Department of Environment and Conservation

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DEC Nature Conservation Service

Biodiversity

Monitoring Protocol

Monitoring the effects of stock access and weed invasion on a vegetation unit within the Billeranga System Threatened Ecological Community

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Significant Native Species and Ecological Communities – Resource Condition Monitoring Project

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Table of Contents

1 Introduction

This monitoring protocol provides information and procedures for surveying and monitoring the effects of stock access and weed invasion on the plant assemblages of the Billeranga System threatened ecological community in Morawa, Western Australia (Figure 1).

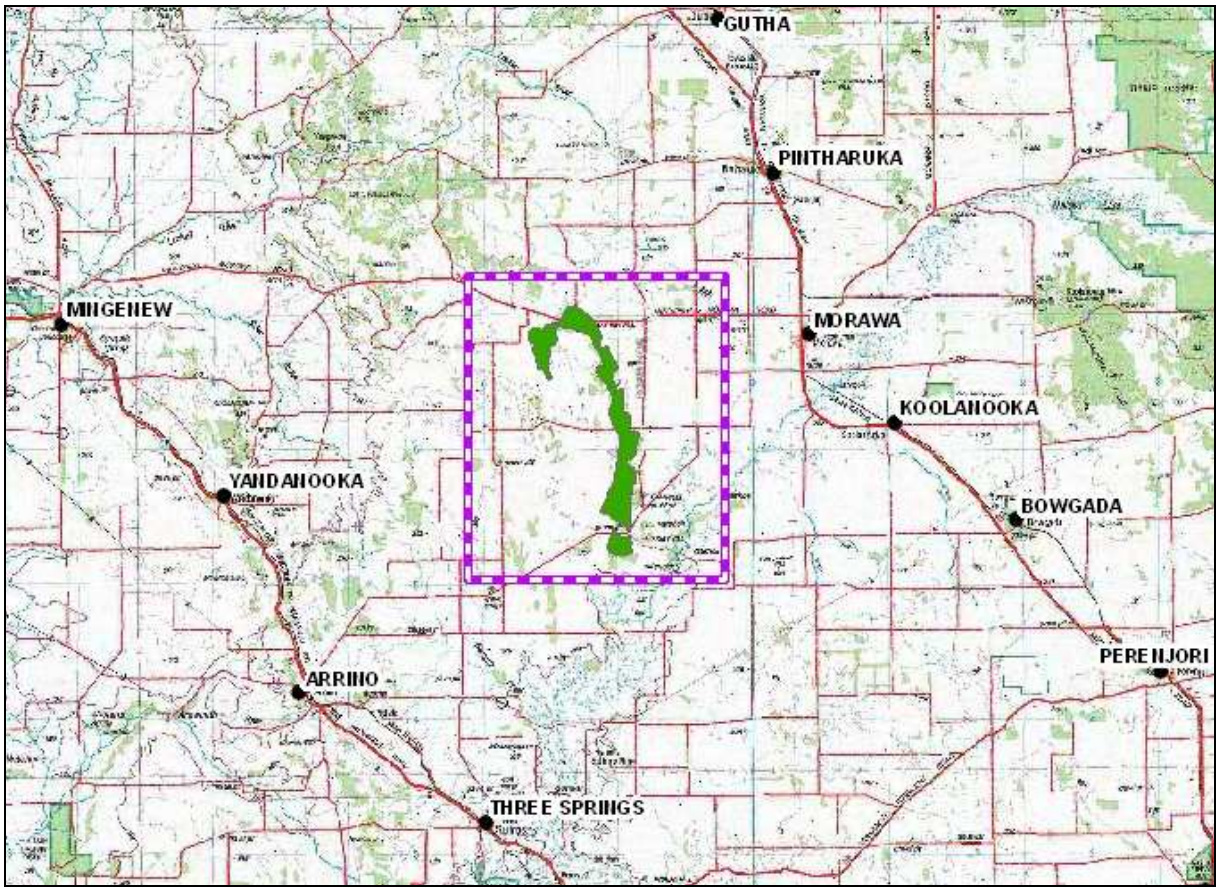

Figure 1 Location of the Billeranga System, Morawa, Western Australia.

2 Protocol Constituents

This protocol consists of this Protocol Narrative and the following Standard Operating Procedures (SOPs):

SOP 4.1:	Setup of the SokkiaTM Axis3 Differential GPS
SOP 4.2	Using an Optical Square
SOP 6.1:	Establishing vegetation quadrats
SOP 6.2:	Establishing vegetation transects
SOP	Collection of Herbarium Specimens (in draft)

3 Background and Objectives

3.1 Background and history

The Billeranga System is located within the Shire of Morawa, an agricultural district approximately 370 km or three and a half hours drive north of Perth. The Billeranga System is a very distinct, small, localised vegetation system restricted to the ridgeline landscape west of Morawa. The threatened ecological community (TEC) is currently ranked as vulnerable (endorsed by the Minister in 2001) and

the TEC boundary is based on mapping by Beard (1976). The mapped TEC boundary covers the outcropping of the Billeranga group of Proterozoic rocks and includes five different vegetation units. The TEC is defined by the following description:

"Melaleuca filifolia – Allocasuarina campestris thicket on clay sands over laterite on slopes and ridges; open mallee over mixed scrub on yellow sand over gravel on western slopes; Eucalyptus loxophleba woodland over sandy clay loam or rocky clay on lower slopes and creeklines; and mixed scrub or scrub.". The "*Melaleuca filifolia – Allocasuarina campestris thicket on clay sands over laterite on slopes and ridges"* vegetation unit is the subject of monitoring established and detailed in this document.

Threats listed for this TEC include: clearing; weed invasion; drought; high intensity and/or too frequent fires; and impacts of stock, such as grazing and trampling. Only 4% of this TEC occurs in conservation reserves (Mt Nunn Nature Reserve).

A 1997 community bushland survey (Australian Trust for Conservation Volunteers, World Wide Fund for Nature and Department of Conservation And Land Management (True and O'Callaghan 1998)) established seven 10 x 10 metre quadrats on private properties across the Billeranga System. The survey was intended to report on the flora and fauna of the area and for the data to be provided to land managers. The data were designed for use as a reference guide by landowners within the study sites. True and O'Callaghan (1998) noted that the data collected are integral to establishing an ongoing monitoring program to determine the impact of on-ground nature conservation works as they are implemented.

Some baseline data have also been collected for the Hidden Treasures project (a joint Department of Environment and Conservation (DEC) and Northern Agricultural Catchment Council (NACC) project) where seven transects (not permanently marked) were set up in the southern portion of the Billeranga System on private property. Additional fieldwork and transects are planned for the southern portion of the range during 2008 by the Hidden Treasures team (E. O'Connor DEC pers. comm.).

3.2 Rationale for selecting this resource to monitor

The Billeranga System TEC has been selected for the establishment of monitoring as part of the Resource Condition Monitoring - Significant Native Species and Ecological Communities Project. Additional baseline floristic survey was also undertaken within the TEC during field work for the project.

The Billeranga System TEC was prioritised for survey as it provides a good example of a vegetation-based TEC that is subject to grazing, for which some baseline floristic survey information exists. However, comprehensive floristic data from systematic survey of the TEC is lacking and monitoring data have previously only been collected within two of the five occurrences of this TEC, and monitoring sites were not permanently marked.

The TEC was also prioritised for development of monitoring as, in addition to having areas subject to grazing, it contains vegetation both within private property and in conservation reserves, and provides an opportunity to monitor across tenures with varying levels of management (fenced and unfenced private property). The TEC also contains a nature reserve, however at present this is only fenced on three sides.

Although boundaries of the vegetation units within the Billeranga System TEC have not been mapped, it appears that the *"Melaleuca filifolia – Allocasuarina campestris thicket on clay sands over laterite on slopes and ridges"* unit forms a majority of the system. For this protocol, monitoring has only been established within this unit. Baseline survey quadrats have been established in other vegetation units within the TEC.

The perceived impacts of stock and weed invasion on community structure and plant diversity will be monitored. Grazing is thought to have caused alterations to the species composition of much of the TEC by selective grazing of edible species, the introduction of weeds and nutrients, and trampling and general disturbance (Hamilton-Brown 2000). Weed levels have been observed to be quite high in all occurrences of the TEC except one (Hamilton-Brown 2000).

Statistical analyses will be undertaken on the monitoring data, which over time, should indicate if the species dominance and composition is changing. It may then be determined whether these changes

are in response to the actions undertaken to manage the identified threats.

The mixed scrub (*Acacia acuminata*, *Allocasuarina campestris* and *Dodonaea inaequifolia*) and *Dodonaea inaequifolia* dominated scrub are restricted to the red loamy soils of the slopes and summits of the southern portion of the Billeranga system, and the latter is thought to occur nowhere else in Western Australia (S.Hamilton-Brown 2000, Beard 1976). These plant communities will be included in baseline floristic survey.

The monitoring proposed for the *"Melaleuca filifolia – Allocasuarina campestris thicket on clay sands over laterite on slopes and ridges"* community within the Billeranga System TEC seeks to answer the following questions:

- is stock access affecting the plant community composition and structure?;
- are weeds more prevalent in unfenced occurrences?; and
- do transects in the fenced occurrences have greater species diversity than occurrences in similar vegetation types on unfenced occurrences?

Although there are currently no programs for weed control in place in the TEC, it is possible that weed control will be undertaken in the future. If weed control work is initiated, the effectiveness of such a program could be determined by developing monitoring that investigated the following monitoring question:

- are weed control activities effective in reducing the density of weed species in transects within the community?

If such monitoring revealed that the weed control was effective in reducing the cover of weeds along transects, it would indicate that the particular weed control measures being used could be continued. However, if the weed control was determined to be ineffective, alternative management measures would need to be employed.

3.3 Measurable objectives

This protocol has the following objectives:

- to establish permanent monitoring transects within the *"Melaleuca filifolia – Allocasuarina campestris thicket on clay sands over laterite on slopes and ridges"* to determine the effectiveness of on-ground management (fencing) in reducing the impacts of stock access and weed invasion on vegetation structure and plant composition in the TEC;
- to provide baseline data that will allow the effectiveness of future management such as weed control to be determined; and
- to establish quadrats for systematic floristic survey of vegetation units communities within the Billeranga system TEC, for which limited information is currently held by the department.

The monitoring will be designed to provide data that can be analysed:

- to determine if weed species are increasing in transects in vegetation where stock are not excluded; and
- to determine if weed species are causing significant change to vegetation structure and plant community composition.

3.4 Benchmarks

Significant changes in plant community composition, dominance and community structure over the longer term may be indicative of adverse effects from stock access and/or weed invasion or may instead be related to other factors, such as climatic factors (for example drought, or current fire regimes).

A benchmark for an acceptable degree of change to this TEC should provide guidance to nature conservation staff in implementing and adapting management. Several vegetation types

(communities) are encompassed within the Billeranga Hills TEC. This project has involved the establishment of monitoring transects within the *"Melaleuca filifolia – Allocasuarina campestris thicket on clay sands over laterite on slopes and ridges"* vegetation unit, from which transects in areas of vegetation in the best condition will be used as a benchmark for acceptable degree of change to the community. Floristic data obtained from the 1997 community bushland survey within this vegetation unit will also be used when defining benchmarks for native species diversity in the community.

Monitoring transect data will be entered into an ordination analysis program (for example Primer) to analyse trends with reference to native and weed species diversity. Analysis will allow any differences in diversity in vegetation between variables (fenced/unfenced) to be assessed, in order to determine whether the fencing appears to be influencing diversity.

Data from survey quadrats established for this project in remaining vegetation units within the Billeranga System TEC may serve as benchmarks for future monitoring of other vegetation units within the TEC. The quadrat data can also be collated and analysed using PATN, and if required may be analysed with data collected for other surveys in the region.

At this point in time there is insufficient baseline information to indicate the time period, or degree of change that should be used as a trigger for management intervention. However, with continued monitoring and discussion of the first round of data analysis with a biometrician, benchmarks for management intervention will be established, and any requirements for further replication of monitoring sites will be determined.

4 Sampling Design

4.1 Rationale for selecting this sampling design over others

For the monitoring detailed in this protocol, transects have been selected as the appropriate method to provide monitoring data relating to plant diversity and responses to perceived threats. Transects are often used to estimate cover and the techniques are well established in vegetation sampling (Elzinga *et al*. 1998).

With reference to the floristic survey undertaken as part of this project, the use of floristic quadrats is considered to be an appropriate tool for sampling floristics, and quadrats are commonly used in Western Australia (EPA 2004). DEC has used 20 x 20 metre quadrats for surveys of the banded ironstone formation that occur in reasonably comparable habitat, and it is therefore appropriate to use the same sized quadrats for this survey.

4.2 Site Selection

4.2.1 Criteria for selection

Monitoring transects were placed within the *"Melaleuca filifolia – Allocasuarina campestris thicket on clay sands over laterite on slopes and ridges"* vegetation unit within the Billeranga System TEC and stratified to encompass the following variables:

- fenced from stock on private property; and
- unfenced private property;

Floristic survey quadrats were placed within vegetation in best condition in the various vegetation units within the TEC.

4.2.2 Procedures for selecting sampling locations

The procedure for selecting monitoring transects and floristic survey quadrats involved an initial desktop study. An A0 sized map displaying colour aerial photography at a high resolution was printed at a scale of 1:200 000. Areas for survey sites which appear to have intact vegetation of suitable size were delineated on the printed map.

Monitoring transect sampling locations were based on the need to establish adequate replicates of the 'management variables' (fenced and unfenced private property) to ensure sufficient power in statistical analysis. Suitable transect sites were marked out on the printed map.

A field reconnaissance visit to sites to confirm suitability for survey and monitoring was undertaken. Sites for the floristic survey quadrats were chosen to target vegetation in best condition on properties owned by land managers willing to participate in the survey and monitoring project, and in vegetation within the nature reserve.

4.3 Sampling replication

Sampling replication was limited to site variables (fenced and unfenced private property).

Monitoring transects are 20 metres in length and are sampled at 50 centimetre intervals starting at 50 cm and ending at 2000 cm. Eight transects were established within the *"Melaleuca filifolia – Allocasuarina campestris thicket on clay sands over laterite on slopes and ridges"* vegetation unit.

The floristic survey of the Billeranga Hills System TEC involved the establishment of 15 quadrats throughout the various vegetation units.

4.4 Recommended number and location of sampling sites

Quadrats and transects need to be placed in areas which cover most of the variability in the vegetation being sampled (Elzinga *et al.* 1998).

Eight monitoring transects have been established and permanently marked with two plastic dumpy pegs within the *Melaleuca filifolia – Allocasuarina campestris* thickets, based on the monitoring site variables (fenced and unfenced private property). An adequate number of transects needs to be established to ensure that conclusions are based on data that are statistically valid. Data collected from the transects will be analysed and discussed with a biometrician to determine whether further transects will be required to collect sufficient data.

For the floristic survey, 15 quadrats have been established and permanently marked with one metal and three plastic dumpy pegs in vegetation in best condition across the range of vegetation units within the TEC.

4.5 Recommended frequency and timing of sampling

Monitoring should be conducted during peak flowering, which for this bioregion is spring, and then repeated at the same time of year at an interval of no greater than 5 years. Sampling during the peak flowering period enables the maximum number of taxa to be recorded and offers the best opportunity to fully identify all plants recorded. Monitoring should occur immediately prior to and after any major management action is initiated (such as weed control).

The floristic quadrats established for the floristic survey should be sampled during the peak flowering period.

4.6 Level of change that can be detected for the amount/type of sampling being instituted

Due to the paucity of baseline data for the Billeranga System TEC and the low level of sampling proposed in this monitoring protocol, the level of change that can be detected is likely to be negligible for a number of years. Other monitoring in WA has indicated that at least 20 years of monitoring is required to obtain useful data (M. Lyons pers. comm.).

The data collected in the first round of monitoring will be analysed through a statistical package (eg. Primer), which should indicate whether the number of replicates installed will provide enough power in analysis to detect significant changes in the data. Discussions with a biometrician may reveal that further monitoring transects are required in order to detect the desired changes.

5 Field Methods

5.1 Field season preparations and equipment setup

Field work must be scheduled and organised prior to the start of each field season. Contact needs to be made with DEC Regional and District staff to schedule field trip dates and access arrangements. Additionally, contact needs to be made with land mangers to access private property occurrences. Prior to working in the field, staff must complete a field advice form and review safety protocols and this protocol.

Observers should familiarise themselves with species (native and weeds) previously recorded for the monitoring and survey sites, by using herbarium specimens, keys, and photographs. Review of GPS navigation and compass use may be necessary prior to fieldwork.

The following are required to undertake the desktop study prior to field reconnaissance:

- digital data including aerial photography, vegetation mapping and tenure information;
- a printed A0 sized map displaying the digital data;
- detailed maps with sites selected;
- species lists and other relevant survey information; and
- management and fencing information.

The following equipment is required to undertake the field component of the reconnaissance visit and the spring survey and monitoring.

- The printed A0 sized map with directions and proposed sites delineated;
- Smaller detailed maps for use in the field and for discussions with landholders;
- Plant collection permits (refer SOP Collection of Herbarium Specimens (in draft));
- Secateurs;
- Plant tags;
- Small paper bags/envelopes;
- Newspaper and cardboard corrugates;
- Plants presses;
- Pens, pencils, permanent thick black marker pens;
- Survey recording sheets (if not using PDA);
- TEC Occurrence Report Forms (Appendix A);
- Bushland Plant Survey recording sheets (Appendix B);
- Transect data recording sheet (Appendix C)
- Digital camera, memory card, batteries;
- PDA with GPS (note if using PDA, electronic data sheets should be loaded);
- GPS (ideally DGPS);
- Survey pegs (1 metal and 3 plastic for quadrats, 2 metal for transects);
- Hammer;
- 2 x 50m measuring tapes;
- Optical square;
- Small blackboard and chalk;

- Point intercept device (long metal pin);
- Plant specimen books (for the collection of small pieces of plant material for each quadrat/transect); and
- 3M 'breathable' sticky tape for specimen books.

Preliminary preparations

Prior to the field season a field reconnaissance visit to potential sites was undertaken to identify the broad plant communities and discuss the project with landholders.

Plant collection licences (including Permit to Take Declared Rare Flora (DRF)) should be organised at least one month prior to field reconnaissance. Accommodation in close proximity to the Billeranga System needs to be booked as soon as field dates are determined and a full list of groceries and meal planning should be prepared prior to field reconnaissance. Shared vehicles and equipment should be booked in advance on the relevant field equipment booking sheets.

5.2 Sequence of events during field season

The following will be undertaken during the field season:

- prior to visiting the sites, the landholders and DEC district staff will be contacted and the Northern Agricultural Catchment Council (NACC) may be contacted;
- a field advice form will be completed and copies sent to the relevant people;
- all equipment required for sampling will be assembled and checked and observers trained
- the vehicle will be checked and packed with the relevant equipment;
- sufficient travel time will be allowed to reach accommodation destination and to unpack;
- sufficient time will be allowed for meetings with landholders if necessary and to undertake field work;
- quadrats and transects will be visited and all necessary observations recorded;
- plant specimens will be correctly pressed on return to the vehicle or accommodation; and
- the vehicle will be rechecked and packed for return trip to Perth.

The following needs to be completed on return to the office:

- all data from the PDA, GPS and digital camera downloaded;
- label, back-up data and store safely;
- check all Bush Survey Recording sheets and transect recording sheets for legibility and completeness;
- complete data verification and validation checks on data;
- scan Bush Survey Recording sheets and transect recording sheets to a central drive and file the originals;
- enter the relevant information from Bush Survey Recording sheets, transect recording sheets and occurrence report forms into the TEC/PEC database;
- data to be analysed needs to be processed into a usable format to be analysed (either into Site Species Database or an excel spreadsheet which as been correctly set up for input into analysis software); and
- new maps created using ARCGIS 9 after the initial site visit to reflect the vegetation mapping, quadrat sites and transect sites.

5.3 Details of taking measurements, with example field forms

At each sampling site, the quadrat should be set out using an optical square and two 50m measuring tapes. For each quadrat, every plant species will be recorded and a sample collected from outside the quadrat and pressed into a permanent collecting book with a full sized specimen collected for lodgement with the WA Herbarium. Collection and lodgement of specimens should be discussed with the WA Herbarium prior to field work. Herbarium and collection book specimens will be labelled with collecting number, date, location and field identification name. The Bushland Plant Survey recording sheets (Keighery 1994) will be used to record information for each quadrat.

For each transect the point intercept method will be used, which involves recording every plant species intercepting the transect line at pre-determined points. As with the survey quadrats,

specimens will be collected outside of the transect line for identification purposes for lodgement with the WA Herbarium, and for collecting books. Transects were established using SOP 6.2: Establishing Vegetation Transects.

The following is required for the monitoring transects:

1. Locate each transect and mark it out with the measuring tape;
2. Provide a general description of the vegetation along each transect including form and estimated height range;
3. Identify all live plant species that intercept the transect line at 50cm intervals along the line beginning at 50cm; and.
4. Take photographs from the start point and the end point. Record the photograph numbers and times on the recording sheet, or the quadrat/transect number on a blackboard that will be visible in the photograph.

For the floristic survey, quadrats were established using SOP 6.1: Establishing Vegetation Quadrats, and the following was undertaken at each site:

1. Locate the quadrats and mark them out with the measuring tapes and optical square;
2. Fill in site information on page 1 of the recording sheet;
3. Identify all tree, shrub, herb, sedge, grass and introduced species within each quadrat and record on page 3 of the recording sheet;
4. Record vegetation structure, cover class and dominant species as per page 2 of the recording sheet; and
5. Take photographs from the North West corner of the quadrat using a standard lens. Record the photograph numbers and times on the recording sheet, or the quadrat/transect number on a blackboard that will be visible in the photograph.

If any species cannot be identified with confidence in the field, two samples with key identification features such as flower, fruit, rhizomes etc will be taken. One sample will be taped with botanical tape into a collecting book and the other will have a labelled jewellers tag attached and pressed as soon as possible (preferably within a few hours of collecting) to be identified and lodged with the herbarium (see SOP: How to collect Herbarium Specimens (in draft)). Every specimen collected needs to have the following information recorded:

- a unique identification number;
- a general descriptive name;
- date;
- collectors name; and
- site location.

5.4 Post-collection processing of samples

The procedure for post-collection of plant specimens includes:

- newspapers changed every fortnight;
- drying of specimens (i.e. placed in freezer or microwave);
- preliminary plant identifications to be undertaken using reference collection and keys;
- Rare Flora Report Forms (RFRF) to be completed for DRF and priority taxa;
- details for each specimen collected entered into the MAX database;
- labelling of photographs taken of the specimens;
- collecting details for all specimens, either as printed or handwritten labels, inserted into each specimen's newspaper sheet or as a MAX file on CD (with the specimens tagged using numbers that match the specimen records); and
  specimen and associated photograph batches sent by post or delivered in person to the Western Australian Herbarium and addressed to the Collections Manager. If a batch contains a number of specimens they should be protected in a cardboard box of suitable size. If a batch

contains a small number of specimens, they should be tied into a bundle between cardboards and posted safely.

5.5 End-of-season procedures

The following tasks are to be undertaken at the end of the field season:

- plant specimens processed, mounted, boxed and sent to the WA Herbarium;
- equipment has been cleaned, stored and is ready for the next season;
- data stored appropriately in a central corporate location;
- quadrat and transect data collated and input into an ordination analysis program (eg. Primer); and
- report preparation.

6 Data Handling, Analysis and Reporting

Data collected as per this monitoring protocol will be handled, analysed, stored and reported on according to the methods prescribed below. The *Natural Resource Management - Regional Spatial Information Management Toolkit* (2008) (the NRM Toolkit) states that it is important that data is collected and managed according to agreed industry standards. The benefits of doing this include (modified from NLWRA 2003):

- improved data consistency;
- higher quality data;
- greater opportunity for data integration and aggregation;
- increased opportunities for sharing data;
- improved documentation and understanding of data and information resources;
- improved control over data updating; and
- improved data security.

6.1 Metadata procedures

Metadata is “data about data”. That is, a statement about a dataset which describes the content, quality, currency and location and custodianship of the data.

The Australia New Zealand Land Information Council has developed guidelines for the collection of metadata (ANZLIC 2001). Metadata collection under this protocol will be compliant with these guidelines.

The data custodian should develop the original metadata record. Metadata records can be created in a Word document or text file and should be saved in the same directory as the dataset. See Appendix D for the metadata collected for this project.

Metadata for this project will be for the data collected from both the survey and monitoring components of this protocol. The DEC TEC Database and regional databases will be the repository for the metadata statements.

6.2 Overview of database design

DeBacker *et al*. (2004) recognise that biodiversity monitoring creates large numbers of files and folders to store various databases; reports; GIS data; etc. and the organisation and linkages increase in complexity as data accumulates through time. The authors also note that foresight in database design is integral to ensuring data quality.

The DEC Threatened Ecological Communities Database (Microsoft Access) is the primary software environment for threatened ecological community data. ESRI ArcGIS 9 serves as a tool for viewing spatial data residing in this Microsoft Access database. The Microsoft Access database Site Species (by T.Griffin) has been designed on “a vision that through using an organised and standardised system, data can be compiled across the botanical sector to benefit the sector and the community. It is designed to manage the capture of, manipulation of, and reporting on information related to collections of plants in a systematic manner.” Monitoring data collected according to this monitoring protocol can therefore be stored in Site Species, with copies stored in the regional DEC database.

6.3 Data entry, verification and editing

Data entry involves transporting raw data from field sheets/notebooks into an electronic form such as a database. Quality assurance and control are important during the data entry process. DeBacker *et al*. (2004) suggest that where electronic data forms and databases are used for data entry, features such as drop-down lists and value limits may ensure minimal errors. Only valid names or measures should be allowed to be entered and spelling mistakes must be eliminated. Databases should be capable of receiving updates from the WA Herbarium to ensure name changes are addressed.

Data collected according to this monitoring protocol was entered as soon as possible after data collection into the TEC database and Site Species database by people familiar with the data. This helped to minimise errors as and allowed errors to be detected and easily corrected. Where edits to data were required, information was crossed out and replaced with the correct information on the hardcopy datasheets, in order to document decisions made about the data.

GPS points for quadrat and transects locations were entered into the TEC database and converted into a GIS layer for use in ArcMap9 using the linking tool available. Additional GPS data not suitable for the TEC database were transferred into ArcMap9 following the procedure detailed in second link below. Location data were verified for accuracy in relation to survey area boundaries.

For using GPS co-ordinates to create shapefiles in ESRI ArcMap 9.1/9.2 using the “Add XY data” tool, the link to the ESRI online is:

http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?id=202&pid=200&topicname=Adding_x,y_coordinate_data_as_a_layer.

For extracting/clipping data such as orthophotos in ESRI ArcMap 9.1/9.2 for use in ArcPad on a PDA, the link to the ESRI online is:

http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?id=5597&pid=5593&topicname=Getting_data_for_ArcPad.

As noted in DeBacker *et al*. (2004), data verification should immediately follow data entry and involve checking the accuracy of electronic records against the original source (eg. paper field records). Once the electronic data have been verified as accurately reflecting the original field data, the paper forms can be archived (according to section 6.7 of this monitoring protocol) and the electronic version used for all subsequent activities.

6.4 Recommendations for routine data summaries and statistical analyses to detect change

A critical component of any long-term monitoring protocol is a consistent and systematic way of analyzing (sic) and reporting on information (data) collected (DeBacker *et al*., 2004, p. 33). DeBacker *et al*. (2004) also note that data summaries and statistical analyses need to describe the current condition, or status, of the subject being monitored and be robust enough to detect community changes through time. The information provided in data summaries must be complete, descriptive and easily interpreted.

Monitoring transect data will be entered into an ordination analysis program (for example Primer) to analyse trends with reference to native and introduced species diversity. Analysis will allow any differences in diversity in vegetation between variables (fenced/unfenced) to be assessed, in order to determine whether the fencing appears to be influencing diversity. Analysis of the first round of data collected will be discussed with a biometrician, and benchmarks for management intervention and requirements for further replication of monitoring sites investigated.

Data summaries and statistical analyses for this project need to detail information about changes in native and introduced species composition, and densities. Any management interventions (i.e. fencing) that may influence these indicators need to be noted in the data summaries.

Data summaries will be undertaken at the end of each monitoring occasion. Given monitoring is recommended on a five-yearly basis, data summaries at this interval should not be too laborious. As

additional data are collected, appropriate analyses will be undertaken to detect temporal trends in the monitoring data.

Data from survey quadrats established in vegetation units within the Billeranga System TEC can be collated and analysed using PATN, and if required may be analysed with data collected for other surveys in the region.

6.5 Recommended reporting schedule

Reports will be prepared and distributed within the same year as data collection and include maps, graphs, figures and other visuals to facilitate comprehension of findings. DeBacker *et al*. (2004) suggest that more extensive summary reports, including trend analysis, should be completed every five to ten years depending on the rate of change in the monitoring data and the need for summary information to guide resource management. Summary reports may be used in place of annual reports for that year.

6.6 Recommended methods for long-term trend analysis

Simple data analyses may include comparisons of total cover of weeds and native taxa over time for the different monitoring variables (fenced/unfenced private properties). Analyses offered through Primer (Clarke, K.R., Gorley, R.N., 2006) are currently being considered.

A repeated measures ANOVA and/or regression analyses could be employed to estimate rates of change or the trajectory of change (i.e., linear or nonlinear). Because sites will only be sampled every five years, however, statistical analyses will only be undertaken after enough data points are obtained to ensure sufficient statistical power.

6.7 Data archival procedures

The *Natural Resource Management - Regional Spatial Information Management Toolkit* (2008) states that data must be copied and stored separately from the original dataset to ensure availability for other uses such as on-going monitoring, natural resource assessments or as agreed by the data custodian. The NRM toolkit also emphasises the importance of appropriate security and continuing recoverability of archived data as well as the inclusion of metadata and/or other relevant supporting documentation to enable use of that data and other information. See the WALIS Data Management Guidelines (WALIS 2006) for more information on appropriate archival procedures.

Long-term archives of the Billeranga System TEC data (both electronic and hardcopy materials) will be stored at the DEC Species and Communities Branch in Kensington. The data will be stored on the DEC server and the TEC/PEC database. Hard copy materials may also be stored at the DEC region/district headquarters. In this case, copies of all materials will be made and sent to the DEC Species and Communities Branch archive.

7 Personnel Requirements and Training

7.1 Roles and responsibilities

General roles of the project team leader include:

- liaision with managers and other stakeholders;
- co-ordination of field visits;
- determination of team logistics (delegation);
- preparation of survey reports (EPA, 2004)
- overseeing review of reports; and

- finalisation of protocols.

General requirements of a team botanist or ecologist include:

- ability to undertake floristic surveys as per Section 3.2.3 of the EPA's "Guidance for the Assessment of Environmental Factors Western Australia (in accordance with the Environmental Protection Act 1986) No. 51 (June 2004)".
- the ability to identify plant specimens;
- writing up statistical methods in liaison with a statistician; and
- analysing and interpreting findings in liaison with a statistician.

A Biometrician is required to:

- assist in statistical design;
- run analyses; and
- assist in interpretation of findings.

A project/field officer is required to:

- use GIS applications such as ArcMap 9;
- enter data into the relevant database applications such as the TEC Database;
- organise field visits (accommodation, equipment etc);
- undertake field work with suitably qualified botanist/ecologist; and
- write up reports in liaison with botanist/ecologist and statistician.

It is important to note at this stage that the EPA expects that "persons engaged in flora and vegetation surveys will act as scientific advocates and bring to the scientific, government and public arenas, new information arising from surveys" (EPA, 2004, p. 20).

7.2 Qualifications

This monitoring program includes vegetation surveys; therefore the following recommendation is relevant.

The EPA's *Guidance for the Assessment of Environmental Factors Western Australia* (2004 recommends the following:

> Flora and vegetation surveys should be coordinated and led by botanists who have had training, mentoring and experience in flora and vegetation survey. It is expected that they will have specific training and/or experience in ecology and taxonomy of the Australian flora and would normally have had a wide exposure to WA's flora and vegetation, preferably with knowledge and experience in the region being surveyed.
>
> It is recognised that some surveys may be done by survey teams that include members with less experience. These members should be supervised and mentored by the specialists mentioned above. This is seen as useful in training new practitioners. (p. 12)

7.3 Training procedures

Training is essential for developing competent observers. A refresher on species identification, GPS navigation, compass use, and foliar cover estimation may be necessary for observers. Observers will need to be trained to undertake all SOPs relevant to this protocol.

An experienced user of the monitoring protocol can provide some information and training to others in their team. Discussions and instruction in the field about the use of techniques is valuable in building the capacity of an observer in the use of the monitoring protocol. This on-ground application strengthens the formalised use of training materials focused on specific skills.

8 Operational Requirements

8.1 Annual workload and field schedule

Monitoring will require at least one team of two people for each site visit. One visit every five years may take up to one week to complete. The time required may vary depending on logistics, weather and team skill level.

The field schedules for site visits need to be prepared in consultation with district DEC staff and landholders a number of months prior to field work.

8.2 Facility and equipment needs

- Meals and accommodation in close proximity to the Billeranga System TEC need to be organised for field staff.
- The equipment listed in this document under "Field season preparations and equipment setup" needs to be gathered together, and missing items borrowed or purchased. Equipment needs should be amended accordingly if more than one team undertake monitoring during a field visit.
- The appropriate computer hardware and software need to be purchased and/or loaded onto field computers. This should include computers with Microsoft Office for all staff, ArcMap9 for some staff, and Primer.
- Storage space for equipment needs to be organised.

8.3 Startup costs and budget considerations

The following costs need to be considered in the budget set aside for this monitoring project:

- staff and consultant wages;
- purchase and hire of field equipment;
- accommodation and meals during field trips; and
- vehicle hire and running costs.

Limitations such as project duration and financial year constraints need to be considered.

9 References

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10 Appendix

Field data forms should be printed onto write-in-the-rain paper or stored electronically on a field computer and taken into the field. The relevant databases have data entry screens that coincide with the fields in these forms.

(a) TEC occurrence report form

(b) Bushland Plant Survey recording sheet

(c) Example transect recording sheet

(d) Metadata statement

Appendix A. TEC occurrence report form

Department of Environment and Conservation
Our environment, our future

Threatened Ecological Community (TEC) Occurrence Report Form

Version 5.2 June 2009

Community: _____ **OBSERVATION DATE:** ____/____/____

New occurrence ☐ **Site ID:** _____ **CONS CODE:** _____

OBSERVERS: _____ **ORGANISATION:** _____

ROLE: _____ **DISTRICT:** _____ **SHIRE:** _____

DESCRIPTION OF LOCATION: _____

_____

_____

DATUM:
GDA94 ☐
AGD84 ☐
WGS84 ☐
Unknown ☐

COORDINATES:
LAT/Northing: _____
LONG/Easting: _____
MGA ZONE: __

METHOD USED:
GPS/ Differential GPS/ MAP
No. Sats: _____
Map Used: _____
Map Scale: _____

SURVEY EFFORT:
Edge survey ☐
Partial survey ☐
Full survey ☐
Area surveyed (ha):

LAND TENURE:

Nature Reserve ☐ Timber Reserve ☐ Private Property ☐ Rail Reserve ☐ Shire Rd Res ☐
National Park ☐ State Forest ☐ Pastoral Lease ☐ MRWA Rd Res ☐ Shire Reserve ☐
Cons. Park ☐ Water Reserve ☐ UCL ☐ SLK/Pole ____ to ____ Other (Specify) _____

Landowners permission sought: ☐ Landowner present: ☐ Reserve: _____

Threat type and supporting information: Eg clearing, recreation, too frequent fire, grazing, weeds, disease, fragmentation, hydrological change. • Rate current and potential threat impact: 1=LOW, 2=MEDIUM, 3=HIGH, 4=EXTREME.	Current impact (1-4)	Area affected	Potential Impact (1-4)	Onset: Imminent	Onset: Long Term
•	____	____%	____	☐	☐
•	____	____%	____	☐	☐
•	____	____%	____	☐	☐
•	____	____%	____	☐	☐
•	____	____%	____	☐	☐
•	____	____%	____	☐	☐

CONDITION OF SOIL: Moist ☐ Waterlogged ☐ Inundated ☐ Mud ☐
Dry ☐ Cracked ☐ Saline ☐ Other: _____

CONDITION OF OCCURRENCE
(Bush Forever Scale)
(estimate % of area in each):

Pristine ☐ ____%
Excellent ☐ ____%
Very Good ☐ ____%
Good ☐ ____%
Degraded ☐ ____%
Completely Degraded ☐ ____%

RECOMMENDED MANAGEMENT ACTIONS: eg. roadside markers required, weed control, etc.

_____

_____

_____

_____

ACTIONS IMPLEMENTED (include date):

_____

_____

_____

Submitter of Record:_____ Role: _____ Signed:_____ Date:____/____/____

Please return completed form to, DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: Please forward to **TEC Database Administrator**, SCB. **Record Entered in Database** ☐ Date:____/____/____

Threatened Ecological Community (TEC) Occurrence Report Form

Version 5.2 June 2009

HABITAT INFORMATION:

LANDFORM:	ROCK FORM:	ROCK TYPE:	SOIL TYPE:	SOIL COLOUR:	DRAINAGE:
Crest ☐	Bedrock ☐	Granite ☐	Sand ☐	Red ☐	Well drained ☐
Hillock ☐	Boulder ☐	Dolerite ☐	Sandy loam ☐	Brown ☐	Mod. drained ☐
Ridge ☐	Cobble ☐	Laterite ☐	Clay loam ☐	Yellow ☐	Seasonally inundated ☐
Slope ☐	Coarse gravel ☐	Ironstone ☐	Light clay ☐	White ☐	
Flat ☐	Medium gravel ☐	Limestone ☐	>20% Gravel ☐	Grey ☐	Permanently inundated ☐
Outcrop ☐	Fine gravel ☐		Peat ☐	Black ☐	Tidal ☐
Closed depression ☐		Specify other:	Specify other:	Specify other	
Open depression ☐					
Wetland ☐					
Drainage line ☐					

Specific Landform Element:

VEGETATION CLASSIFICATION:

1.
2.
3.
4.

FIRE HISTORY: **Last Fire:** Season/Month:_____ Year: _____ **Fire Intensity:** High/Medium/Low Long unburnt ☐

LANDUSES: **SITE:**

ADJACENT:

OTHER COMMENTS (include recommended management actions and/or implemented actions (include date):	**Associated Species:**

ATTACHED: Map ☐ Mudmap ☐ GIS data ☐ Photo ☐ Field notes ☐ Other: _____

Submitter of Record:_____ Role: _____ Signed:_____ Date:____/____/____

Please return completed form to, DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: Please forward to **TEC Database Administrator**, SCB. **Record Entered in Database** ❑ Date:____/____/____

Appendix B. Bushland Plant Survey recording sheet (Keighery, 1994)

BUSHLAND PLANT SURVEY RECORDING SHEET 1 (2005 update) – use pencil only

BUSHLAND AREA_____ SITE NUMBER_____

DATE TRIP_____ BOTANIST_____ RECORDERS_____

DATE TRIP_____ BOTANIST_____ RECORDERS_____

DATE TRIP_____ BOTANIST_____ RECORDERS_____

1. LOCATION of the QUADRAT/SAMPLE POINT

Mud Map Draw a sketch of the location of the site below.

From '*Bushland Plant Survey*' written by B. Keighery (1994) and published by the Wildflower Society of WA (Inc.), PO Box 64 Nedlands WA 6008.

↑N

Road Location

Geographic Location **Latitude** S **Longitude** E

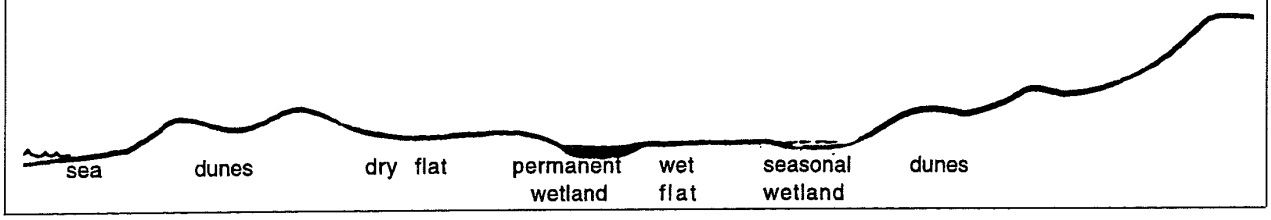
GPS Used: yes/no ***GPS Datum OR Reference Map Used:***

Photograph Photographer's Name Photo No.

Topographic position Circle position of site on the transect (alter the transect if necessary eg. for Jarrah Forest)

SWAN COASTAL PLAIN

Upland or Wetland? (circle one)



2. SITE DATA Circle the correct response.

Slope: flat gentle steep	***Aspect:*** N NE E SE S SW W NW na

Surface Soil: sand, loamy sand, sandy loam, loam, clay, gravel/laterite ***Colour***
Exposed Rock: type % surface

Sub-surface Soil: sand, loamy sand, sandy loam, loam, clay, gravel/laterite ***Colour***
Sub-surface Rock: type depth to rock

Drainage: well mod poor	**Water depth** cm	***Wet:*** all year winter/spring na

Litter: % cover	***Bare Ground*** % cover
Depth cm	

BUSHLAND PLANT SURVEY RECORDING SHEET 2 (2005 update) – use pencil only

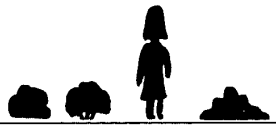
From '*Bushland Plant Survey*' written by B Keighery (1994) and published by the Wildflower Society of WA (Inc.), PO Box 64 Nedlands WA 6008.

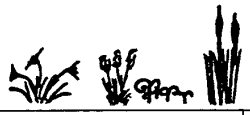
3. VEGETATION STRUCTURE AND COVER

For each layer **record** – appropriate **growth form**, **cover class** (see below) and **dominant species** in their order of dominance, up to a maximum of 3 species. If more than 3 species are obviously dominant record as many as appropriate to describe each layer. For NVIS record max. height of layer & % crown cover to nearest 5%.

Cover Class	**2 – 10%**	**10 – 30%**	**30 – 70%**	**over 70%**

	TREES			**MALLEES**	
	over 30m	10 – 30m	under 10m	over 8m	under 8m
GROWTH FORM					 30m 10m
COVER CLASS (%)	#	#	#	#	#
HEIGHT & CROWN COVER (NVIS)					
DOMINANT SPECIES					

	SHRUBS		**SHRUBS**
	over 2m	2m – 1m	under 1m
GROWTH FORM			 2m 1m
COVER CLASS (%)	#	#	#
HEIGHT & CROWN COVER (NVIS)			
DOMINANT SPECIES			

	GRASSES	**HERBS**	**SEDGES**	**OTHER (eg. ferns)**
GROWTH FORM				1m
COVER CLASS (%)	#	#	#	#
HEIGHT & CROWN COVER (NVIS)				
DOMINANT SPECIES				

4. VEGETATION CONDITION - Keighery (1994) Vegetation Condition Scale

1 'PRISTINE'		COMMENTS (give reasoning for choice)
2 EXCELLENT		
3 VERY GOOD		
4 GOOD		
5 DEGRADED		

BUSHLAND PLANT SURVEY RECORDING SHEET 3 (2005 update) – use pencil only

5. SPECIES PRESCENCE **Label** each plant with **plant's number, site code, date and plant's name or working name if required**

From '*Bushland Plant Survey*' written by B. Keighery (1994) and published by the Wildflower Society of WA (Inc.), PO Box 64 Nedlands WA 6008.

SITE No	
Date	

Record on sheet
- **Column 1** **plant name**
- **Column 2** **plant number (#)**
- **Column 3** **identification checked** - √ when checked

TREES	#	ID	SHRUBS (cont.)	#	ID	HERBS (cont.)	#	ID
MALLEES								
SHRUBS			GRASSES					
			HERBS			SEDGES		

Appendix C. Example transect data recording sheet

TEC Name:				
Transect Id:				
Location:		**Date:**		
		Notes:		
Recorders				
Photos:		**Time:**		
Datum:				
	Latitude	**Longitude**		
Soil Depth (cm)		**Soil Type**		**Soil Colour**
Start of transect:				
End of transect				
Point	**Field name**	**Strata**	**Ht**	**Voucher No.**
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Appendix D. Metadata statement for Billeranga System

Category	Element	Comments
Dataset	**Title:** Monitoring of the Billeranga System Threatened Ecological Community	The ordinary name of the dataset.
	Custodian: Department of Environment and Conservation, Species and Communities Branch	The organisation responsible for the dataset.
Description	**Abstract:** Scanned Bushland survey datasheets, electronic Microsoft excel transect sheets and ESRI shapefiles from baseline floristic surveys and monitoring of the effects of stock access and weed invasion on the plant assemblages of the Billeranga System Threatened Ecological Community	A short description of the contents of the dataset.
	Search Word(s): Billeranga; Belleranga; monitoring; survey; quadrats; transects; plots	Words likely to be used by a non expert to look for the dataset.
	Geographic Extent Name(s): Shire of Morawa. Bound by Mingenew Morawa Rd, Yamma Pool Rd, Old Three Springs Rd and Morawa Three Springs Rd. Top left co-ordinate: -29.19 S; 115.81E Bottom right co-ordinate: -29.36 S; 115.90E	A list of geographic extents such as • map sheets; • local government areas; • catchments; • IBRA regions; and • latitude/longitude co-ordinates for the top left and bottom right corners of the area covered, that reasonably indicate the spatial coverage of the dataset.
	Geographic Extent Polygon(s) TEC/PEC boundary polygon tecpolys_gcs_gda94 available to TEC database administrator.	An alternate way of describing geographic extent if no pre-defined area is satisfactory. Provide polygon title and location/directory address.
Date Currency	**Commencement date:** 1/09/2008	Commencement date (of field work/data collection)
	Completion date: 8/09/2008 – shapefile created	Last date of information in the dataset.
Dataset Status	**Status:** Ongoing	What is the current status of the database? Ongoing/Completed/Under development/Planned.
	Maintenance and Update Frequency Every 5 years	Frequency of changes or additions made to the dataset

Access	**Stored Data Format:** Microsoft Access TEC database, Microsoft Excel Spreadsheets, ESRI shapefiles, scanned pdf sheets.	The format or formats in which the dataset is stored by the custodian. Eg. Microsoft Access database, Microsoft Excel Spreadsheets, ESRI shapefiles etc.
	Location/Directory address: TEC database – maintained by Species and Communities Branch on shared drive Spreadsheets, shapefiles and scanned pdf sheets stored in Species and Communities shared T drive Currently in: T:\147-Wildlife Administration\Shared Data\SP_AND_COM\RCM\SurveyAndMonitoringComponent\TEC\Monitoring\2008_Monitoring_Established	Where can the data be found
	Available Format Types: Both digital and non digital	The formats in which the dataset is available, showing at least, whether the dataset is available in digital or non digital form.
	Reports/Publications: Hunter, M. (2008). Monitoring Protocol: Monitoring the effects of stock access and weed invasion on the plant assemblages of the Billeranga System threatened ecological community. Version Number 1.1 (December 2008). Prepared for the Significant Species and Communities component of the State-wide Resource Condition Monitoring (RCM) project.	What reports and publications have been produced using the dataset?
	Access Constraint: Access to dataset available only through request to TEC database administrator or Principal Ecologist, Species and Communities Branch	Any restrictions or legal prerequisites applying to the use of the dataset, eg. Licence required. Access and reliability.

Data Quality	**Lineage:** Data collected during September 2008 field trip was entered into the TEC database and shapefiles were created during the week immediately following data collection by the data collectors.	A brief history of the source and processing steps used to produce the dataset.
	Positional Accuracy: A differential global positioning system (DGPS) was used to record all markers for quadrats and transects set up.	A brief assessment of the closeness of the location of spatial objects in the dataset in relation to their true position on the Earth.
	Attribute Accuracy: Should be complete.	How accurate are the values in the Attribute Table of this spatial data in respect to the real world values? Eg. 'complete' = all tables are correctly labelled in the dataset.
	Logical Consistency: Should be complete.	A brief assessment of the logical relationships between attributes and spatial objects in the dataset. Eg. 'consistent' = attribute values have been checked and validated for consistency; logic checked in relation to attribute names; and all attributes that require values have values assigned.
	Completeness: Data covers all sites that have been visited during September 2005 and data should be correctly classified and verified.	A brief assessment of the completeness of coverage, classification and verification.
Contact Information	**Contact Organisation:** Department of Environment and Conservation, Species and Communities Branch	Ordinary name of the organisation from which the dataset may be obtained.
	Contact Position: TEC database ecologist/administrator	The relevant position in the Contact Organisation.
	Postal Address: Locked Bag 104 Bentley Delivery Centre 6983	Postal address of the Contact Position.
	Telephone Number: 9334 0116	Telephone of the Contact Position.
	Facsimile: 9334 0300	Facsimile of the Contact Position.
	Electronic Mail Address: Monica.Hunter@dec.wa.gov.au	Electronic Mail Address of the Contact Position.
Metadata Date	30/12/2008	Date that the metadata record for the dataset was created.
Additional Metadata		Reference to other directories or systems containing further information about the dataset.