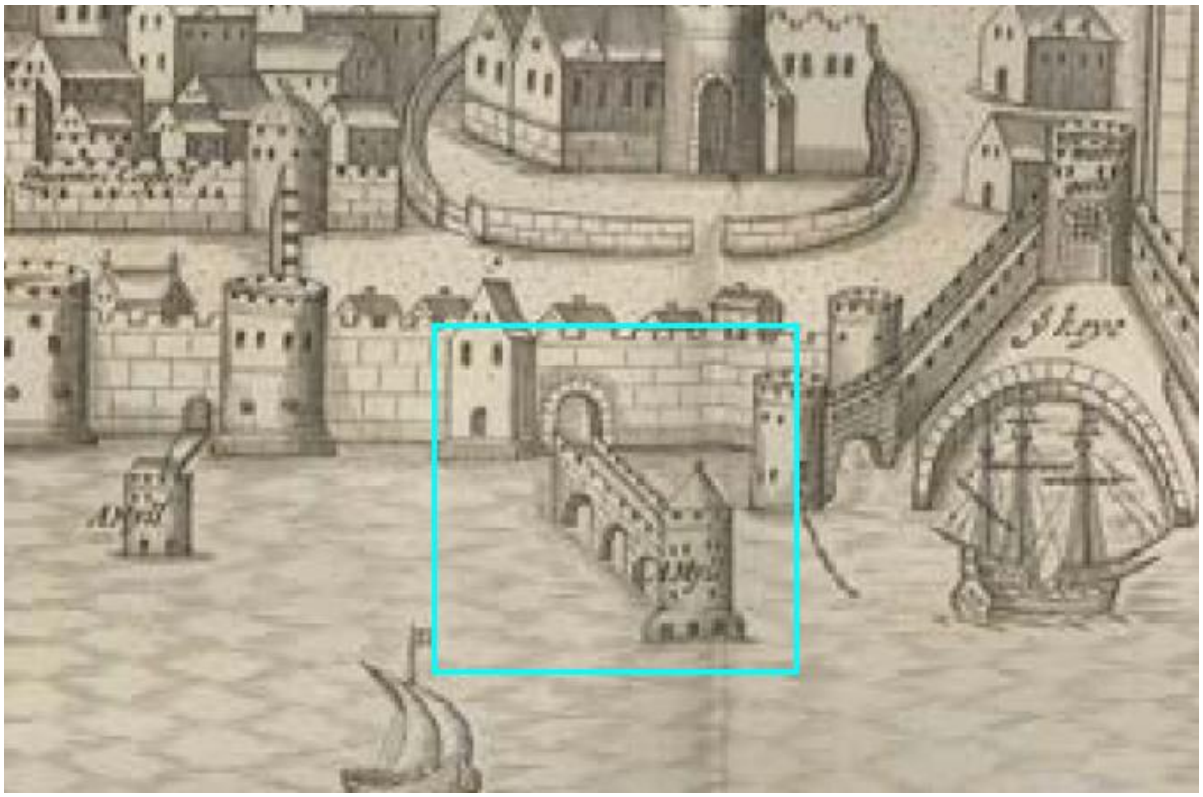

Figure 3. Extract from Limerick, 1633, (Pacata Hibernia 2) (Irish Historic Towns Atlas No. 21 Limerick, Map 9) with location of gate, bridge and mill indicated.

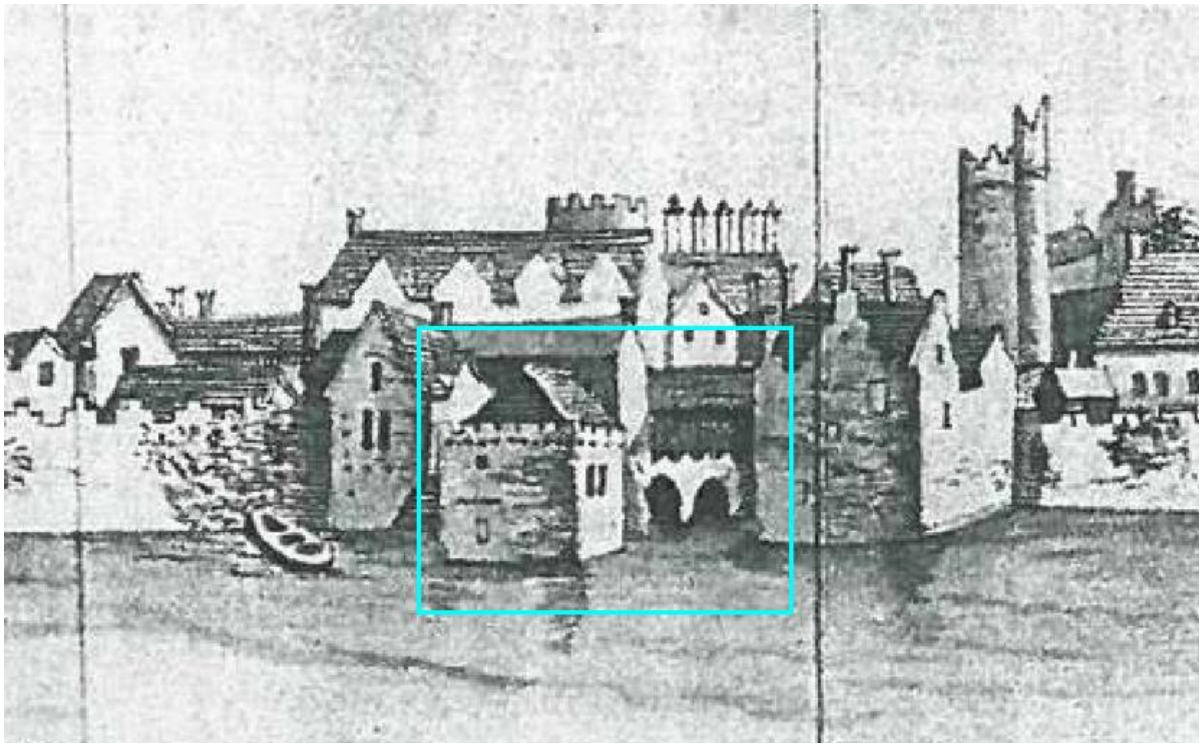

Figure 4. Extract from Limerick, looking north east, 1685 by Thomas Phillips (National Library of Ireland) (Irish Historic Towns Atlas No. 21 Limerick, Plate 2) with Bridge and Mill indicated.

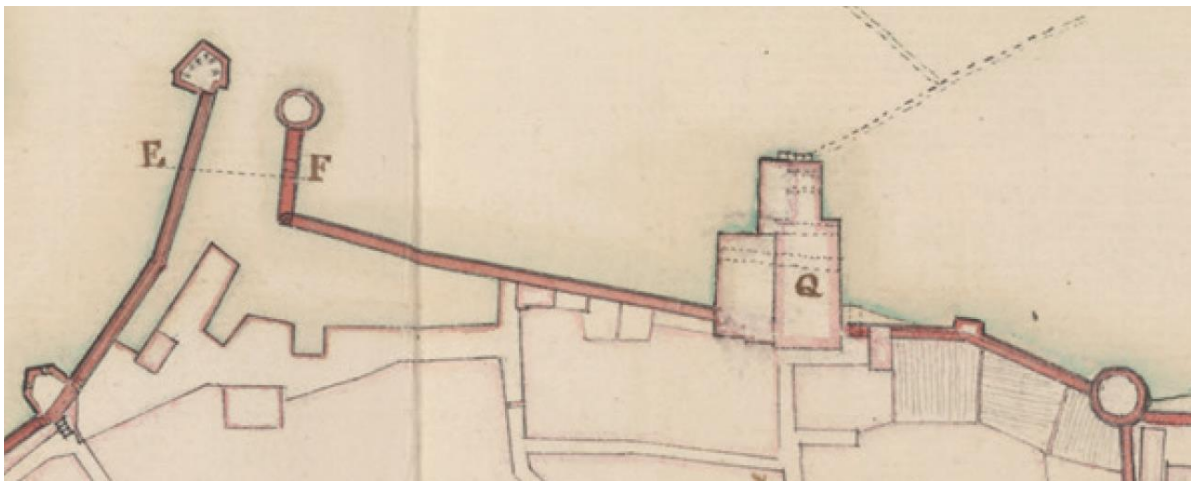

Figure 5. Extract from Willian Eyres' map, 1752, (British Library) (Irish Historic Towns Atlas 21 Limerick, Map 15) with what appear to be tunnels at 'Q Mills and Breweries'.

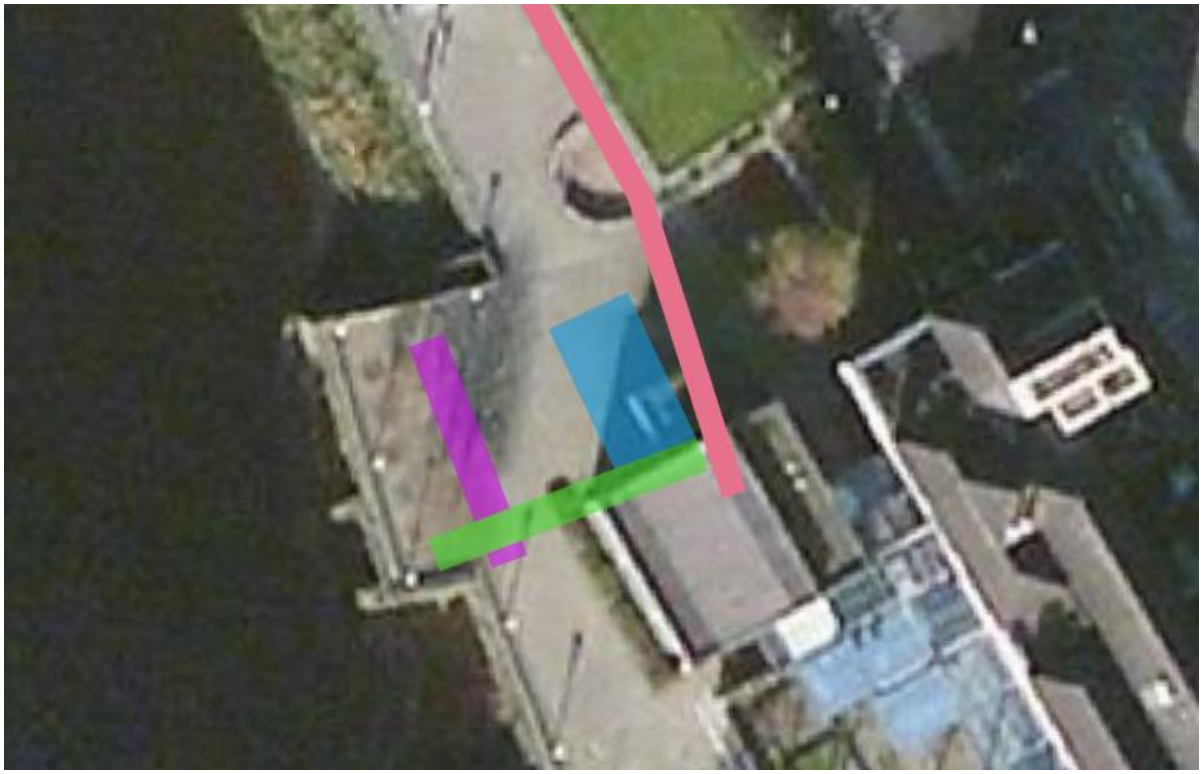

Figure 6. Possible location of tunnel (magenta), bridge (green), quay area (blue) and City Wall (Red).

Proposed Works

Area 1 is situated to the north west of the Limerick City and County Council's Offices at Merchant's Quay. Flood defences are proposed along the coastal margins consisting of reinforced concrete walls clad in stone with stone copings and glass panelling (Figure 7).

The proposed works avoid the remains of the bridge, mill and tunnel, which will remain in situ. The proposed concrete flood defence wall will cross over the bridge and tunnel from south to north supported on a raft foundation above the level of the bridge and tunnel. The raft foundation is to be supported on piles to prevent any loads on the bridge or tunnel. The wall will continue to a point to the north of the remains of the mill, before turning to the west and joining with the quay wall. Dig-out to the rear of the quay wall, to the west, will facilitate the construction of a concrete backing wall of mass concrete that will act as a support for cantilevered glass panels which will be situated above the quay. The northern flood defence wall is to be constructed of reinforced concrete and will bridge the tunnel on a raft foundation supported on piles.

Proposed dig-out for the glass panelling is approx. 3 m wide by 4 m deep. For the piled raft foundations, the proposed dig-out is approximately 1.5 m. Proposed test excavations for the raft foundation areas are deeper to ascertain the extent of the features that are to be preserved in situ.

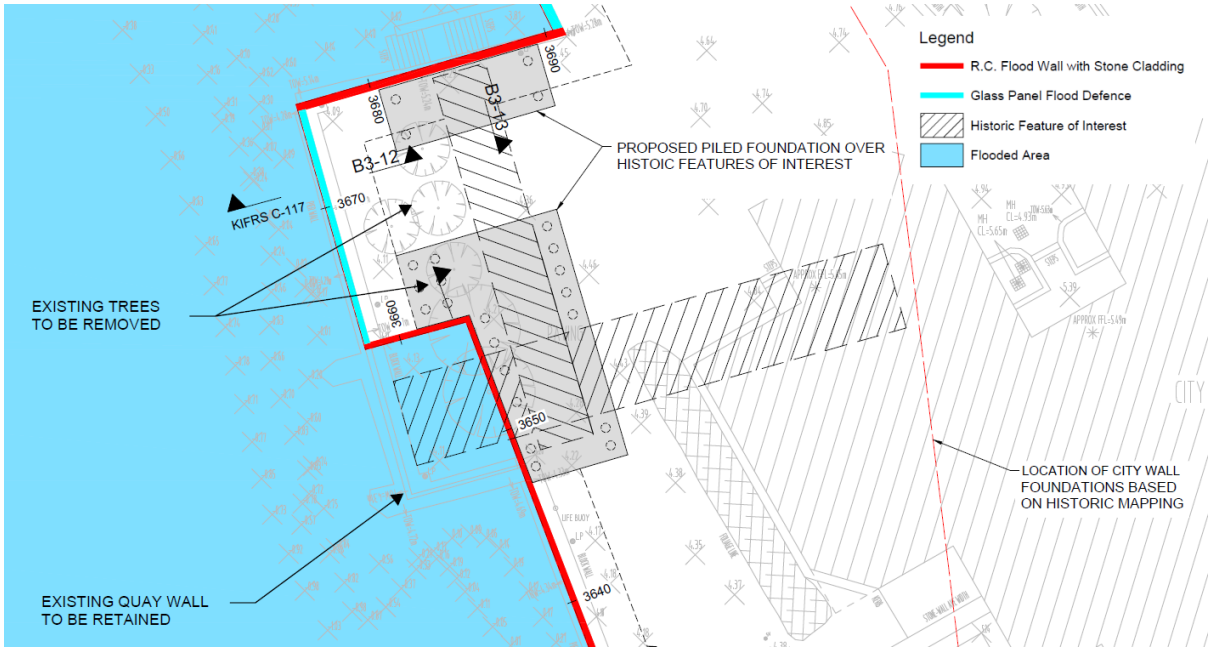

Figure 7. Proposed development in Area 1.

Proposed Testing

Four test trenches are proposed in Area 1 (Figure 8). Given the location of the trenches to the rear of quay walls only one trench will be open at any one time. Trenching will be undertaken to coincide with low tide.

Archaeological testing to the rear of quay walls will also help to identify the condition of the rear of the quay walls and the nature of the substrate to the rear of the quay walls. This information will inform the methodologies for the consolidation of the quay walls for their long-term preservation.

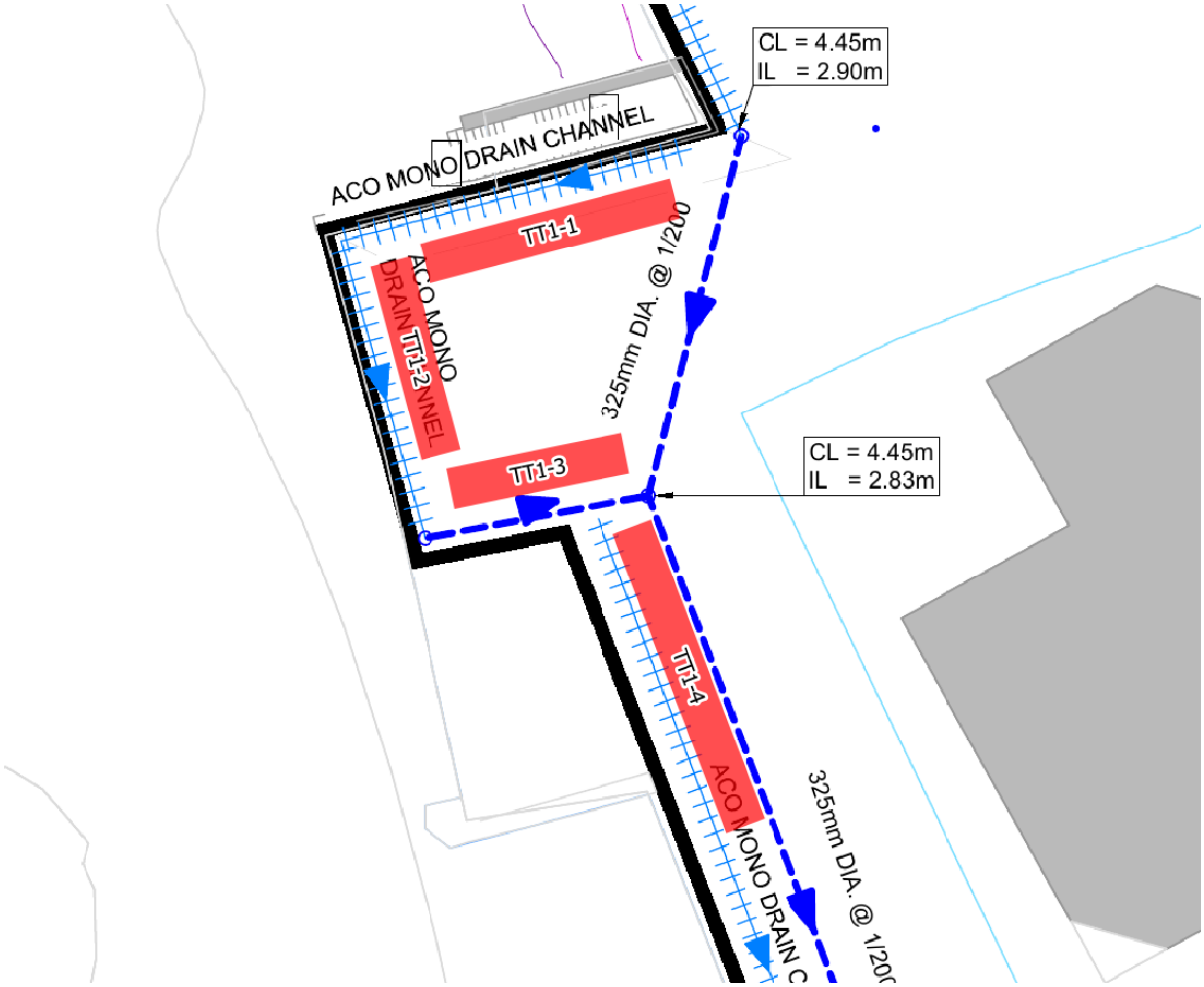

Figure 8. Proposed test trenches in Area 1.

TT1-1

Approx. 1.5 m x 9 m, depth approx. 4 m

The purpose of TT1-1 is identify the northern extent of the tunnel noted by O'Rahilly. The dimensions for the length of the tunnel recorded by O'Rahilly appear to coincide with OSI 1870 mapping of mill walls in the area (Figure 9). To the north of the mill is what appears to be a slipway into the river.

Figure 9. Extract from OSI 1870 mapping[1].

TT1-2

Approx. 1.5 m x 7 m, depth approx. 4 m

The purpose of TT1-2 is to identify the nature of the rear of the quay wall to the west and ascertain whether the distance between the quay and tunnel will influence the design of the mass concrete backing in this area.

TT1-3

Approx. 1.5 m x 7 m, depth approx. 4 m

The purpose of TT1-3 is to identify the dimension of the tunnel for the design of the raft foundation and associated piling.

TT1-4

Approx. 1.5 m x 10 m, depth approx. 4 m

The purpose of TT1-4 is to identify the location of the bridge and southern extent of the tunnel.

[1] "Ordnance Survey Ireland (OSi) 19th Century Historical Maps," held by Ordnance Survey Ireland. © Public domain. Digital content: © Ordnance Survey Ireland, published by UCD Library, University College Dublin <http://digital.ucd.ie/view/ucdlib:40377>

Area 2

Archaeological Potential

Early mapping such as Thomas Phillips' map of 1685 indicates a narrow entrance into the harbour at the south western corner of King's Island (Figure 10). William Eyres' later map of 1752 indicates a similar entrance into the harbour (Figure 5) but shows more detail in a section (E-F) through the entrance into the harbour which indicates the width of the opening to be approximately 90 feet (Figure 12).

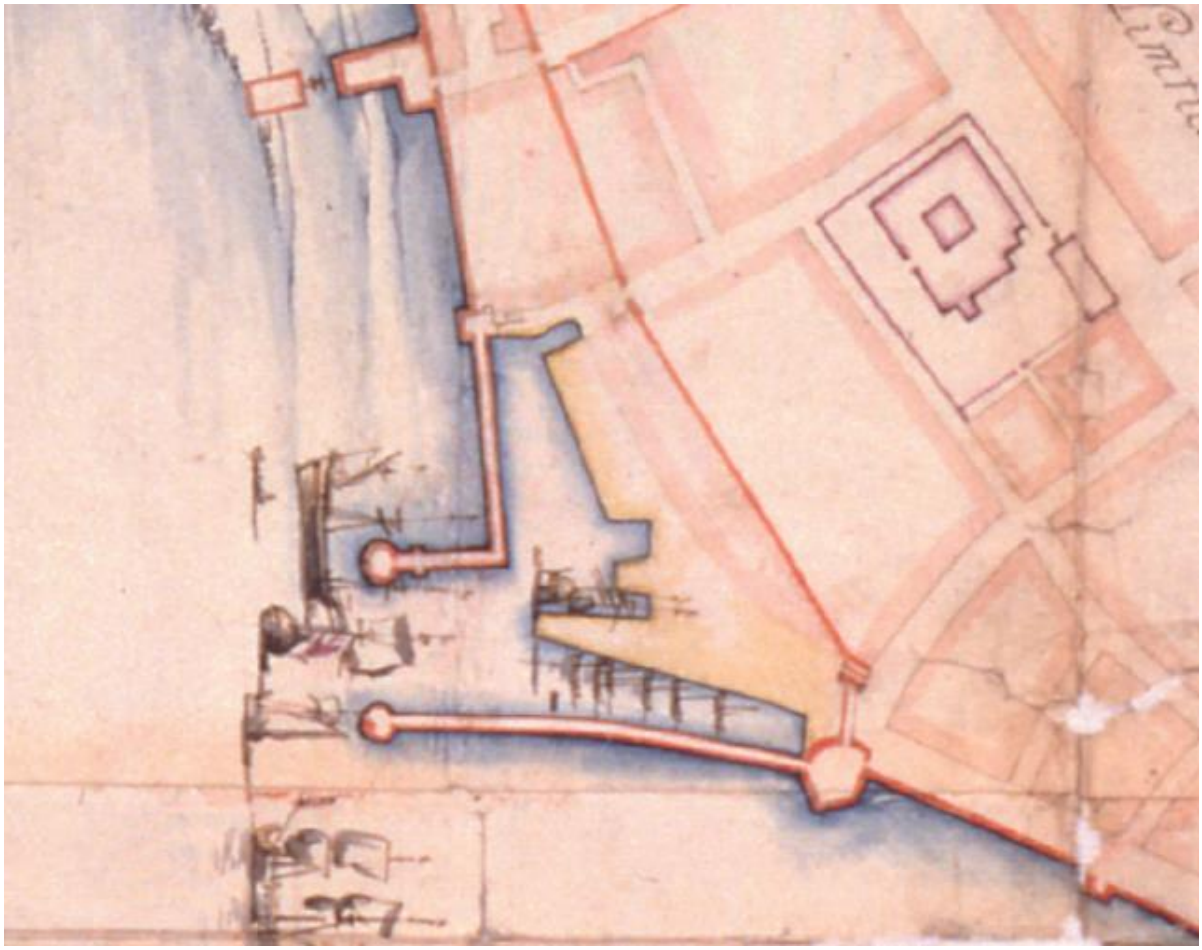

Figure 10. Extract from Limerick, 1685 by Thomas Phillips (National Library of Ireland) (Irish Historic Towns Atlas No. 21 Limerick, Map 12) showing a single entrance into the harbour.

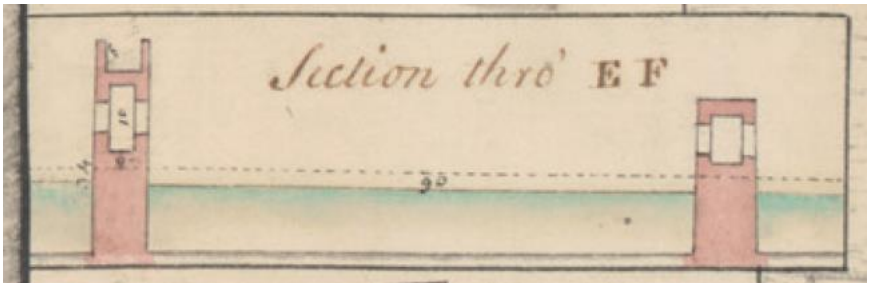

Figure 11. Section E-F from Eyres Map through the entrance into the Harbour (British Library – Irish Historic Towns Atlas 21 Limerick Map 15).

It is clear from mapping by Colles and Sauthier that the layout of the harbour and quays saw significant changes during the latter half of the 18th Century. Whereas previously there had