COMER GROUP IRELAND

OVERALL MASTERPLAN FOR RESIDENTIAL DEVELOPMENT, AT CENTRE PARK ROAD,CORK CITY

INVASIVE SPECIES MANAGEMENT PLAN

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1.0 INTRODUCTION

1.1 Background

O' Donovan Agri-Environmental Services have been appointed by Comer Group (Ireland) Ltd. to provide specialist Invasive Alien Plant Species (IAPS) advisory services with respect to the presence of Japanese knotweed (*Fallopia japonica*) in the footprint of the "overall masterplan" for proposed residential development, within the former Tedcastles Site on the Centre Park Road in the docklands area of Cork City (see Figures 1.1-1.4).

The overall masterplan for the former Tedcastles Site consists of two separate parcels of land which for the purposes of the invasive species management plan are referred to as Site A - 7.27ha approx. and Site B - 1.31ha approx. in area (see Figures 1.1-.2).

Planning is currently being sought in respect of a 4.7ha subsite within Site A (see Figure 1.3-1.4). The proposed residential development within the 4.7ha subsite includes the "*demolition of the existing structures on site and the construction of a strategic housing development of 823 no. apartments, resident amenity and ancillary commercial areas including childcare facilities. The development will comprise 6 no. buildings. The proposed development also comprises hard and soft landscaping, pedestrian bridges, car parking, bicycle stores and shelters, bin stores, ESB substations, plant rooms and all ancillary site development works. Vehicular access to the proposed development will be provided via Centre Park Road"* (ARUP, 2022).

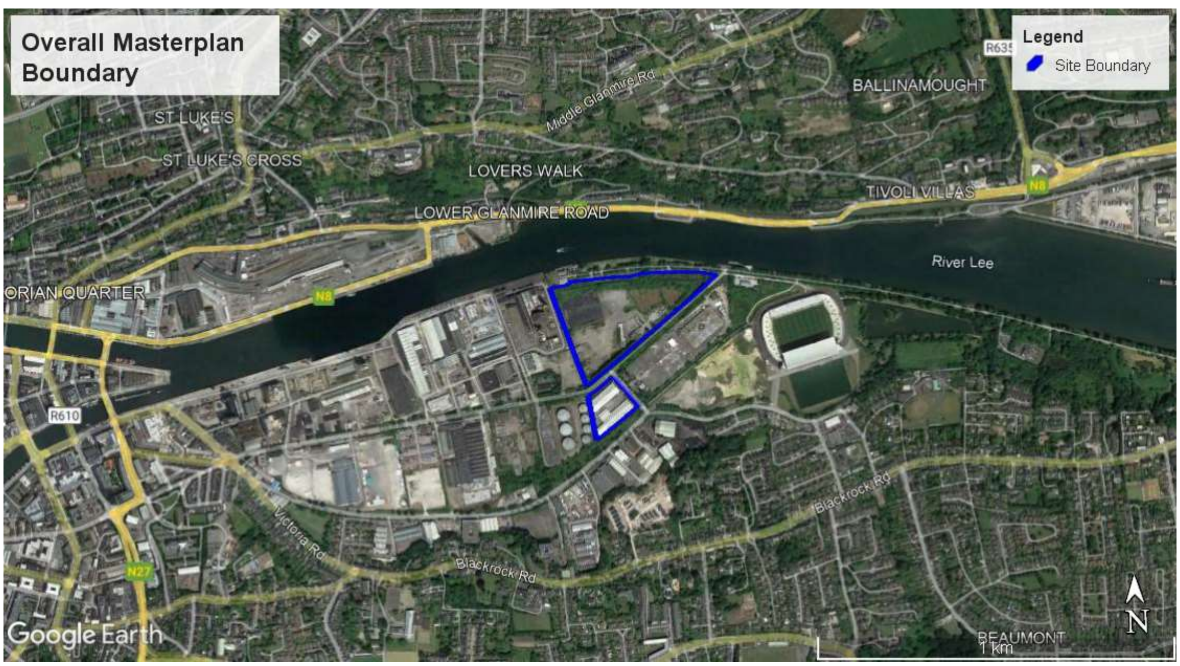
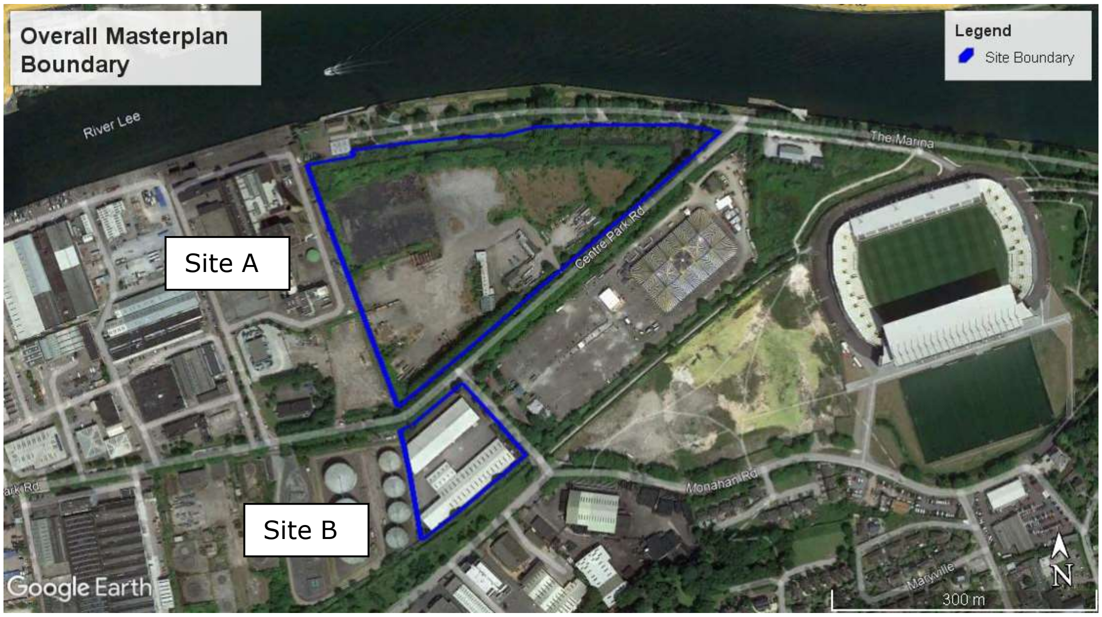
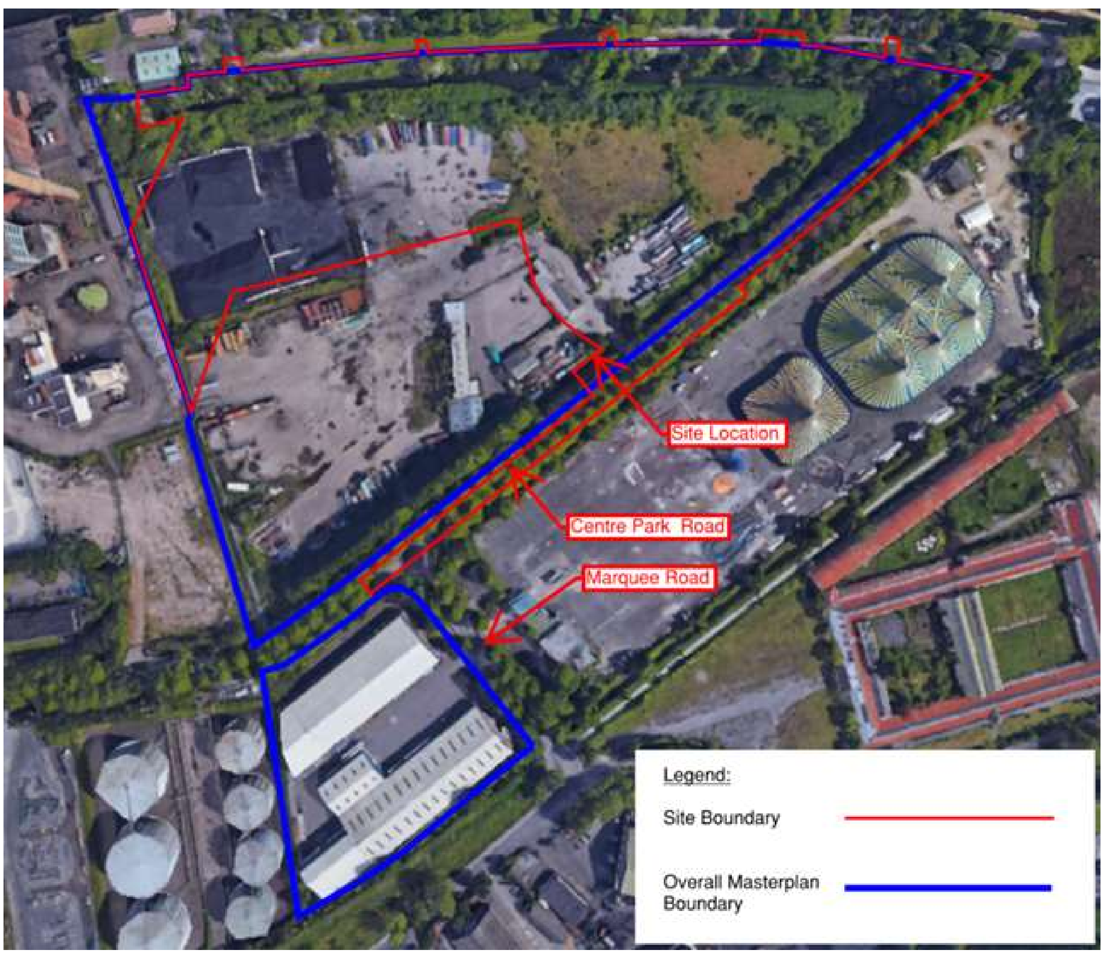


Figure 1.1 Location of lands within the Overall Masterplan Boundary for Proposed Residential Development at Centre Park Road (Source: Google Earth Pro)





Figures 1.2 & 1.3 Location of Site A and B within the Overall Masterplan Boundary at Centre Park Road (Source: Google Earth Pro; ARUP, 2022)

Figure 1.4 Layout of the Proposed 4.7ha Residential Development within Site A at Centre Park Road (Source: ARUP, 2022)

In light of the presence of IAPS, O' Donovan Agri-Environmental Services have been engaged by Comer Group (Ireland) Ltd. to prepare an Invasive Species Management Plan (ISMP) to facilitate the eradication of Japanese knotweed, and any other relevant invasive species, from within the lands of the overall masterplan boundary.

In this regard, a specialist walkover survey was undertaken at Centre Park Road on the 14th December 2021 to inform the preparation of the management plan.

The specialist IAPS services in respect of the lands within the overall masterplan boundary are being led by the following project team:

John O' Donovan is a Specialist Weed Control Consultant with over 20 years' industry experience in the design of specialist chemical herbicide treatment programmes aimed at the successful and timely eradication of Japanese knotweed, and in the research, development, and patenting of innovative specialist equipment for the application of herbicides and species-specific biosecurity equipment.

Lisa M. J. Dolan is an IAPS Specialist Ecological Consultant with over 20 years' industry experience in the preparation of IAPS Management Plans and the onsite management and successful eradication of invasive species, in particular Japanese knotweed. Lisa is experienced in specialist targeted surveys and reporting, environmental impact assessments, design and deployment of specialist biosecurity protocols and equipment, and as a Clients

Representative (for local authorities, state, and semi-state bodies) the preparation of tender documents for the procurement of IAPS Specialist Contractors, site supervision and the management of IAPS Contracts for successful invasive species eradication programmes.

2.0 MANAGEMENT OF INVASIVE ALIEN PLANT SPECIES

2.1 Necessity for a Management Plan

The preparation of an Invasive Species Management Plan is required to meet with legal obligations in terms of avoiding the accidental dispersal of invasive species including vector material during the vegetation removal, site clearance, demolition, construction and landscaping stage of a Project.

A management plan is also necessary to ensure that appropriate measures are taken to avoid the dispersal of invasive species, during the deployment of control and eradication programmes for invasive species within a site.

A management plan should ensure that best practice is deployed to control or eradicate Japanese knotweed in the most cost effective, environmentally sustainable, and timely manner.

A management plan is one of a number of documents required by National Parks and Wildlife Service (NPWS) as part of a license application for the transportation of Japanese knotweed vector material off site for disposal at a licensed receiving facility (see Section 2.3).

Where present on a site the costs of eradicating invasive species generally increase overtime, with the maturity of an infestation, which may be exacerbated by delayed treatment, inappropriate treatment, disturbance regimes and accidental dispersal. In addition to these impacts, delays to the control or eradication of certain invasive species may also pose a risk to adjacent lands and semi-natural habitats, including downstream habitats, depending on the invasive qualities of the IAPS in question (see Appendix II).

In this regard, the management of invasive species within the lands of the overall masterplan boundary is necessary to address or to meet with:

- Environmental legislation
- Future planning conditions
- Risk of further accidental dispersal

And the potential for invasive species to:

- Encroach on downstream native habitats with connectivity to Centre Park Road via the stormwater network *e.g.* River Lee, Cork Harbour SPA, Douglas River Estuary pNHA, Dunkettle Shore pNHA and non-designated SWDTEs and GWDTEs
- Encroach on adjacent land-uses, public footpaths, dwellings, and infrastructure
- Encroach on new structures, footpaths, services, internal access roads and green open spaces within the site of the proposed residential development
- Diminish the ability to use and enjoy the green open spaces within the site of the proposed residential development due to impediments to access
- Encroach on sight lines and signage along the internal access paths
- Result in long-term maintenance requirements

Please be advised that a management plan is a 'live' document and will be updated where required as the project progresses to include the findings of further monitoring surveys and additional eradication or control programmes, where required.

2.2 Preparation of a Management Plan

The first step in the preparation of an Invasive Species Management Plan for the lands within the overall masterplan boundary, is to select the most appropriate management programme (s).

The selection of the most appropriate management programme requires an in-depth assessment of a number of site-specific factors including characteristics of the Japanese knotweed infestation, identification of site-specific constraints and hazards, knowledge of the study area together with best practice guidance, expert opinion, and experience of the authors.

Project constraints will play a significant role in the selection of a programme. Any planning conditions laid down by the local authority; time available to achieve eradication; availability of suitable lands for burial on site; and the budget for the eradication of the Japanese knotweed, will all influence the decision-making process. Site constraints may also feature, for example, where bedrock or the water table is at or near surface level which could rule out burial of the vector material onsite, or indeed, where there is limited access to a site for trucks to facilitate the recovery and transportation of vector material offsite (see Section 3.4.1).

In addition, any hazards (see Tables 3.2 & 3.3) which could impact on the deployment of a management programme need to be identified such as the presence of receptors which are sensitive to the use of chemical herbicides. Restricted areas & receptors as per the Sustainable Use of Pesticides Directive (SUD Directive) and ecological receptors, require careful consideration, as these may pose limitations with regards to use of chemical herbicide (see Sections 3.4.2 & 3.4.3).

Environmental, occupational health & safety hazards should also be noted and tabulated as these may impact on the selection, practical implementation, and successful outcome of any recommended management programmes (see Section 3.4.4).

Table 2.1 Factors which may influence the approach to management

FACTORS
▪ Characteristics of the infestation *e.g.,* maturity, density, extent of rhizomes ▪ Project constraints ▪ Site constraints ▪ Presence of SUD restrictions and receptors ▪ Presence of ecological receptors ▪ Presence of environmental, occupational health & safety hazards ▪ Source of introduced vector material and pathways for dispersal ▪ Presence of disturbance regimes ▪ Potential for additional outliers due to ongoing disturbance regimes ▪ Best practice guidance notes and manuals

The presence of any such hazards and constraints should be identified via a desktop study and a walkover survey of the site of the proposed residential development. The hazards and constraints should be addressed in the preparation of the Risk Assessment and Method Statement for the management of Japanese knotweed, via the inclusion of relevant control measures. The deployment of the control measures will ensure a successful outcome from the selected management programme, in terms of eradication.

The control measures are also necessary to ensure that the management programme is deployed in accordance with best practice, relevant standards and environmental, waste, occupational health & safety legislation (see Section 8.0).

2.3 Types of Management Programmes

Once the most appropriate Management Programme for the eradication of invasive species within the site has been identified, the plan should then elaborate on the best practice methodology to complete the programme.

For example, there are typically 5 no. different management programmes which may be deployed to eradicate Japanese knotweed within a site. Please note a combination of one or more options may be required for some sites.

- Option 1: Deployment of a Chemical Herbicide Treatment Programme (*in situ*)
- Option 2: Recovery of Vector Material & Burial Onsite
- Option 3: Recovery of Vector Material & Disposal Offsite
- Option 4: Installation of Japanese Knotweed Rhizome Barrier
- Option 5: Recovery of Vector Material & Construction of a Bund Facility

Irish and UK best practice guidance notes and manuals are utilised to inform the selection of the most appropriate management programme for a site, and include the following:

- CIRIA (2008) CIRIA C679 Invasive species management for infrastructure managers and the construction industry.
- Environmental Agency (EA, 2013) Managing Japanese Knotweed on Development Sites: The Knotweed Code of Practice (**withdrawn 11th July 2016 by the EA**).
- EA (2016a) Guidance Note: Prevent Japanese knotweed from Spreading. Environment Agency, Natural England, and DEFRA.
- EA (2016b) Treatment & Disposal of Invasive Non-Native Plants: RPS 178.
- NetRegs Environmental guidance for your business in Northern Ireland & Scotland http://www.netregs.org.uk/environmental-topics/land/japanese-knotweed-giant-hogweed-and-other-invasive-weeds/.
- PCA (2014) Code of Practice for the Management of Japanese knotweed. Version 2.7.
- SEPA (2016) Biosecurity and management of invasive non-native species for construction sites and Controlled Activities.
- Welsh Government (2011) The Control of Japanese Knotweed (*Fallopia japonica*) in Construction and Landscape Contracts.

- NRA (2010) NRA Guidelines on the Management of Noxious Weeds and Non-Native Invasive Plant Species on National Road Schemes.
- http://nonnativespecies.ie/risk-assessments/

3.0 METHODS

3.1 Study Site

The overall masterplan boundary encompasses 2 no. parcels of land Site A - 7.27ha approx. (to the north) and Site - B 1.31ha approx. (to the south) in area. Site A and Site B are located on Centre Park Road within the docklands area of Cork City at GPS coordinates 51.900226°, -8.442560° approximately 2km east of Cork City centre (see Figures 1.1-1.4).

3.2 Study Area

Site A and Site B are surrounded by urban industrial buildings, civil infrastructure, a sports stadium, a riverside walkway and marina and city streets categorised as Buildings and artificial surfaces (BL3). Namely, Centre Park Road, by Shandon Rowing Club and the Marina to the north, former ESB power station to the west and Páirc Uí Chaoimh stadium to the east.

In terms of habitats, Recolonising bare ground (ED3), Scrub/transitional woodland (WS1), Drainage ditches (FW4), Scattered trees and parkland (WD5), Ornamental/non-native shrubs (WS3) were recorded within the study area along with the River Lee located to the north which is a Tidal River (CW2) (see Photographs 3.1-3.6).

Site A is described as a "*brownfield site containing several storage containers and external storage areas. Ground levels vary across the site, with a high point along the northern boundary, varying between 5.3m at the western end and 3.6m at the eastern end. There are two open channels, one adjacent to the southern boundary and one adjacent to the northern boundary, which join at the eastern end of the site. The centre of the site generally falls from a high point of 2.67m to the open channels along the northern and southern boundaries*" (ARUP, 2022).

Site B is also a brownfield site containing a standing warehouse and a second partially demolished warehouse.

Bedrock

Both Site A and Site B are underlain by the Lee Valley Gravels Groundwater Body (GWB) IE_SW_G_094. There is no available initial characterisation for the Lee Valley Gravels GWB to describe its main aquifer lithology and other features.

According to the GSI Mapviewer, the bedrock beneath Site A of the proposed residential development, consists of Carboniferous "Flaser-bedded sandstone & mudstone" of the Cuskinny Member (Kinsale Formation) from the Dinantian series (https://dcenr.maps.arcgis.com). It is described as a "Flaser-bedded sandstones and lenticular-bedded mudstones; sand dominant". There is a fault zone located to the north of the site (GSI Mapviewer). Bedrock outcrops were not recorded within the site during the walkover survey.

Beneath Site B, the bedrock consists of a Carboniferous limestone "Dark muddy limestone, shale" of the Ballysteen Formation from the Dinantian series (https://dcenr.maps.arc gis.com). Again, bedrock outcrops were not recorded within the site during the walkover survey.

Aquifer Classification

The Lee Valley Gravels GWB underlying Site A and majority of Site B, is considered to have bedrock which is Moderately Productive only in Local Zones and is categorised as a Locally Important Aquifer (Ll). The southern parcel is in part underlain by a Regionally Important Aquifer (Rkd) - Karstified (diffuse).

Quaternary Deposits

In terms of the subsoil overburden, both Site A and B are dominated by 'Urban' deposits (GSI Mapviewer).

Soils

According to the Teagasc Soil Maps (GSI Mapviewer) both Site A and Site B are also dominated by 'Made ground' (GSI Mapviewer).

Photographs 3.1 & 3.2 Habitats within Site A
(Source: O' Donovan Agri-Environmental Services)

Photographs 3.4 & 3.5 Habitats within Site A
(Source: O' Donovan Agri-Environmental Services)

Photographs 3.5 & 3.5 Habitats within Site B
(Source: O' Donovan Agri-Environmental Services)

Photographs 3.6 Habitats within Site B
(Source: O' Donovan Agri-Environmental Services)

3.3 Ground & Surface Water Features

3.3.1 Groundwater

Vulnerability

According to the EPA Mapviewer Site B is underlain by an aquifer with 'Moderate vulnerability" while Site A by a "Moderate" to "High vulnerability" aquifer.

Karstified features or landforms were not recorded during the walkover survey. There are no mapped springs, karst features or fault zones within the site (GSI Mapviewer). However, Site B is partially underlain by a karstified aquifer which is of "High vulnerability".

There is a fault zone located to the north of Site A (GSI Mapviewer).

According to the GSI Mapviewer, the closest known karst feature on contemporary mapping is Ballinlough Cave [1707SWK010] which is located 1.0km to the southeast.

Groundwater Flow

Based on the topography and contour data (OSi Webmapper), the overall groundwater flow direction in the bedrock aquifer is inferred as being from south to north towards the River Lee.

3.3.2 Surface water

Site A and Site B are located within the Water Framework Directive (WFD) Catchment Lee, Cork Harbour & Youghal Bay (Catch_ID:19).

There is a surface water feature in the form of a drainage stich on the northern, eastern, and southern boundaries of Site A.

There is also a drainage ditch on the northern boundary of Site B.

The drainage ditches and the storm water gullies within the sites and on the adjacent streets (which are connected to the stormwater network) outflow to the River Lee and Cork Harbour.

3.4 Detailed Desktop Study

In order to inform the selection of the most appropriate management programme for the overall masterplan, it is first necessary to identify any existing and potential site-specific hazards and constraints which could impact on its implementation *e.g.,* project and site constraints; SUD restrictions & receptors, ecological receptors and environmental, health & safety hazards (see Sections 4.4.1-4.4.4).

3.4.1 Project & Site Constraints

Project Constraints

The following project constraints will need to be reviewed with respect to identifying the most appropriate management programme, amongst others:

- Time available to achieve eradication *e.g.* the start and end date of the construction programme
- Volumes of vector material which require burial onsite/disposal offsite
- Budget available for eradication

- Responsibility for a monitoring programme
- Requirement for a Waste License under the Waste Management (Licensing) Regulations 2004 from the EPA to bury onsite
- Stewardship of an onsite burial cell
- Possibility that an onsite burial cell may impinge on future land uses and property values

Site Constraints

In addition to project constraints there are also a number of site constraints which may influence the selection of the management programme including:

- Type and location of existing and proposed infrastructure (above and below ground) within a site relative to the location of the Japanese knotweed infestation
- Distance between the Japanese knotweed infestation and the site boundary
- Risk of flooding events *e.g.,* pluvial, fluvial, or coastal flooding
- Potential for finds of archaeological interest
- Potential for contaminated soils *e.g.,* hydrocarbons, asbestos
- Extent of suitable lands available for burial onsite
- Accessibility to the site for trucks to facilitate the recovery and transportation of vector material offsite
- Requirement for traffic management at the site entrance to facilitate access onto the site by plant machinery and trucks
- Distance from a receiving waste facility for offsite disposal (impact of haulage costs of budgetary constraints)

A number of the project and site constraints will have a specific or greater influence on the practical implementation of certain management programmes as follows:

Option 1: Chemical Herbicide Treatment (*in situ)*

- Time available to achieve eradication (treatment *in situ* requires a number of years to achieve eradication)
- Proximity to an adjacent property
- Presence of receptors which are sensitive to the use of chemical herbicides
- Possibility that the ongoing presence of the infestation may impinge on access and use of a site, imminent construction works, future land uses and property values

Option 2: Recovery & Burial Onsite

- Requires a Waste License under the Waste Management (Licensing) Regulations 2004 from the EPA
- Volumes of vector material which require disposal: will influence size of burial cell; extent of rhizome barrier; and other costs associated with burial onsite
- Extent of suitable lands available for burial onsite *e.g.* depth to bedrock and water table, presence of services, distance from site boundary, infrastructure, watercourses, and designated conservation areas *etc*.
- Presence of overhead and underground power cables and other services
- Monitoring of the onsite burial cell

- Risk of regrowth (whether perceived or actual) from the burial cell
- Possibility that the permanent burial cell may impinge on future land uses and property values

Option 3: Recovery & Disposal Offsite

- Requires a license under Regulation 49(2) of the European Communities (Birds and Natural Habitats) Regulations 2011 to 2015 from NPWS
- Accessibility of the site for articulated or rigid trucks
- Budgetary constraints depending on volumes of vector material which require disposal
- Distance from a receiving waste facility for offsite disposal

3.4.2 SUD Restrictions & Receptors

Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 more commonly referred to as the 'Sustainable Use Directive' or 'SUD', aims to establish a framework for Community action to achieve the sustainable use of pesticides (including chemical herbicides). It was transposed into Irish law by Statutory Instrument No. 155 of 2012, European Communities (Sustainable Use of Pesticides) Regulations 2012. The European Communities (Sustainable Use of Pesticides) Regulations 2012 places additional restrictions and, in some cases, prohibitions, on the use of pesticides in certain restricted and sensitive areas (referred to herein as SUD restrictions & receptors).

These SUD restrictions & receptors include transport routes (such as railway lines); areas used by the general public or defined vulnerable groups (*e.g.* public parks, hospitals, public schools and public playgrounds); groundwater vulnerable landscape features; and Natura 2000 sites (see Table 4.3).

There are also safeguard zones or exclusion zones (see Table 4.1) where no plant protection products can be applied in order to protect surface water abstraction sources (*e.g.* areas for the abstraction of drinking water such as surface waters, springs, wells or boreholes) and groundwater vulnerable landscape features (*e.g.* karst areas, sinkholes or collapse features).

Table 3.1 Safeguard Zones for Open Wells, Boreholes and Water Abstraction Points

Water Source	Distance
Abstraction point of any surface waters, borehole, spring or well used for the abstraction of water for human consumption in a water scheme supplying 100 m^3 or more of water per day or serving 500 or more persons	200 m
Abstraction point of any surface waters, borehole, spring or well used for the abstraction of water for human consumption in a water scheme supplying 10 m^3 or more of water per day or serving 50 – 500 persons	100 m
Abstraction point of any surface waters, borehole, spring or well used for the abstraction of water for human consumption in a water scheme supplying 1-10 m^3 of water per day or serving 10-50 persons	25 m
Abstraction point of any surface waters, borehole, spring or well used for the abstraction of water for human consumption in a water scheme supplying 1m^3 or less of water per day or serving 10 or less persons	5 m

It should be noted that the gathering of data on SUD restrictions & receptors is essential to the preparation of a management plan, as the presence of any such constraints will underpin the ability to deploy chemical herbicides, including the type of chemical herbicide, timing of application and application methods. In this regard, chemical herbicides selected for use on any site should be fit for the purpose for which they are intended.

Details of permitted pesticides authorised for use by the Irish competent authority, the Pesticide Registration and Controls Divisions and the Pesticide Control Laboratory of the Department of Agriculture Food and the Marine (DAFM) can be found at http://www.pcs.agriculture.gov.ie/ (see Appendix I for further details). Consultation should be undertaken with a Registered Pesticide Advisor and/or the Pesticides Control Service where there is any doubt in relation to the safe use of herbicides.

Groundwater Vulnerable Landscape Features & Surface Water Abstraction Sources

In relation to the identification of Groundwater Vulnerable Landscape Features and surface water abstraction sources in the study area, the following Geological Survey of Ireland (GSI) and Environmental Protection Agency (EPA) databases were accessed on the OSI Geohive Mapviewer (http://map.geohive.ie/mapviewer.html), EPA (https://gis.epa.ie/EPAMaps/) and GSI (https: //dcenr.maps.arcgis.com/apps/webappviewer/):

- Groundwater Bodies WFD, EPA Water Maps
- Groundwater Vulnerability, GSI
- Groundwater Drinking Water Protection Areas, GSI
- Groundwater Karst Features, GSI
- Groundwater Wells & Springs, GSI
- Borehole Locations, GSI
- Public Water Supply Protection Areas, GSI
- WFD Register of protected areas (rivers, lakes & groundwater for drinking water), EPA
- Groundwater Bodies, Rivers and Lakes utilised for Drinking Water Abstraction, EPA

Further details on the initial characterisation of the relevant groundwater bodies in the study area was sought from the GSI and WFD websites including the Initial Characterisation of the groundwater body (GSI website) and Water Management Unit Action Plans (WFD website) and https://www.catchments.ie/data/#/waterbody/.

Natura 2000 Sites

A desktop review of the relevant technical literature and databases was undertaken for the site of the proposed residential development in order to identify the presence of any Natura 2000 sites [Special Areas of Conservation (SACs), Special Protection Areas (SPAs)] within the study area which could be impacted upon by the use of chemical herbicide (http://webgis.npws.ie/ npws viewer/).

3.4.3 Ecological Receptors

Aside from the sensitive ecological receptors identified under the SUD Directive, there are other ecological receptors which could be at risk from the use of chemical herbicide.

In this regard, the presence of other designated conservation areas *i.e.* Natural Heritage Areas (NHAs), proposed Natural Heritage Areas (pNHAs) or non-designated sites of ecological/ botanical interest within the site along with notable, rare, or protected flora or fauna were also identified.

There are also local ecological receptors such as trees, hedgerows, woodlands, small mammals, birds, pollinators, and aquatic species which could be impacted by the use of chemical herbicide.

3.4.4 Environmental, Occupational Health & Safety Hazards

In terms of the deployment of a management programme, there are various environmental, occupational health & safety hazards which need to be considered in order to avoid or minimise risks to persons who utilise, work or live within or adjacent to a site as follows:

- As above SUD restrictions and receptors
- Areas of high pedestrian traffic
- Vehicular and pedestrian traffic requiring traffic management
- Areas subject to flooding events *e.g.,* where instream or riverbank works are required
- Presence of overhead and underground power cables and other services
- Presence of other sensitive receptors *e.g.,* livestock, domestic pets, vegetables/crop
- Presence of non-target areas *e.g.,* adjacent dwelling houses, amenity grassland, gardens *etc.*

3.5 Walkover Survey

A detailed walkover survey of the proposed residential development was undertaken on the 14th December 2021. During the walkover survey the characteristics of the invasive species recorded was noted (see Section 4.5.1).

Information was also gathered on the events which may have led to the introduction of the vector material to the site; and, to identify any further risk of dispersal or indeed reintroduction of vector material to the site via a Source – Pathway – Receptor (S-P-R) Analyses.

The walkover survey also afforded an opportunity to identify any additional project and site constraints; and further SUD restrictions & receptors and ecological receptors which may be at risk, again via a Source – Pathway – Receptor (S-P-R) Analyses.

Any environmental, occupational health & safety hazards over and above those identified during the desktop study were also noted (see Sections 4.4.1 – 4.4.4).

3.5.1 Characteristics of the Infestation

During the walkover survey undertaken on the 14th December 2021, I.D. numbers were allocated to each of the infestations for the purposes of reporting on any changes to the baseline going forward. The locations were recorded utilising a GPS (Garmin Oregon 650t). Details of the following baseline information was captured during the walkover survey:

- Accurate records including GPS coordinates and mapping of the extent of above ground plant material and location of outliers during the optimum survey period (where possible) using a trundle wheel and tape measures
- Photographic record of the infestations as a baseline for treatment and monitoring
- Confirmation that a hybrid knotweed species is not present on site
- Nature (maturity, growth patterns, extent of radial or lateral growth) and extent of the infestation including outliers on the site and adjacent lands
- Presence or absence of shade (Japanese knotweed plants under shade often do not flower/seed prior to senescence)
- Seasonal constraints *e.g.* timing, flowering, senescence
- Variations in seasonal plant cycle due to local temperatures (day and night)
- Presence of flowering and seeds *e.g.* inflorescences, seed pods, *etc*.
- Details of plant growth stage *i.e.* shoots, immature plants, mature plants, bonsais, or other sub-lethal growth
- Above and below ground soil conditions (*e.g.* soil type, soil horizon layers, rocky outcrops, parent bedrock type and depth to water table)

Please refer to Section 4.0 for findings of the walkover survey.

3.5.2 Suboptimum Survey Period

The timing of the specialist survey in December 2021 is outside of the optimum survey period for those perennial invasive plant species which die back for the winter months, at the end of each growing season.

During walkovers in the suboptimum period, surveyors make every effort to minimise any seasonal survey constraints using their considerable previous field experience and expertise in carrying out surveys very late or early in the growing season. Typically, a second detailed specialist survey of a site would be undertaken during the optimum survey period; such that the preliminary survey findings can be validated in the absence of any seasonal constraints.

Japanese Knotweed

While Japanese knotweed dies back (goes into senescence) for the winter months and typically does not produce new growth until suitable temperatures are present in spring, the "woody" crowns and dead stems from the previous year's growing period may persist and can still be recorded during surveys carried out in winter and early the following spring.

Whilst such surveys are technically seasonally constrained and do not provide accurate information as to the full extent of an infestation, in the absence of recent disturbance, the presence of crowns and dead woody stems can provide a good proxy for the overall area of an infestation.

There does, however, remain a possibility that surveys undertaken outside of the optimum period could fail to detect the presence of immature plants or indeed an immature infestation which has not yet developed any woody stems (*i.e.* plants which are <2yrs old). Thus, a survey undertaken outside of the optimum survey period can fail to accurately confirm or detect (1) the presence/absence of an immature knotweed infestation (<2 years old) or (2) the full extent of an infestation where there are immature outlier plants (<2 years old) scattered around a mature infestation.

Spanish Bluebell & Three-cornered Garlic

With respect to Three-cornered garlic (*Allium triquetrum*), new growth may start to appear within a site as early as September while Spanish bluebell (*Hyacinthoides hispanica*) clumps only start to appear in December each year.

Where possible, targeted surveys should be undertaken at the time of year when such species are in leaf *i.e.* Three-cornered garlic is in leaf from September to July, while Spanish Bluebell is typically in leaf from December through to July each year.

There is potential for small clumps of Spanish bluebell to have gone undetected given the extent of cover present, while the survey is outside of the growing period for Three-cornered garlic.

3.5.3 Disturbance & Plant Defence Mechanisms

In addition to seasonal constraints, invasive species may go undetected on a site, if there has been recent disturbance, burial, or soil importation.

It should also be noted that Japanese knotweed can survive for a number of years at considerable buried depths.

Japanese knotweed also exhibits a number of plant defence mechanisms including a response to inappropriate chemical herbicide treatment, known as chemically dormancy, where the plant can remain dormant beneath the ground for a number of years with no above ground leafy green growth (see Appendix II).

It also has the ability to produce a 'bonsai' growth form in response to inappropriate chemical herbicide treatment or cutting. This defence mechanism enables the plants to develop into a cryptic miniature growth form. As a result, it is possible, in the absence of a thorough systematic survey, for outliers to go undetected even if surveys are undertaken during the optimum survey period (see Appendix II).

During walkover surveys, surveyors make every effort to detect the presence Japanese knotweed, using their considerable previous field experience and expertise in carrying out such surveys.

3.5.4 Classification & Legislation

All non-native and potentially invasive species recorded within the site were subsequently checked for a 'listing' under the following risk assessments, classifications, guidance documents and websites (please refer to Appendix I for further details):

- Invasive Species Ireland - risk assessment and classification
- National Biodiversity Data Centre - risk assessment and classification
- NRA (2010 revised) Guidelines on the Management of Noxious Weeds and Non-native Species on National Roads
- Department of Agriculture, Food, and the Marine (DAFM) - Plant Health Trade webpage

All non-native and potentially invasive species recorded were also checked for a listing under the following relevant legislation:

- EU Regulation 1143/2014 on Invasive Alien Species
- Third Schedule: Part 1 of European Communities (Birds and Natural Habitats) Regulations, 2011 (S.I. No. 477 of 2011) to 2015, as amended.

Please refer to Section 4.3 for findings in relation to the classification of the species recorded within the site and relevant legislation.

3.6 Source-Pathway-Receptor Analyses

A Source-Pathway-Receptor (S-P-R) model is typically applied to assist in determining the potential for indirect or secondary impacts. A number of factors need to coexist in order for an indirect or secondary impact to occur. Firstly, there must be a risk enabled by the presence of a "*source*" of impact, followed by the existence of a "*receptor*" in the wider environment and a "*pathway*" connecting the source to the receptor. This is referred to as a complete Source-Pathway-Receptor chain.

The source refers to the confined or discrete point from which the impact is released into the environment, the pathway is the route by which the particular impact then travels through the environment and the receptor is the location where the impact occurs.

With respect to the management of Japanese knotweed S-P-R Analyses is a useful tool which can be utilised to assess potential risk of the following indirect impacts:

- Risk of Dispersal (see Section 3.6.1)
- Risk of Water Pollution (see Section 3.6.2)
- Risk of Exposure to Spray Drift (see Section 3.6.2)

Table 3.2 Risk of Dispersal

Source – Pathway – Receptor (S-P-R) Chains
Sources or Origins ▪ Imported soil, gravel, other stone material ▪ Stem fragments from cutting or strimming ▪ Lateral growth from an adjacent property Pathways for Dispersal ▪ **Land** *e.g.* disturbed soils ▪ **Air** *e.g.* strimming, seeds ▪ **Water** *e.g.* drainage ditches, streams, rivers, canals, culverted drainage ditches or stream and gullies leading to a waste or storm water network outfalling to a watercourse or other water features Disturbance Regimes ▪ **Physical** *e.g.* soil disturbance, cutting, grazing ▪ **Chemical** *e.g.* inappropriate spraying ▪ **Natural** *e.g.* rain, flooding, storms

Dispersal mechanisms

- **Biotic** dispersal mechanisms *e.g.* zoochory, hydrochory, anemochory *etc*.
- **Abiotic** dispersal mechanisms *e.g.* agochory, hemerochory, anthropochory *etc.*
- **Vectors** *e.g.* insects, animals, people (footwear), wind, water, tyres of vehicles *etc*.

3.6.1 Risk of Dispersal

With respect to the risk of dispersal of Japanese knotweed vector material within the site of the proposed residential development, an S-P-R Analyses was carried out in order to gather information on the events which led to the introduction of the vector material to the site and to identify any ongoing disturbance regimes which could lead to further dispersal of Japanese knotweed within the site.

The S-P-R Analyses was also utilised to assess the potential risk of vector material being reintroduced to the site at a future date and to identify any control measures which need to be deployed to avoid the repetition of such an event (see Table 4.2).

The following information was collated to inform the S-P-R Analyses:

Dispersal

- Presence of disturbance regimes including disturbed land
- Presence of 'bonsai's', outliers, or evidence of lateral growth
- Presence of sub-lethal bonsai regrowth or chemically dormant Japanese knotweed
- Type and location of existing and proposed infrastructure (above and below ground) within a site relative to the location of the Japanese knotweed infestation
- Distance of the Japanese knotweed infestation from the site boundary
- Socio-demographics of persons with access to the site

Reintroduction

- Planned construction or landscaping works
- Importation of soil, stone to the site
- Presence of Japanese knotweed in adjacent lands

3.6.2 Risk of Water Pollution & Exposure to Spray Drift

An S-P-R Analyses was also completed in respect of the potential for indirect impacts on water quality arising from the use of chemical herbicide or the accidental spillage or release of hydrocarbons from machinery and equipment utilised in the deployment of chemical herbicide. There is also the potential risk of exposure of vulnerable groups, sensitive ecological receptors, and non-target areas to 'spray drift' during the deployment of chemical herbicide. Examples of potential sources, pathways and receptors are detailed in Tables 4.3 and 4.4.

During the walkover survey particular focus was paid to the presence of receptors which may be at risk from the use of chemical herbicide and hydrocarbons. A number of web browsers and geobrowsers Google Streetview, Google Earth Pro and Ordinance Survey Irelands Geohive Mapviewer (http://map.geohive.ie/map viewer.html) were utilised in advance of the walkover to assist in a more targeted survey of these features.

Table 3.3 Risk of Water Pollution & Exposure to Spray Drift

Water Pollution & Exposure to Spray Drift
Sources ▪ Leakage/spillage during pouring/mixing/spraying of chemical herbicide ▪ Spray drift of chemical herbicide due to wind or inappropriate/defective equipment ▪ Leakage/spillage during pouring of hydrocarbons when refuelling, or oils and greases (lubricants) and hydraulic fluids utilised in the maintenance of vehicles or equipment or from poorly maintained or malfunctioning vehicles or equipment Pathways ▪ Stormwater gullies and stormwater drainage networks ▪ Watercourses ▪ Overland surface water flows ▪ Percolation to groundwater ▪ Karstic systems Receptors *Chemical Herbicide* ▪ SUD Restrictions & Receptors ▪ Ecological receptors ▪ NPWS Circular Letter 2/08 *i.e.* Natura 2000 sites, Annex IV species, wild birds, and their habitats ▪ Non-target areas *e.g.* dwelling houses, amenity grassland, gardens *etc*. ▪ Any other site-specific sensitive receptors *Hydrocarbons* ▪ As above ▪ Presence of karstified features or landforms, shallow bedrock, fault zones ▪ Any other site-specific sensitive receptors

Table 3.4 Details of SUD Restrictions & Ecological Receptors

SUD Restrictions & Ecological Receptors

SUD Restrictions & Receptors

- Areas of general public use *e.g.,* playgrounds, parks, footpaths
- Presence of defined vulnerable groups *e.g.,* elderly, pregnant mothers, young children
- Transportation routes *e.g.,* railway corridors
- Sealed surfaces
- Groundwater vulnerable landscape features *e.g.* springs, karst features
- Drinking water abstraction sources *e.g.,* well, borehole, spring, surface water
- European Sites *i.e.* Natura 2000 sites
- Any other SUD restrictions and receptors

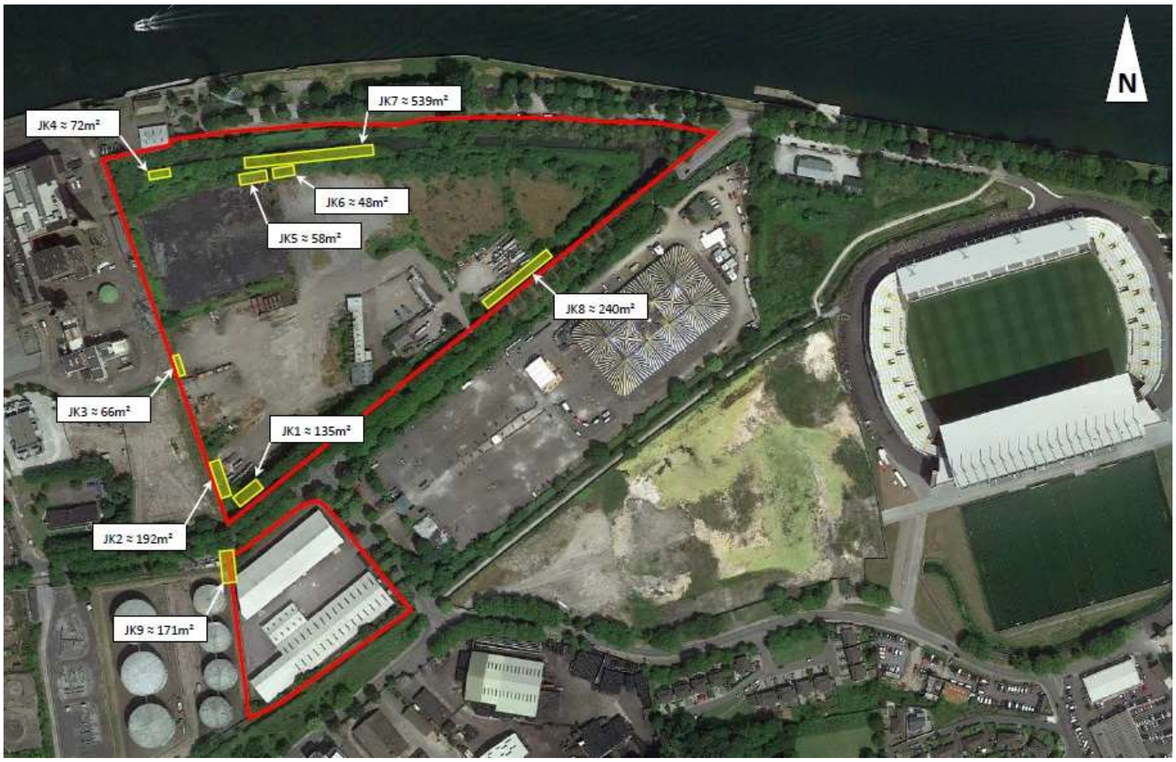
Ecological Receptors

- Other designated conservation areas *i.e.* NHAs and pNHAs
- Habitats and species as per NPWS Circular Letter 2/08 *i.e.* Natura 2000 sites, Annex IV species, wild birds, and their habitats
- Notable, rare, or protected flora and fauna
- Surface waterbodies *e.g.* Drainage ditch (FW4), Depositing lowland river (FW2), Eroding upland river (FW1), ponds, lake, and other aquatic habitats
- Groundwater dependant terrestrial ecosystems (GWDTEs) located down gradient
- Surface water dependant terrestrial ecosystems (SWDTEs) located downstream
- Adjacent ecological receptors *e.g.* trees, hedgerows and woodlands, pollinators, birds, and small mammals
- Any other site-specific ecological constraints

4.0 EXTENT OF INVASIVE SPECIES

4.1 Extent of Japanese Knotweed

During the walkover survey on the 14th December 2021, Japanese knotweed was identified at *n* = *8* locations within the overall masterplan boundary (see Figures 4.1-4.2 and Table 4.1).



Photograph 4.1 Extent of Japanese Knotweed within the Overall Masterplan (Source: ARUP)

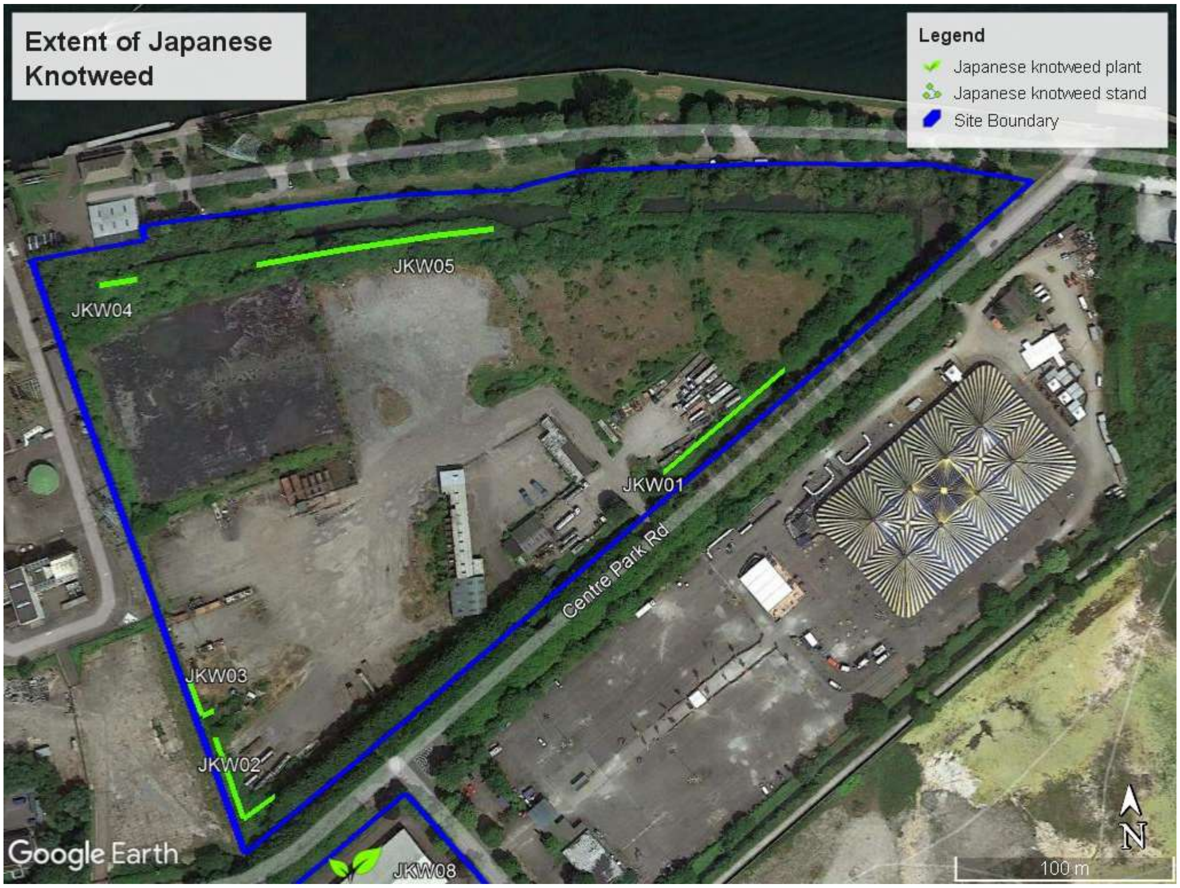
Within Site A, Japanese knotweed was recorded at JKW01–JKW05. The presence and diameter of the "crown" structures, within the stands, would indicate the plants are at least 10 years old. The largest and most mature stands were located at JKW01, JKW04 and JKW05 in the 4.7ha subsite. JKW04 and JKW05 are located along the bank of a large open drainage ditch on the northern boundary of the site (see Figure 4.2).

The specialist survey did not identify Japanese knotweed at JK3 in Site A as per Figure 4.1, however, a knotweed stand (JKW03) was recorded further south along the same boundary (see Figure 4.2). This is likely due to a drafting error.

Japanese knotweed was also recorded within Site B at JKW06-JKW08 (see Figure 4.3).

Additional Japanese knotweed plants over and above those identified in Site B, as per Figure 4.1, were recorded to the rear of the warehouse *i.e.,* JKW07 and JKW08 (see Figures 4.2-4.3). Of note is that JKW07 and JKW08 appear to be growing out from beneath the foundation of the remaining warehouse structure in Site B. JKW06 is located in close proximity to an open drainage ditch on the northern boundary of Site B (see Figure 4.3).

More specific details on the extent of Japanese knotweed in m.sq. at JKW01-JKW08, will be gathered during the targeted specialist site investigation works, to determine volumes of vector material, as the works will make the stands more accessible for surveying (see Section 7.1).



Photograph 4.2 Extent of Japanese Knotweed within Site A
(Source: O' Donovan Agri-Environmental Services)

4.2 Extent of Other Invasive Species

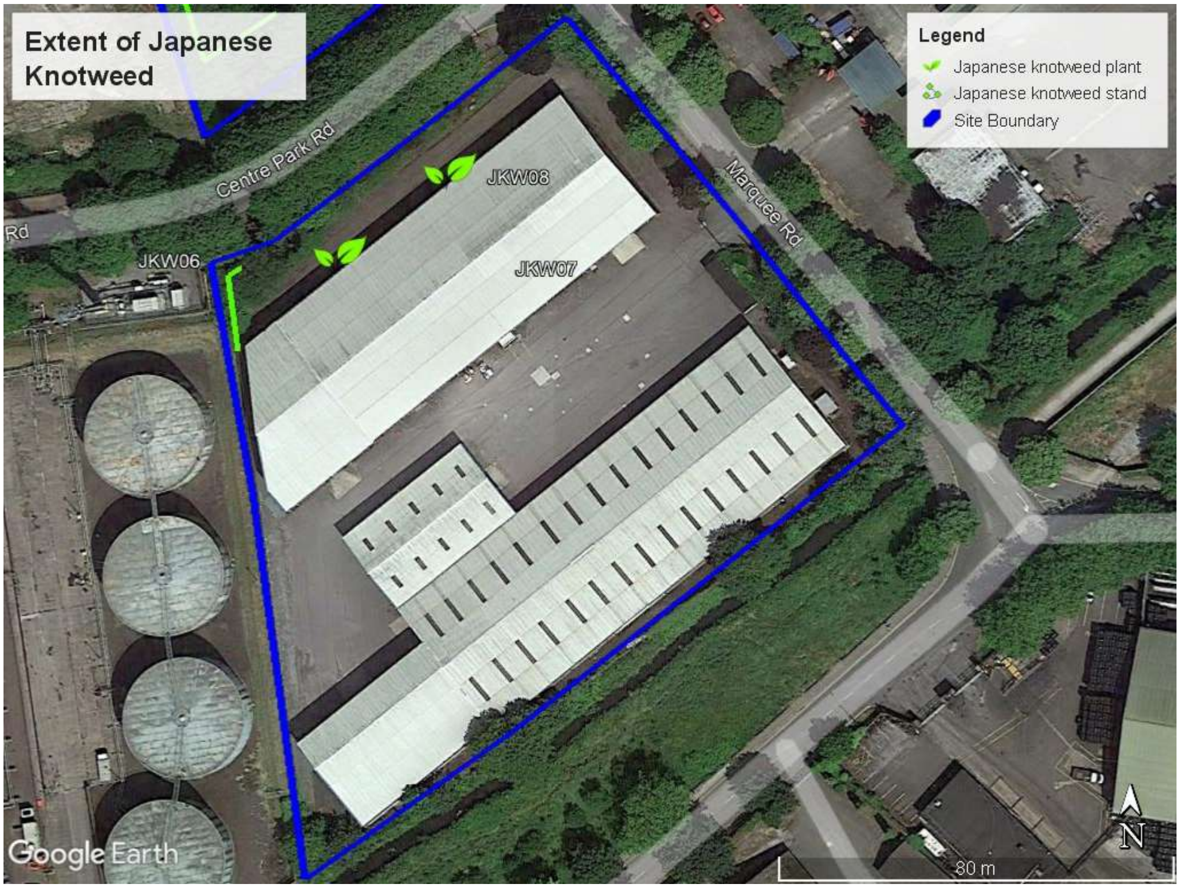
In addition to Japanese knotweed, Buddleia (*Buddleia davidii*), Traveller's joy (*Clematis vitalba*), 2 no. *Cotoneaster* spp., Montbretia (*Crocosmia* x *crocosmiiflora*), Winter heliotrope (*Petasites fragrans*) and Pampas grass (*Cortaderia selloana*) were also recorded at various locations within Site A and Site B (see Table 4.2). Of these species Buddleia was found to be the most dominant invasive species across the entire survey area.

4.3 Classification & Legal Obligations

A total of *n = 8* potentially invasive alien plant species were recorded within the overall masterplan boundary during the walkover survey on the 14th December 2022 (see Table 4.3).

None of the invasives recorded are a regulated species on the "Union list" of 49 No. species under EU Regulation on Invasive Alien Species 1143/2014 ((see http://ec.europa.eu/environment/nature/invasivealien/index_en.htm).

Some of the core provisions of EU Regulation 1143/2014 deal with, among other things, bringing into the territory of the Union, keeping, breeding, transporting, and placing on the market, species included on the list of invasive alien species of Union Concern (*i.e.,* the 'Union list').



Photograph 4.3 Extent of Japanese Knotweed within Site B
(Source: O' Donovan Agri-Environmental Services)

Japanese knotweed is listed under Irish legislation *i.e.* the Third Schedule: Part 1 of the European Union (Birds and Natural Habitats) Regulations 2011 to 2015.

Japanese knotweed is also listed on the Third Schedule: Part 3 which governs the movement of soil or spoil taken from places infested with Japanese knotweed (http://www.irishstatutebook.ie/eli/ 2011 si/477/made/en/print).

Plants listed under the Third Schedule: Part 1: Plants and Part 3: Vector Materials are subject to restrictions under Regulations 49 & 50. Part 3: Vector Materials refers to soil or spoil taken from places infested with Japanese knotweed (*Fallopia japonica*). Regulation 49 deals with the 'Prohibition on introduction and dispersal' while Regulation 50 deals with the 'Prohibition on dealing with and keeping certain species'.

Regulation 50 has yet to be enacted into Irish law. A licence is required from NPWS under Regulation 49(2) to transport vector material off a site.

A Waste License is required under the Waste Management (Licensing) Regulations 2004 from the EPA to bury soil contaminated with vector material within a site.

Table 4.1 Japanese Knotweed at JKW01 – JKW08

Photographs	Details
JKW01	
	Specialist survey on the 14th December 2021
JKW02A	
	Specialist survey on the 14th December 2021

JKW02B	
	Specialist survey on the 14th December 2021

JKW03	
	Specialist survey on the 14th December 2021

JKW04	
	Specialist survey on the 14th December 2021

JKW05A	
	Specialist survey on the 14th December 2021

JKW05B	
	Specialist survey on the 14th December 2021

JKW06A	
	Specialist survey on the 14th December 2021

JKW06B	
	Specialist survey on the 14th December 2021
JKW07	
	Specialist survey on the 14th December 2021

JKW08	
	Specialist survey on the 14th December 2021

Japanese knotweed is classified by the National Biodiversity Data Centre (NBDC) as an invasive species with a "High Impact", while Traveller's joy, Buddleia and Pampas grass are deemed "Medium Impact' species by the NBDC.

Japanese knotweed, Travellers joy, Montbretia, Winter heliotrope and Buddleia are included in the NRA Guidelines on the Management of Noxious Weeds and Non-native Species on National Roads (NRA, 2010) as these species have been shown to have an adverse impact on landscape quality, native biodiversity or infrastructure (https://www.tii.ie/technical-services/environment/planning/).

Japanese knotweed, Traveller's joy and Montbretia are also listed by the Department of Agriculture, Food and Marine (DAFM) on their Plant Health Trade webpage (https://www.agriculture.gov.ie/dontriskit/alieninvasivespecies/).

While Traveller's joy, Montbretia, Winter heliotrope and the 2 no. *Cotoneaster* spp., have not been classified as 'high' and or 'medium' impact species, or have yet to be risk assessed, they are recognised as having invasive qualities and under certain environmental conditions are known to spread locally.

For the purposes of clarity, the 2 no. *Cotoneaster* spp. recorded were not identified as Wall Cotoneaster (*Cotoneaster horizontalis*) a "Medium impact" species.

Table 4.2 Other Invasive Species Recorded Within Site A & B

Photographs	Details
Buddleia	
	Specialist survey on the 14th December 2021
Travellers Joy	
	Specialist survey on the 14th December 2021

Winter Heliotrope	
	Specialist survey on the 14th December 2021
***Cotoneaster* sp.**	
	Specialist survey on the 14th December 2021

Cotoneaster sp.	
	Specialist survey on the 14th December 2021
Pampas Grass	
	Specialist survey on the 14th December 2021

Montbretia	
	Specialist survey on the 14th December 2021

Table 4.3 Invasive Alien Plant Species (IAPS) Recorded

No.	Species Name	EU Regulation 1143/2014	Habitats Regulations 2011 to 2015	NBDC Impact Level	NRA (2010)	DAFM
1	Japanese knotweed		*✓	High Impact	✓	✓
2	Traveller's joy			Medium Impact	✓	✓
3	Buddleia			Medium Impact	✓	
4	Pampas grass			Medium Impact		
5	Montbretia				✓	✓
6	Winter heliotrope				✓	
7/8	*Cotoneaster* spp.					

*Part 1: Plants and Part 3: Vector Materials

5.0 SOURCE-PATHWAY-RECEPTOR ANALYSES

This section of the management plan describes the findings of the Source-Pathway-Receptor Analyses in relation to the risk of dispersing Japanese knotweed within the lands of the overall masterplan boundary and the potential for indirect impacts on water quality arising from the use and/or accidental spillage or release of chemical herbicide or hydrocarbons, from machinery and equipment utilised in the deployment of chemical herbicide.

There is also the potential risk of exposure to 'spray drift' by vulnerable groups, areas of general public use, sensitive ecological receptors and non-target areas during the deployment of chemical herbicide. Examples of potential sources, pathways and receptors are detailed in Tables 5.1 and 5.2.

5.1 Risk of Dispersal

Sources

The walkover survey to identify the potential source of Japanese knotweed vector material and the presence of site-specific disturbance regimes which could result in the dispersal of Japanese knotweed, was undertaken on the 14th December 2021 (see Table 5.1).

It should be noted that there are several potential sources of vector material which could result in the reintroduction and further spread of Japanese knotweed within the overall masterplan boundary in the future (see Table 5.1). These include the importation of vector material within soil, stone, and other material and on machinery or equipment required for site investigation, vegetation removal, demolition, construction, and landscaping works and as a result of the fly-tipping of waste. In the absence of control measures, there is a risk that vector material could be reintroduced to the Site A and Site B via these sources.

Pathways for Dispersal

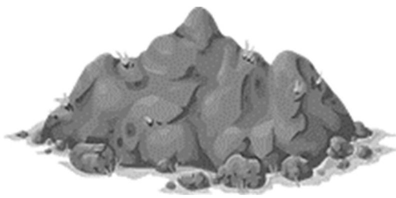
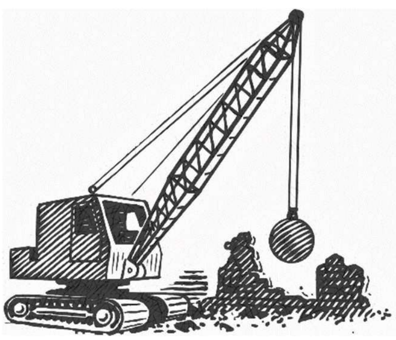
In the event that the Japanese knotweed is not managed in a timely manner there is a high risk that Japanese knotweed will be dispersed within the overall masterplan boundary given the requirement for Geotechnical Site Investigation, vegetation removal, demolition, construction and landscaping works.

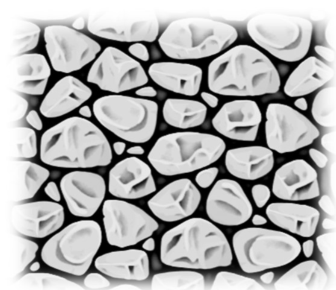
The risk of dispersing Japanese knotweed within the overall masterplan boundary will arise where vector material becomes adhered to (1) the footwear of site personnel/staff, surveyors, and visitors to the site, (2) the tyres of construction related and domestic vehicles in the car park, (3) buckets, tyres, and tracks of plant machinery and on construction/landscaping equipment, or (4) is carried within soil loads.

Vector material could also be transferred to other sites within soil loads, waste arising from demolition and landscaping works, on domestic vehicles, plant machinery and on geotechnical site investigation/vegetation removal/demolition/construction and landscaping equipment.

There is also a risk to land-uses and habitats downstream of the overall masterplan boundary, if viable rhizome or stem fragments were to gain entry into the drainage ditches or washed into stormwater gullies within Site A or Site B, which are connected to the stormwater drainage network which outflow to the River Lee and Cork Harbour.

Table 5.1 Disturbance Regimes at the Proposed Residential Development, Centre Park Road

Disturbance Regime	Description	Control Measures
	**Soil movement** Risk of dispersing vector material in soil loads and on associated plant machinery, site personnel within the site.	Soil movement within the overall masterplan boundary at Centre Park Road should not be undertaken unless authorised by the IAPS Specialist Ecologist.
	**Geotechnical Site Investigation & Demolition works**	Biosecurity measures to be deployed under the supervision of the IAPS Specialist.
	**Mowing, Strimming & Vegetation Removal**	Mowing & strimming, or other vegetation removal is not permitted within the overall masterplan boundary unless authorised by the IAPS Specialist Ecologist.
	**Site Clearance & Main Construction Stage** Risk of dispersing vector material in the form of plant fragments by site personnel, site vehicles, plant machinery and visitors to the site.	Biosecurity measures to be deployed under the supervision of the IAPS Specialist.

Disturbance Regime	Description	Control Measures
	**Chemical Herbicide Treatment**	Chemical herbicide should only be deployed by an IAPS Specialist Contractor.
	**Wind** There is a risk of the dispersal of plant fragments by wind.	Monitoring and walkover surveys should be undertaken to identify any new outliers for incorporation into the management programme.
	**Importation of Topsoil, Subsoil, Stone, or Fill** There is a risk of introducing invasive species to the Residential development, No. 31-33 Centre Park Road.	Imported topsoil, subsoil and stone into the site should be certified to BS 3882:2015 and BS 8601:2013 to ensure that it is free from IAPS vector material.

During the chemical herbicide treatment process and the recovery of Japanese knotweed vector material there is also a risk pertaining to the accidental dispersal of fragments on the footwear of the Registered Professional User's (RPUs) in the absence of appropriate biosecurity measures.

In the event that the Japanese knotweed was left untreated within the site over a prolonged period of time, there is also a risk that it may spread by lateral growth of rhizomes beneath the ground.

Receptors

Where Japanese knotweed is not adequately managed within the overall masterplan boundary, the adjacent land-uses in the vicinity of the site may be at risk from Japanese knotweed (see Section 3.1 for details).

5.2 Risk of Water Pollution & Exposure to Spray Drift

Sources

While a considerable volume of chemical herbicide will need to be deployed to treat the extensive Japanese knotweed within the overall masterplan boundary, in particular Site A, there is a low risk of contaminants entering groundwater flow paths in Site A and in the northern half of Site B given the nature of the overburden and underlying aquifer.

While there is a higher risk of contaminants gaining entry to the karstified aquifer in the southern half of Site B, there are no invasive species present as the Japanese knotweed is confined to the north-eastern boundary of Site B.

There is also a risk of contaminants entering surface waters via the drainage ditches on the boundaries of Site A and Site B. In particular, during the application of chemical herbicide to JKW04 and JKW05 on the banks of the drainage ditch in Site A, and to JKW06 on the banks of the drainage ditch in Site B.

The accidental spillage or release of larger volumes of chemical herbicide or undiluted herbicide during pouring/mixing/spraying could result in the release of a higher concentration or volume of contaminants.

Given the maturity *i.e.* height of the infestation there is a potential requirement for the use of a Mobile Elevated Work Platforms (MEWPs) and/or compact tractor, in the deployment of herbicide within Site A. In this regard, there is also potential for the accidental spillage or release of hydrocarbons in terms of fuels, oils, greases, and hydraulic fluids.

Pathways for Contaminants

It should be noted that contaminants such as chemical herbicides and hydrocarbons, not only cause localised direct impacts at the spill zone but can also gain access to groundwater, enter surface waters via overland flows and stormwater drainage networks (where present), and finally, can enter surface waters and adjacent lands or habitats via seepages.

Given the absence of bedrock at or near the surface, there is limited hydrogeological connectivity via the direct entry of contaminants to the underlying aquifer or percolation through the overburden in Site A and in the northern half of Site B.

Based on the topography, the overall groundwater flow direction in the bedrock aquifer is inferred as being from south to north. Given the overall direction of the groundwater flow paths, any contaminants which manage to gain entry to groundwater could impact on receptors located downgradient, to the north of the overall masterplan boundary, including the drainage ditches on the northern boundaries, the River Lee and Cork Harbour.

There is also hydrological connectivity between the overall lands and the River Lee and Cork Harbour via the drainage ditches and stormwater gullies within and adjacent to the site. The drainage ditches and stormwater gullies are connected to the stormwater drainage network which discharges to the River Lee and Cork Harbour.

The third and final pathway is the risk of spray drift during the foliar application of chemical herbicide in circumstances where chemical herbicide is deployed during windy conditions or as a result of the use of inappropriate/defective equipment. Spray drift may travel on the wind, from the use of chemical herbicide within the overall masterplan boundary, and into adjacent properties or land uses.

5.3 SUD Restrictions & Receptors

The following sections identify the various SUD restrictions & receptors which are at risk from the use of chemical herbicide via the pathways identified in Section 5.2.

5.3.1 Areas of General Public Use & Defined Vulnerable Groups

Given that the Japanese knotweed is to be treated within an urban environment there is a risk that a defined vulnerable group could be exposed to chemical herbicide *e.g.* pregnant mothers, elderly persons and children utilising the adjacent public footpath on Centre Park Road, the car parking area and riverside walk along the River Lee, and Shandon Boat Club, and any employees working in adjacent civil or industrial infrastructure.

In summary, there is a potential risk of impacts to the following groups, from the deployment of chemical herbicide to Japanese knotweed within the overall masterplan boundary:

- Members of the general public utilising the adjacent footpath on Centre Park Road, the carparking and walkway along the River Lee, and Shandon Boat Club
- Members of vulnerable groups including children, elderly and pregnant mothers utilising the adjacent footpath on Centre Park Road, the car parking and riverside walkway along the River Lee
- Members of the general public working within adjacent civil infrastructure, industrial units and Shandon Boat Club

Control measures should be deployed to ensure that members of these vulnerable groups and the general public, in particular children, the elderly and pregnant mothers do not come into contact with chemical herbicide. The control measures will focus on minimising spray drift and the avoidance of interactions with these groups when deploying chemical herbicide. These measures will include timing of spraying, preventing access to the areas requiring chemical herbicide treatment and strict adherence to best practice guidance and instructions on the Product Label in order to minimise spray drift (see Section 8.0 for further details).

5.3.2 Groundwater Vulnerable Landscape Features

The results of the desktop study confirmed that while there are no mapped groundwater vulnerable landscape features such as springs or fault zones within the site (GSI Mapviewer) which could be at risk from the use of chemical herbicide, a karstified aquifer is present within the southern half of Site B.

Bedrock outcrops, karstified features or landforms were not recorded within the site during the walkover survey. According to the GSI Mapviewer, there is also a fault zone located to the north. The closest known mapped karst feature is Ballinlough Cave 1707SWK010 which is located 1.0km to the southeast (GSI Mapviewer).

As the use of chemical herbicide is not proposed in the southern half of Site B, there is minimal risk to the karstified aquifer.

5.3.3 Surface Water Abstraction Zones/Drinking Water

The potential for Public Water Supply Schemes, Group Water Schemes, and private supplies within 5km of overall masterplan boundary was examined to assess any potential risk to drinking water supplies from the use of chemical herbicide.

Public Water Supply Schemes (PWSSs)

The public water supply for Cork City and environs is the Lee Road Water Treatment Plant (LRWTP) located immediately upstream of the Salmon Weir on the River Lee. While there is hydrological connectivity between the lands within the overall masterplan boundary and the River Lee, the drainage ditches and the stormwater network within Site A and Site B outfall to the River Lee downstream of the Salmon Weir. Therefore, no constraint exists in relation to this drinking water abstraction zone.

There is no known well on site.

National Federation of Group Water Schemes (NFGWS)

There are no NFGWS drinking water abstractions within 5km of the site ([Ireland's Group Water Schemes (nfgws.ie)]).

Table 5.2 Potential Groundwater Abstraction Sources

Abstraction Type	Yield (m^3)	Data Source	Distance	Connectivity
		Groundwater Abstractions		
Borehole 1407SEW065	1527.75 (Excellent)	GSI	1.875m to SW	1955
Borehole 1407SEW061	Unknown	GSI	1010m to W	1964
Conglomerate of boreholes Glover SI Ltd.	Unknown	GSI	935m	2002. Described as window sampler. No connectivity
Ballyphilip WS1707SWW085	27.3 (poor)	GSI	1275 to SE	1899
Conglomerate of boreholes	Unknown	GSI	460m to S	1998

Groundwater Source Protection Area

The closest Groundwater Source Protection Area is located greater than 10km to the north and south of the overall masterplan boundary at Minane Bridge and Carrignavar.

Boreholes, Wells & Springs

The results of the desktop study for vulnerable landscape features identified a number of historic groundwater fed supplies *i.e.* wells and boreholes within the study area in the vicinity of the overall masterplan boundary (see Table 5.2). A conglomerate of recent boreholes

(2002) was identified; however, these were described as being for window sample purposes (GSI Mapviewer).

Consultation is required with Cork City Council to confirm that these wells are no longer in use/there is no risk to water supplies (see Table 5.2).

While there is potential for additional private wells which may not be indicated on the GSI Mapviewer, the city is generally served by the local authority main drinking water supply rather than directly from groundwater wells, therefore, active domestic private wells are not likely to be located within the study area. It is therefore not envisaged that local domestic water supplies will be impacted by the use of chemical herbicides.

In light of the above, it is unlikely that drinking water supplies will be impacted by the use of chemical herbicide within the lands of the overall masterplan boundary.

5.3.4 Natura 2000 Sites

As per Section 5.2, there are hydrological pathways between the overall masterplan boundary and the River Lee/Cork Harbour via the presence of 1st order drainage ditch tributaries and the stormwater drainage network which also outfalls to the River Lee and Cork Harbour.

Figure 5.1 Distance from Natura 2000 Sites
(Source: Google Earth Pro and NPWS Map Data)

While a karstified aquifer, underlies the southern half of Site B, there is no requirement to utilise chemical herbicide at this location, given that the Japanese knotweed in Site B is confined to the north-eastern boundary. In this regard there is limited potential hydrogeological pathways between the lands within the overall masterplan boundary and any ecological receptors located downgradient or to the north of the proposed residential development *i.e.* the River Lee and Cork Harbour.

In the event that chemical herbicide was to percolate into the karstified aquifer or gain entry to the drainage ditches or stormwater network (via storm water gullies within the site) there is a low risk of impacts to the lower reaches or the brackish intertidal zone of the River Lee and the marine habitats of Cork Harbour which are designated as Cork Harbour SPA (Site Code: 004030), located at least 2.4km (at its closest point) to the east of proposed residential development, given the distance and dilution effects.

5.4 Ecological Receptors

In addition to the Natura 2000 sites identified in Section 5.3.4, the lower reaches of the River Lee and the marine habitats of Cork Harbour are also designated as Douglas River Estuary proposed National Heritage Area [1]pNHA (Site Code: 001046) and Dunkettle shore pNHA (Site Code: 001082).

In the event that chemical herbicide was to percolate into the karstified aquifer or gain entry to the drainage ditches or stormwater network (via storm water gullies within the site) there is a low risk of impacts to Douglas River Estuary pNHA and Dunkettle Shore pNHA located at least 1.9km (at the closest point) to the east of the overall masterplan site, given the distance and dilution effects.

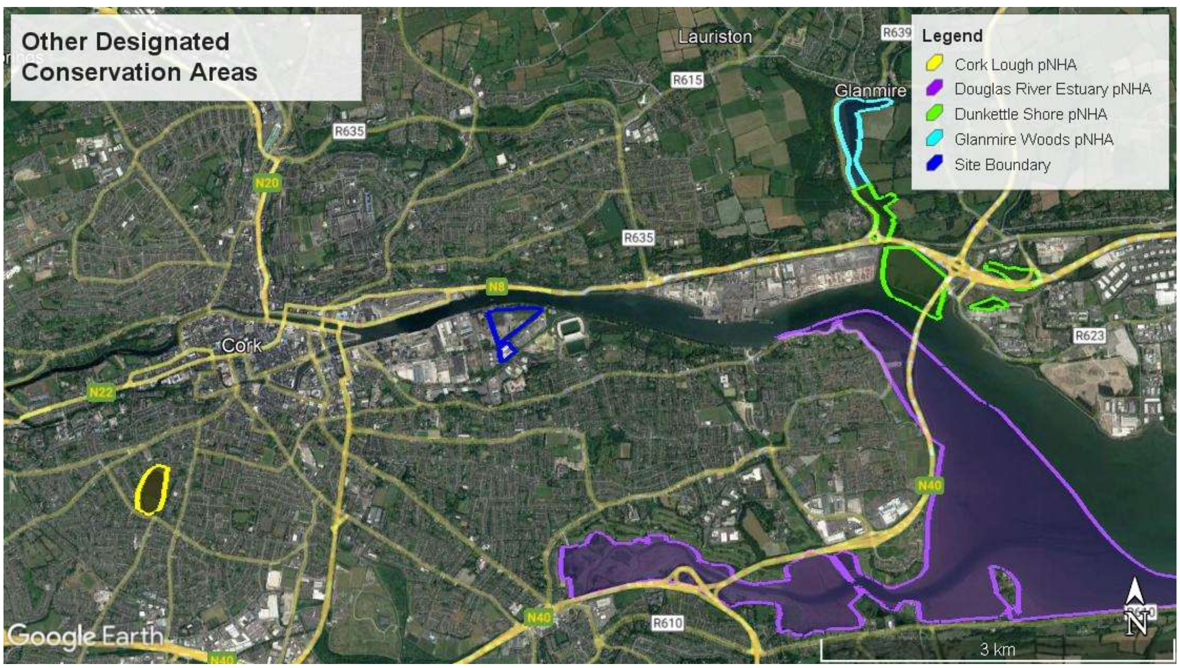


Figure 5.2 Distance from Other Designated Conservation Areas
(Source: Google Earth Pro and NPWS Map Data)

[1] The Irish Wildlife (Amendment) Act 2000 provides for the designation and conservation of Natural Heritage Areas (NHAs); which are sites that support features of importance at a national level. A list of approximately 630 No. proposed NHAs (or pNHAs) was published on a non-statutory basis in 1995, however, these pNHAs have not been statutorily proposed or designated since that time. The pNHAs cover approximately 65,000ha and designation is to proceed on a phased basis over the coming years. Prior to statutory designation, pNHAs are subject to limited protection (see https://www.npws.ie/protected-sites/nha for details).

While the lands within the overall masterplan boundary are located at least 2.9km northeast of Cork Lough pNHA (Site Code: 001081) there is limited hydrological or hydrogeological connectivity given the overall direction of groundwater flow and the fact that the stormwater network outfalls to the River Lee.

Outside of the designated conservation areas within Cork Harbour, there are non-designated groundwater (GWDTEs), surface water dependant terrestrial ecosystems (SWDTEs) and aquatic species within the River Lee which could be impacted upon by the spillage of chemical herbicide given the presence of drainage ditches and the stormwater drainage network which discharge directly to the River Lee. There are limited terrestrial ecosystems adjacent to the overall masterplan boundary which could be impacted, given the contextual framework of the surrounding urban environment.

Aside from designated and non-designated habitats in the wider landscape, there are also local ecological receptors within or adjacent to the site which could be impacted by spray drift including:

- Woody scrub/shrub/trees supporting pollinators, birds, and small mammals
- Pollinators, birds, and small mammals

Pollinators, birds, and small mammals may utilise vegetation including Japanese knotweed and other invasive species for cover, nesting, or foraging. Therefore, pollinators, birds and small mammals are at risk from the use of chemical herbicide, where it is directly applied to Japanese knotweed, or from the effects of spray drift on adjacent woody scrub/shrub/tree vegetation and non-target areas.

Control measures should be deployed to protect ecological receptors from indirect impacts arising from the use of chemical herbicides.

5.5 Environmental, Occupational Health & Safety Hazards

Aside from the SUD restrictions and receptors outlined in Section 5.4, there is a potential risk of impacts to other groups of people from the deployment of chemical herbicide including:

- RPUs deploying the chemical herbicide to Japanese knotweed
- Site personnel/staff completing site investigation, vegetation removal, demolition and construction works
- Surveyors gathering data for ecological assessments, engineering purposes *etc*
- Caretakers for the site

Control measures should be deployed to ensure that caretakers, surveyor and site staff at the site investigation, vegetation removal, demolition, construction and landscaping stage do not come into contact with chemical herbicide.

Registered Professional User's (RPUs) involved in the handling of chemical herbicide, and the operation of sprayers, may also interact with chemical herbicide via direct contact with skin, inhalation, and ingestion, where appropriate Personal Protective Equipment (PPE) such as gloves and breathing apparatus are not worn.

In addition, there is a risk to non-target areas including the adjacent industrial unit, civil infrastructure and the riverside walk from spray drift or accidental spraying. Control measures should also be deployed to minimise spray drift and accidental spraying.

The IAPS Specialist Contractor should acquire information pertaining to the presence of overhead and underground cables and other services at the site in order to inform the Method Statement and Risk Assessment for any management programme where equipment or plant machinery could come into contact with services present within the works area.

Traffic management may also be necessary to facilitate access by plant machinery to the lands within the overall masterplan boundary during the management of Japanese knotweed, given the site is located off an urban street Centre Park Road.

6.0 PROJECT & SITE CONSTRAINTS

Of the 8 no. invasive species recorded, Japanese knotweed is the only species which is listed in environmental legislation, and which could interfere with future infrastructure within the overall masterplan boundary, in terms of accessing existing weaknesses or joints in bitumen, concrete work, stone masonry and hard standing areas; thus, causing impacts to hard landscaping or services (see Section A. of Appendix II).

There are extensive mature stands of Japanese knotweed within the lands of the overall masterplan boundary. In particular, stands JKW01, JKW04 and JKW05 are well established and are at least 10 years old. These stands are located in the 4.7ha subplot of Site A, for which planning is currently being sought. As such the eradication of Japanese knotweed from these locations is time sensitive, given the intention to develop these lands, if and, when planning is granted.

Japanese knotweed plants can exhibit a tolerance for chemical herbicide and can deploy plant defense mechanisms where a sub-lethal dose is applied, leading to the production of sub-lethal bonsai regrowth and/or chemical dormancy (see Section A. Japanese knotweed of Appendix II).

Available information would suggest that the Japanese knotweed within Site A and Site B has not been treated previously with chemical herbicide or at least in recent times. Therefore, the possibility that mature rhizome networks may be lying dormant below ground outside of the recorded stands at JKW01-JKW08, as a result of past chemical herbicide use within the site, is deemed unlikely. Similarly, the presence of cryptic sub-lethal regrowth is not anticipated (see Table A.3 in Appendix II).

There is, however, a possibility that Japanese knotweed may have been missed given: (1) the timing of the survey was outside of the optimum survey period, (2) the presence of disturbance regimes, (3) difficulties gaining access due to dense vegetation, and (4) due to the steep vegetated banks of the drainage ditches in Site A.

The lands within the overall masterplan have been the subject of a number of disturbance regimes including past demolition works, and possibly fly-tipping, which could have disturbed and/or buried knotweed. JKW06 is growing from a spoil heap of construction and demolition waste in Site B.

Of note is that the Japanese knotweed stands at JKW04, JKW05 and JKW06 are located in close vicinity to drainage ditches. The application of chemical herbicide in these areas needs to take into account the presence of hydrological connectivity with the River Lee and Cork Harbour.

The Japanese knotweed at JKW07 and JKW08 appears to be growing out from underneath the foundations of the warehouse in Site B. The plants growing out from underneath the foundations of the structure need to be treated *in situ* with chemical herbicide via foliar application of herbicide and stem filling to accelerate the eradication process prior to the completion of demolition works to facilitate future proposed residential development.

Management Programme Options

The deployment of a 3 yr (up to 5yr) chemical herbicide treatment programme *in situ* is not considered a feasible option in respect of the overall masterplan boundary, as the eradication of Japanese knotweed from JKW01-JKW08 is time sensitive, given the intention to develop these lands.

The Japanese knotweed at JKW01-JKW08 was treated by foliar application of chemical herbicide in October 2021 and is due to undergo stem harvesting followed by stem filling with chemical herbicide in the coming weeks (see Section 7.1.5).

Given the extent of lands present within the overall masterplan boundary, the option of burial onsite should be considered. The feasibility of burying vector material onsite will depend on the layout of the future planned residential development within the overall masterplan boundary, and on a number of other factors which need to be taken into account in the selection of a suitable onsite burial location (see Section 7.1). A number of these factors may limit the dimensions of a burial cell, and hence the volumes of vector material which can be buried onsite *e.g.,* depth to bedrock. It should be noted that the permanent presence of an onsite burial cell will impinge on future land uses in the footprint of the cell and will require monitoring.

The potential presence of contaminants within the sites, such as hydrocarbons, could also influence the ability to bury Japanese knotweed vector material onsite, where hydrocarbons are detected within the vector material.

Aside from potential difficulties of soils contaminated with hydrocarbons, the onsite burial of vector material requires a Waste License under the Waste Management (Licensing) Regulations 2004. A Waste Licence application could result in delays to the construction programme and as well as the costs associated with providing the necessary documentation and environmental assessments to inform the process.

An alternative option is to transport the vector material offsite to a licensed waste facility for deep burial or for thermal treatment.

A cost-benefit analysis of disposal offsite versus burial onsite is required, given the potential presence of contaminated soils and the pending construction programme. It should be noted that the presence of other contaminants within the vector material may also have a cost implication, as the cost per tonne for disposal offsite is likely to be higher.

In circumstances, where there aren't immediate plans to develop all lands within the overall masterplan boundary, an alternative option would be to recover the vector material from JKW01, JKW04 and JKW05 within the 4.7ha subplot and consolidate it at a location such as JKW02 and JKW03 within Site A, where it can be stored in a temporary holding facility for further treatment to reduce the volumes of viable vector material. The location of JKW02 and JKW03 would be ideal, given the existing presence of Japanese knotweed which would avoid the setting up of such a facility on lands which do not already contain Japanese knotweed.

In order, for this option to be feasible a minimum of 3 years would be required to facilitate treatment at JKW02/JKW03 which would impede the development of these lands within the overall masterplan boundary for this extended period of time. Any remaining viable vector material, in Year 3, could be transported offsite under licence from NPWS. The feasibility of this approach would depend on future plans and timing of the construction programme for this land.

7.0 Best Practice Methodology

There are a number of best practice management programmes which can be deployed to control or eradicate Japanese knotweed from the lands within the overall masterplan boundary as follows:

- Option 1: Chemical Herbicide Programme (treatment *in situ*)
- Option 2: Recovery of Vector Material & Burial Onsite
- Option 3: Recovery of Vector Material & Disposal Offsite
- Option 4: Installation of Japanese Knotweed Rhizome Barrier
- Option 5: Recovery of Vector Material & Construction of a Bund Facility

In light of the project constraints discussed in Section 6.0, the most practical management programmes for Japanese knotweed within the lands of the overall masterplan boundary are **Option 2 - Recovery & Burial Onsite** or **Option 3 - Disposal Offsite** of the vector material (see Section 7.1 and 7.2 for details). Table 7.1 and 7.2 details the optimum periods for the deployment of these management programmes.

Table 7.1 Optimum Periods for the Management of Japanese Knotweed

Management Programmes	J	F	M	A	M	J	J	A	S	O	N	D
1. Chemical Herbicide Programme												
*Spraying												
#Stem Filling												
#Stem Injecting												
2. Recovery & Burial Onsite												
Site Investigation												
#Pre-treatment (see Table 7.2)												
Recovery and burial onsite												
3. Recovery & Disposal Offsite												
Site Investigation												
#Pre-treatment (see Table 7.2)												
Recovery and Disposal Offsite												
4. Installation of a Rhizome Barrier												
Installation of a Rhizome Barrier												

Table 7.2 Optimum Periods for Pre-Treatment prior to Recovery

Pre-treatment	J	F	M	A	M	J	J	A	S	O	N	D
*Spraying only												
#Spraying and Stem Filling Combination												
#Spraying and Stem Filling Combination												

*Timing is dependent on seasonal factors *i.e.* onset of flowering/seeding and before senescence

#Ideally stem filling and stem injecting should also be undertaken during the optimum treatment period to achieve a maximum effective reduction in the viability of the underground rhizome network

7.1 Option 2 - Recovery & Burial Onsite

This management programme involves the recovery of the vector material followed by encapsulation within a burial cell onsite.

There are a number of site constraints which will determine the feasibility of burying vector material onsite (see Section 6.0). In particular, burial onsite requires the availability of suitable lands for the construction of cell. The dimensions of the burial cell will depend on the volumes of vector material and extent of suitable lands available for burial, including the presence of underground services, depth to bedrock and the water table.

The site-specific tasks which need to be completed in respect of this management programme are outlined in Table 7.3.

Most notably a Waste License is required under the Waste Management (Licensing) Regulations 2004 from the EPA to bury soil contaminated with vector material within a site.

Table 7.3 Site-Specific Tasks

Tasks	Description	Status
Task 1	IAPS Specialist Ecologist to undertake a specialist walkover survey of the lands within the overall masterplan boundary at Centre Park Road	Completed on the 14th December 2021
Task 2	Comer Group (Ireland) Ltd. to implement Biosecurity Protocols and Control Measures in conjunction with the IAPS Specialist Ecologist to avoid further spread: ▪ Set up of Exclusion Zones Avoid disturbance regimes highlighted in Table 5.1	Completed
Task 3	IAPS Specialist Ecologist to prepare an Invasive Species Management Plan	Completed (subject of this document)

Tasks	Description	Status
Task 4	IAPS Specialist Ecologist to prepare a Risk Assessment & Method Statement for the recovery of vector material	To be completed
Task 5	Soil testing to be undertaken to ensure that the vector material is acceptable for burial onsite *i.e.,* Waste Acceptance Criteria (WAC) Analysis	To be completed
Task 6	IAPS Specialist Ecologist to supervise specialist site investigation works to inform volumes for disposal	To be completed
Task 7	Comer Group (Ireland) Ltd. to undertake targeted geotechnical site investigations at the location of the proposed onsite burial cell to determine suitability of lands	To be completed
Task 8	Comer Group (Ireland) Ltd. to apply to the EPA for a Waste Licence	To be completed
Task 9	Comer Group (Ireland) Ltd. to excavate the burial cell to accommodate the vector material	To be completed
Task 10	IAPS Specialist Ecologist to supervise the lining of the burial cell, and the recovery and encapsulation of the vector material	To be completed
Task 11	O' Donovan Agri-Environmental Services to undertake a 2-yr Monitoring Programme for Japanese knotweed regrowth. Spot treatment with chemical herbicide will be undertaken where required	To be completed

7.1.1 Assessment of Land Suitability

Burial onsite requires the availability of suitable lands for the construction of a burial cell.

A. When undertaking a suitability assessment for the establishment of a burial cell on site, the following should be considered:
   - A 10m setback from a site boundary
   - An appropriate setback from a watercourse, wetland or other sensitive receptor
   - An appropriate setback from a designated conservation area
   - Depth to water table
   - Depth to bedrock
   - Depth to/or absence of services
   - An appropriate setback from existing and proposed infrastructure
   - Preference for green open space or car park area (*i.e.* little or no infrastructure constructed above or in the vicinity of the cell)

B. Depth of the burial cell (depends on volumes and extent of lands available). There are two options available:
   i. **2m buried depth** if fully lined/encapsulated with a rhizome barrier. All seams should be overlapped and sealed with lap tape before backfilling to 2m deep with suitable material such as inert fill or topsoil
   ii**.** **>5m buried depth** if unlined. A horizontal layer of rhizome barrier should be placed over the vector material. All seams should be overlapped and sealed with lap tape before backfilling to 5m deep with inert fill or topsoil

C. Nature, type, location and extent of infrastructure, land-use and future works proposed on the site relative to the proposed location for a burial cell

7.1.2 Typical Sequence of Works

The typical sequence of works for burial onsite is as follows:

1. Complete a specialist walkover survey
2. Pre-treatment of the Japanese knotweed with a non-persistent chemical herbicide to achieve tissue viability reduction prior to recovery
3. Complete targeted site investigation to determine an estimate of volumes of vector material for disposal
4. Excavate and prepare the burial cell and line with rhizome barrier
5. Recover *i.e.,* excavate the vector material from within the 7m buffer (depending on results of site investigation) and place within the burial cell or a temporary holding facility until such time as the burial cell is ready to receive the vector material, under strict biosecurity protocols
6. Seal the rhizome barrier within the burial cell once all vector material has been added
7. Backfill the excavation to a depth of 2m
8. Take GPS coordinates of the burial cell location
9. Undertake monitoring

A rhizome barrier is required to facilitate the encapsulation of knotweed in a lined onsite burial cell 2m deep (or as a horizontal layer over vector material buried to a depth of 5m).

Hy-tex C3 root barrier is an example of a triple coated linear barrier, which is UV stabilised and highly resistant to natural acids, alkalis, bacteria, and fungi. The barrier is predicted to be durable for over 50 years in natural soils with a pH of between 4 and 9 and soil temperature lower than 25°C. All joints should be overlapped and sealed with HDPE backed bitumen Root Barrier Lap tape which is supplied in 300mm x 20m reels (https://www.hy-tex.co.uk/docs/geotextiles/Root_Barrier_C3/r_rbc3_03.pdf). Hy-tex C3 membrane can be supplied in rolls up to 4.00m x 100.00m long, as a special order, to reduce laps and the membrane can be site welded to form larger sheets with improved joint integrity.

7.1.3 Geotechnical Site Investigation

Geotechnical site investigation of the proposed location for the burial cell and details of existing services, which may be present within the proposed burial site, is required to confirm suitability/extent of available lands.

Geotechnical site investigation should include the opening up of a trial pit in the selected burial location in advance of the commencement of recovery works to determine suitability of the lands in terms of depth to bedrock, water table and presence/absence of services *etc*.

7.1.4 Targeted Specialist Site Investigation

Specialist Japanese Knotweed site investigation works are required to determine the volumes of vector material for burial on site.

While the standard conservative radial buffer zone proposed for the potential lateral growth of rhizomes is 7m with a below ground vertical buffer zone of 4m deep (NRA, 2010), based on the experience of the authors and recent published scientific literature, rhizomes do not typically extent beyond 3m laterally and 2.5m deep (see Section 8.2). In this regard, it is recommended that targeted site investigation is undertaken to determine the actual extent of rhizomes and to determine more accurate volumes of vector material which may require recovery and burial onsite. Typically, site investigation will reduce the volume of vector material for burial onsite or transportation offsite in comparison with the standard conservative 7m radial buffer zone proposed by NRA (2010).

It is recommended that site investigation works are undertaken by an IAPS Specialist Contractor to determine the actual extent of rhizomes and vector material. The works should be carried out under strict biosecurity & site hygiene protocols and should be supervised by the IAPS Specialist Ecologist.

Care should be taken to minimise the disturbance and fragmentation of rhizomes during this process, where possible.

Once the volumes for recovery are known, this information can be utilised to inform the size of the burial cell. Where the volumes identified from the site investigation process can be accommodated via burial onsite, the Japanese knotweed should be pre-treated prior to recovery to reduce the viability of the rhizomatous material to be excavated and buried.

7.1.5 Pre-treatment

Prior to recovery, it is first necessary to pre-treat the Japanese knotweed *in situ* with an appropriate chemical herbicide to reduce the viability of any above ground or below ground material, and to minimise dispersal of viable material during recovery process.

Based on the extensive experience of the specialist project team in the successful eradication of IAPS from sites, it is deemed **extremely effective**, beneficial, and advisable to pre-treat invasive rhizomatous material, with a suitable non-persistent chemical herbicide, to minimise the risk of accidentally dispersing highly viable rhizomes during the recovery of vector material, and indeed, the transportation of highly viable vector material on the public road network and for deep burial at the receiving facility. Pre-treatment will reduce the risk of regrowth within the lands of the overall landscape masterplan and at the receiving waste facility.

Pre-treatment is therefore a pre-requisite when dealing with problematic invasive species which can regrow from fragments of rhizomes or stems.

Ideally pre-treatment should take place during the optimum treatment period where feasible (see Tables 7.1 and 7.2) subject to the plant's growth stage and local day and night temperatures. Pre-treatment can involve the foliar application of chemical herbicide only and stem harvesting followed by stem fillings where time constraints allow (see Table 7.2)

In this regard, the timing of the recovery works needs to strike a balance between deploying herbicide during the optimum treatment period for Japanese knotweed, allowing a sufficient period of time for the maximum effective dose of herbicide to accomplish a reduction in tissue viability, and the need to meet with contractual commitments *i.e.* the construction programme.

As discussed in Section 6.0 the Japanese knotweed plants within the overall masterplan boundary were treated with chemical herbicide by O' Donovan Agri-Environmental Services in October 2021.

It is important that a non-persistent herbicide is utilised in the pre-treatment of Japanese knotweed, which is proposed for burial onsite, in order to avoid classification of the soil containing the vector material as hazardous; which would deem the vector material unsuitable for burial onsite and result in the material needing to be disposed of offsite at a licenced receiving facility.

7.1.6 Recovery Process

The excavation of the IAPS vector material should be supervised by an IAPS Specialist Ecologist to ensure (1) compliance with biosecurity & site hygiene protocols, and (2) that all visible rhizomatous material is recovered.

Utilising the presence of surface vegetation and findings of the site investigation process, in relation to the extent of rhizomes as a guide, care should be taken to recover all rhizomatous material within the footprint of the stands to minimise the risk of regrowth.

The excavator should dig and extract the vector material and set it into the pre-lined burial cell, if burying 2m deep, or into an unlined cell if 5m deep, or load in onto a dumper for transportation to a temporary holding facility within the site, for burial at a later date; until such time as the cell is ready (see Section 7.1.6).

During the recovery process, the excavator should be operated so as to facilitate the monitoring of the excavation by the IAPS Specialist Ecologist, by gently pulling back the soil layers to expose the rhizomes such that they can be tracked until the growing tip (white where new growth is present) is located.

Depending on the depth of rhizomes uncovered, the Topsoil and Subsoil *i.e.* Horizon A and B soil layers may need to be removed until the Horizon C layer, consisting of loose weathered parent bedrock, is exposed. The loose parent bedrock material within the Horizon C layer should be carefully scraped with the bucket of the machine to track and remove any rhizomes which have penetrated crevices, crack, or fissures in the bedrock. Where required a rock breaker should be utilised to open up any friable bedrock layers to remove rhizomes which may have penetrated crevices, crack or fissures in the bedrock. The use of hand tools such as hammers and chisels, in localised areas, should also be considered. All contaminated rock material should be recovered.

There may also be a requirement for waste separation, for example, where Japanese knotweed is growing through construction and demolition waste or large pieces of woody debris. Such works should be supervised by the IAPS Specialist Ecologist, in order to identify waste which can be declared free of vector material, and which can enter normal waste disposal streams.

7.1.7 Temporary Holding Facilities

Temporary storage and doubling handling of the vector material should be avoided where possible. However, where required excavated materials can be stockpiled within an existing area already contaminated with vector material or on 1200-gauge polythene (or similar heavy-duty plastic) via side casting with the excavator and covered, where required, until such time as it is ready to be transported off site (or to a burial cell).

7.1.8 Monitoring Programme

The location of the burial cell should be surveyed, to record accurate GPS Coordinates, to inform any future maintenance or construction works at the location of, or in the vicinity of the burial cell.

Monitoring involves an assessment of the presence/absence of above ground regrowth or new growth of IAPS at both the donor site (former location of the Japanese knotweed stands) and at the recipient site (location of the burial cell) based on a detailed walkover, to be undertaken at the beginning, in the middle of and on completion of the growing season by an IAPS Specialist Ecologist for a minimum of 2 yrs post-completion of burial onsite. Spot treatment of growth from any remaining Japanese knotweed vector material is be undertaken as required.

7.2 Option 3 - Recovery & Disposal Offsite

All other options need to be thoroughly explored prior to arriving at the decision to select offsite disposal as a solution for Japanese knotweed control/eradication.

Offsite disposal is typically the last resort when dealing with Japanese knotweed, because of the risk of dispersal associated with recovering and transporting knotweed, and the possible prohibitive costs.

The positives of disposal offsite relate to the fact that there will be no permanent burial cell beneath the site, which could pose a risk of regrowth (whether perceived or actual), and which could impinge on future land uses and possibly even property values.

Offsite disposal options include deep burial at EPA licensed landfill facilities in Ireland, or any other sites where approval/licenses can be acquired from the EPA and NPWS. As there is a limited number of waste facilities in Ireland which can accommodate Japanese knotweed, export to mainland Europe for thermal treatment is also a viable disposal route.

Prior to recovery, it is first necessary to pre-treat the Japanese knotweed *in situ* with an appropriate chemical herbicide to reduce the viability of any above ground or below ground material and to the minimise dispersal of viable material during recovery and transportation. Pre-treatment will also reduce the risk of regrowth at the site and at the receiving waste facility (if going for deep burial). Once completed the vector material can be recovered and transported off site in order to permit construction works to proceed.

A license is required from NPWS in order to facilitate the offsite disposal of Japanese knotweed vector material at a receiving facility. The following information is required by NPWS to process a license application:

- Letter of acceptance from the receiving facility
- Waste Collection Permit Number from the National Waste Collection Permit Office (NWCPO) for the haulage company
- Japanese Knotweed Management Plan
- Method Statement and Risk Assessment

The site-specific tasks which need to be completed in respect of this management programme are outlined in Table 7.4.

Table 7.4 Site-Specific Tasks

Tasks	Description	Status
Task 1	IAPS Specialist Ecologist to undertake a specialist walkover survey at the site of the proposed residential development at No. Centre Park Road	Completed on the 14th December 2021
Task 2	IAPS Specialist Ecologist to supervise specialist site investigation works to inform volumes for disposal	To be completed

Tasks	Description	Status
Task 3	IAPS Specialist Ecologist to prepare an Invasive Species Management Plan	Completed (subject of this document)
Task 4	IAPS Specialist Ecologist to prepare a Risk Assessment & Method Statement for the recovery of vector material	To be completed
Task 5	Comer Group (Ireland) Ltd. to implement Biosecurity Protocols and Control Measures in conjunction with the IAPS Specialist Ecologist to avoid further spread: ▪ Set up of Exclusion Zones ▪ Avoid disturbance regimes highlighted in Table 5.1	Completed
Task 6	Soil testing to be undertaken to ensure that the vector material is acceptable to the receiving facility *i.e.,* [2]Waste Acceptance Criteria (WAC) Analysis	To be completed
Task 7	Identify a suitable receiving facility *e.g.,* a licensed EPA landfill facility or other waste receiving facility for thermal treatment	To be completed
Task 8	Comer Group (Ireland) Ltd. to apply for a Letter of Acceptance from the receiving facility	To be completed
Task 9	Acquire details of the waste permit number from the haulage company who will be transporting the vector material to the receiving facility	To be completed
Task 10	Comer Group (Ireland) Ltd. to provide a letter confirming responsibility for and duration of the monitoring programme	To be completed
Task 11	IAPS Specialist Ecologist to apply to NPWS for a licence for the transportation of vector material offsite	To be completed
Task 12	IAPS Specialist Ecologist to supervise the recovery works and loading of trucks	To be completed
Task 13	O' Donovan Agri-Environmental Services to undertake a 2-yr Monitoring Programme for Japanese knotweed regrowth. Spot treatment with chemical herbicide will be undertaken where required	To be completed

[2] WAC stands for Waste Acceptance Criteria and is used to determine whether the soil will be accepted at a particular type of landfill. WAC testing is used to determine how a waste will behave once it's buried in a landfill. This is carried out primarily through analysis of leachate derived from that waste during laboratory analysis.

7.2.1 Typical Sequence of Works

The typical sequence of works for the recovery of vector material and offsite disposal is as follows:

1. Complete a specialist walkover survey
2. Pre-treatment of the Japanese knotweed with a non-persistent chemical herbicide to achieve tissue viability reduction prior to recovery
3. Complete targeted site investigation to determine an estimate of volumes of vector material for disposal
4. Recover *i.e.,* excavate the vector material from within the 7m buffer (depending on results of site investigation)
5. Load the vector material directly onto waiting trucks, or place the recovered vector material in a temporary holding facility in preparation for removal off site, under strict biosecurity protocols
6. Remove vector material offsite in a sealed truck with a tipper body and a roll over cover under licence from NPWS to the approved receiving facility
7. Install a rhizome barrier to protect infrastructure, where deemed necessary

7.2.2 Pre-treatment

Based on the extensive experience of the specialist project team in the successful eradication of IAPS from sites, it is deemed **extremely effective**, beneficial, and advisable to pre-treat invasive species, with a suitable non-persistent chemical herbicide, to minimise the risk of accidentally dispersing highly viable rhizomatous material during the recovery process, and indeed, the transportation of highly viable vector material on the public road network for deep burial at the receiving facility. Pre-treatment will reduce the risk of regrowth within the lands of the overall landscape masterplan and at the receiving waste facility.

It is important that a non-persistent herbicide is utilised in the pre-treatment of Japanese knotweed, which is to be transported offsite for disposal at a licensed waste facility, in order to avoid the potential classification of the vector material as a hazardous material. This could have an implication, in that the cost per tonne for disposal offsite is likely to be higher.

See Section 7.1.5 for further details on pre-treatment.

7.2.3 Recovery Process

The excavator should dig and extract the vector material and load it directly onto waiting trucks, or a dumper for transportation to a temporary holding facility within the site, for loading at a later date (see Sections 7.1.6-7.1.7 for details).

7.2.4 Temporary Holding Facility

See Section 7.1.7.

7.2.5 Monitoring Programme

Monitoring involves as assessment of the presence/absence of above ground regrowth or new growth of IAPS based on a detailed walkover, to be undertaken at the beginning, in the middle of and on completion of the growing season for a set period time post-completion of recovery and transportation of the vector material offsite. Spot treatment of growth from any remaining Japanese knotweed vector material is be undertaken as required.

8.0 SITE-SPECIFIC CONTROL MEASURES

In light of the risk of dispersal, it is recommended that the recovery & disposal offsite of Japanese knotweed is deployed in order to eradicate the Japanese knotweed in a timely manner.

The selected management programmes will need to be deployed as soon as practically possible in light of the potential for further dispersal of Japanese knotweed vector material, within overall masterplan boundary, which could impact on the success of the selected management programme.

Where a 'do nothing' approached is taken, further dispersal of Japanese knotweed may occur within the lands of the overall masterplan boundary. Without any intervention there is a risk that Japanese knotweed may in the long-term have the potential to:

- Encroach on downstream native habitats with connectivity to Site A and Site B via the drainage ditches and the stormwater network *e.g.* River Lee, Cork Harbour SPA, Douglas River Estuary pNHA, Dunkettle shore pNHA and non-designated SWDTEs and GWDTEs
- Encroach on adjacent land-uses, public footpaths, dwellings, and infrastructure
- Encroach on new structures, footpaths, services, internal access roads and green open spaces within the site of the proposed residential development
- Diminish the ability to use and enjoy the green open spaces within the site of the proposed residential development due to impediments to access
- Encroach on sight lines and signage along the internal access paths
- Result in long-term maintenance requirements

The risk of dispersing Japanese knotweed within the lands of the overall masterplan boundary will arise where vector material becomes adhered to (1) the footwear of surveyors, site personnel/staff, and visitors to the site, (2) on the tyres of construction related and domestic vehicles in the car park; and (3) on tyres and tracks of plant machinery and on geotechnical site investigation/vegetation removal/demolition/construction/landscaping equipment.

There is also a low risk that surveyors, site personnel/staff and visitors to the site could transport viable vector material offsite on footwear and tyres of domestic vehicles. Vector material could also be transferred to other sites within in soil loads, on plant machinery and on construction/landscaping equipment. In addition, if viable Japanese knotweed stem or rhizome fragments were to gain entry to the drainage ditches and the stormwater network via the gullies within and adjacent to Site A and Site B, this could result in the spread of Japanese knotweed to the River Lee and Cork Harbour (see Section 5.2, 5.3.4 and 5.4 for further details).

Site-specific control measures are required to address the dispersal of Japanese knotweed vector material. These control measures are detailed below in Sections 8.1–8.5.

8.1 Preparation of a Site-Specific RAMS

A site-specific Risk Assessment and Method Statement (RAMS) should be prepared by the IAPS Specialist Ecologist prior to the deployment of the management programmes and should include details of the following site related background information, site related activities and control measures required to avoid or reduce the risks associated with the implementation of the management programmes including the dispersal of Japanese knotweed.

The RAMS should be distributed to all site personnel in advance of the commencement of works to control or eradicate IAPS. The RAMS should contain the following information at a minimum:

- Site description for the proposed residential development
- Details of locations of IAPS infested areas
- Step by step details for the implementation of the management programmes
- Details of site hygiene and biosecurity protocols
- Details of site-specific hazards/constraints
- Details of hazard/environmental control measures (identified in the risk assessment)
- Details of ecological control measures (identified in the risk assessment)
- Details of site specific and seasonal constraints
- Specific details of duration and timing of site supervision
- Details and timing of monitoring requirements

The preparation of the site-specific Risk Assessment and Method Statement is a concurrent process.

The site-specific Risk Assessment will identify low, medium, and high-risk factors associated with the hazards and constraints identified during the preparation of the management plan and the Method Statement for the recovery of the Japanese knotweed vector material.

Where appropriate, the control measures will need to be deployed by the Contractor under the supervision of the IAPS Specialist Ecologist, during the recovery of the vector material within Site A and Site B; and by any other subcontractors which need access to the site of the proposed residential development to undertake works.

Specific control measures will be required in the Risk Assessment and Method Statement to address or minimise risk to the following:

- Dispersal of Vector Material (see Section 8.2)
- Accidental spillage, Spraying or Spray Drift of Chemical Herbicide (see Section 8.3)
- SUD Restrictions & Receptors (see Section 8.3)
- Environmental, Occupational Health & Safety Receptors (see Section 8.3)
- Ecological Receptors & Non-target Areas (see Section 8.4)
- Monitoring Programme (see Section 8.5)

8.2 Control Measures to Reduce Dispersal

It is recommended that the following biosecurity, site supervision and & site hygiene control measures are supervised by, or deployed by the IAPS Specialist Ecologist, within Site A and Site B in order to avoid dispersal/introduction of Japanese knotweed during the recovery and disposal offsite of the vector material:

- Provision of toolbox talks to ground operatives by the IAPS Specialist Ecologist.
- Installation of an Exclusion Zone in the form of temporary fencing around the infestation(s)

- Supervision of the installation of a dedicated biosecurity wash facility for footwear and tools within the site to treat equipment and personal footwear on entry and exiting the infested areas.
- Checks on biosecurity protocols *e.g.* use of appropriate biosecurity signage and temporary fencing, minimising site access and footfall, use of the footwear wash facility by ground operatives and adherence to dedicated entry and exit points.
- Checks for the provision of temporary fencing to minimise site access and foot fall by pedestrians where required.
- Checks for the creation of a delineated access track (to be maintained free of IAPS through the site) to minimise the spread of IAPS by permitted plant machinery and equipment accessing the site.
- Checks on the control and minimisation of movement of all plant and equipment, site personnel and visitors in and out of the site during the excavation of vector material.
- Supervision of the treatment of vehicles wheels/tyres, undercarriage of machines and chassis of trucks and tractors, tracks, back actors, buckets, hand tools (shovels, trowels) to eradicate/reduce the viability of any vector material present.
- Checks on footwear and equipment for any vector material. Any fragments should be treated with suitable chemical herbicide and disposed of within the temporary holding facility.
- Plant machinery, site vehicles and equipment may only be removed from the site after being checked and cleared to do so by the IAPS Specialist Ecologist.
- Checks for IAPS on imported soil and stone required for construction works at source and at arrival on site.

In accordance with legal obligations and/or best practice, the various risk assessments, and method statements to be prepared by other Contractors who may require access to the site will also need to include biosecurity and site hygiene control measures to avoid the disturbance and further dispersal of Japanese knotweed within the site of the proposed residential development. This is to ensure that viable plant material is not accidentally or otherwise dispersed by surveyors, site personnel/staff or visitors to the site either on their footwear, equipment, or tyres/tracks of vehicles. These control measures, required to avoid or limit dispersal, are necessary to ensure compliance with the European Union (Birds and Natural Habitats) Regulations 2011 to 2015.

Setting up of Exclusion Zones

The standard 7m rule or buffer zone described in Irish and UK government guideline documents, suggests that mature Japanese knotweed rhizomes may extend seven metres laterally from a parent plant (*e.g.* NRA, 2010; Environment Agency, 2013) and 4m deep (NRA, 2010). However, based on the authors experience of recovering Japanese knotweed vector material from a broad range of sites across Ireland, rhizomes of Japanese knotweed have rarely been found to extend beyond 3m laterally and 2.5m deep.

Fennell *et al*. (2018) demonstrated that even large stands of Japanese knotweed do not usually produce rhizomes that extend further than 4m. The study found that Japanese knotweed rhizomes rarely extend more than 4m from above ground plants and are typically found within 2m for small stands and 2.5m for large stands. Similarly, the mean vertical extent recorded averaged between 1.02m for the small stands and 1.64m for the large stands, (with a maximum of 3.2m recorded). The study concluded that the 7m rule is not a statistically robust tool for estimating likely rhizome extension (Fennel *et al*., 2018).

In this regard, the IAPS Specialist Ecologist shall provide site specific advice onsite pertaining to the required Exclusion Zone for the Japanese knotweed at JKW01-08 within Site A and Site B, based on the maturity and other characteristics of the infestation.

Recovery Works & Use of Plant Machinery

Prior to the commencement of the recovery works, a CAT scanner should be deployed to check for existing services.

A small toothless digging (or grading) bucket on a rubber tracked excavator are generally recommended for use. A grading bucket will permit a clean cut through the soil layers such that the rhizomes can be more easily tracked. Typically, a rubber tracked excavator is selected for such works to minimise the extent of soils which may be caught between the tracks and the fragmentation of rhizomes on or just below the surface. The rubber tracks should be kept out of the known locations of vector material, where possible.

These works should be carried out under strict biosecurity & site hygiene protocols and supervised by the IAPS Specialist Ecologist.

The excavator should be operated in such a manner so as to prevent further dispersal and contamination of the site during works, as follows:

- Avoid spillage of vector material from the bucket
- Laying down and changing bucket – ensure that it remains within the contaminated area and is not temporarily stored outside of the contaminated area
- Ensure that the tracks of the machine remain outside the contaminated area where possible. Where tracks have to enter the contaminated area, the driver should ensure that they do not contaminate additional lands by straying outside of the contaminated area. The contaminated area should be covered with heavy duty plastic and plywood to prevent the disturbance of rhizomes at or near the surface (the plastic and plywood should be appropriately cleaned or disposed of)
- The method of work of work should ensure that the machine does not have to track over an area which has already been stripped of vector material resulting in the recontamination of an area
- The machine driver should not step off the machine in the contaminated area, and contaminate additional lands by straying (on foot) outside of the contaminated area or into the area which has already been stripped of vector material resulting in the recontamination of the excavation

- The machine should not be brought outside of the contaminated area until biosecurity protocols have been deployed to decontaminate machine

Temporary Storage

The doubling handling and temporary storage of vector material should be avoided where possible. However, where required excavated vector material can be stockpiled within a temporary holding facility under strict biosecurity protocols and under the supervision of an IAPS Specialist Ecologist until such time as it is ready to be removed off site.

The location of the temporary holding facility should be agreed in advance as it needs to be positioned to allow for the use of a decontamination area and for the loading of the vector material via side casting onto the trucks. The holding facility should ideally be located on an existing contaminated area, or on a hard surface lined with 1200-gauge polythene or similar heavy-duty plastic/material or stored in one-tonne bags (lined with heavy duty plastic). The material should be stockpiled to facilitate efficient loading of the trucks.

Where considered appropriate the material within the temporary holding facility should be covered, until such time as it is to be transported offsite to the approved receiving facility, in a sealed truck with a tipper body and a roll over cover, under license from NPWS.

8.3 Control Measures for Chemical Herbicide Use

Areas of General Public Use & Defined Vulnerable Groups

There is potential for interaction with the following groups during the deployment of chemical herbicides under the management programme:

- Members of the general public utilising the adjacent footpath on Centre Park Road, the carparking and walkway along the River Lee, and Shandon Boat Club
- Members of vulnerable groups including children, elderly and pregnant mothers utilising the adjacent footpath on Centre Park Road, the car parking and riverside walkway along the River Lee
- Members of the general public working within adjacent civil infrastructure, industrial units and Shandon Boat Club

Environmental, Occupational Health & Safety Receptors

There is also potential for interactions with the following receptors:

- RPUs deploying the chemical herbicide to Japanese knotweed
- Site personnel/staff completing site investigation, vegetation removal, demolition and construction works
- Surveyors gathering data for ecological assessments, engineering purposes *etc*
- Caretakers for the site

A number of control measures should be deployed to ensure that these groups and receptors do not come into contact with chemical herbicide including:

- Erection of an Exclusion Zone *i.e.* temporary fencing around the treatment area
- Warning signage in advance of spraying operations
- Consultation in advance of spraying operations

- Timing of treatment to avoid peak pedestrian traffic times on Cotters Street
- Minimisation of spray drift and accidental spraying of adjacent areas
- Cessation of treatment where members of the public, children or domestic pets gain access to the treatment area
- Adherence to the SUD Directive and Plant Protection Products Regulations
- Adherence to Regulation 12 of SUD Directive in terms of the requirement to complete specific site records as part of pre- and post-treatment reporting
- Adherence to the Product Label and MSDS sheet
- Use of appropriate PPE
- Avoidance of spillage of chemical herbicide (see Section 8.4)
- Consultation with a Registered Pesticide Advisor and/or the Pesticides Control Service where there is any doubt in relation to the safe use of herbicides
- Site supervision by the IAPS Specialist Ecologist

Natura 2000 Sites

There is 1 No. Natura 2000 site at risk from the accidental spillage or release of chemical herbicide (during pouring/mixing/spraying) as follows:

- Cork Harbour SPA (Site Code: 004030)

A hydrological pathway has been identified between the site and this Natura 2000 sites *i.e.* chemical herbicide or hydrocarbons may gain entry to the drainage ditches or the stormwater network via storm water gullies within Site A and Site B (and in the adjacent streets) which discharge to the River Lee and Cork Harbour; located 2.4km to the east. There is limited hydrogeological connectivity (see Section 5.3.4).

Specific control measures will be required in the Risk Assessment and Method Statement to reduce the risks of accidental spillage or release of chemical herbicide. It is anticipated that the risk of spillage and entry to surface water pathways and the stormwater network will significantly be reduced by the implementation of the control measures.

Given the control measures which are to be deployed, distance from the site and dilution effects, significant impacts on this Natura 2000 site is considered unlikely.

8.4 Ecological Control Measures & Non-target Areas

The Risk Assessment will also identify control measures to minimise impacts on ecological receptors and non-target areas within the zone of influence of the proposed residential development.

Ecological receptors and non-target areas within or adjacent to the site, which could be impacted by spray drift or accidental spraying include:

Ecological Receptors

- Natura 2000 sites (see Section 8.3)
- Douglas River Estuary pNHA and Dunkettle Shore pNHA
- Woody scrub/shrub vegetation supporting pollinators, birds, and small mammals
- Pollinators, birds, and small mammals

Non-target Areas

- Adjacent terraced houses/apartment blocks
- Adjacent offices
- Adjacent commercial units

The following control measures should be included in the Risk Assessment and Method Statement to protect ecological receptors and non-target areas from chemical herbicides:

Herbicides

- Undertake regular checks on spraying equipment for defects
- Use bunded equipment and twin-lined or double hoses
- Provide trays for mixing of herbicide
- Ensure chemical herbicide spill kits are available at all times
- Provide a source of water for mixing of herbicide (other than a local water body)
- Avoid the creation of spray drift
- Avoid spraying during poor weather conditions *i.e.* in the rain and wind and when rain is forecasted in accordance with the Product Label
- Disturb vegetation to ensure that pollinators, birds, and small mammals take evasive action and move out of vegetation which is to be sprayed with chemical herbicide
- Comply with Circular Letter NPWS 2/08

Hydrocarbons

- Adhere to defined setback distance from drainage ditches storm water gullies for refuelling, use of lubricants and vehicle maintenance
- Ensure hydrocarbon spill kits are available at all times
- Undertake regular maintenance and checks on plant machinery and equipment

While some literature recommends the use of herbicides in the evening, to avoid impacts to pollinators, the use of herbicides may be impacted by high moisture levels associated with heavy dew fall and the closure of stomata which could reduce the efficacy of the herbicide treatment. In this regard, the IAPS Specialist Ecologist will disturb Japanese Knotweed and adjacent vegetation prior to commencement of spraying to ensure that pollinators, birds, and any small mammals have moved out of the zone of influence.

In order to ensure that the use of chemical herbicides does not contravene environmental legislation, the IAPS Specialist Contractor must comply with Circular Letter NPWS 2/08 which deals with the application of chemical herbicides to non-target areas as well as the SUD Regulations.

8.5 Monitoring Programme

Monitoring involves as assessment of the presence/absence of regrowth or new growth of Japanese knotweed based on a detailed walkover, to be undertaken at the beginning, in the middle of and on completion of the growing season for a set period time post-completion of the recovery works. Spot treatment of growth from any remaining Japanese knotweed vector material is undertaken as required.

A minimum 3-year monitoring programme is recommended for the lands within the overall masterplan boundary which will commence from the date of the recovery works and will continue to the end of the growing season in Year 3 (at least).

The importance of a monitoring programme cannot be underestimated in the context of the lands within the overall masterplan boundary, given recent disturbance activities. In an undisturbed site, if vector material is recovered from all known locations of above ground plant material, this would minimise the risk of future growth. However, given that the survey was undertaken outside of the optimum survey period and the identification of recent disturbance regimes, there is a risk that plants are located elsewhere within Site A and Site B which have yet to be identified.

There is an ongoing risk of the reintroduction of vector material to the lands within the overall masterplan boundary via the same sources and pathways which resulted in the introduction of viable plant fragments on previous occasions including fly-tipping of waste.

It is of paramount importance, that control measures are deployed to ensure that all contractors involved in the proposed residential development are made aware of best practice guidance to minimise the risk of importing vector material, onto the site as a result of geotechnical site investigation, vegetation removal, demolition, construction and in particular, via landscaping works (see Section 5.3.1 for details).

9.0 CONCLUSION

It is recommended that the Japanese knotweed vector material at JKW01-08 is pre-treated with chemical herbicide prior to the recovery and disposal of the vector material offsite or burial onsite.

Pre-treatment of the knotweed should ideally be completed during the optimum treatment period in late summer/autumn 2022, subject to the plant's growth stage and local day and night temperatures. In this regard, JKW01-JKW08 were treated with chemical herbicide by O' Donovan Agri-Environmental Services in October 2021 and will undergo stem filling in the coming weeks.

Given that a residential development is proposed within the 4.7ha subsite of Site A, it would be prudent to commence with the recovery & offsite disposal or burial onsite works as soon as practically feasible to allow sufficient time to complete the recovery process and to facilitate a monitoring where practically feasible.

Other Invasive Species

It is recommended that any growth of Buddleia, Traveller's joy, 2 no. *Cotoneaster* spp., Montbretia, Winter heliotrope and Pampas grass within Site A and Site B are treated, where required, with chemical herbicide during the optimum treatment period to avoid any future encroachment by these IAPS and to minimise long-term landscape maintenance requirements.

In relation to the existing seed bank the rapid growth of new outliers of Buddleia within the site is likely during the main construction stage, due to the fecundity of this species. These plants should be dealt with, as they emerge, as part of the chemical herbicide treatment to be deployed in preparation for the hard and soft landscaping works to be undertaken within the site.

The remaining invasive species identified within the overall masterplan boundary will also regrow from the existing seed bank, but at a slower rate than the aforementioned. These species should be dealt with as they emerge as part of the chemical herbicide treatment to be deployed in preparation for the hard and soft landscaping works which are to be undertaken within the site (see Appendix II for details).

10.0 REFERENCES

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Appendix I

DEFINITION, CLASSIFICATION, LEGISLATION & BEST PRACTICE

Definition of Invasive Alien Plant Species

Alien (or non-native) plants are defined as those plants which have been introduced into Ireland by humans and their activities, either purposefully or accidentally.

Alien (or non-native) **invasive** species are so-called as they typically display one or more of the following characteristics or features: (1) prolific reproduction through seed dispersal and/or re-growth from plant fragments; (2) rapid growth patterns; and (3) resistance to standard weed control methods.

Where a non-native species displays invasive qualities, and is not managed appropriately, it can potentially: (1) outcompete native vegetation, affecting plant community structure and habitat for wildlife; (2) cause damage to infrastructure including road carriageways, footpaths, walls and foundations; (3) result in soil erosion; (4) have an adverse effect on landscape quality through a loss of naturalness, aesthetics and regional identity; and, (5) impact on road safety (Dolan, 2004).

The introduction of *Rhododendron ponticum,* to Glengarriff Nature Reserve and Killarney National Park was perhaps the most widely cited example of an invasion by a non-native invasive species which has had a significant effect on the Irish landscape and elements within it. However, Japanese knotweed has recently become the focus of much media attention given the rate at which it has spread and its potential for infrastructural impacts.

Classification of Invasive Alien Plant Species

A number of Irish agencies are monitoring and classifying invasive alien species in an effort to focus research programs, further monitoring, risk assessments, management and action plans and to meet with statutory obligations associated with the introduction of recent and future legislation.

Invasive Species Ireland

Invasive Species Ireland (www.invasivespeciesireland.com) a joint initiative by the Northern Ireland Environment Agency and NPWS, previously classified invasive species under the following headings based on a risk assessment:

- Most Unwanted: Established Threat
- High Risk: Recorded Species
- Amber List: Recorded Species (which under the right conditions could represent a significant impact on native species or habitats)
- Amber List: Uncertain Risk (their ecological impact remains uncertain due to lack of data showing impact or lack of impact)

The classification was based on the publication Kelly *et al*. (2013) Risk Analysis and prioritisation for invasive and non-native invasive species in Ireland and Northern Ireland (http://invasivespeciesireland.com/wp-content/uploads/2013/03/Risk-analysis-andprioritization-29032012-FINAL.pdf). The Invasive Species Ireland website currently lists a number of species under 'Established' or 'Potential'.

National Biodiversity Data Centre

The National Biodiversity Data Centre (http://www.biodiversityireland.ie/projects/invasive-species/species-lists/) has prepared a catalogue of invasive alien plant species and has risk assessed and classified a number of species into the following headings

- High Impact (http://www.biodiversityireland.ie/wordpress/wp-content/uploads/ Invasives _taggedlist_HighImpact_2013RA-1.pdf)
- Medium Impact (http://www.biodiversityireland.ie/wordpress/wp-content/uploads/ Invasives_taggedMediumImpact_2013RA-2.pdf)
- Watch List Species (http://www.biodiversityireland.ie/wordpress/wp-content/uploads /Invasives_tagged_PotentialHighmpact_2013RA-1.pdf)

A detailed risk assessment for 41 of these species was undertaken in 2014 (http://non nativespecies.ie.) The detailed risk assessment is called NAPRA Ireland.

The classification is also based on the publication Kelly *et al*. (2013).

National Roads Authority/Transport Infrastructure Ireland (NRA/TII)

In 2008, the NRA first prepared Guidelines on the Management of Noxious Weeds and Non-native Species on National Roads (NRA, 2010 revised) and identified 9 No. invasive species which have been shown to have an adverse impact on landscape quality, native biodiversity

or infrastructure; and are likely to be encountered during road schemes as follows:

- Japanese knotweed
- Giant hogweed
- Himalayan balsam
- Giant rhubarb
- Montbretia
- Winter heliotrope
- Old man's beard
- Common or Pontic rhododendron
- Buddleia

Department of Agriculture, Food and the Marine (DAFM)

The Department of Agricultural, Food and Marine have named 7 No. Alien Invasive Plant Species *i.e.* Giant hogweed, Giant rhubarb, Himalayan balsam, Japanese knotweed, Montbretia, Old man's beard and Rhododendron on its Plant Health Trade webpage (https://www.agriculture.gov.ie/farmingsectors/planthealthtrade/alieninvasiveplantspecies/

CERIS

It is understood that the control of Winter Heliotrope is currently the subject of an EPA funded project led by CERIS, Institute of Technology, Sligo which is targeting the Prevention, Control and Eradication of Invasive Alien Species (IAS) on the Island of Ireland.

RELEVANT LEGISLATION

There is a range of legislation under which statutory obligations directly or indirectly apply to invasive species, and indeed, conventions which underpin the requirement to survey for and manage IAPS where they occur:

- EU Regulation 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species [2014] OJ L 317/35
- European Communities (Birds and Natural Habitats) Regulations, 2011 (S.I. No. 477 of 2011) to 2015, as amended
- Wildlife Acts, 1976 to 2012, as amended
- European Conventions

The main pieces of legislation are discussed in this section.

EU Regulation 1143/2014 on Invasive Alien Species

The EU Regulation 1143/2014 on Invasive Alien Species came into force on the 3rd August 2016. Some of the core provisions of EU Regulation 1143/2014 deal with, among other things, bringing into the territory of the Union, keeping, breeding, transporting and placing on the market, species included on the list of invasive alien species of Union Concern (the 'Union list'). This first "Union List" of 37 No. species consisting of 23 animals and 14 plants came into force, following the publication of the Commission Implementing Regulation (2016/1141), in the Official Journal of the Union on the 14th July 2016. The 'Union list' comprises species whose potential adverse impacts across the European Union are such that concerted action across Member States is required (https://www.npws.ie/sites/default/files/files/Union%20 list%20of%20IAS.pdf). Japanese knotweed is not included on the Union List.

On the 13th July 2017, Giant rhubarb along with a further 11 other species were added to the 'Union List' under EU Regulation 1143/2014 as per the Commission Implementing Regulation 2017/1263.

European Communities (Birds and Natural Habitats) Regulations 2011 to 2015

There are statutory obligations under S.I. 477 of 2011 of the European Communities (Birds and Natural Habitats) Regulations 2011 to 2015 to address invasive species in Ireland. There are a number of plant species including Japanese knotweed listed under the 3rd Schedule: Part 1 – Plants and Part 3: Vector Materials which are subject to restrictions under Regulations 49 & 50. Part 3: Vector Materials refers to soil or spoil taken from places infested with Japanese knotweed (*Fallopia japonica*), Giant knotweed (*Fallopia sachalinensis*) or their hybrid Bohemian knotweed (*Fallopia* x *bohemica*). Regulation 49 deals with the 'Prohibition on introduction and dispersal' while Regulation 50 deals with the 'Prohibition on dealing with and keeping certain species'. Regulation 50 has yet to be brought into Irish law (http://www.irishstatutebook.ie/eli/2011/si/477/made/en/print and http://www.Irishstatutebook.ie/eli/2015/si/355/made/en/print). A license application to NPWS is required under

Regulation 49(2) in order to transport soil or spoil *i.e.,* vector material containing Japanese knotweed, Giant knotweed and Bohemian knotweed off site.

Further to consultation with Gerry Lecky of the Wildlife Licensing Unit of NPWS, an invasive species management plan, a method statement, a letter of acceptance from the receiving waste facility and the Waste Collection Permit Number from the National Waste Collection Permit Office (NWCPO) for the haulage company is required as part of the license submission.

Where treatment of an IAPS which poses a threat to the Conservation Objectives of a Natura 2000 site (European Site), is required, a licence pursuant to 49(14) [an amendment to the 2011 Regulations under Regulation 12 of the European Communities (Birds and Natural Habitats) (Amendment) Regulations 2015] may be required. Where it is determined that an invasive species poses a threat to the conservation status of a habitat or species, and it is necessary to treat an invasive species during the overwintering period, a licence under Regulation 49(13) may be required.

The treatment of an invasive species within a Natura 2000 site may also require Ministerial Consent under Regulation 30.

The Wildlife Acts

The Wildlife Acts, 1976 to 2012, contain a number of provisions relating to invasive species covering several sections and subsections of the Acts. With regard to exotic species, it is prohibited without a licence to plant or otherwise cause to grow in a wild state, in any place in the State, any species of flora, or the flowers, roots, seeds or spores of flora.

In relation to the management of invasive species, the Wildlife Amendment Act 2000 (S.46.1) provides that it is an offence to cut, grub, burn or destroy any vegetation on uncultivated land or such growing in any hedge or ditch from the 1st March to the 31st August. Exemptions include the clearance of vegetation in the course of road or other construction works or in the development or preparation of sites on which any building or other structure is intended to be provided.

European Conventions

Ireland has also ratified a number of European conventions including

- Convention on Biological Diversity
- Bern Convention
- International Plant Protection Convention

The ratification of these conventions obliges the Irish government to address the issue of invasive alien plant species.

SUD Directive and PPP Regulations

The main method of managing IAPS is through the use of pesticides *i.e.* herbicides and the burial of recovered spoil. In addition to the statutory obligations discussed above the following are relevant to the management of invasive species using herbicides and burial of recovered spoil:

- Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides *i.e.* the 'Sustainable Use of Pesticides Directive' or 'SUD'
- European Communities (Sustainable Use of Pesticides) Regulations, 2012, (S.I. No. 155 of 2012)
- Regulation (EC) No. 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC- 'Plant Protection Products Regulation'
- European Communities (Plant Protection Products) Regulations, 2012 (S.I. No. 159 of 2012)
- Waste Management Acts, 1996 to 2013, and related legislation.

Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 more commonly referred to as "the Sustainable Use Directive" or "SUD", aims to establish a framework for Community action to achieve the sustainable use of pesticides. It was transposed into Irish law by Statutory Instrument No. 155 of 2012, European Communities (Sustainable Use of Pesticides) Regulations 2012. The European Communities Sustainable Use of Pesticides Regulations 2012 (S.I. 155 of 2012) places additional restrictions and, in some cases, prohibitions, on the use of pesticides in certain restricted and sensitive areas (referred to herein as SUD restrictions and restricted/sensitive areas). These SUD restrictions and restricted/sensitive areas include transport routes (such as railway lines); areas used by the general public or defined vulnerable groups (*e.g.* public parks, hospitals, public schools and public playgrounds); and Natura 2000 sites.

There are also safeguard zones or exclusion zones (see Table 1.1) where no plant protection products can be applied in order to protect surface water abstraction sources (*e.g.* areas for the abstraction of drinking water such as surface waters, springs, wells or boreholes) and groundwater vulnerable landscape features (*e.g.* karst areas, sinkholes, collapse features).

Table 1.1 Safeguard Zones for Open Wells, Boreholes and water abstraction points

Water Source	Distance
Abstraction point of any surface waters, borehole, spring or well used for the abstraction of water for human consumption in a water scheme supplying 100 m^3 or more of water per day or serving 500 or more persons	200 m
Abstraction point of any surface waters, borehole, spring or well used for the abstraction of water for human consumption in a water scheme supplying 10 m^3 or more of water per day or serving 50 – 500 persons	100 m
Abstraction point of any surface waters, borehole, spring or well used for the abstraction of water for human consumption in a water scheme supplying 1-10 m^3 of water per day or serving 10-50 persons	25 m
Abstraction point of any surface waters, borehole, spring or well used for the abstraction of water for human consumption in a water scheme supplying 1m^3 or less of water per day or serving 10 or less persons	5 m

It should be noted that the gathering of data on SUDS Restrictions and Restricted/Sensitive Areas is essential to the preparation of an IAPS management plan, as the presence of any such constraints will underpin the ability to deploy chemical herbicides, the selection of chemical herbicide, timing and application methods. In this regard, pesticides selected for use on any site should be fit for the purpose for which they are intended. Details of permitted pesticides authorised for use by the Irish competent authority, the Pesticide Registration and Controls Divisions and the Pesticide Control Laboratory of the Department of Agriculture Food and the Marine (DAFM) can be found at http://www.pcs.agriculture.gov.ie/.

Only a Registered Professional User (RPU) with the Department of Agriculture, Food and Marine can apply herbicides authorised for professional use from the 26th November 2015. A risk assessment and method statement for the management of IAPS should be prepared by an IAPS Specialist Ecologist in conjunction with an IAPS Specialist Contractor to take into account the various constraints/disturbance regimes/SUDS restrictions identified in an IAPS management plan and should propose and detail site specific control measures to avoid or minimise these risks including adherence to Regulation 12 of SUD Directive which identifies the requirement to complete specific site records as part of pre- and post-treatment reporting.

Waste Management

Specific obligations under the Waste Management Acts, 1996 to 2013, and related legislation pertaining to the waste categorisation of spoil and burial onsite or offsite are unclear in the absence of guidance from the Environmental Protection Agency (EPA) for Japanese knotweed contaminated soil.

The EPA has recently clarified that a Waste License is required under the Waste Management (Licensing) Regulations 2004 to bury soil contaminated with vector material within a site.

As discussed above a license application to NPWS is required under Regulation 49(2) European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. 477 of 2011) in order to transport soil or spoil *i.e.* vector material containing Japanese knotweed, Giant knotweed and Bohemian knotweed off site.

Appendix II

INVASIVE SPECIES

A. JAPANESE KNOTWEED

A.1 Species Description & Ecology

Native to Japan, northern China, Taiwan, and the Korea peninsula, Japanese Knotweed (*Fallopia japonica*) is an invasive perennial herbaceous plant which was introduced to Europe in the 1820's.

The first record for Japanese knotweed in Europe appears to be from an artificial wetland habitat in Chiswick, London from 1825. A second introduction to Europe is known from 1847, to a nursery in Leiden, The Netherlands. In 1850, Japanese knotweed plants arrived at the Royal Botanical Gardens at Kew, UK, and by 1854, the plant, had also arrived at the Royal Botanic Gardens in Edinburgh.

Japanese knotweed plants were subsequently sold by commercial nurseries around the UK and Europe as it became one of the most popular garden plants of the 19th Century. During this period the sharing of cuttings and the discarding of unwanted rhizomes was the primary pathway for dispersal. While it was originally planted for its foliage and "attractive" white flowers, in later years Japanese knotweed was also promoted as a potential source of animal fodder. Of note is that the plant could still be found widely available for sale in garden centres in the 1930s and even up until the 1980s in the UK (Bailey & Connolly, 2000; History of Japanese Knotweed in Europe — University of Leicester).

The first naturalised record of Japanese Knotweed in Ireland is dated 1905 from a garden in Dublin. Since its introduction to Ireland, it has spread across the island, particularly along watercourses, transport routes and in waste or disturbed ground. During the 'Celtic Tiger' years, in particular, rhizome fragments were dispersed as a result of soil movement associated with road building and other construction projects.

A.2 Invasive Qualities

In its native countries, it is found growing along riverbanks, roadside verges, managed pastures and in sunny places on hills and high mountains. Over thousands of years, it has evolved to become one of the first species to colonise lands within 20 years of volcanic activity and is replaced by other herbaceous species after 50 years or so. It typically reaches 0.3 - 1.5m tall and is attacked by a suite of 226 natural enemies, including insects and fungi, which keep it in check.

In Ireland (and other countries to which it has been introduced worldwide), the absence of natural enemies combined with its ability to colonise volcanic landscapes means that the plant can grow unchecked reaching heights of up to 3-4m, to form dense colonies, and like a number of tree species is capable of accessing existing weaknesses or joints in bitumen, concrete, stone masonry and hard standing areas; thus, causing impacts to hard landscaping or services (see Photographs A.1, A.2 and A.4).

Japanese knotweed has an underground network of stems known as rhizomes. In more mature Japanese Knotweed plants, a central rhizome 'crown', develops from which the main stems emerge above ground (see Table A.1 for details of the plants life cycle). The ability to penetrate existing weaknesses and joints comes from its underground rhizome network.

Underneath, the central crown, the radial rhizomes twist together to form a sizeable and considerable upward penetrating force. As the plant matures the crown expands thus opening up existing weaknesses such as cracks or joints which may cause damage to hard landscaping or services. However, while Japanese knotweed has the ability to cause damage, it rarely does so, as rhizomes will typically grow around any objects and structures which they encounter.

Photograph A.1 Japanese Knotweed breaking through a bituminous surface in Cork City (Source: John O' Donovan, O' Donovan Agri-Environmental Services)

The crown also acts as the plants' carbohydrate food store during the winter months when the leaves die back. While most of the plants' rhizomes are found in the top 0.25m of the soil, they can also go deep into the soil and extend up to several metres out from the plant, depending on ground conditions and disturbance regimes. Based on the authors experience of recovering Japanese knotweed vector material from a broad range of sites across Ireland, rhizomes of Japanese knotweed have rarely been found to extend beyond 3m laterally and 2.5m deep.

Fennell *et al*. (2018) demonstrated that even large stands of Japanese knotweed do not usually produce rhizomes that extend further than 4m. The study found that Japanese knotweed rhizomes rarely extend more than 4m from above ground plants and are typically found within 2m for small stands and 2.5m for large stands. Similarly, the mean vertical extent recorded averaged between 1.02m for the small stands and 1.64m for the large stands, (with a maximum of 3.2m recorded).

While Japanese Knotweed is generally not considered capable of producing viable seeds in Ireland (in simplistic terms only female cloned plants are present), the species displays an extraordinary ability to disperse and rapidly regenerate predominantly from rhizome (but also stem) fragments to colonise and invade disturbed land. Previous studies indicated that less than 0.7g of a rhizome can produce roots and shoots in 10 days, however, current research indicates that viable rhizome fragments are typically larger (see Table A.2).

Photograph A.2 Japanese Knotweed having gained internal access to a private dwelling in Co. Cork (Source: O' Donovan Agri-Environmental Services)

Under favourable conditions it can grow up to 10cm a day and can rapidly invade disturbed ground in the absence of native vegetation. No correlation between soil type, plant size or vigour has been identified, suggesting that it can grow on any substrate.

While Japanese Knotweed is generally not considered capable of producing viable seed, it has evolved in terms of its ability to hybridise with close relatives *e.g.* Giant Knotweed to produce Bohemian Knotweed which is capable of producing viable seed.

It also has a number of plant defence mechanisms which it may deploy when under threat including an ability to remain dormant underground for a number of years following chemical herbicide treatment; known as chemical dormancy. It can also produce bonsai regrowth in response to cutting and sub-lethal bonsai regrowth in response to chemical herbicide treatment (see Table A.3). Bonsai regrowth is cryptic given its small size, unusual stem and leaf colour and morphology and is therefore easily overlooked in the absence of a specialist survey (see Photograph A.3).

Photograph A.3 Bonsais of Japanese Knotweed within amenity grassland in Cork City (Source: Lisa M. J. Dolan, Ecosystem Services)

Knotweed has the ability to execute the following plant defence mechanisms in response to herbicide:

- Sub-lethal bonsai regrowth (see Photograph A.3)
- Lateral growth of rhizomes and development of new radial shoots
- Chemical dormancy - rhizomes can lay dormant and viable for a number of years before regrowth
- Compartmentalisation
- Resistance or tolerance to standard chemical herbicide-based programmes

Japanese Knotweed can also respond to cutting or burial by deploying a number of other plant defence mechanisms. Therefore, to cut, flail, mow, dig or bury the plant may only result in:

- Dispersal of plant fragments which can regrow elsewhere
- Bonsai regrowth
- Rapid regrowth and increase in the height and extent of the plant
- Lateral growth of rhizomes and the development of new radial shoots
- Regrowth from buried depths of <5m
- Buried rhizomes can survive for up to 20 years

Given the plant defence mechanisms displayed by this species, herbicides should only be applied by those who are qualified and have knowledge and understanding of the ecology of the plant and industry best practice treatment options to eradicate the species.

Photograph A.4 Japanese Knotweed breaking through cavity blocks resulting in a structural crack in the wall of a garden in Co. Cork (Source: Lisa M. J. Dolan, Ecosystem Services)

A.3 Impacts from Japanese Knotweed

In terms of ecology, landscapes and amenities, Japanese knotweed is known to have potential significant negative ecological impacts on native habitats and species, on landscape character and quality, and on visual and recreational amenities.

In relation to semi-natural habitats, the species out-competes native herbaceous and juvenile woody plants, reducing species diversity (see Photograph A.5). Once established the height, dense canopy and aggressive nature of the plant essentially excludes other species.

In addition, Japanese Knotweed has also been shown to have allelopathic effects on native vegetation, permitting germination but limiting biomass.

Along riverbanks, new shoots have been observed developing primarily from floating stems from which fragments can be broken off by floods which lodge downstream to form new outlier populations; therefore, an upstream catchment wide management approach is required to achieve eradication of knotweed species along habitats where there is upstream surface water connectivity.

Photograph A.5 Japanese Knotweed dominating riverbanks of a stream in Co. Kerry (Source: Lisa Dolan, Ecosystem Services)

In Ireland, Japanese Knotweed is often associated with roadsides, railways, car parks, car wash facilities, quarries, maintenance depots, abandoned/waste ground; in particular, disturbed areas where native vegetation is absent and where fly-tipping of spoil has occurred.

During landscaping and construction activities Japanese Knotweed can be disturbed by machinery, and spread within or be brought onto a site, in the form of plant fragments within the soil load or on the tyres of machinery and dumpsters, especially on machinery with tracks. The maintenance of Japanese Knotweed by mechanical methods such as cutting and strimming can distribute fragments, which can then be carried along road corridors by wind or on the tyres of vehicles including cars (see Wace, 1977; Wilcox, 1989). Fragments can also be carried on the footwear of pedestrians. Cutting and mowing results in the creation of bonsai regrowth which can go undetected.

With regards to increased flood risk, Japanese knotweed once established can dominate watercourses where it may impede water flow through the obstruction of conveyance (or drainage) in ditches, streams, and rivers, particularly when water levels are high; thus, contributing to flooding. During senescence or winter dieback, Japanese knotweed may leave riverbanks exposed to erosion, leading to bank collapse.

Land use and access to lands and infrastructure can also be impacted or restricted where large dense monospecific stands block access routes, invade landscaped areas and open spaces such as gardens and urban parks/woodlands, impact on the quiet enjoyment and use of domestic gardens, encroach on roadways and agricultural fields, and occupy large swathes of unmanaged lands. Signage and sightlines on roadways can also be impinged. In addition to these impacts, Japanese knotweed, like certain tree species, also has the ability to access existing weaknesses and joints and may in certa*in situ*ations cause damage to footpaths and hard landscaping and based on experience may impact on more vulnerable structures such as old stone masonry walls and walls constructed from cavity blocks. However, while Japanese knotweed has the ability to cause damage, it rarely does so, as rhizomes will typically grow around any objects and structures which they encounter.

Table A.1 Life Cycle of Japanese Knotweed

Details	**Photographs**
An excavated crown structure in winter. Old dead stems from previous years growth are scattered on the ground	
Crown *in situ* with pink buds and stems emerging in early spring	

Details	Photographs
Red stems turning green as the plant grows, red leaves unfurl in late spring	
Red leaves changing to green as stems grow in early summer	
Fully opened leaves in summer	

Details	Photographs
Japanese knotweed commences flowering from July onwards	
Senescence or winder dieback occurs after flowering and depends on local day and night temperatures and other environmental stress factors. Typically occurs from September onwards	
After leaf fall, only the crown structures with dead stems remain in winter. The dead stems may persist over winter or break off and fall to the ground.	

Japanese knotweed has acquired its infamous reputation, as it exhibits a number of characteristics which are not typically displayed by those tree species whose roots have the potential to damage infrastructure. Namely, it is a rhizomatous species which can be easily dispersed, it exhibits a rapid growth pattern and is considerably more tolerant to chemical herbicide, thus making it significantly more difficult to eradicate than most trees. However, onsite experience and recent research has shown that it does not live up the reputation it has previously been afforded in terms of risk to infrastructure (see Fennell *et al*., 2018 for further details).

A.4 Legal Obligations

In light of the potential risk of negative impacts posed by Japanese knotweed on semi-natural habitats, it is a 'listed' species under Irish legislation *i.e.,* the Third Schedule: Part 1 of the European Communities (Birds and Natural Habitats) Regulations 2011 to 2015 which is a list of invasive alien plant species subject to restrictions under Regulations 49 & 50.

Regulation 49 of the European Communities (Birds and Natural Habitats) Regulations 2011 to 2015 deals with the 'Prohibition on introduction and dispersal' while Regulation 50 deals with the 'Prohibition on dealing with and keeping certain species'. Regulation 50 has yet to be enacted into Irish law (http://www.irishstatutebook.ie/eli/2011/si/477/made/en /print and http://www.Irishstatutebook.ie/eli/2015/si/355/made/en/print).

Japanese knotweed is also listed under the Third Schedule: Part 3 Vector Materials of the European Communities (Birds and Natural Habitats) Regulations 2011 to 2015. Part 3 governs the movement of soil or spoil taken from places infested with Japanese knotweed, Giant knotweed (*Fallopia sachalinensis*) or their hybrid Bohemian knotweed (*Fallopia* x *bohemica*). A license application to National Parks and Wildlife Service (NPWS) is required under Regulation 49(2) in order to transport soil or spoil *i.e.* vector material containing Japanese knotweed, Giant knotweed and Bohemian knotweed off a site.

Table A.2 Establishment of Japanese Knotweed from a Rhizome Fragment

Details	Photographs
Rhizome fragment recovered from the ground	

Details	Photographs
Transverse section through the rhizome fragment showing evidence of viable (**orange**) tissue when cut open.	
Signs of new rhizome growth are visible on the old rhizome fragment. New white rhizomes are emerging.	
The **growing tip** of the rhizome is initially white. The rhizome becomes dark brown, thick and woody with a knotty appearance as it matures.	

Details	Photographs
New leaves emerging from a rhizome fragment	
New plant leaf appearing above ground from a buried rhizome fragment	
Young plant emerging from a buried fragment in the ground	

Details	Photographs
Multiple young plants emerging from buried rhizome fragments	
Leaves will change from red to green and start photosynthesising as the growing season progresses. After 4 years of spring/summer growth and winter dieback the plant will start to develop a crown structure as per Table 2.1.	

The licensing process is required to ensure that in circumstances where vector material is to be taken off site for disposal, that it is appropriately disposed of at a licensed receiving facility.

The licencing process also requires that best practice is deployed throughout all stages of the recovery process *i.e.* during excavation of the vector material at the donor site, transportation by the haulage company along the public road network and during disposal at the receiving facility. This level of scrutiny is necessary as any fragments of rhizomes or stems which are accidentally dispersed during the recovery process can readily sprout shoots and establish new plants within the donor site, along the public road network, or indeed, at the receiving facility.

A.5 Control & Management Programmes

The foliar application of chemical herbicide usually requires up to 3 years (+) of treatment to acquire an effective reduction in the viability and eradication of the underground rhizome network; as sufficient herbicide has to enter the plant via the leaves and travel to the underground network to achieve eradication. Alternative methods of delivering a higher and more effective dose of herbicide to the underground rhizome network via the stem, are referred to as stem injection or stem filling. As the names suggest these methods involve directly introducing herbicide to the stem of the plant such that a larger dose of herbicide reaches the underground rhizomes. This achieves a higher effective kill and/or eradication of the underground rhizome network in a shorter period of time, reducing future risk to a development by reducing the extent of any regrowth. As stem injection and stem filling are labour intensive, and more costly to deploy than foliar application, they are only deployed where time is a limiting factor, or where sensitive habitats exist in close proximity to the Japanese knotweed (which could be indirectly impacted from spray drift during the foliar application of herbicide), or where crowns are found to be growing up against infrastructure.

Treatment via the foliar application of chemical herbicide should be undertaken during the optimum treatment period. The optimum treatment period for the deployment of chemical herbicide treatment (on an annual basis), to Japanese knotweed is dependent on the timing of the plants' annual growth cycle, its unusual plant physiology, seasonal factors and local day and night temperatures. It is considered best practice to spray after the commencement of flowering and before the first frost *i.e.* the commencement of senescence. Flowering typically commences between July and October each year. Japanese knotweed goes into senescence (commences winter die back) after the first frost. It is important that Japanese knotweed is sprayed each year before the commencement of senescence to ensure that a maximum effective dose is delivered to the underground rhizome network of the plant and to avoid triggering the plants defence mechanisms.

A treatment programme should be followed by monitoring and viability testing of the underground rhizomes of Japanese knotweed at the location of each infestation to determine the presence/absence of viable plant tissue in the underground rhizome network as per Paragraph B2.8 of The Control of Japanese Knotweed (*Fallopia japonica*) in Construction and Landscape Contracts (Welsh Government, 2011) on completion of the growing season in the fourth and fifth year following a 3 yr treatment programme. Whether 'eradication' of Japanese knotweed has been achieved should be determined by the IAPS Specialist Ecologist.

Inappropriate Treatment

It should be noted that the inappropriate deployment of herbicide during the treatment of knotweed species can result in the following:

D. Above ground kill of leafy vegetation *i.e.* '**Top Kill**' only (with viable stems remaining post-treatment)
E. **'Partial'** above ground kill of vegetation (green leaves and/or viable stems remaining post-treatment)

'Top Kill' or 'Partial Kill' of leafy vegetation and stem tissue may trigger:

I. The creation of dormant rhizomes below ground which can go undetected for several years before regrowth
II. Rapid regrowth the following April resulting in an increase in the height of the infestation

III. The activation of dormant rhizomes the following April resulting in an increase in the extent of the infestation and the active rhizome network
IV. Lateral growth in the rhizome network the following April resulting in an increase in the extent of the infestation
V. Slow regrowth of the plants with smaller, curled, or red leaves and red stems which are cryptic; known as sub-lethal 'bonsai' regrowth the following growing season. Plants displaying sub-lethal bonsai regrowth are not receptive to herbicide treatment.

'Top Kill' or 'Partial Kill' are most likely to occur where:

I. An incorrect chemical herbicide is used
II. A sub-lethal dose of chemical herbicide is used (too little or too much herbicide)
III. The correct chemical herbicide is used outside of the optimum treatment period *i.e.* at the incorrect time of year or seasonal plant cycle /plant growth stage
IV. Weather conditions are not suitable *i.e.* significant spray drift/volatilisation or rain/dew pre- or post-treatment
V. Poor application methods are deployed
    - The equipment utilised is not to the standard required
    - Herbicide is not applied to the canopy/leaves in accordance with best practice
    - Herbicide is not applied to entire canopy; access not gained to the adjacent property or to the necessary height in order to treat the entire stand

Consequences for a Development Site

The main consequences of Top or Partial Kill in relation to a development site are as follows:

Top Kill

- The viability of plant tissue in the underground rhizome network will not have been effectively reduced and continues to remain highly viable. The treatment will therefore have been rendered ineffectual.
- The unproductive use of herbicide in the environment
- The creation of a protracted *in situ* treatment regime going forward with associated costs and delays to commencement of Site Clearance and construction at the site.
- Plants may exhibit a greater resistance to chemical herbicides in the following growing season

Partial Kill

- The viability of plant tissue in the underground rhizome network will not have been effectively reduced and continues to remain highly viable. The treatment will therefore have been rendered ineffectual.
- The plant will be in a position to transport carbohydrates to the crown for food storage for the winter months
- The remaining presence of highly viable rhizome tissue post treatment means that there will continue to be a high risk of dispersal and regrowth from these plant fragments *e.g.* where it is proposed to remove the soil containing vector material of

Japanese Knotweed off site there is a higher risk of regrowth and the donor and receiving facility.

- The unproductive use of herbicide in the environment
- The creation of a protracted *in situ* treatment regime going forward with associated costs and delays to commencement of Site Clearance and construction at the site.
- Plants may exhibit a greater resistance to chemical herbicides in the following growing season

Inappropriate Biosecurity Measures

The inappropriate deployment or lack of biosecurity measures during the treatment of knotweed species can result in the dispersal of viable plant fragments by the following vectors:

A. Accidental physical disturbance during the deployment of herbicides or recovery of soils resulting in the dispersal of plant fragments on tools, footwear, wheels of vehicles, in surface water runoff *etc*.
B. Where mechanical cutting methods are selected to gain access to a stand to 'assist' treatment of large stands resulting in the dispersal of plant fragments and the reduced receptivity of the plant to herbicide and therefore effectiveness of the treatment

As a result, there will be a higher risk of dispersal of viable plant fragments within a site and off site to adjacent lands, semi-natural habitats, watercourses, licensed waste facilities, plant hire facilities, waste segregation hire facilities, other development sites, refuelling depots, service areas, private residences, road networks and other sites.

Details of the classification, risk assessment and legislative requirements in relation Japanese knotweed, are presented in Appendix I.

Table A.3 Bonsai and Sub-lethal Bonsai Regrowth

Details	Photographs
Bonsai regrowth is a particular miniature growth form of Japanese knotweed which is triggered by the plants defence mechanisms in response to frequent cutting. The bonsai plant will persist unless the mowing regime ceases.	

Details	Photographs
Sub-lethal bonsai regrowth is another particular miniature growth form of Japanese knotweed which is triggered by the plants defence mechanisms in response to the inappropriate use of chemical herbicide.	

B. BUDDLEIA

B.1 Species Description & Ecology

Buddleia (*Buddleja davidii*) is a deciduous shrub native to China, that grows 1-4m tall with arching stems. The leaves are opposite, 10-20 cm long, and lanced-shaped with a slightly serrated edge and a felted-velvety whitish under surface.

It typically flowers during the period June to September, when dense clusters of tubular flowers develop. These flowers have 4 petals and can be purple, white, or pink. The flowers produce high quantities of nectar and are attractive to butterflies, hence the common name – Butterfly Bush.

The desiccated flower heads and seed capsules may remain on the shrub over winter. The developing seed pods are small upright and ovate and may not be readily visible through the remnants of the flower. When mature, the pods area a dark brown and opened at the tip. The seeds produced are extremely small and numerous with up to 3 million produced per plant. The seeds are dust-like particles which can easily be distributed by the wind. They can also remain viable in soils and gravels for many years (https://www.invasiveplantatlas.org/subject. html?sub=11608; NRA, 2010).

Although butterflies use Buddleia as a nectar source, their larvae cannot survive on it. By replacing native larval food source plants, Buddleia can have a negative impact on wildlife (https://www.invasiveplantatlas.org/subject.html?sub=11608).

B.2 Invasive Qualities of Buddleia

Buddleia as a prolific reseeder can quickly establish scrub transitional communities, in particular disturbed sites. Like many invasives, it can rapidly colonise bare ground forming mono-typic stands.

As buddleia can tolerate nutrient poor soils, it is capable of growing on walls, rocky outcrops or sub-soils. Buddleia can also readily establish on very dry hard standing areas constructed from gravel, and other similar compacted loose materials, and in cracks and crevices in old concrete and bituminous finished surfaces.

In particular, Buddleia creates issues on road schemes where features are being left to re-colonise naturally as in rock cuttings, eskers, *etc*. (NRA, 2010) for wildlife conservation purposes.

It can result in considerable maintenance of landscaped areas and hard standing, in particular car parks, yards, brownfield sites, building sites, quarries and road schemes.

B.3 Control & Management Programmes

According to Ream (2006) formulations of glyphosate effectively control Buddleia up to two years old; where required it should be followed up at 6 monthly intervals.

For more mature plants a combination of spraying the entire plant and painting herbicide concentrate on recently cut stumps is effective in controlling Buddleia (Ream, 2006), thus preventing the dispersal of seeds within a site and into the surrounding landscape.

According to NRA (2010) recommended practice for the application of herbicides requires the cutting back of plants to a basal stump during active growth (late spring to early summer) which is then treated (brushed on) immediately with a systemic weed killer mix (Starr *et al*., 2003).

Even after the Buddleia shrub has been cut down, a new sprout may grow from the stump. In order to completely eradicate the shrub, it may be necessary to remove the stump using a stump grinder or similar to grind the stump down to ground level, followed by digging out major connecting roots.

It is also possible to kill the stump using accelerated decay to rot the stump before removing it. To use this method, a series of holes are drilled into the top and sides of the stump. The holes are then filled with slow-release fertilizer and watered well before the stump is covered with a mound of soil to begin the process of decay. After a few weeks, the stump will have rotted from the inside out and ready for removal.

Management methods such as digging it out (grubbing) are applicable only to minor infestations at the initial stage of invasion. Hand-picking of young plants is feasible but should be undertaken with care to avoid soil disturbance which can give rise to a flush of new seedling. Grubbing of mature stands as a sole attempt at control is not recommended for the same reason.

After uprooting, it is essential to monitor for regrowth and treat with chemical herbicide or to plant the ground in order to prevent a flush of new seedling growth. Mowing of young plants does not provide control as they re-sprout with vigour.

Where removal of mature plants is not feasible in the short term, the flower heads should be cut off in June before seeds are released. Where desiccated flower heads and seed capsules remain on the tree over winter these can also carefully be removed to minimise further dispersal.

C. THREE-CORNERED GARLIC

C.1 Species Description & Ecology

Three-cornered garlic (*Allium triquetrum*) is native to the west and central Mediterranean (Preston *et al*., 2002; Stace, 1997) including Portugal, Southern Spain (including the Balearics), France (including Corsica), Italy (including Sardinia and Sicily) and Africa: Algeria, Morocco and Tunisia (Dowen, 2011).

It is thought to have been introduced to Ireland some three-hundred years ago (Devlin, 2014) and has become established in the south and southeast of Ireland, outside of which it has a scattered occurrence (Preston *et al*, 2002; Reynolds, 2002; Stace, 1997). A large discrepancy between the Botanical Society of Britain and Ireland (BSBI) maps and those of the National Biodiversity Data Centre (NBDC) suggest that the true extent of the species in Ireland may be greater. It is likely, as in the case with many alien plants, to be poorly reported in that many of the sites it grows in are in large demesnes or wild gardens, many of which are privately owned and often not recorded as 'wild' places as they border the margins of cultivation. The extent of Waterford and Wexford records is largely due to intensive floristic work in these two counties.

C.2 Invasive Qualities

Typical habitats where it is known to invade or naturalise include hedgerows, parks, footpaths, roadsides, waste areas, disturbed/cultivated sites, orchards, open woodlands, forests, moist pastures, riparian areas (Reynolds, 2002; Stace, 1997) and gardens. The species is also intentionally planted in gardens.

In Ireland the Three-Cornered Leek flowers from April to June. In Western Australia, time to first flower from seed is 2 years with a medium seedbank persistence of 1 to 5 years and generally survives fire (https://florabase.dpaw.wa.gov.au/browse/profile/1378).

Three-Cornered Leek is known to spread via natural and human assisted dispersal. Human assisted dispersal plays a greater role in the long distance spread of the species relative to natural dispersal.

Localised spread of the species is likely underpinned by natural dispersal. It can spread vegetatively in clumps producing daughter bulbs, while seeds are spread by ants (BSBI, 2011; Preston *et al*., 2002). According to Davies (1992) the seeds have an oil-bearing appendage which is attractive to ants. Thus, the ants carry the seed away to eat the oil and then discard the seed, thus aiding dispersal of the plant.

Anthropogenic dispersal occurs through garden waste, transportation of bulbils and/or seeds on grass-cutting equipment, while the seed can also be transported in the air turbulence created by vehicles along road corridors which is likely to be the most significant means of future long distance spread of the species, with roadside verges the most at risk habitat to future spread (Dowen, 2011, BSBI, 2011).

Further spread of the species is dependent on suitable climatic conditions, which are likely to manifest over the coming years as a result of global warming. Habitat availability is not expected to be a limiting factor to future spread.

There is no published literature on the impact Three-cornered Leek on biodiversity in Ireland to-date. It is known to become dominant in grass swards where it has been present for over 10 years, total cover can be as high as 10-33%. There is no data on the effects of such cover on native species especially as many other cultivated species (Narcissus, Crocus, Hyacinthoides *etc*.) are often present. In Australia, Three-Cornered Leek has been shown to reduce understory biodiversity significantly and to affect regeneration of native flora. It forms monocultures and its allelopathic traits endanger species such as orchids, native lilies and grasses (Tehranchian, 2011) (cited in http://nonnativespecies.ie/wp-content/uploads/2014/03/Allium-triquetrum-Three-cornered-Leek1.pdf).

C.3 Control & Management Programmes

There are no known eradication campaigns currently in place in Ireland for this species. Control in other countries has been shown to require a combination of manual cultivation, removal and herbicide spraying of the exposed bulbs (HerbiGuide, 2014). Recovery is easier to do in spring when surface vegetation is present, providing an indicator of the extent of the infestation and, ensuring that all bulbous material is removed.

In addition to Glyphosate and 2-4, D a number of other chemical herbicides have been identified in the literature, however, none of these are suitable for use or approved for use by the Pesticide Control Service for use in Ireland.

Annual spraying in early flowering stage *i.e.* before April is recommended as this will result in the application of herbicide at the bulb exhaustion stage.

When applying foliar herbicides, it is advised to use a wetting agent, especially on young plants as they are hard to wet given the limited surface area and run off associated with the narrow lanceolate waxy leaves and associated run off (https://florabase.dpaw.wa.gov.au/browse /profile/1378). Ideally leaves should be allowed to mature to provide maximum surface area for absorption of chemical and the waxy leaves should be bruised or trampled to increase uptake.

D. SPANISH BLUEBELL

D.1 Species Description & Ecology

The Spanish Bluebell (*Hyacinthoides hispanica*) is native to the western Iberian Peninsula (Portugal and western Spain) and North Africa (Hackney, 2008; Meek, 2011; Parnell and Curtis, 2012; Taylor, 2002). The common Bluebell, (*H. non-scripta*), is native to Ireland, Britain & western Europe as far south as central Spain (Hackney, 2008; Kohn *et al*., 2009 Taylor, 2002). The Hybrid Bluebell, (*H. hispanica* x *H. non-scripta*), is perhaps the commonest cultivated bluebell in gardens. In the wild this hybrid is said to arise spontaneously where the native and/or introduced ranges of the parents meet (Taylor, 2002). There are unresolved questions, however, about the taxonomic status of these taxa; whether the 'Spanish' Bluebell is the same as the bluebells in Spain and whether it is merely a subspecies of the common bluebell, as the two hybridise freely (BSBI, 2010; Rix, 2004; Taylor, 2002).

The Spanish Bluebell was introduced as a garden plant more than 300 years ago, but it took another 200 years before it was present in the wild. In the UK, the increasing distribution of the Spanish and Hybrid bluebell was recognised in the late 1980s (Kohn *et al*. 2009).

Spanish Bluebells have a localised distribution in Ireland, with most existing records of the species concentrated in the southeast and south, respective (Taylor, 2002; BSBI, 2010,). The hybrid bluebell's range and frequency are increasing but it is still unevenly recorded (Taylor, 2002). The Spanish Bluebell may be continuing to increase slowly, but it has long been confused with the hybrid and probably remains somewhat over recorded in error for the hybrid (Reynolds, 2002; Taylor, 2002; Hackney, 2008). A key to distinguish the different *Hyacinthoides* spp. can be found in Grundmann *et al*. (2010).

Spanish and Hybrid Bluebells are intentionally planted domestically in horticultural habitat *e.g.,* gardens demesnes, parkland, churchyards, cemeteries. From cultivation in horticultural habitat, the species can spread via natural and human assisted dispersal into the wild *e.g.,* woodlands, roadsides and waste ground. Spanish and Hybrid Bluebell are also intentionally planted in the wild, particularly woodland areas for perceived 'landscape improvement' and 'wildlife value'.

The Spanish and Hybrid bluebell are spring-flowering, bulbous perennials, producing the fresh season's leaves in about December (Kohn *et al*., 2009).

The Spanish Bluebell and Hybrid is fully fertile and produces abundant seed. All bluebells retain much of their seed in the papery fruits until well into the winter and leaves die back completely from about the end of summer (Hackney, 2008). The plant can establish from seed sown at any time of the year (Seedaholic, 2014). The seeds of Spanish Bluebell take five years to reach the mature stage (Merryweather & Fitter 1995a; Van der Veken *et al*. 2007) and is likely due to plants taking time to accumulate enough resources to develop a bulb before allocating resources to flower production. Rix (2004) also reports that Spanish Bluebell typically only flowers after four years of age, indicating that flowering is dependent on resource accumulation rather than some internal mechanism that takes exactly five seasons of growth (cited in Allum, Lill, Natalie, 2016). Flower spikes appear in April and May and the flowers are insect-pollinated (Hackney, 2008). It is said to have no, to some, self-compatibility, with insect pollinators consisting mainly of Bombus species and syrphids (Corbet, 1998).

The longevity of the seed is not known, and no dormancy has been detected beyond the ability to remain quiescent through their first winter (Blackman and Rutter, 1954; Meek, 2011; Thompson and Grime, 1979). (cited in http://nonnativespecies.ie/wp-content/uploads/2014/03/Hyacinthoides-hispanica-Spanish-Bluebell-and-Hybrid.pdf). The bulb is entirely renewed annually and as a result flowering and plant size are sensitive to drought and leaf loss experienced in the previous year (Blackman and Rutter, 1954; Littlemore and Barker, 2001). The bulb renewal process can sometimes lead to the bulb splitting in two *i.e.* clonal reproduction (Wilson 1959; Grabham & Packham 1983; Merryweather & Fitter 1995a). Seeds have no apparent adaptations for dispersal (Knight, 1964) (cited in Allum, Lill, Natalie, 2016). Seedling survival and establishment is facilitated by mycorrhizal associations (Merryweather and Fitter, 1995).

There is a dearth of information to be found in the literature about the fecundity and dispersal of Spanish Bluebell and the native Bluebell. Spanish Bluebells are however considered to be poor natural dispersers and spread of the taxa is thought to be largely depended on human-assisted dispersal. (cited in http://nonnativespecies.ie/wp-content/uploads/2014/03/Hyacinthoides-hispanica-Spanish-Bluebell-and-Hybrid.pdf). Natural seed dispersal is achieved when the raceme and fruit dry and the plants collapse or are knocked to the ground by wind action or by animals, *i.e.* barochory (Honnay *et al*. 1999). Van der Veken *et al*. (2007) reported very slow spread for the English Bluebell, and due to their similar dispersal method, this is likely also true for the Spanish Bluebell. Kohn *et al*. (2009) suggest that, if the spread is indeed equally slow, then hybridisation is likely the bigger threat to the native Bluebell (cited in cited in Allum, Lill, Natalie, 2016).

D.2 Control & Management Programmes

Bluebells are resistant to many herbicides commonly used in the garden. Applications of herbicide are best made after the plant has flowered in April and May. Flower heads should be cut to prevent the formation of seed. Repeat applications may be required to deplete the soil seed bank, although a persistent seed bank is not associated with Spanish Bluebell as no dormancy has been detected beyond the ability to remain quiescent through their first winter (Blackman and Rutter, 1954; Meek, 2011; Thompson and Grime, 1979). The seeds of Spanish Bluebell take five years to reach flowering (Merryweather & Fitter 1995a; Van der Veken *et al*. 2007).

The plants and bulbs can be mechanically excavated and removed. The best time to undertake mechanical control is early spring before the plant starts flowering. These perennial plants form large clumps via self-seeding and are said to send out underground runners that spread rapidly and form new bulbs, although the presence of runners is disputed by some. It is important to ensure to uproot all of the bulbous material and associated runners where present. Where all bulbous material is not removed regular follow up will be required with chemical herbicide to deal with regrowth from bulbs or split bulbous material.

E. Winter Heliotrope

The recommended optimum treatment period for the deployment of Glyphosate to Winter Heliotrope is February and March after flowering or in mid to late summer according to the NRA (2010). New foliage begins to appear after flowering later in spring (though last years' foliage may not dieback completely). Winter Heliotrope flowers between January and March and in certain climatic conditions the plants flower between November and March (http://www.irishwildflowers.ie/pages/200a.html;(http://www.irishwildflowers.ie/pages/200a.html; http://www.irishwildflowers.ie/pages/433a.html).

According to NRA (2010) the recovery of Winter Heliotrope vector material can be undertaken at any time of year. It is important to ensure to uproot the entire rhizome network. Where all rhizomes are not removed regular follow-ups will be required to deal with regrowth from rhizomes. Deep burial (more than 2m deep) of recovered material is recommended (NRA, 2010).

It is understood that the control of Winter Heliotrope is currently the subject of an EPA funded project led by CERIS, Institute of Technology, Sligo which is targeting the Prevention, Control and Eradication of Invasive Alien Species (IAS) on the Island of Ireland.

F. Montbretia

Non-chemical treatment, chemical treatment, or a combination of both can be employed to remove this species.

Physical control of Montbretia is difficult as the corms break up from their chains very readily and cause re-infestation or further spread. Where infestations are limited in extent, the entire stand of Montbretia can be controlled by removing the plants and corms (NRA, 2010; Weeds of New Zealand, 2016) and burying them to a depth of at least 2m, alternatively they can be incinerated or disposed of to a licensed landfill. Corms should be disposed properly in order to avoid re-sprouts. It should be noted that the corms are very hardy and are not suitable for composting.

As Montbretia is capable of regeneration from corms and small fragments of rhizome, all material must be handled and disposed of in a way which does not result in the potential for further spread. Small pieces of plant material may be spread unintentionally on shoes, clothes, and agricultural equipment; therefore, biosecurity protocols should be strictly adhered to at all times.

According to DAFM, the most effective time to excavate Montbretia is just before full flowering occurs in summer, while NRA (2010) states that excavation can take place at any time of the year, when the soil is suitably dry.

Due to the potential for reinfestation from corms and fragments of rhizomes, regular follow-up with chemical herbicide may be required for a number of years to deal with any regrowth (NRA, 2010;(https://www.agriculture.gov.ie/media/migration/farmingschemesandpayments/glastraining/MontbretiaFinalDraft230616.pdf).

Chemical control can be achieved using glyphosate or Metsulfuron during active growth in late spring or summer with foliar spray, wiper applicator or spot treatment (NRA, 2010). In Australia and New Zealand, herbicides such as glyphosate and Metsulfuron-methyl have been used to control infestations of Montbretia (Ensbey *et al*., 2011; Weeds of New Zealand, 2016; https://www.cabi.org/isc/datasheet/107826/aqb).

Complete eradication of Montbretia from a site may take a number of years. Non-chemical treatment, chemical treatment, or a combination of both can be employed to remove the species. As Montbretia is capable of regeneration from corms and small fragments of rhizome, all material must be handled and disposed of in a way which does not result in the potential for further spread. Small pieces of plant material may be spread unintentionally on shoes, clothes, and agricultural equipment. The most effective time to remove Montbretia is just before full flowering occurs in summer. Please note that control will require continued input and follow-up over a number of years to deal with any re-growth by corms or rhizomes (https://www.agriculture.gov.ie/media/migration/farmingschemesandpayments/glastraining/MontbretiaFinalDraft230616.pdf).

G. Sycamore

Sycamore trees can be felled and with herbicide applied immediately to the stump with a brush. Even after the sycamore tree has been cut down, a new sprout may grow from the stump. In order to completely eradicate the tree, the stump should be removed using a stump grinder to grind the stump down to ground level, followed by digging out major connecting roots. It is also possible to kill the stump using accelerated decay to rot the stump before removing it. To use this method, a series of holes are drilled into the top and sides of the stump. The holes are then filled with slow-release fertilizer and watered well before the stump is covered with a mound of soil to begin the process of decay. After a few weeks, the stump will have rotted from the inside out and ready for removal (https://homeguides.sfgate.com/methods-killing-sycamore-trees-27914.html).

H. Travellers Joy

Glyphosate can be used as a foliar spray or as a spot treatment for Traveller's Joy and should be applied in summer during active growth before senescence, when it is not very hot or during drought. Following control, regular monitoring will be required with appropriate follow up to deal with regrowth or new seedling germination over a period of 2–3 years.

For mature plants, they can be physically removed from the ground, or the vines can be cut back to ground level or waist height in winter or spring with a straight horizontal cut. Herbicide is then applied immediately to the wound with a brush and the subsequent regrowth can be then foliar sprayed. This method will avoid impacting on the host plant the vine may be covering. The plants should be left *in situ* until they are dead. Where plants are not killed in a single application, wait until re growth before re spraying.