

FINAL REPORT

Wheatbelt Wetlands Assessment

Prepared for

Department of Water

for the Wheatbelt Drainage Evaluation

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**Department of
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Our environment, our future



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1 Executive summary:

Evaluating the biological impacts of discharging saline and possibly acidic water from Wheatbelt drainage schemes into wetlands is difficult. This project further developed the processes that the Drainage Impacts Working Group, hosted by the Department of Environment and Conservation (DEC) under the State Wetlands Coordinating Committee proposed in their Framework for Evaluation of Drainage Proposals 2003. This Wheatbelt Wetlands Assessment is an important piece of wetland research conducted by the Wetlands Section of the DEC and is part of a larger program managed by the Department of Water (DoW): "Wheatbelt Drainage Evaluation – Framework for Implementation" (WDE). The WDE is funded by the Australian and West Australian governments through the National Action Plan on Salinity and Water Quality.

The project was identified to assist in streamlining the Notice of Intend to Drain (NOID) approach by identifying wetlands in the Wheatbelt that may potentially receive drainage water and to develop cost-effective and rapid assessment protocol to evaluate potential impacts on these systems.

The project ended slightly behind schedule, but all the objectives were met except for the final peer review of the rapid assessment protocol and subsequent endorsement by the Wetlands Coordinating Committee. Also, uploading of the data onto WetlandBase has become a more complex issue than originally anticipated. In most cases, the level of detail was exceeded - a total of more than 40,000 entities (wetlands and granite outcrops) were mapped and more than 20,000 wetlands were classified for conservation significance. The project was completed within the allocated budget. The following deliverables were produced as a result of the project objectives:

- *Regional identification of specific wetland types in the Wheatbelt region of Western Australia (Stage One level): methodology and outcomes* ([Lizamore 2008a](#))
- *Wetlands of the Wheatbelt and other prioritised areas: Metadata* ([Lizamore 2008b](#))
- *Notice of Intent to Drain: Field manual for Rapid Assessment or Initial Inspections for the Department of Environment and Conservation of Western Australia* ([Lizamore et al 2008b](#))
- *GIS datalayer: Wetlands of the Wheatbelt and other prioritised areas* ([Lizamore et al 2008a](#))

In addition to the project requirements, other milestones were reached and significant linkages made with other projects, these are detailed in Section 7: [Additional achievements](#) and Section 8: [Linkages with other activities](#) respectively. However the project failed to address all issues encountered and various research and information gaps have been identified. These are indicated in Section 10: [Recommendation for future work](#).

2 Background

An excess of 7 million tons of wheat and related produce are produced in the wheatbelt of Western Australia (WA) annually ([ABS 2006](#)). This production does not come without an environmental cost. Groundwater aquifers throughout the wheatbelt have become salinised, risen considerably and resulted in extensive, secondary salinisation of surface soils as a result of the widespread clearing of native vegetation to accommodate agricultural production. The process of salinisation (e.g. [Hart 1990](#), [Schofield et al. 1988](#)) and its negative effect on biodiversity (e.g. [Keighery et al. 1999](#), [Halse et al. 2003](#)) have been widely documented.

Deep drainage is one engineering solution that may halt the spread of salinity and, in some cases, recover salinised land. In order to do this, drainage water have to be discharged downstream. However, the downstream impacts of discharging drainage water may be severe and will be related to the quality of discharge water, the change to natural hydrological regimes and the nature of the receiving landscape.

To ensure a managed approach to drainage, the Office of the Commissioner for Soil and Land Conservation administers the *Soil and Land Conservation Act 1945* and the *Soil and Land Conservation Regulations 1992* with the support of the Department of Agriculture and Food of WA and other government agencies. All landholders planning to drain or pump water need to complete the “Notice of Intent to Drain” or Pump Water.

Although several methodologies exist to evaluate the potential impacts on the downstream environment, all require detailed information, are reported to be time-consuming, costly and not accurate enough. In order to address some of these concerns and potentially expedite the NOID process, the DoW and the DEC initiated the Wheatbelt Wetlands Assessment to identify potential natural receptor basins capable of receiving drainage water. This included a GIS mapping layer of the wetlands in the wheatbelt, an evaluation of their conservation significance and a rapid assessment protocol to evaluate the risk of potential impacts on the wetlands.

A Drainage Evaluation Project Advisory Group was established to assist and guide the project team. The Project Advisory Group (PAG) consisted of:

- Barbara Cook (Research Fellow – University of Western Australia)
- Catherine Prideaux (Acting Wetlands Conservation Coordinator – DEC)
- Ken McIntosh (Team Leader: Salinity Engineering – DoW)
- Ken Wallace (Manager Natural Resources Branch – DEC)
- Lance Mudgway (Regional Hydrologist – DEC)
- Adrian Pinder (Senior Research Scientist – DEC)
- Richard Silberstein (CSIRO Land and Water)

Several other specialists attended the PAG meetings to assist in providing technical advice and input:

- Andrew Watson (Commissioner for Soil and Land Conservation – DAFWA)
- Anna Leung (Technical Officer – DEC)
- Bruce Bone (Regional Manager – DEC)

- Buddy Wheaton (Research Officer – DAFWA)
- Danielle Halliday (Technical Officer – DEC)
- Holly Smith (Acting Wetlands Conservation Coordinator - DEC)
- Jane Filmer (Project Coordinator – DoW)
- Jenny Davis (Associate Professor - Murdoch University)
- Lien Sim (Research Scientist – DEC)
- Michael Coote (Ramsar Coordinator – DEC)
- Natalie Smart (Research Officer - CSIRO Land and Water)
- Peter Hudson (Consultant – Rokit Science, software developer for DoW)
- Ryan Vogwill (Hydrologist/Hydrogeologist – DEC)
- Susan Jones (Research Scientist – DEC)
- Wayne Elliott (Acting Regional Manager – DEC)
- Stuart Halse (Senior Research Scientist – DEC)

3 Objectives

The original project objectives were described as:

1. By January 2008, complete an objective and transparent assessment, at a scale of 1:100,000, of the condition of the basin wetlands in the Wheatbelt that are most likely to receive drainage water, and assign them to three broad categories (near natural, significant anthropogenic disturbance & considerable anthropogenic disturbance).
2. By January 2008, complete an objective and transparent assessment, at a scale of 1:250,000, of the condition of all remaining basin wetlands in the Wheatbelt, and assign them to three broad categories ('near natural', 'significant anthropogenic disturbance' & 'considerable anthropogenic disturbance').
3. By June 2008, produce a cost-effective protocol to evaluate the biological and ecological values of, and effect of drainage on Wheatbelt wetlands that have undergone 'significant anthropogenic disturbance'.

Apart from delays in projected timelines, all of the above objectives were met and are discussed in greater detail below in Section 5: [Project deliverables](#). The project was divided into 2 stages, Stage 1 having consisted of Objectives 1 and 2 (i.e. mapping and classifying the wetlands) and Stage 2 the development of the NOID rapid assessment criteria.

During the course of the project, the initial intended classification description (as indicated in Objectives 1 and 2) changed from 'near natural', 'significant anthropogenic disturbance' & 'considerable anthropogenic disturbance' to 'high', 'medium' and 'low' *conservation significance* (Jones *et al* [2008a in prep:9](#)).

At the meeting of the Drainage Evaluation Project Advisory Group on 7th March 2008 it was also resolved to change Objective 3 to include all categories of basin wetlands. The objective therefore now reads:

- 3 By June 2008, produce a cost-effective protocol to evaluate the biological and ecological values of, and effect of drainage on basin wetlands in the Wheatbelt that have been assigned the above broad categories.

Note that this now refers to Wheatbelt basin wetlands of high, intermediate and low conservation significance.

4 Prioritised areas

The following areas were prioritised for inclusion in the project and for evaluation at a scale of 1:100,000. These areas were identified by staff in the Salinity Program of the Department of Water (K. McIntosh, pers. comm.) and they are indicated on the map in [Appendix A](#). It included areas prone to salinisation, where drainage has been used as a salinity management tool, where landholders are showing increased interest in using drainage as a salinity management tool and where current NOID proposals are being reviewed. They are listed and are indicated in the order of priority below:

1. Avon North-East (Yilgarn Catchment);
2. Yarra Yarra Lakes system
3. Yenyening Lakes system;
4. Lockhart system;
5. Blackwood River Catchment;
6. Mortlock river Catchment;
7. Dalyup, Lort and Young River Catchments including (South Coast);
8. Eastern parts of the Moore river system.

The project area was adapted during the course of the project to include areas beyond the clearing line in the Avon catchment (pers. comm. Susan Jones) and additional areas within the Bandy Creek catchment (pers comm. Tilo Massenbauer). A map of the final project area is shown in [Appendix B](#), it includes an indication of the mapping scale used for the assessment, as per [Objectives 1 and 2](#) above.

5 Project deliverables

[Objectives 1 and 2](#) duplicated the initial requirements of the Avon wetland baselining project, coordinated by Dr Lien Sim (and later taken over Susan Jones). To avoid duplication, and improve efficiency, the two projects amalgamated efforts. The Avon baselining project was responsible for developing the predictive modelling tool in order to initially assign identified wetlands into three broad conservation value classes for the entire Wheatbelt (including the Avon). This was done as a remote sensing exercise by measuring and predicting attributes such as wetland vegetation changes on the wetland fringe and by using the indicator results to predict wetland disturbance and conservation significance. This assessment method is described by Jones ([2008a in prep](#)).

As the basis for this process, a remotely-sensed wetted extent layer was produced from Landsat imagery (as described by [Behn, 1990](#)) and used to map the location of wetlands within the study area. John Lizamore took responsibility for refining and augmenting the remote sensing this wetland layer at a scale of 1:100,000 for the prioritised areas in the Wheatbelt. A wetland mapping methodology was developed ([Lizamore 2008a](#)) and it has

been endorsed by DEC's Wetland Status Working Group, a sub-group of the Wetlands Coordinating Committee in accordance with departmental criteria ([DEC 2006](#)).

Ben Smith initially took responsibility for refining and augmenting the remote sensing of the wetland layer for the Avon catchment NRM region outside the prioritised areas, to a scale of 1:100,000. When Ben left the Department, two additional data-capturers (Danielle Halliday and Anna Leung) were appointed. Due to budget and time constraints, areas in the Wheatbelt falling outside of both the prioritised areas and the Avon catchment NRM region were only mapped at a scale of 1:250,000.

The final product is available as a GIS datalayer entitled *Wetlands of the Wheatbelt and other prioritised areas* ([Lizamore et al 2008b](#)). It is DEC's intention to make this layer and the classification undertaken by Jones et al ([2008a in prep](#)) available online on WetlandBase on DEC's Naturebase website. Refer to www.dec.wa.gov.au > Management and protection > wetlands. The GIS datalayer, containing more than 40,000 entities (wetlands and granite outcrops), will also soon be available to DEC personnel on the internal GIS system 'DECGIS'. A summary of wetland numbers is provided in [Table 1](#).

[Objective 3](#) involved verifying the accuracy of the wetland evaluation methodology developed by Jones et al ([2008a in prep](#)). Jones et al ([2008b in prep](#)) developed a methodology for assessing wetland condition to a stage 3 assessment level, as described by *Framework for mapping, classification and evaluation of wetlands in Western Australia* ([DEC 2006](#)). This methodology was utilised to evaluate 67 wetlands in the WA Wheatbelt during September to November 2007, whilst more than a 100 additional sites were visited but not sampled. Staff of the Avon baselining project verified the accuracy of the wetland evaluation methodology for all sites visited within the Avon catchment, whilst Wheatbelt Wetland Assessment staff verified the accuracy of assessment methodology for sites visited outside of the Avon catchment. Dave Cale (DEC), Ross Gordon (DEC) and Russ Shiel (Russell J. Shiel & Associates Environmental Consultants) were appointed to sort and identify the aquatic invertebrates from the sampled wetlands; Grant Pearson (Bennelongia Environmental Consultants) was appointed to undertake bird surveys. Water chemistry analysis was also undertaken for each wetland by the Perth Chemcentre.

The information collated, along with other existing monitoring data was utilised to further refine, augment and correct the spatial wetlands layer *Wetlands of the Wheatbelt and other prioritised areas* ([Lizamore et al 2008b](#)). Findings were incorporated into changes to the mapping methodology ([Lizamore 2008a](#)) to indicate the accuracy of the compiled spatial layer and to ensure that the data was of an acceptable standard according to DEC guidelines ([DEC 2006](#)). This also included recommendations for future improvements to the accuracy of the datalayer.

Initial site verification of wetland boundaries indicated less than 1% error at the intended usage scale of 1:100,000 (Lizamore [2008a](#) and [2008b](#)). There was no verification for areas mapped at 1:250,000 scale. Despite the success of the verification, the verification can not be considered as representative as less than 200 wetlands were visited out of more than 40,000 entities that were mapped. As such, the GIS datalayer can only be used as an indication of the presence of wetland for regional planning purposes and further field verification is essential for individual sites where drainage is proposed.

Catchment name	Granite outcrops	Basin	Basin > 1ha	Channel	Flat	Reservoir	Reservoir > 1ha	Slope	Total
Avon-Lockhart	1719	3838	3077	196	419	389	37	19	6544
Avon-Main	509	331	156	36	40	24	2	4	945
Avon-Mortlock	586	2997	2452	179	980	95	11	10	4842
Avon-Salt	165	178	161	65	53	1	0	4	465
Avon-Yilgarn	3336	5541	4853	198	438	290	92	76	9806
Bandy Creek	12	3677	2585		1	36	2		3726
Coolmalbidgup Creek	0	237	160			3	2		240
Culham Inlet & Phillips West	30	79	50	7	1	8	0		124
Blackwood-Hardy Estuary	143	95	90	585	227	28	7	26	1104
Blackwood-Cobline	213	430	350	577	714	45	20	14	1993
Blackwood-North Arthur River	35	58	53	126	49	12	1	10	290
Lake Gore	4	2423	1641	3		18	4		2448
Lake Moore	117	333	272	14	25	46	3		530
Magenta Internal	74	1126	642	30	66	59	6	12	1367
Moore River	3	1776	1647			1	1		1780
Stokes Inlet, Lort & Young River	180	662	448	4		40	9		886
Yarra Monger	141	4461	3287	15	156	24	17		4797
	7267	28242	21924	2035	3169	1119	214	175	41887

Table 1: Numbers of wetlands mapped as part of the GIS datalayer *Wetlands of the Wheatbelt and other prioritised areas* (Lizamore et al 2008b). Shaded areas indicate wetlands/data that was classified by Jones et al (2008a in prep) for conservation value.

The objective of Stage 2 was to identify the most cost- and time-effective indicators of wetland condition and change so that a rapid assessment approach to evaluating potential downstream impacts from drainage proposals can be used. Although several more intensive methodologies exist for assessing impacts of drainage on downstream systems, these have been termed as too time consuming and expensive to utilise. These include (but are not limited to):

- *Impacts of Rural Drainage on Nature Conservation Values: Proposed Evaluation Guidelines* (RFQ46510/99) (Coleman & Meney; 2000a).
- *Impacts of Rural Drainage on Nature Conservation Values- Cost-effectiveness of the Environmental Impact Assessment: Process for Evaluating Drainage Proposals* (RFQ46510/99) (Coleman & Meney; 2000b).
- *Impacts of Rural Drainage on Nature Conservation Values. Nyabing Case Study 1: Self Assessment* (RFQ46510/99) (Coleman & Meney; 2000c).
- *Impacts of Rural Drainage on Nature Conservation Values. Nyabing Case Study 2: Technical Assessment* (RFQ46510/99) (Coleman & Meney; 2000d).
- *Review of safe disposal in salinity management for preparing engineering options* (Technical Report for Water and Rivers Commission). (Coleman & Meney; 2003)
- *Impacts Assessment and Management of Drainage- Water Discharge to Lakes in the Moore River Catchment, W.A.* (Sinclair; 2008).

- *Evaluating the conservation significance of basin wetlands within the Avon Natural Resource Management region: Stage Three Assessment Method.* (Jones *et al.*: [2008b in prep](#)).

A rapid assessment tool based on a risk assessment approach was therefore developed (Lizamore *et al* 2008a). Dave Cale was appointed to assist in developing the biotic component of the protocol and several other people assisted by contributing time and comments (as listed in the Section 11: [Acknowledgement](#))

The rapid assessment protocol consists of background information (explaining the reasoning behind the protocol), an Excel spreadsheet for scoring risks and impacts of wetlands identified that may potentially receive drainage water, and information to explain the use of the spreadsheet. This assessment protocol utilises the information contained within the GIS datalayer *Wetlands of the Wheatbelt and other prioritised areas* ([Lizamore *et al* 2008b](#)) and the classification undertaken by Jones *et al* ([2008a in prep](#)). It was field tested during September 2008 on 54 wetlands situated in various parts of the wheatbelt. Tested wetlands included:

- 'Low', 'Intermediate' and 'High' conservation value wetlands as described by Jones *et al* ([2008a in prep](#));
- Wetlands currently receiving drainage water
- Wetlands that have been identified as potential receptor basins for receiving drainage water as described in the NOID process.

The results from the field trials were utilised to further develop the rapid assessment protocol and refine the classification by Jones *et al* ([2008a in prep](#)). The field trials also contributed to Regional Scale Drainage Evaluation (one of the project milestones) by assessing 5 potential drainage sites in the Narembreen area. Some of the case studies were included as examples in the rapid assessment protocol.

6 Project milestones

[Table 2](#) provides the project milestones (with target dates) and the actual outcome delivered (with dates). The project required a four month extension. All milestones were reached except for the final peer review of the rapid assessment protocol (due early November 2008), and subsequent endorsement by the Wetlands Coordinating Committee (WCC). If the peer reviews are received in time the WCC may review the protocol in mid November, otherwise the next meeting is February 2009. Also, uploading of the data onto WetlandBase has become a more complex issue than originally anticipated and it will require additional input of resources. In the mean time the GIS datalayer *Wetlands of the Wheatbelt and other prioritised areas* will be available to DEC staff.

Due to the extra detail provided in the final deliverables, none of the target dates were met. Despite project delays and delivering more detailed information than initially intended, the project costs remained within the allocated budget (See [Table 3](#) for more information).

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Milestone	Target Date	Deliverables	Completed Date
Contract in place with DoW	30 Jun 2006	Contract with milestones of deliverables and reporting	
Appoint Phase 1 staff	01 Feb 2007	Technical Officer, Wetland Evaluation in place	01-Feb-07
Appoint GIS technical assistants	23 Apr 2007	GIS technical assistants in place	23 Apr 07
Conduct consultations with wetland ecologists and hydrologists for evaluation of wetlands downstream from selected drainage sites	30 Apr 2008	Sites for evaluation selected, evaluation parameters and condition indicators agreed	30 Sep 2008
Complete Drainage Evaluation Protocols for small scale and Catchment Scale Drainage	30 Jun 2008	Draft Drainage Evaluation Protocol for Catchment Scale Drainage endorsed by project advisory committee	29 Oct 2008
Population of ecological conservation value tables for identified wetlands	11 Jul 2008	Population of ecological conservation value tables for 4 NRM regions	29 Oct 2008
Field verification of wetland classification and evaluation	31 Jul 2008	Field verification of wetland conservation significance tables for 4 NRM regions	21 Oct 2008
Testing of wetland classification in targeted wetlands downstream from selected drainage sites	31 Jul 2008	Wetlands receiving drainage classified under conservation significance tables	30 Sep 2008
Input Into Regional Scale Drainage Evaluation	31 Jul 2008	Final Drainage Evaluation Protocol for Catchment Scale Drainage	30 Sep 2008
Contact consultancy to assist with peer review of draft report	31 Jul 2008	Peer review of draft report undertaken	07 Nov 2008
Complete the listing of ecological conservation value tables for prioritised regions	31 Aug 2008	Endorsement of wetland ecological conservation significance tables for 4 NRM regions by project advisory committee	29 Oct 2008
Input final ecological conservation value tables into State Wetlands Database and make available on-line	31 Aug 2008	Published wetland ecological conservation significance tables for 4 NRM regions	Awaiting GIS section time allocation and update of SLIP portal by Dept of Ag .
Demonstrated effectiveness of Drainage Evaluation Protocols for small scale and Catchment Scale Drainage schemes. Draft Report	31 Aug 2008	Drainage Evaluation Protocols endorsed by Wetlands Coordinating Committee	12 Nov 2008
Final report published	30 Sep 2008	Final Report.	29 Oct 2008

Table 2: Project Milestones, target dates and actual deliveries

7. Additional achievements

Other milestones were reached in addition to the project requirements:

- Assistance to Department of Water in providing wetland data in various areas where drainage proposals have been received. The information has been forwarded to the regional DEC representative (Lance Mudgeway) for further action.
- Participation in the 'AusAID Rehabilitation Assistance Facility: Iraq Program' by supplying technical assistance on remote wetland mapping techniques.
- A mapping methodology has been developed ([Lizamore 2008a](#)) and endorsed by the Wetland Status Working Group, a sub-group of the Wetlands Coordinating Committee.
- A delineation methodology as a field verification technique for wetland boundaries was investigated. A presentation was given to the Wetlands Section of DEC Species and Communities Branch on delineation methodologies used for verification of the remotely delineated wetlands presented within the GIS datalayer *Wetlands of the Wheatbelt and other prioritised areas* ([Lizamore et al 2008b](#)). This was in order to assist DEC to develop a wetland delineation guideline for WA.
- Invertebrate, bird and water quality sampling was undertaken at 67 Wheatbelt wetlands previously unsurveyed. This sampling data will also be available on WetlandBase.
- Extent and distribution data from the GIS datalayer was used as part of a Western Australian trial of National Wetland Indicators ([Sim et al 2008](#)). The Wheatbelt region was chosen for the trial because of availability of comprehensive monitoring data, in particular the datalayer *Wetlands of the Wheatbelt and other prioritised areas*.
- An article entitled 'Mapping Wetlands in the Wheatbelt of Western Australia' was published in the 2008 edition of *Wetlands Australia* ([2008:17](#)) - an annual publication bringing together information and resources from across Australia relating to wetlands conservation, management and education.
- A poster presentation of the project was given at the WA Wetlands Management Conference held on 1st February 2008.

8. Linkages with Other Activities

In addition to its close links with the Avon Baselineing project, the Wheatbelt Wetlands Assessment links with the other projects within the Wheatbelt Drainage Evaluation (WDE) and the Engineering Evaluation Initiative (EEI) programs, particularly in stage 2 where EEI sites will be targeted to test the wetlands classification methodology from onstage 1. The project also links into WetlandBase - the Statewide Wetlands Database, with the indicative conservation significance for wetlands being available on-line through the database as well as in hard copy. WetlandBase will be used to inform the NOID Rapid Assessment protocol. See '[Other milestones reached that were not required by the project](#)' for more information.

9. Financial reporting

The project has gone beyond the original envisaged deliverables and succeeded in providing more detail than originally required. Due to start-up delays (in appointing staff) and other problems experienced (software glitches and climatic factors), the project was not completed by June 2008 as originally intended. However, the original project period was indicated as two years and the project managed to be completed in less time. Furthermore, there was no financial over-expenditure. The details of expenditure till the end of the project are provided in [Table 3](#). The projected remaining funds will be allocated towards additional expenses that will be required to make the data available on WetlandBase and managing possible changes to the data once it is made publicly available.

2007 - 2008 Administration Budget						
Description	2006-2007	2007-2008	July 2008 - Oct 13th	Projected expenditure to the end of the project	Total costs	Explanation
Salaries	51,425.60	102,389.59	14,510.12	8,000.00	176,325.31	Senior technical officer - 21 months salary (128k) 2 x GIS technical officers - 3 months salary (12k each) 1 x project officer - 4 months salary (16k)
Other travel, accommodation, training and meeting expenses	0.00	8,275.28	0.00	2,500.00	10,775.28	Boat handling course, Rangelands Ecology course, Field trips to Wheatbelt
Vehicle lease/rental/hire (government vehicle use)	351.13	7,362.16	3,000.25	2,500.00	13,213.54	Approx 13,000 km at \$0.8 per km
Professional services	0.00	30,821.11	0.00	21,750.00	52,571.11	Bennelongia bird survey, Chem Centre, Russ Shiel invertebrate ID
internally supplied transfer costs	4,850.00	8,097.67	0.00	5,000.00	17,947.67	Woodvale admin costs; Arcview training \$250 x 3; DEC GIS costs
PC software	0.00	1,305.93	0.00	0.00	1,305.93	ESRI licences
Other establishment materials (consumables)	21.79	615.61	8.10	12.00	657.50	Clothing
operational materials	517.41	836.09	0.00	134.00	1,487.50	Map tiles, Phone
TOTAL	57,165.93	159,703.44	17,518.47	39,896.00	274,283.84	
Remaining funds					15,716.16	

Table 3: Summary of financial expenditure for project ([Prideaux 2008](#))

10. Recommendation for future work

The need for the rapid assessment protocol resulted from a lack of information to assess the impacts of drainage proposals (less than 1% of basin wetlands in the wheatbelt have been surveyed). The process could benefit from further study and development in the following areas:

- Mapping of remaining wetlands (types and areas) in the wheatbelt not covered by Lizamore *et al.* ([2008b](#))
- Verification of the mapping done by Lizamore *et al.* ([2008b](#)) to improve accuracy and consistency to the level of a stage 2 assessment ([DEC 2006](#)). This includes:
 - o **Vegetation type:** Current vegetation classes are very broad and based on what was seen on the aerial-photographs. The layer could be improved by verifying/enhancing it with broad-scale infrared band detection. This would indicate certain vegetation types that were not easily detected during the 1st level screening, such as sedges. It might also differentiate between trees and salt-bushes (that are currently one class).
 - o **Vegetation buffer:** Multiple year spatial analysis of several years' of satellite imagery data would be able to indicate how fringing and buffer vegetation has changed. It could also be used to predict changes in buffer vegetation for various wetland types. Lyons ([2004](#)) has undertaken similar work for more than 15 specific wetlands and his empirical data could be used to calibrate the model. Satellite data should be available from as early as 1976 up to 2007.
 - o **Geology and Pedology:** Soil and substrate data could be used to indicate areas where drainage will not be effective (too high clay content, etc) on a broad scale. Pedology information could also be used to indicate areas where wetlands are likely to occur. This could be used to verify wetlands currently included in the layer, as well as indicate possible areas where wetlands were not identified, such as seep zones.
 - o **HGM classification:** The HGM classification ([Brinson 1993](#)) differs from the Semeniuk classification system ([Semeniuk and Semeniuk 1995](#)). This classification was only applied to the Blackwood system and Esperance areas. This data could be used to indicate which wetlands are groundwater dependant and which are surface water dependant.
 - o **Soil wetness:** It is believed that certain infrared and radar bands in satellite imagery can indicate soil wetness. This type of analysis could be used to identify seep zones and other groundwater dependant systems. This could be a valuable indicator of the perennial nature of some of the systems. It would also indicate seep zones, which were very difficult to predict during the 1st level screening done thus far (and believed to not have been captured properly).
- Classification of the remaining wetlands types in the Wheatbelt, other than basin wetlands, in terms of conservation value and/or condition to the same level/standard as prescribed by Jones ([2008a in prep](#)).
- Development of a Wetland Delineation Methodology for the wetlands of the wheatbelt with specific reference to:
 - o Soil indicators and descriptors for different wetness zones and periods of saturation

- o Vegetation indicators and descriptors for different wetness zones and periods of saturation
 - o Topographic indicators.
- Provide workshops to DEC regional personnel on the use of the spreadsheet provided for the field assessment.
- Review and update of the document: *Notice of Intent to Drain: Field manual for Rapid Assessment or Initial Inspections for the Department of Environment and Conservation of Western Australia* ([Lizamore et al 2008b](#)) every 6 to 12 months to reflect relevant scientific changes and improve the effectiveness

11. Conclusion

Although the project has ended behind schedule, all the intended objectives were achieved to the accepted level. In most cases, the level of detail was exceeded - a total of more than 40,000 wetlands were mapped and more than 20,000 wetlands were classified for conservation significance. The project concluded within the allocated budget. The following deliverables were produced as a result of the project objectives:

- *Regional identification of specific wetland types in the Wheatbelt region of Western Australia (Stage One level): methodology and outcomes* ([Lizamore 2008a](#))
- *Wetlands of the Wheatbelt and other prioritised areas: Metadata* ([Lizamore 2008b](#))
- *Notice of Intent to Drain: Field manual for Rapid Assessment or Initial Inspections for the Department of Environment and Conservation of Western Australia* ([Lizamore et al 2008b](#))
- *GIS datalayer: Wetlands of the Wheatbelt and other prioritised areas* ([Lizamore et al 2008a](#))

In addition, the project assisted in delivering and informed the following projects:

- *Evaluating the conservation significance of basin and granite outcrop wetlands within the Avon Natural Resource Management region: Stage One Assessment Method.* ([Jones 2008a in prep](#))
- *Evaluating the conservation significance of basin wetlands within the Avon Natural Resource Management region: Stage Three Assessment Method.* ([Jones 2008b in prep](#))
- *The known effects of groundwater disposal on wetland associated biota.* ([Jones 2008c in prep](#))
- *Trialling a framework and indicators for wetland extent, distribution and condition in Western Australia.* ([Sim et al 2008](#)).
- *Wetland & Riparian Delineation: South African case study of a Practical Field Procedure & the possibility of implementing the principles thereof in the WA Wheatbelt.* ([Lizamore 2008c](#))

The project failed to address all issues encountered and various research and information gaps have been identified. These are indicated in Section 9: [Recommendation for future work](#).

12. Acknowledgements

This project would not have been possible without the guidance and assistance of the following people:

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Appendix A: Initial project boundary (March 2007).



