Roe Highway Extension

Typha orientalis Control Program

December 2015

Prepared for
Main Roads Western Australia
by Strategen

December 2015

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1. Introduction

Main Roads Western Australia (Main Roads) proposes to construct the Roe Highway Extension (the Project, Figure 1) as part of the Perth Freight Link Project. This document presents the **Typha orientalis* Control Program (TOCP) to manage occurrences of **T. orientalis* within the Ramsar listed Thomsons Lake (Figure 2).

The Project involves the construction of approximately 5 km of highway, extending Roe Highway from its current terminus at the Kwinana Freeway in Jandakot to Stock Road in Coolbellup. The proposed extension to Roe Highway is largely located within a primary regional road reserve which adjoins Beeliar Regional Park.

1.1 Background

The Project is located approximately 14 km south of Perth within the Swan Coastal Plain Bioregion. The Project is largely contained within the City of Cockburn, however, parts of the design extend northward in to the City of Melville along Murdoch Drive and Kwinana Freeway. Generally, the proposed Project is oriented east-west largely, within a road reserve that was set aside in the Metropolitan Region Scheme (MRS) in 1963. The alignment is between North and Bibra Lakes, which are part of the Eastern Chain of the Beeliar Wetlands.

The Project will consist of a dual carriageway with two lanes in each direction, separated by a concrete barrier in place of a median strip. The preferred design was selected following an extensive options analysis and consultative process. Once selected, the preferred design was optimised to avoid and minimise environmental impacts to the maximum extent possible.

In 2009 the Project was referred to the Environmental Protection Authority (EPA) under the Environmental Protection Act 1986 (EP Act), and to the then Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), now the Department of the Environment (DotE), under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The Project was set a level of assessment of Public Environmental Review (PER) and the bilateral agreement between the State and Commonwealth governments was enacted. The PER was released on the 20 June 2011 for a 12 week public review period.

The Project was approved by the Minister for Environment in July 2015, with the release of Ministerial Statement 1008 (Statement 1008) establishing conditions for the Project implementation.

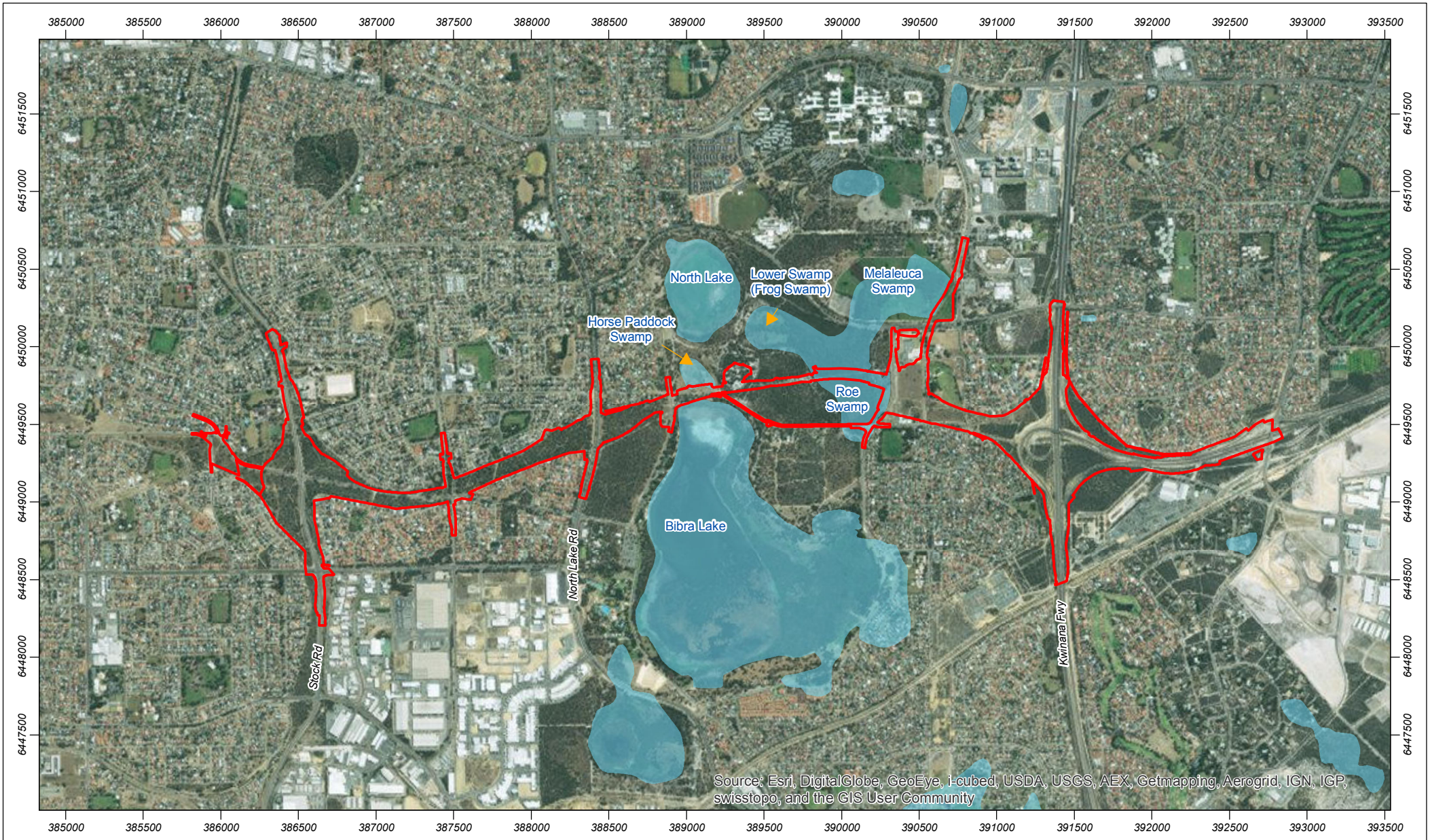

Figure 1: Project development envelope

Scale 1:33,110 at A4

0 200 400 600 800 1,000 Meters

Coordinate System: GDA 1994 MGA Zone 50

Note that positional errors may occur in some areas

Date: 27/10/2015

Author: jcrute

Source: Aerial image: ESRI online approx. 2010. Wetlands: DPAW 2014. Development envelope: Client 2015

Legend

- Project development envelope
- Wetlands

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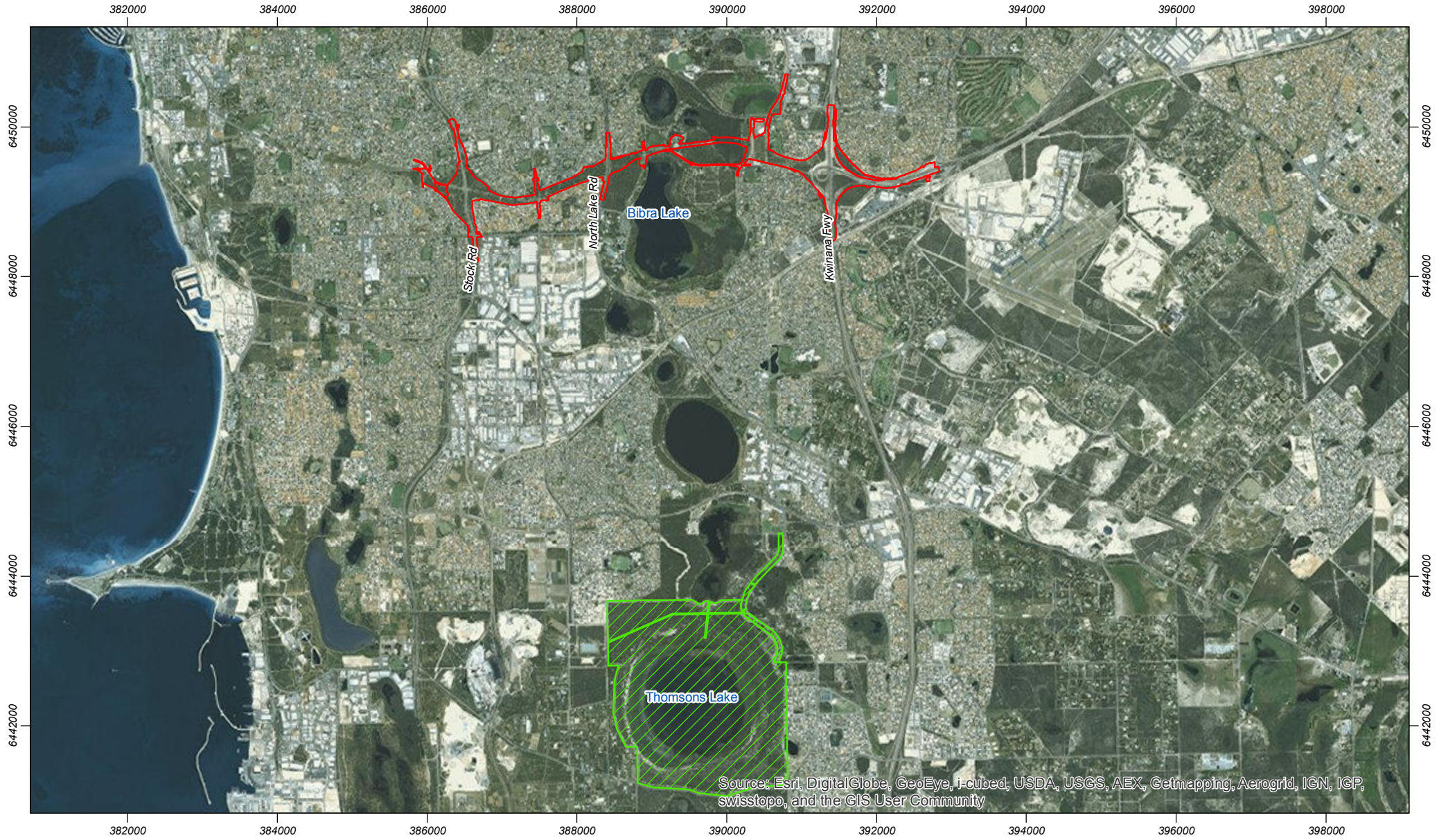

Figure 2: Thomsons Lake Nature Reserve

Scale 1:70,000 at A4

0 500 1,000 1,500 2,000 2,500 m

Coordinate System: GDA 1994 MGA Zone 50

Note that positional errors may occur in some areas

Date: 27/10/2015

Author: jcrute

Source: Aerial image: ESRI online approx. 2010. Nature Reserve: DPAW 2014. Development envelope: Client 2015

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Legend

- Project development envelope
- Thomsons Lake Nature Reserve

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1.2 Purpose and scope of document

1.2.1 Statement 1008

This TOCP has been prepared on behalf of Main Roads to address the requirements under Conditions 12-14, 12-15 and 12-16 of Statement 1008, as outlined in Table 1.

Table 1: Relevant Statement 1008 condition 12 requirements

Condition	Requirement	Section
12-14	Prior to commencement of construction, or as otherwise agreed by the CEO, the proponent shall prepare a *Typha orientalis* Control Program for Thomsons Lake to the requirements of the CEO.	N/A – refers to this document
12-15	The *Typha orientalis* Control Program identified in condition 12-14 shall include: 1. an assessment and mapping of the existing *Typha orientalis* infestation	Section 4.2
	2. activities to be undertaken	Section 4 and 5
	3. timeframes for undertaking management activities	Section 4.1, 4.4 and 5.2
	4. roles and responsibilities	Section 7
	5. funding arrangements for implementation of the program	Section 7.1
	6. monitoring and reporting requirements	Section 5 and 8
	7. completion criteria.	Section 6
12-16	Prior to commencement of construction, or as otherwise agreed by the CEO, the proponent shall implement the *Typha orientalis* Control Program and continue implementation until the CEO advises implementation may cease.	Section 4.1

1.2.2 Previous documentation

This TOCP also includes commitments and management actions for **T. orientalis* control as outlined in the following documents:

- PER and relevant appendices (Southmetro Connect 2011)
- Proponent Response to Submissions and relevant appendices (South Metro Connect 2013)
- EPA Report 1489 (EPA 2013)
- Flora, Vegetation and Fauna Management Plan (AECOM 2012a)
- Rehabilitation Strategy (AECOM 2012b).

1.2.3 Objectives

The environmental objectives of this TOCP are to:

- ensure compliance with Statement 1008 conditions 12-14, 12-15 and 12-16 outlined above
- control the **T. orientalis* population within Thomsons Lake in Beeliar Regional Park.

This plan will be made publically available in a manner approved by the Chief Executive Officer (CEO) of the OEPA.

1.3 Consultation

As part of the preparation of the TOCP, consultation was undertaken as detailed in Table 2.

Table 2: Stakeholder consultation

Stakeholder	Date	Outcome
Department of Parks and Wildlife (DPaW)	27 August 2015	The TOCP was provided to DPaW for comment and comments were received from DPaW on the 27 August 2015. The TOCP has been updated to address relevant comments.

2. Program description

This document has been prepared to satisfy Conditions 12-14, 12-15 and 12-16 of Statement 1008.

2.1 Reason for program

The TOCP involves Main Roads controlling the **T. orientalis* population within the Ramsar listed Thomsons Lake in Beeliar Regional Park as an offset for potential impacts as a result of the Project. The TOCP will reduce the percentage cover of **T. orientalis* and therefore improve the value of existing habitat for migratory waterbirds within Beeliar Regional Park.

2.2 Biology of **Typha orientalis*

**Typha orientalis* is a rhizomatous, perennial sedge between 2 m-4.5 m high (Western Australian Herbarium 1998-). The species is native to eastern Australia and is an aggressive coloniser of disturbed wetlands on the Swan Coastal Plain (Hussey et al. 1997). The rapid growth and dense clusters of **T. orientalis* populations can lead to restricted water flow, siltation and an increased risk of flooding in streams and slow flowing rivers. Decaying biological matter form the plants can also lead to anaerobic conditions that foul the water and provide breeding grounds for mosquitoes. CALM (2005) notes that **T. orientalis* poses a significant threat to native vegetation within Beeliar Regional Park.

3. Environmental setting

The *Thomsons Lake Nature Reserve Management Plan* (CALM 2005) details the existing environment within the area to be subjected to **T. orientalis* control activities. Environmental values of relevance to the management of **T. orientalis* are summarised below.

3.1 Flora and vegetation

3.1.1 Regional

Regional vegetation mapping within the Thomsons Lake reserve indicates the occurrence of four vegetation complexes (Heddle et al. 1980), which are summarised in Table 3.

Table 3: Vegetation complexes

Vegetation complex	Description
Bassendean Complex - Central and South	Woodland of *Eucalyptus marginata – Corymbia calophylla* with well defined second storey of *Calytrix fraseriana* and *Banksia grandis* on the deeper soils and a closed scrub on the moister sites. The understorey species reflect similarities with the adjacent vegetation complexes.
Herdsman Complex	Sedgelands and fringing woodland of *Eucalyptus rudis* and *Melaleuca* species.
Karrakatta Complex - Central and South	Predominantly open forest of *Eucalyptus gomphocephala – Eucalyptus marginata – Corymbia calophylla* and woodland of *Eucalyptus marginata* and *Banksia* species.
Cottesloe Complex - Central and South	Mosaic woodland of *Eucalyptus gomphocephala* and open forest of *Eucalyptus gomphocephala – Eucalyptus marginata* and *Corymbia calophylla*; closed heath on the limestone outcrops.

Source: Heddle et al. (1980)

3.1.2 Previous studies

CALM (2005) summarises the historical flora and vegetation studies which have occurred within Thomsons Lake Nature Reserve.

Flora

A total of 491 species including 360 native taxa have been recorded within Thomsons Lake Nature Reserve. This assemblage represents 89% of the native taxa identified within the wider Beeliar Regional Park and includes one conservation significant taxa; *Dodonaea hackettiana* (Priority 4) (CALM 2005).

Vegetation

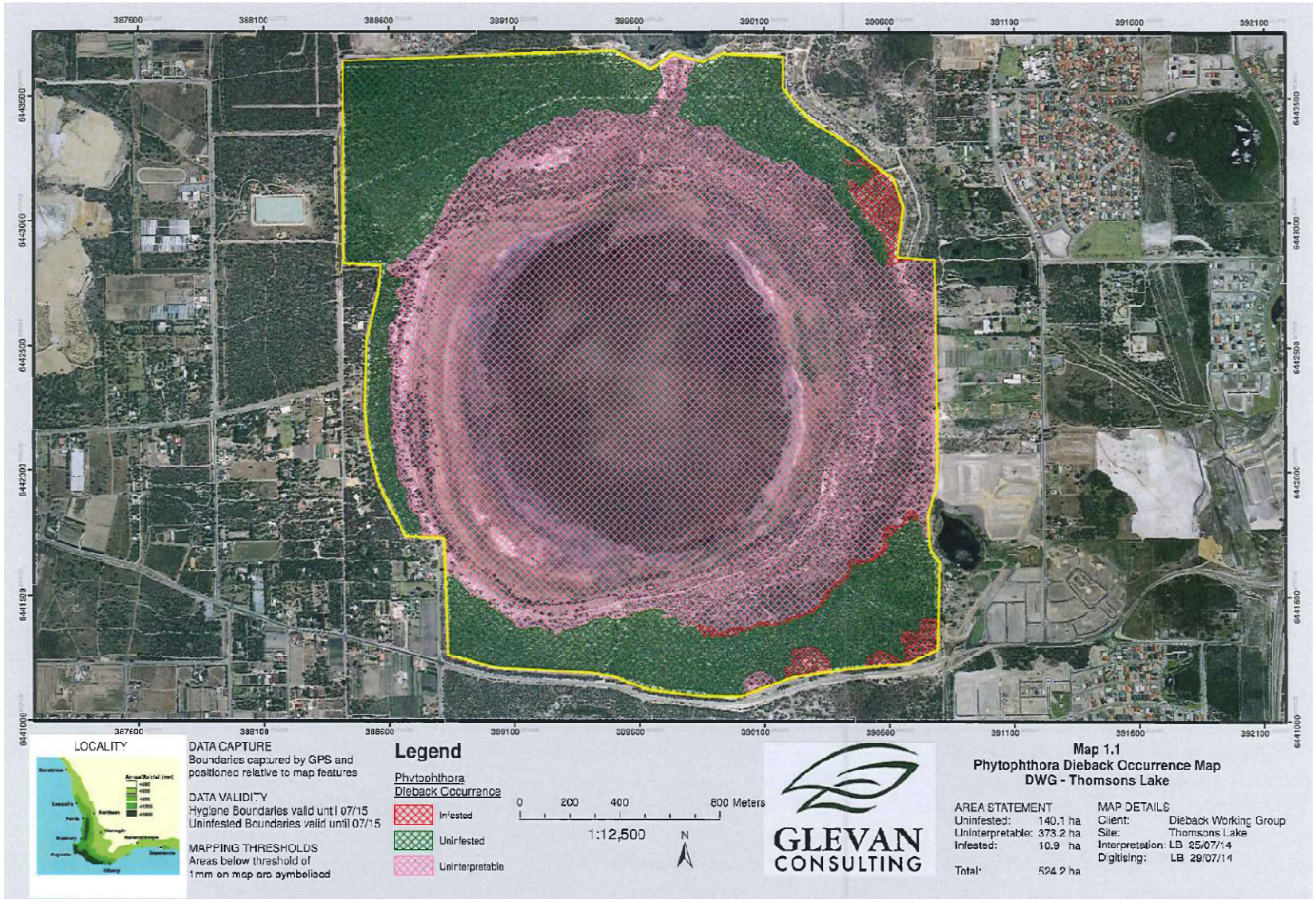
Gibson et al. (1994) defined the vegetation of the Swan Coastal Plain into 43 Floristic Community Types (FCTs). Four of the 43 FCTs are inferred to occur within the Thomsons Lake area:

- FCT 11: Wet forests and woodlands
- FCT 12: *Melaleuca teretifolia* and or *Astartea* aff. *fascicularis* shrublands
- FCT 24: Northern Spearwood shrublands and woodlands
- FCT 28: Spearwood *Banksia attenuata* or *B. attenuata – Eucalyptus* woodlands.

Current densities of **T. orientalis* within Thomsons Lake have not been determined. Section 4.2 outlines an assessment methodology which will determine the level of **T. orientalis* infestation within Thomsons Lake prior to the commencement of control measures.

Phytophthora Dieback assessment

A dieback assessment was undertaken within Thomsons Lake Nature Reserve by Glevan Consulting (Glevan) in 2014 (Figure 3). Areas were mapped as infested, uninfested and uninterpretable. The majority of the assessment area was found to be uninterpretable (373.2 ha), while 10.9 ha was observed to be infested and 140.1 ha as uninfested (Glevan 2014). The assessment concluded that it is highly likely that Phytophthora Dieback is present in the uninterpretable within the wetland and surrounding vegetation and therefore recommend that the uninterpretable areas be treated as infested (Glevan 2014).



Source: Glevan 2014

Figure 3: Phytophthora Dieback occurrence map of Thomsons Lake

4. Control program

The TOCP has been developed in order to effectively control the occurrence and spread of **T. orientalis* in Thomsons Lake. Direct and indirect impacts of weed spray on native vegetation, stock, pets and humans are intended to be managed as a part of this control program. To achieve this, this plan details:

- current extent of the existing **T. orientalis* infestation (section 4.2)
- control activities to be undertaken (section 4)
- timeframes for undertaking management activities (section 4)
- roles and responsibilities (section 7)
- funding arrangements for the implementation of the program (section 7.1)
- monitoring and reporting requirements (section 5 and section 8)
- completion criteria (section 6).

4.1 TOCP implementation timing

Implementation of this TOCP must commence prior to the commencement of construction to ensure compliance with condition 12-16 of Statement 1008. Funding for the TOCP will be provided for three years, with the program commencing in 2016 (i.e. 2016-2018).

This TOCP must continue to be implemented until the CEO advises implementation may cease, as stated in condition 12-16 of Statement 1008.

4.2 Assessment and mapping of existing **Typha orientalis* infestation

The current extent of the **T. orientalis* infestation within Thomsons Lake Nature Reserve has been mapped based on DPaW mapping of **T. orientalis* within Thomsons Lake Nature Reserve in 2009 and a desktop analysis of recent aerial photography (Figure 4). These areas identified in Figure 4 are considered to have the highest densities of **T. orientalis* and will be the key target areas for the control program.

Each target area will be subjected to control measures and assessed against completion criteria. Percentage cover (dead and alive) of **T. orientalis* within each target area will be determined during the pre-control survey prior to the commencement of herbicide application.

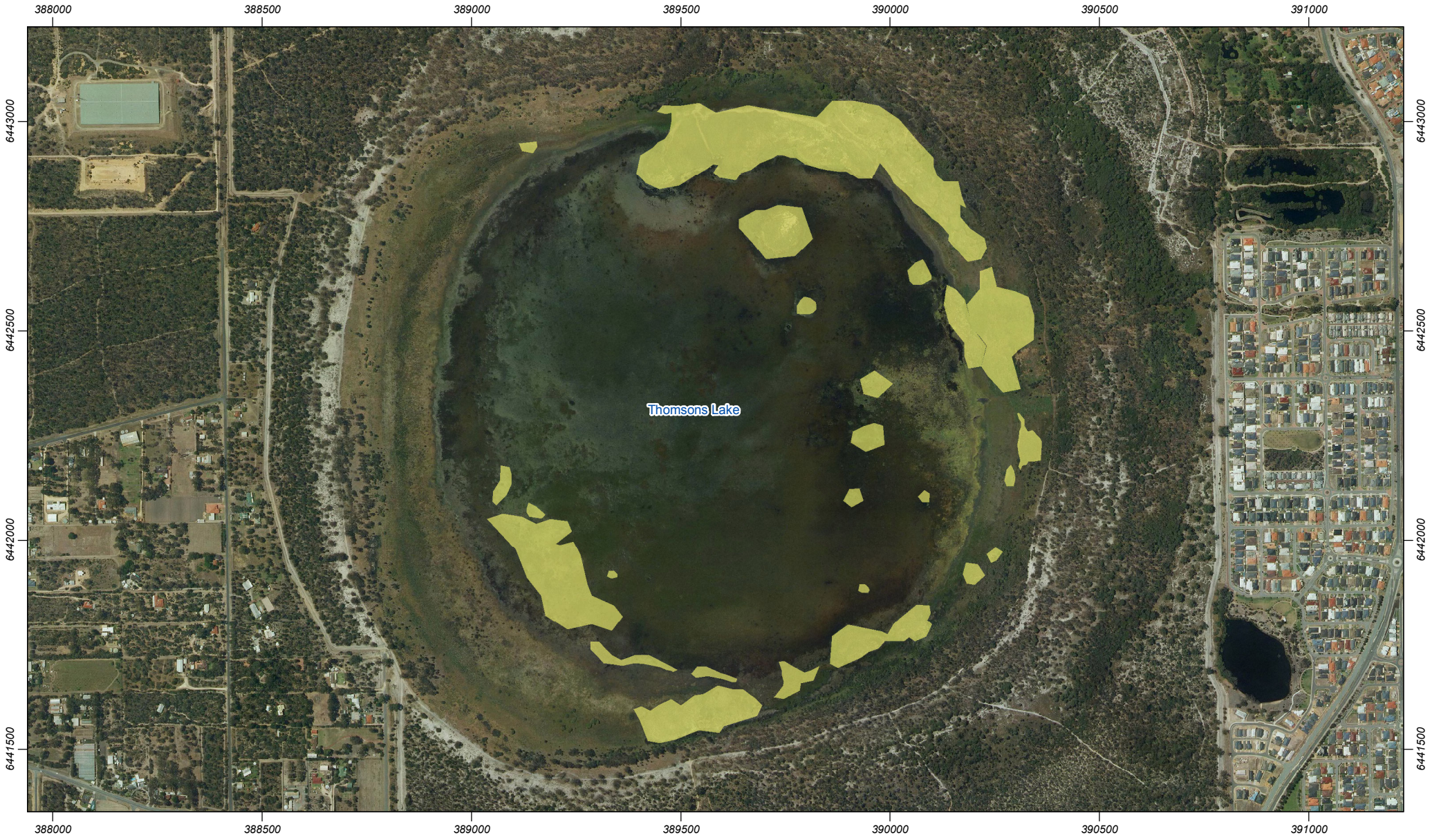


Figure 4: Distribution of **T. orientalis* around Thomsons Lake

Scale 1:12,500 at A4

0 100 200 300 400 500 m

Coordinate System: GDA 1994 MGA Zone 50

Note that positional errors may occur in some areas

Date: 18/12/2015

Author: jcrute

Source: Aerial image: ESRI online approx. 2010. Nature Reserve: DPAW 2014. Development envelope: Client 2015

Legend

- Current *Typha* extent based on desktop analysis and 2009 *Typha* mapping by DPaW
- Project development envelope

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4.3 Recommended methods of control

In consultation with DPaW, herbicides were selected as the preferred treatment to control **T. Orientalis.*

The recommended method of herbicide treatment for the control of **T. orientalis* is through the use of Glyphosate biactive approved for aquatic use (at 2% strength or manufacturers guidelines) in conjunction with a sticking agent. Given the target site contains wetland vegetation and open water, the use of wetting agents is not recommended as these have the potential to contaminate waterways and impact on native fauna. It is recommended that **T. orientalis* be brush cut as close to the base of the stem as possible (approximately six weeks after herbicide application) to minimise the chances of regrowth. Herbicide application will be undertaken by a mixture of two techniques:

- motorised pump
- wiping.

4.4 Management actions

Management actions required to implement this TOCP successfully are outlined in the sections below and are summarised in Table 4.

4.4.1 Herbicide application and brush cutting

Populations of **T. orientalis* within Thomsons Lake Nature Reserve will be segmented into target areas (determined after assessment and mapping activities outlined in Section 4.2) prior to control activities commencing. The exact method of herbicide application will be determined during control activities. A variety of different methods may need to be used within Thomsons Lake Nature Reserve due to site conditions. These are, application via:

- directed motorised pump to targeted areas four-wheel-drive vehicle: in areas with existing vehicle access tracks and areas of sparse vegetation
- wiping with a 'wand': in sensitive areas where four wheel drive application cannot be used due to the risk of damage to native vegetation i.e. amongst existing clumps of native rushes.

Brush cutting will take place following herbicide application in areas not inundated with water. Due to the nature of the site (i.e. within a Nature Reserve with limited access), **T. orientalis* will be brush cut as close to the base of the stem as possible and left to break down as it lies.

Brush cutting will only take place if a minimum 90% of **T. orientalis* within the target area is observed to be dead 4-6 weeks after initial herbicide application. If this is not achieved, the target area will be subjected to additional herbicide application prior to brush cutting.

Herbicide application and brush cutting will be undertaken at the following approximate intervals over the course of the program:

- initial herbicide treatment – January every year
- brush cutting – mid February every year (approx. 4-6 weeks after herbicide application)
- second herbicide treatment (spot spraying) – March every year.

4.4.2 Expertise

The safe and effective application of the herbicide to eradicate **T. orientalis* in Thomsons Lake Nature Reserve requires relevant training and expertise. These measures are outlined below:

1. All personnel undertaking control activities will have plant identification skills – both native and introduced species.
2. All personnel undertaking control activities will have a WA Pest Management Technicians Licence issued under the Health (Pesticides) Regulations 2011.
3. The contractor undertaking control activities must be a registered pest management business in accordance with the Health (Pesticides) Regulations 2011.
4. The contractor undertaking control activities shall place signs at all entrances to public access ways and around the perimeter of the treatment area at no more than 200 m intervals. Warning signs must be as per the Health (Pesticides) Regulations 2011.

Table 4: Management actions

Item	Management actions	Purpose	Timing	Responsibility
Site preparation				
1	Undertake a pre-control survey to confirm the extent and percentage cover of the **T. orientalis* infestation within the target areas shown in Figure 4 and to determine baseline condition at ongoing monitoring quadrats (refer to Section 5).	To understand where herbicide application activities should be targeted	Prior to herbicide application	Weed control contractor
Hygiene control measures				
2	Wash down all vehicles and equipment prior to exiting known infested or uninterpretable areas of Thomsons Lake Nature Reserve, as mapped by Glevan consulting (2014) (see Figure 3)	To prevent introduction of dieback and weeds into uninfested areas of Thomsons Lake Nature Reserve	Prior to entering Thomsons Lake Nature Reserve	Weed control contractor
Safety and environmental harm				
3	Ensure all herbicide spray operators have a WA Pest Management Technicians Licence issued in accordance with the Health (Pesticides) Regulations 2011.	To ensure all operators are suitably qualified in the application of herbicides	At all times	Weed control contractor
4	Apply a non-toxic, water-soluble, biodegradable coloured dye to the herbicide mix to ensure the mixture will be clearly visible for at least 48 hours after the herbicide application.	To allow for thorough herbicide application, to minimise double spraying of herbicide and to make public aware of where herbicide has been used	During herbicide application	Weed control contractor
5	Ensure a biodegradable sticking agent is used instead of a wetting agent in the herbicide mix.	To prevent impact of herbicide on surrounding wetlands and water bodies	During herbicide application	Weed control contractor
6	Ensure that the pressure of herbicide application via spray is kept to a level that prevents excessive spray drift.	To prevent impact on surrounding native vegetation, persons and property	During herbicide application	Weed control contractor
7	Ensure weather conditions are suitable for the spray technique, site and chemicals to be used (i.e. wind are less than 10 km per hour, temperatures are less than 35 degrees Celsius, rain is not forecast or anticipated within 4 hours, vegetation is not wet with dew or rain).	To ensure successful and safe application of the herbicide	Throughout program – prior to spraying	Weed control contractor
8	Erect signage stating that herbicide application is in progress (or similar) at all major entrances and access ways.	To ensure successful and safe application of the herbicide	Throughout program – prior to spraying	Weed control contractor
9	Use measuring containers for all liquid herbicides and scales for accurately measuring granulated herbicides.	To ensure successful and safe application of the herbicide	Throughout program – prior to spraying	Weed control contractor
10	Ensure the identity of any Threatened or Priority species known to occur in the area is clearly understood by operators (refer to mapping outlined in Section 4.2).	To ensure successful and safe application of the herbicide	Throughout program – prior to spraying	Weed control contractor
11	Ensure the presence/absence of susceptible, non-target species is clearly understood by operators (refer to mapping outlined in Section 4.2).	To ensure successful and safe application of the herbicide	Throughout program – prior to spraying	Weed control contractor
12	Ensure the locations of sensitive habitats are clearly understood by operators (refer to mapping outlined in Section 4.2).	To ensure successful and safe application of the herbicide	Throughout program – prior to spraying	Weed control contractor

Item	Management actions	Purpose	Timing	Responsibility
13	Inspect all chemical containers daily for leaks to avoid the possibility of environmental or cross contamination.	To prevent hazardous material spills	Ongoing - daily	Weed control contractor
14	Transfer contents of any leaking containers immediately to an intact empty container of the same type, or if none is available, a thoroughly rinsed container which is then clearly labelled and used as soon as possible.	To prevent hazardous material spills	Ongoing	Weed control contractor
15	Ensure Attapulgite, a shovel and a recovery drum is present on all vehicles.	To clean up any hazardous material spills	Ongoing	Weed control contractor
16	Report any chemical spill involving more than 1 L of concentrate chemical or 10 L of mixed chemicals to the Department of Health.	To prevent impact on surrounding native vegetation, persons and property	During herbicide application	Weed control contractor
Methodology				
17	Ensure all operators flag off areas that have been treated each day.	To ensure all **T. orientalis* plants are treated	During herbicide application	Weed control contractor
18	Undertake herbicide application using one or all of the following techniques as suits site conditions: • vehicle with mounted motorised pump • wiping with a wand.	To control **T. orientalis* occurrences	• Initial treatment – January every year • Second treatment – March every year	Weed control contractor
19	Undertake brush cutting of *T. orientalis* after initial herbicide application (refer to Section 4.4.1)*.	To control **T. orientalis* occurrences	4-6 weeks after initial herbicide application*	Weed control contractor

* Brush cutting will only be undertaken if criteria outlined in Section 4.4.1 are met.

5. Monitoring program

The monitoring program described in this section covers monitoring of the **T. orientalis* population within Thomsons Lake Nature Reserve to determine population changes.

5.1 Monitoring methodology

Monitoring of the **T. orientalis* population within Thomsons Lake Nature Reserve will be undertaken via visual observations and/or review of aerial photography within target areas as defined in section 4.2. Data collected from each target area will include:

- GPS location
- Percentage cover of **T. orientalis* (alive and dead)
- representative photograph from a designated photo point.

Monitoring activities will also focus on noting areas requiring potential additional control on a map to inform follow up herbicide application activities.

5.2 Timing

Target areas will be monitored once between April-May prior to initial control activities commencing to establish baseline data. If approval periods render this timeframe unviable, monitoring will be carried out between July–December to maximise recording of weed prominence following winter rains. This will ensure monitoring is carried out prior to the optimum herbicide application period of end of December-February.

Ongoing monitoring will occur once per annum between April-May from commencement of the initial herbicide application event until completion criteria has been achieved or as otherwise agreed by the CEO of the OEPA or DPaW.

6. Completion criteria

The TOCP will be considered successful and thus complete when alive percentage foliage cover of **T. orientalis* within Thomsons Lake Nature Reserve (measured within target areas) are 80% lower than baseline levels or as otherwise agreed by the CEO of the OEPA or DPaW.

7. Responsibilities

This section provides a summary of the key personnel involved in implementation of the TOCP and their roles and responsibilities.

Table 5: Roles and responsibilities

Role	Responsibility
Main Roads	• Main Roads has the overall responsibility for the implementation of this TOCP • the roles below may be delegated to a contractor by Main Roads • if the roles are delegated, Main Roads has the responsibility to audit compliance and ensure any contingency actions are implemented.
Environmental manager	• overall accountability for auditing and compliance assessment with this TOCP to ensure it is maintained and meets objectives and targets • provide technical support to all Project personnel to ensure this TOCP is implemented correctly and complied with • implement and maintain this TOCP, review its effectiveness and review the implementation as required • undertaking ongoing monitoring and documenting monitoring results • assess the performance against triggers • liaise with stakeholders and technical advisors for advice and resolution of management aspects/objectives as required • review and close out any contingency actions • report as required to regulating authorities • may delegate all or part responsibility to an appropriately qualified person • providing data to Main Roads for inclusion in the annual compliance report.
Weed contractor	• support the proponent's *T. orientalis* management initiative and culture • comply with all legal requirements and the requirements of this TOCP • ensure staff employed are adequately trained in *T. orientalis* management • ensure all personnel involved in the project will adhere to TOCP requirements • seek advice from proponent when in doubt about requirements.
All personnel	• must receive induction prior to commencement of work on site • comply with all legal requirements and the requirements of this TOCP • report incidents to their Supervisor or Site Environmental Coordinator • attend environmental inductions and any other training required • participate in toolbox meetings and suggest improvements to management practices.

7.1 Funding arrangements for implementation of the program

Funding for implementation of the TOCP will be provided to the appointed contractor by Main Roads for the duration of the program.

8. Review and reporting

8.1 Review and revision

The TOCP will be formally reviewed on an annual basis. If monitoring results shows no reduction in *T. orientalis* percentage cover compared to baseline data, management actions will be reviewed and revised. Any proposed amendments to the plan will be provided to the CEO of the OEPA for approval prior to implementation.

8.2 Reporting

A brief summary report will be produced following each monitoring event with a final report summarising the results of the entire program produced in 2018 following completion of the program.

Each report will contain the following:

- **T. orientalis* control activities undertaken between reporting intervals
- percentage cover (dead and alive) of **T. orientalis* within each target area
- a comparison of **T. orientalis* percentage cover within each target area to baseline data and data from the previous monitoring event
- a representative photograph from a designated photo point within each target area.

9. References

AECOM 2012a, *Flora Vegetation and Fauna Management Plan*, report prepared for Main Roads Western Australia.

AECOM 2012b, *Rehabilitation Strategy*, report prepared for Main Roads Western Australia.

Department of Conservation and Land Management (CALM) 2005, *Thomsons Lake Nature Reserve Management Plan – Management Plan No. 54,* Government of Western Australia, Perth.

Environmental Protection Authority (EPA) 2013, *Report and recommendations of the Environmental Protection Authority: Roe Highway Extension – Main Roads Western Australia. Report 1489 – September 2013*, Environmental Protection Authority, Perth, Western Australia.

Gibson N, Keighery BJ, Keighery GJ, Burbidge AH & Lyons MN 1994, *A Floristic survey of the southern Swan Coastal Plain,* report prepared for the Australian Heritage Commission, 1994.

Glevan Consulting 2014, *Thomsons Lake Nature Reserve – Phytophthora Dieback occurrence assessment – Version 0.5*, report prepared for Dieback Working Group, Perth, Western Australia.

Heddle EM, Loneragan OW & Havel JJ 1980, *Darling System, Vegetation Complexes*, Forest Department, Perth.

Hussey BMJ, Keighery GJ, Dodd J, Lloyd SG & Cousens RD 1997, *Western Weeds – A Guide to the weeds of Western Australia,* 2nd edn, The Plant Protection Society of Western Australia (Inc.), Perth.

South Metro Connect 2011, Roe Highway Extension Public Environmental Review, report prepared for Main Roads Western Australia, 2011.

South Metro Connect 2013, Roe Highway Extension Response to Public Submissions, report for Main Roads Western Australia, 2013.

Western Australian Herbarium 1998-, FloraBase – the Western Australian Flora, [Online], Government of Western Australia, Available from: http://florabase.dpaw.wa.gov.au/ [28 May 2015].