Water Authority
of Western Australia

Next Major Public Water Supply Source for Perth (post 1992)

Environmental Review and Management Programme
Stage 1: Evaluation of Alternatives

Supporting Document

Flora and Vegetation of Four Alternative Water Resource Development Sites in the Northern Jarrah Forest, Western Australia

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Havel Land Consultants
April 1987

Water Authority of Western Australia

WATER RESOURCES DIRECTORATE
Water Resources Planning Branch

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This report is published by the Water Authority of Western Australia as a technical supporting document to the Environmental Review and Management Programme, Stage 1 report titled 'Next Major Public Water Supply Source for Perth (post 1992)'.

The document published within these covers is a copy of the Consultant's report to the Water Authority. As such, the Consultant is responsible for the accuracy of the information and statements contained in the report which constitutes specialist technical advice to the Authority.

The Water Authority acknowledges the work of the Consultants for the efficient manner in which they undertook their investigations and provided their advice to the Authority.

FLORA AND VEGETATION OF FOUR ALTERNATIVE WATER RESOURCE DEVELOPMENT SITES IN THE NORTHERN JARRAH FOREST, WESTERN AUSTRALIA

Prepared By: Havel Land Consultants

Prepared For: Water Authority of Western Australia

April, 1987

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLES:

TABLE OF CONTENTS (Continued)

FIGURES:

TABLE OF CONTENTS (Continued)

1. SUMMARY

The following options are based primarily on the occurrence of rare and restricted species and the representation of complexes and site-vegetation types in reserves:

The Canning option is considered least desirable as it involves a severe impact on a gazetted rare species with a limited range of occurrence, as well as intrusion into an A-class reserve for conservation. In addition it severly affects several other restricted species with preference for low lying sites.

On a qualitative basis. the Mundaring option is considered to be the second least desirable option, as it would adversely affect a poorly represented vegetation complex and several unusual variants of site-vegetation types which are inadequately represented elsewhere. In addition it would adversely affect several restricted species which it shares with the regions to the north-west and north-east, where there is a high proportion of alienated land.

On the same basis, the South Canning option is considered to be the third least desirable option. The bulk of the vegetation complexes and site-vegetation types present in it are adequately to amply represented in adjacent reserves. However, it does have a strong adverse impact on one restricted species (Hibbertia nymphaea) that would be near total and another species (Tetratheca nuda) would be strongly affected by inundation to optimum and maximum levels.

However, if the total number of plant species, the range of vegetation complexes and the total area affected are considered, then the order of priorities for South Canning and Mundaring would be altered.

The North Dandalup option is considered to have the least adverse effect from the conservation aspect, as distinct from the forestry viewpoint. The dominant vegetation complex and its component site-vegetation types are now amply represented in the Lane-Poole Reserve to the south as well as the Serpentine Reserve and the Monadnock Reserve to the north. The secondary vegetation complex (Helena M/H) and the component site-vegetation types (R,G) are well represented in the existing system of reserves. Only one restricted species

has been found to be strongly affected by the proposed inundation, the remaining ones being predominantly upland species. The intrusion into the C-class reserve with vesting for dual purpose would be best resolved by excising the small segment likely to be affected by the proposed dam, and by giving the bulk of the reserve more appropriate status and vesting (A-class reserve for conservation of flora and fauna).

Therefore in summary, the preferred option appears to be North Dandalup.

2. LIST OF PARTICIPANTS

The Flora and Vegetation Studies, described in this document were coordinated by Mr I.R. Pound, Principal Project Consultant for the Western Australian Water Authority.

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Data Analysts: Mr P.D. Havel, B.Sc., M.App.Sc., Dip.Ed., Grad.Dip.Appl.Sc.
Mr J.T. Droge, Assoc.Dip.Agr., Dip.Teaching.

Other participants are listed in the Acknowledgements section of this report.

3. OBJECTIVES

The objectives of the study were defined by the Water Authority of Western Australia as follows:

A. To describe the flora and vegetation of the four project sites, including:

   a) Collation of existing information on the flora and vegetation.
   b) Assessment of additional information required to achieve the broader objective.
   c) Desk, field and laboratory investigations to supplemnent existing knowledge.

B. To prepare the botanical data summaries and report as a basis for assisting in the multi-objective analysis of the alternative water supply sources, to choose the option which best balances the technical, economic, social and environmental considerations.

   a) Evaluate absolute and relative importance of each source location.
   b) Predict impacts (positive and negative) of development of each alternative, including loss of rare or endangered species or poorly represented communities.
   c) Suggest ways of mitigating impacts in the design and construction phase by appropriate management of the operational project.
   d) Identify further work required on each source should it be chosen for development.

C. To prepare a report documenting the choice of the source proposed for development, detailing the flora and vegetation values of each of the alternative locations, the impacts which would most likely result from the development of each source, their significance and an indication of management options for those impacts.

As a result of the interaction between the various participants in the study the specifications were subsequently modified to consider not just one level of inundation for each dam proposal, but several. The chief effect of this modification has been the need for a greater degree of vertical control in the studies.

4. INTRODUCTION

On current estimates the growth in demand for water from the public supply system in the Perth-Mandurah region is anticipated to exceed existing and planned supply capacities in the early 1990's. As a consequence the Water Authority of Western Australia has been addressing conservation measures of current supplies and reviewing possible new major water supply sources. Among these is the proposed expansion to the Gnangara Groundwater Scheme. Detailed planning is well underway for this supply. An ERMP (Dames and Moore, 1986) for that Scheme has been prepared for the Water Authority and has been submitted to the E.P.A. which released the document for public comment during its evaluation of the project.

A review by the Water Authority of the water supply situation has identified the need to consider a hills reservoir as the most appropriate next major source of water for the Perth-Mandurah region. The alternatives suggested were the construction of new dams at South Canning or North Dandalup, or raising the dam walls and thereby raising the capacity of Mundaring or Canning Dams. Whilst other technical and economic considerations are underway, the Water Authority believes it appropriate to evaluate the alternatives in the broader perspective of environmental costs and benefits. The following report forms part of the environmental study and assesses the flora and vegetation of the four potential project sites.

These four project sites are located within the region known as the Northern Jarrah Forest (Figure 1.) There is a significant variation of landscapes, topography, soils and climatic conditions between the four project sites. This range in conditions was recognized by the early settlers and by the naturalists. Many of the gravelly or rocky soils which dominate the study areas were considered unsuitable for cultivation. This combined with early recognition of the timber values, has resulted in relatively little clearing in the catchments under consideration. In fact, only small pockets have been cleared in the past for agricultural and silvicultural purposes (e.g. pine plantations in the Mundaring catchment).

In recent decades, as the population of Perth has increased, there have been growing demands placed on the resources within the Northern Jarrah Forest (Havel, 1975c). These have led to a greater awareness of the natural resources and the need to manage the native species.

4.1 Previous Botanical Studies

Diels (1906) carried out the first major study that related to the Northern Jarrah Forest, although others have attempted broad-scale assessments of the flora (see review by Gentilli, 1979). One of the achievements of Diels included the subdivision of the State into three botanical provinces based on the seasonality of rainfall (Beard, 1979). The four project sites are located within the Darling District of the Southwestern Province.

In addition to this broad-scale work, Diels (1906) was also one of the first who attempted to establish relationships between the plant distributions and the underlying environmental conditions. For example he related the distribution of Jarrah to the 750 mm isohyet and the Sheoak (Allocasuarina fraseriana) to the sandy soils on the Darling Plateau. Further observations were made on the distribution patterns of the smaller perennials. As a plant geographer Diels was also interested in endemism, although he identified only a few endemics amongst the 815 plant species which he recorded in the Jarrah forest.

Williams in 1932 and 1945 carried out intensive studies near Darlington and Beraking. These were located within the more dissected section of the Darling Plateau. Williams had considerable success in relating the vegetation to underlying environmental conditions. For example, for the western section of the Northern Jarrah Forest he expanded on the relationships between particular species and soil types, indicating that Eucalyptus marginata (Jarrah) occurred on the laterites and Eucalyptus wandoo (Wandoo) favoured soils derived from dolerite dykes.

Gardner (1942), Gentilli (1947) and Lange (1960) expanded on the earlier work, by correlating plant distributions to underlying conditions and in particular climatic variations in the region.

The next major contribution was that of Speck (1952, 1958), who defined a series of formations, alliances and associations for the vegetation in the region. One of the aspects highlighted by his studies was the continuum concept, where species and groups of species have dissimilar distribution patterns, with vegetation in the field being mixtures of varying proportions of continuity and discontinuity. This multi-dimensional nature of the vegetation led to some confusion when vegetation mapping was attempted.

Havel (1975a,b) was the first to carry out detailed quantitative ecological studies within the Northern Jarrah Forest. Havel included site characteristics in his determination of groupings or site-vegetation types. Findings indicated a close relationship between plant species groupings and site conditions. Havel's classification and subdivision of the vegetation in the Northern Jarrah Forest has been tested in a variety of studies, both on a detailed local scale (e.g. the hygiene mapping currently underway in the Department of Conservation and Land Management) and on a broad-scale through the System 6 or Darling System mapping (Heddle et al., 1980a). This latter work incorporated the site-vegetation types of Havel (1975 a,b) into the definition of a series of vegetation complexes. The mapping of the Darling System was carried out as part of a data gathering exercise to review the adequacy of conservation reserves throughout the area.

There is evidence to suggest that the vegetation is dynamic, and over longer periods the floristic composition of the forests has been variable (Churchill, 1961; Churchill,1968). Further, recent drought years appear to have affected some native communities (e.g. the apparent drought deaths on the shallower soils near granite outcrops). Other influences such as fire and diseases are also recognized as major determinants of the species distributions in different areas of the Northern Jarrah Forest (Shea, 1975; Havel, 1979). Therefore in any review of the native plant communities it is important to recognize that these influences may affect the floristic and structural composition of the communities under investigation.

Although these studies have highlighted some of the regional trends and plant distribution patterns it is only in a few specific areas that detailed investigations have been carried out on the flora and more specifically the rare, restricted or endemic species in the Northern Jarrah Forest. The recent review of the Perth flora has assisted in bridging this gap on the known flora of the western section of the Darling Plateau (Marchant et al., 1987). In addition, many of the specific environmental studies undertaken for proposed projects or developments have highlighted distributions of rare and restricted species. Such studies have assisted in assessing the reviews on rare and restricted species published by Rye and Hopper (1981), Patrick and Hopper (1982), Rye (1982), Barrett (1982), Gillen (1982)and Anon (1985). The recent paper by Heddle and Marchant (1983) summarized some of the specific information available on the rare and restricted species on the shallow soils associated with the Darling Scarp, although many are also known to extend onto similar soils on the Helena and Murray landforms.

4.2 Resources

In planning the investigations, the primary consideration was the availability of relevant existing information.

There is only one source of information that covers all four proposals, namely the Atlas of Natural Resources Darling System Western Australia (Department of Conservation and Environment, 1980), which in addition to verbal description provides 1:250,000 scale maps of

a) Geology and Mineral Resources
b) Landforms and Soils
c) Vegetation
d) Land Use

Of particular relevance are b) and c), the authors of which (McArthur, Mattiske (nee Heddle) and Havel) are participating in current investigations. The vegetation has also been mapped in greater detail for several smaller areas within the Canning and South Canning proposals by Havel (1975b), based on a system of vegetation classification developed for the Northern Jarrah Region (Havel 1975a). The Atlas of Natural Resources formed the basis of the major efforts to put conservation and land use in the region on a factual and logical basis. The first of these, the System 6 Study, was organized by the Environmental Protection Authority to develop a system of parks and nature reserves (Environmental Protection Authority, 1983). The second, carried out by the Darling Range Study Group (1982), was commissioned by the State Government of Western Australia to assist in the resolution of land use conflicts in the region. Although the investigations continued subsequently, these have as yet not been published, and the two earlier major studies, together with the Atlas of Natural Resources and Havel's (1975a,b) publications remain the main source of information for the region.

The implication of this for the evaluation of the four alternative water supply sources is that the overall assessment of the impact, in both relative and absolute terms, can only be carried out at the scale of 1:250,000. To achieve greater detail, new and more detailed studies would be required other than for those portions of the Canning catchment mapped by Havel. Havel's studies also established that, except for extreme sites, such as rock outcrops and treeless swamps, aerial photo interpretation of floristic types is only feasible where a dense network of ground surveys is available. This is because the canopy of the forest is relatively uniform and does not provide a ready basis for the mapping of great floristic variety in the shrub storey, which reflects more accurately the variation in site conditions.

The earlier studies of Havel have also shown that locally the strongest, the most consistent and most predictable source of variation in vegetation is topography, so that in the investigation of individual dam sites the sampling system should be designed across the contours. For comparison between dam sites, and to a lesser degree within the more extensive dam sites, climatic variation must also be reflected in the sampling design. Finally, the geomorphologic work of Churchward and McArthur (1980) has demonstrated that within any river system there is a predictable pattern of valley shapes determined by distance from the Darling Scarp, so that any sampling system must take these into account.

4.3 Selection of Approach

In light of the available information for the region, it was proposed to the Water Authority of Western Australia that the main thrust of the investigation would be across-the-valley survey transects, spaced along the valleys so as to sample maximum climatic and geomorphological variation, and supplemented by photo-interpretation.

The observations along the transect were to be spaced 50m apart, this spacing chosen being considered appropriate to the relatively steep nature of river valleys and the denser vegetation. Havel (1975b) found observations 100m apart appropriate to the uplands, where the rate of change is relatively slow, but not to the valleys, where it is rapid.

In the initial stages, an attempt was made to supplement the surveys along the transects with quadrats. The latter would have made possible a better quantitative assessment of individual species, but this was abandoned when it was realized that this method was too slow, given the magnitude of the task and imminent end of the flowering season. Furthermore, the quadrats failed to pick up the less common species, and were thus unsuitable for the detection of the rare and endangered species.

The decision to use across the valley transects was subsequently vindicated by the need to consider several levels of inundation for each proposed dam site.

In the initial proposal to the Water Authority of Western Australia, a three stage sampling proposal was outlined, whereby the first stage would sample only the extremes and the middle of each dam site. These would subsequently be supplemented by additional transects providing increasingly closer coverage as time and finance permitted.

It was necessary to carry out all stages virtually concurrently because:

a) The limited flowering season dictated early completion of the field studies;

b) Access limitations such as forest quarantine regulations, and the need to use boats, meant that repeated entries into some areas were out of the question.

The effect of these changes has been that on one hand, a better coverage of rare species was obtained at the optimum time, but on the other hand, a massive load of identifications and verifications was generated which delayed the commencement of data analysis. A larger and broader, though by no means excessive data base has resulted.

Ultimately, 66 transects were surveyed, consisting of 520 observation locations. These were distributed between the damsites as follows:

Mundaring	- 21 transects, 116 observation locations.
Canning	- 17 transects, 78 observation locations
South Canning	- 18 transects, 242 observation locations.
North Dandalup	- 10 transects, 84 locations.

The location of transects within the dam sites is shown in Figures 2 to 5. The information recorded at each observation location is described in section 5.1.3 and illustrated in Appendix G.

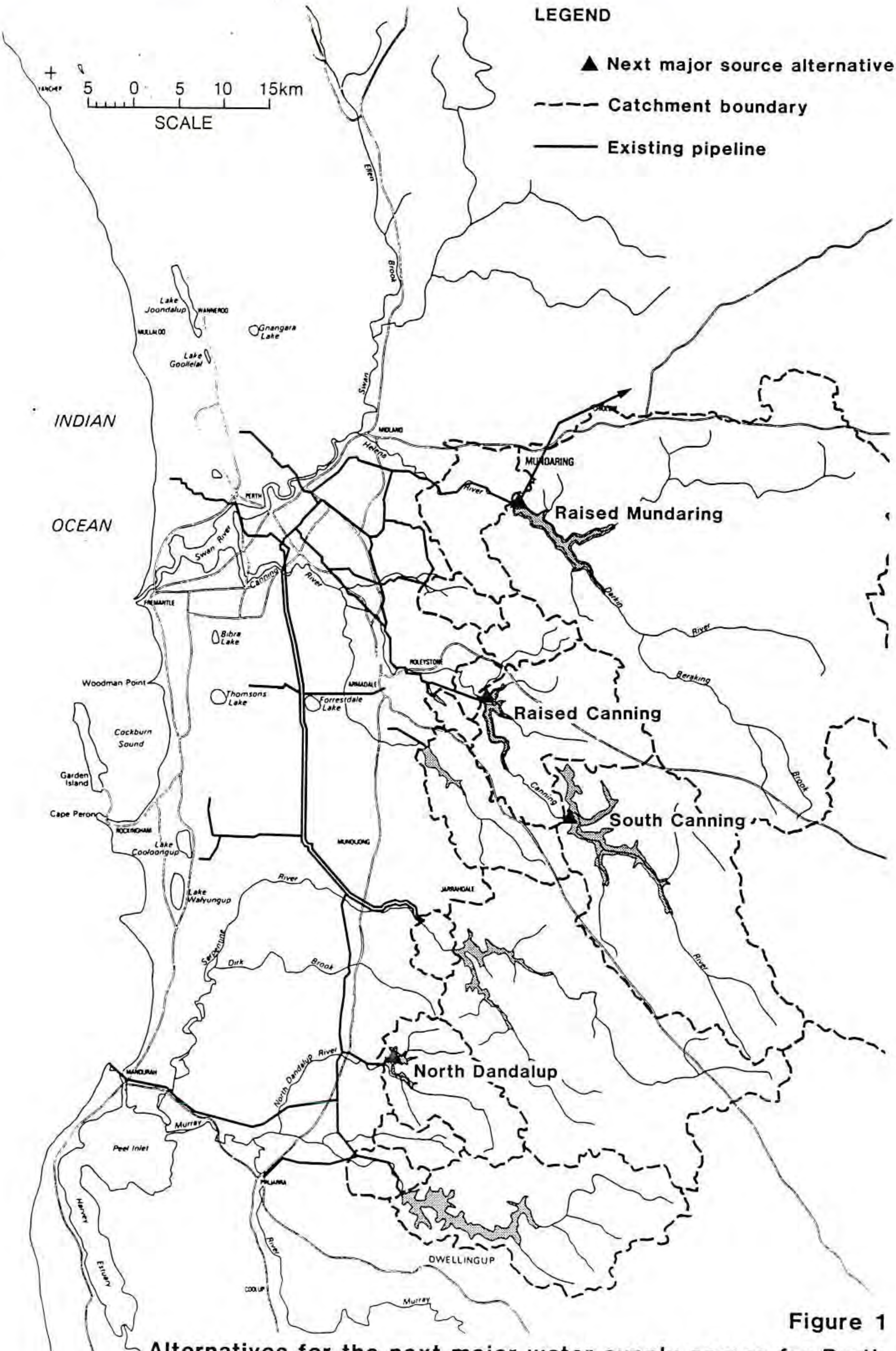
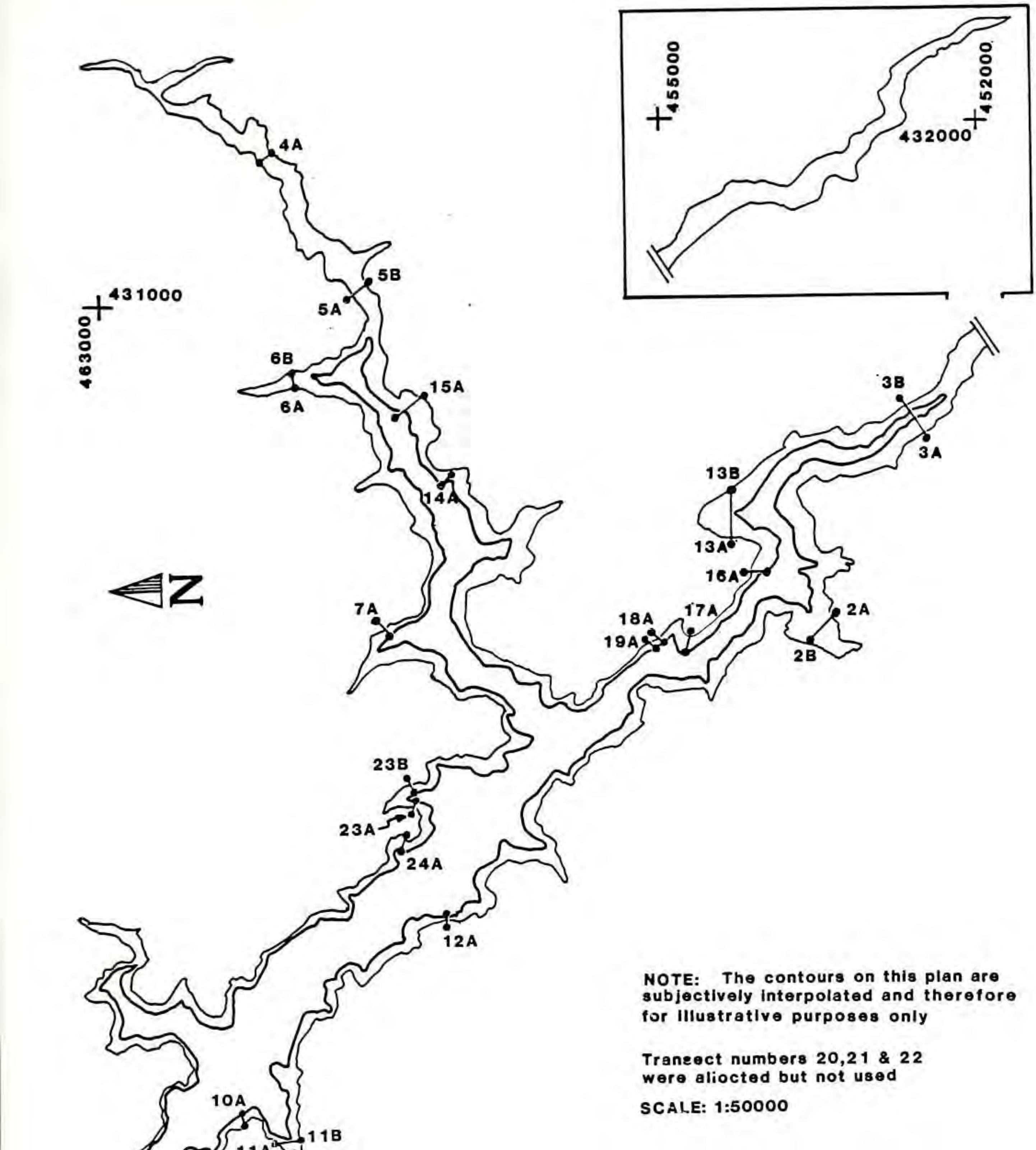


Figure 1
Alternatives for the next major water supply source for Perth



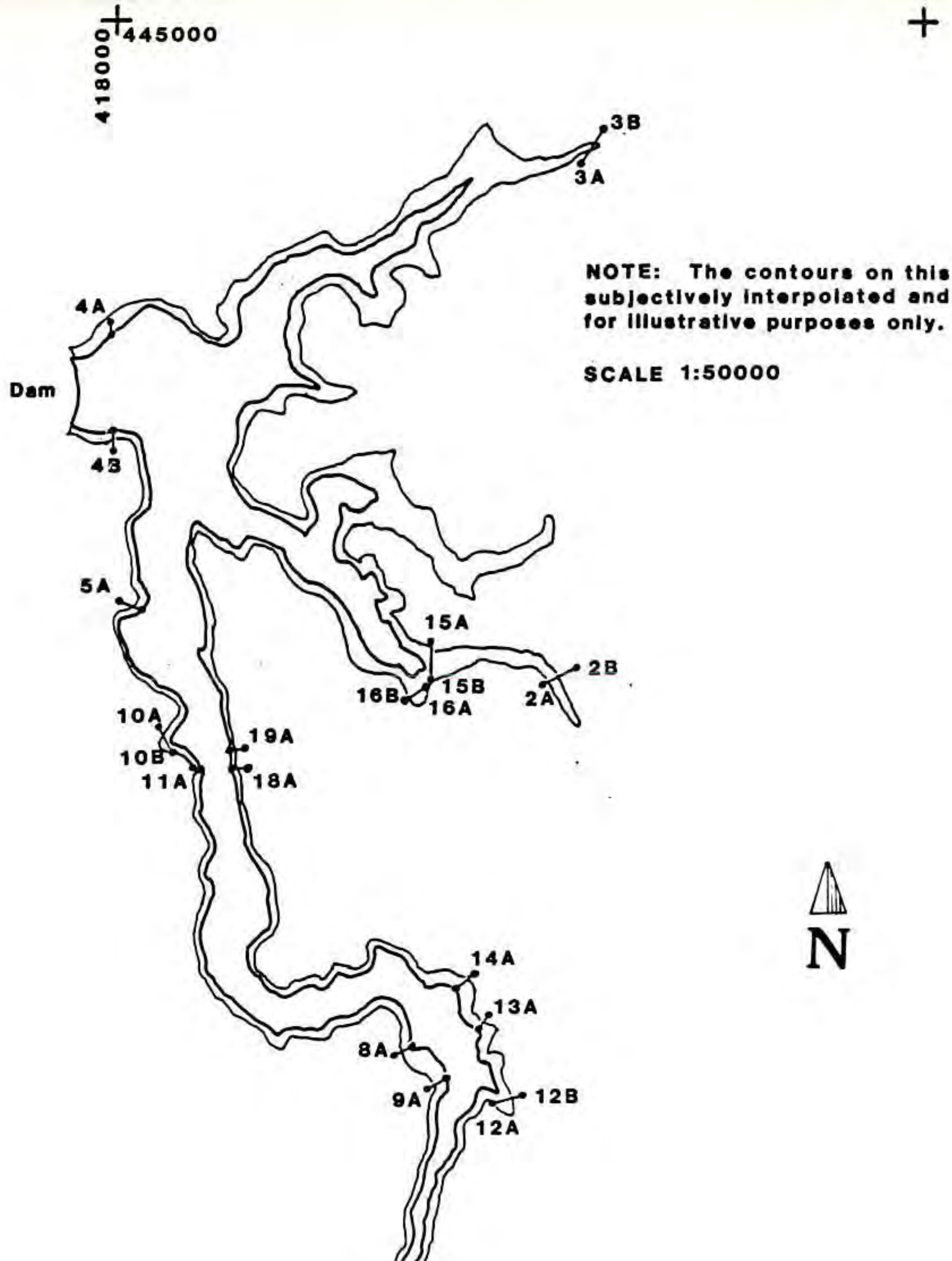
NOTE: The contours on this plan are subjectively interpolated and therefore for illustrative purposes only

Transect numbers 20,21 & 22 were aliocted but not used

SCALE: 1:50000

RAISED MUNDARING DAM   Vegetation and Flora Transects

FIGURE 2

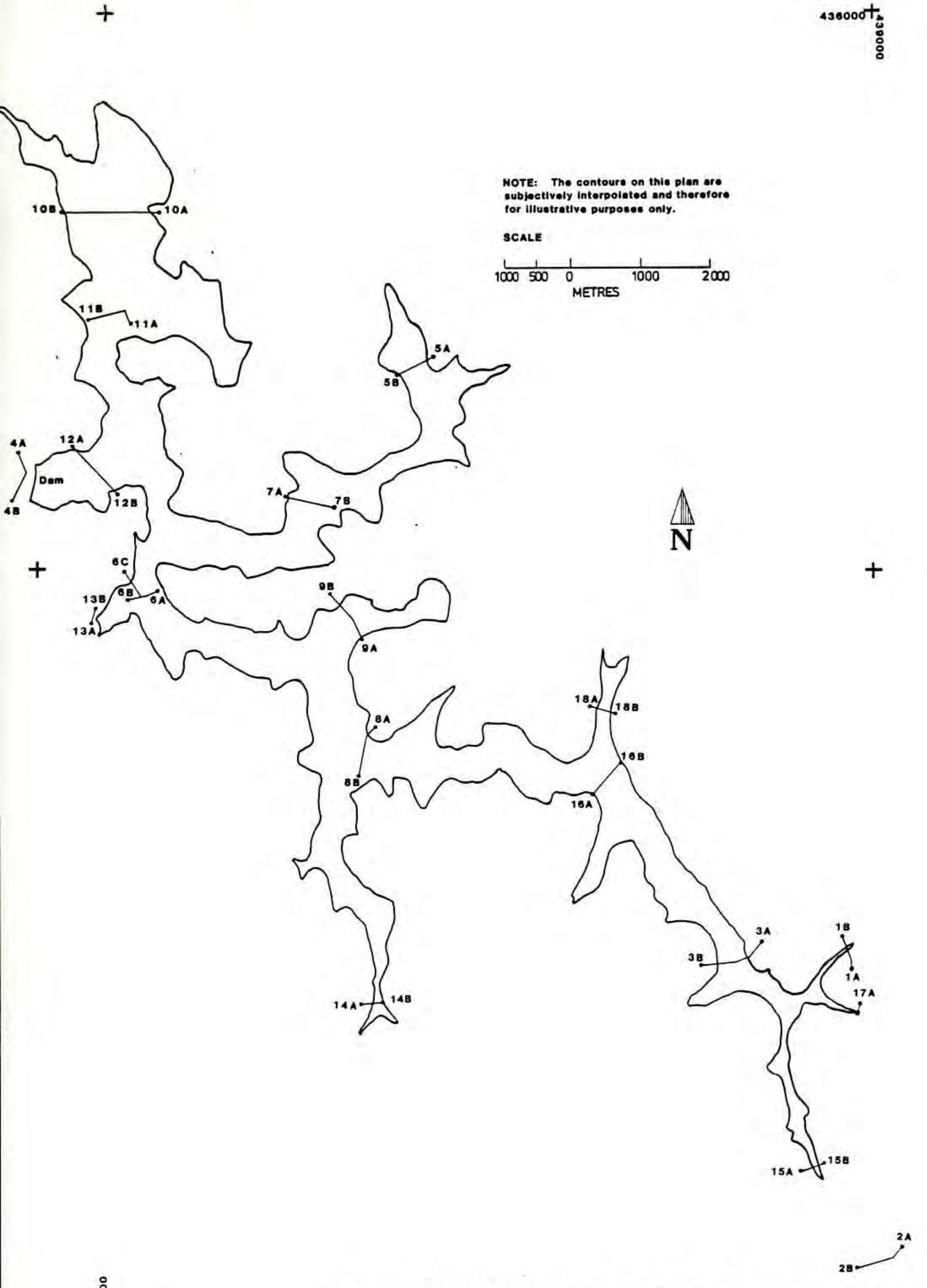


NOTE: The contours on this plan are subjectively interpolated and therefore for illustrative purposes only.

SCALE 1:50000

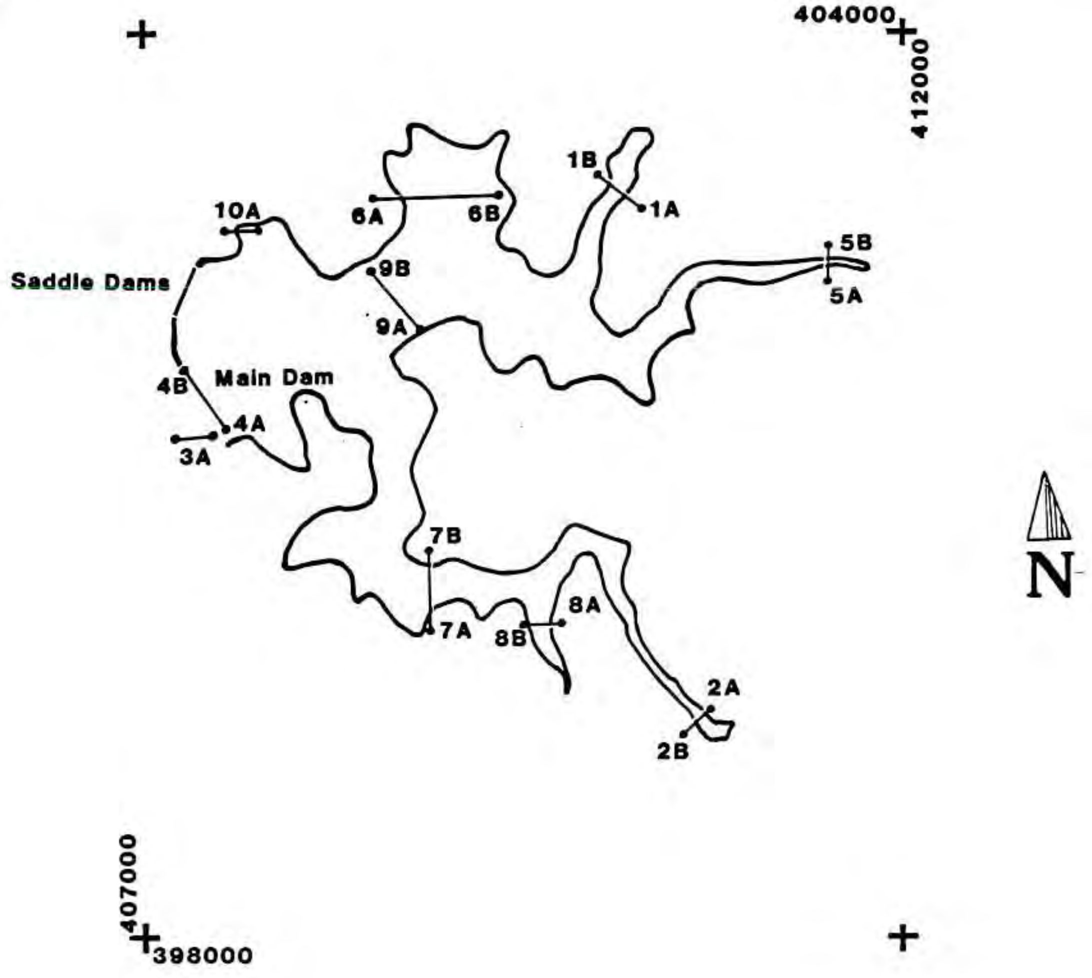
RAISED CANNING DAM Vegetation and Flora Transects

FIGURE 3



SOUTH CANNING Vegetation and Flora Transects

FIGURE 4



NOTE: The contours on this plan are subjectively interpolated and therefore for illustrative purposes only.

SCALE 1:50000

NORTH DANDALUP DAM Vegetation and Flora Transects

FIGURE 5

5. METHODS

5.1 Field Studies

5.1.1 Reconnaissance

A broad-scale reconnaissance of the four project sites was carried out in conjunction with other members of the biological study group. These initial inspections were followed by discussions between the various groups involved in the biological studies.

5.1.2 Aerial Photo Interpretations

Aerial photo interpretation was based on recent (9.2.1986) colour photographs of the region, at the scale of 1:20,000. At this scale, crowns of the individual isolated large trees can be seen, but smaller trees and shrubs cannot. It is also impossible to identify individual tree species as all the dominants are Eucalypts with crowns of similar colour and form. It is, however possible to assess the height and density of the tree stratum, and classify it into broad classes.

It is an excellent scale for the mapping of landforms as it is possible to observe steepness and configuration of the landscape component without losing the overall context within the landscape.

However, as with the vegetation, there are limits to the detail that can be mapped. Whilst it is possible to map rock outcrops, chiefly by reference to the reduced height and density of the cover, it is difficult to identify the composition of the outcrop, except perhaps on the margins of dams, where dolerite dykes are identifiable by the strongly coloured red earths derived from them.

Two different approaches were used in the mapping of the four alternatives. The raising of existing dams, where the area affected is generally a narrow ribbon on the periphery of the dam, has been mapped largely from the ecological viewpoint, as the affected area belongs largely to one geomorphological unit (>98%).

The categories used were:

a) Vegetation of the stream-lines and flood-plains (A, C).
b) Vegetation of the river terraces, valley floors and mild lower slopes (B, D, E, J, Q, W and Y).
c) Vegetation of the steeper but not rocky mid and upper slopes and uplands (H, L, M, O, R, S, T, U and Z).
d) Vegetation of steep, rocky slopes (G, R).

In the case of Mundaring, a further category covering the exotic pine plantations was included. The mapping was largely restricted to the area of likely impact.

The areas likely to be affected by the building of completely new dams (South Canning, North Dandalup) were mapped from a geomorphological viewpoint. In this case the categories used were the primary geomorphological categories:

a) Dwellingup uplands (D).
b) Shallow valley divides within the uplands (S).
c) Yarragil - broad, shallow valleys with streams and swamps in western zone (Yg), sometimes dry (Yg-Dry).
d) Pindalup - broad, shallow valleys and swamps in the eastern zone (Pn), sometimes dry (Pn-Dry).
e) Valley floors of the deeply dissected Murray-type valleys (Myf).
f) Non-rocky slopes of the Murray-type valleys (Mys).
g) Steep rocky slopes, mainly in the Murray-type valleys (R).
h) Low, mildly sloping lateritic remnants within major valleys (DW).
i) Short, gentle slopes of the Myara-type valleys (Mas).
j) Narrow zone of low relief and swampy terraces in Myara-type valleys (Maf).
k) Steep, rocky terrain of the Darling Scarp (DS).
l) Steep rocky slopes of the Helena Valley (H)(R).

Several of the above categories occupied only a minute proportion of the total area mapped, and are not referred to subsequently. The Myara valley type could not be used in regional evaluation, as this is a new type not covered by the System 6 studies (Environmental Protection Authority, 1983) and subsequent quantitative analyses of the adequacy of representation in reserves.

5.1.3 Transects and Site Recordings

Botanical Parameters

Plant community studies were based primarily on the abundance rating of tree and understorey species. Data for trees were recorded in circular sites within 25m radius of the observation point, while all other species were recorded in circular sites within 20m radius of the observation point.

All field observations, other than plant identifications, were coded in the field. For plants, only the rating was coded in the field, so that identification and verification could be completed before coding of the species identity.

The following range of botanical data was collected for each site or observation point:

TREES

a) Height
- Tall (Greater than 30m)
- Medium (15-30m)
- Low (Less than 15m)
- Absent

b) Density
- Dense
- Medium
- Low
- Absent

c) Condition (Scale of 1 to 4, from no apparent disturbance to total destruction)
- Healthy
- Mildly disturbed
- Strongly disturbed
- Completely destroyed

TREES (Cont.)

d) Cause of Disturbance

- Dieback (caused by *Phytophthora cinnamomi*)
- Clearing (for roads, dams or exotic plantations)
- Logging
- Flooding
- Wildfires
- Drought

e) Time Since Disturbance

- Stumps decayed
- Stumps solid, no bark
- Stumps solid, with bark
- Stumps absent

f) Composition

Ranking of trees was based on the previous system of Havel (1975a) on an area of 25 metre radius from the observation point, as follows:

0 - Absent
1 - One or two trees
2 - Three to five trees
3 - Greater than five trees, but less than a third of the total
4 - Greater than a third of the trees, but less than half of the total
5 - Greater than half of the total

UNDERGROWTH SPECIES

Ranking of undergrowth species was based on the previous system of Havel (1975a) on an area of 20 metres radius from the observation points, as follows:

0 - Absent
1 - Very rare - seen only after careful search
2 - Present, observable, but in small numbers only
3 - Common locally, but not uniformly over the whole area
4 - Common over the whole area
5 - Completely dominating undergrowth

Physical Parameters

The following range of physical parameter were recorded for each observation point and summarized on field sheets.

TOPOGRAPHY

a) Position

- Streambank
- Valley Floor
- Lower Slope
- Mid-slope
- Upper Slope
- Crest

b) Slope

- Level or Mild (Less than or equal to 4^{o})
- Moderate (5-8^{o})
- Steep (9-14^{o})
- Very Steep (Greater than or equal to 15^{o})

ROCK OUTCROPS

a) Composition

- Laterite
- Granite
- Dolerite
- Absent

b) Extent

- Massive
- Frequent
- Rare
- Absent

SOILS

a) Colour

- Black
- Grey
- Yellow
- Brown
- Red

SOILS (cont.)

b) Texture
- Clay
- Clay-loam
- Loam
- Sandy-loam
- Sand
- Gravel

5.2 Plant Identifications

All botanical specimens collected during the survey were identified in the Western Australian Herbarium by reference to the Flora of the Perth Region (Marchant et al., 1987), Key to the Western Australian Wildflowers (Blackall and Grieve, 1974,1980,1981,1982) and the Census of the Vascular Plants of Western Australia (Green, 1985). All identifications were checked against the herbarium collection. For taxa currently under review the advice of specialist taxonomists was sought. Voucher specimens will be incorporated into the herbarium collection. The total taxonomic information, including the family numerical code as used in the herbarium and the species numerical code used in the analysis of the data, has been incorporated into a computer-based species register. For collections made in the course of surveys there is also reference to locations along the transect at which it was first found, as well as a reference to the herbarium collection.

5.3 Data Preparation and Analysis

5.3.1 Preliminary Processing of Survey Data

On completion of the survey, all transects were plotted on 1:25,000 contour maps produced by the former Forests Department, and made available by the mapping branch of the Department of Conservation and Land Management. As the compass and abney surveys have limitations as to the vertical accuracy, particularly in steep densely covered valleys, the contour maps were taken as the final authority where discrepancies occurred. The choice of maps was determined by their availability at the time of survey, and by tying of the transects to road junctions and reference trees, only available on Forests Department maps.

The transect profiles were then completed on fine (1mm) meshed graph paper on the scales of 1:5,000 horizontally and 1:1,000 vertically. The valley profiles are thus exaggerated vertically, facilitating the assessment of the impact of inundation.

Each observation location along the transect was given a unique sequence number to facilitate the tying together of all the sources of information in subsequent analysis. The sequence numbers were allocated in blocks per damsite, allowing for some expansion for data base, and early separation of the four dam sites.

5.3.2 Analysis of Vegetation

There were two main lines of investigation

(i) For site-vegetation types R and G, considered to be inadequately defined by earlier studies. These are characteristic of rocky outcrops and are quite extensive, and floristically the richest in the four alternative areas considered for dam construction.

(ii) For the data set as a whole, including types R & G.

5.3.2.1 Detailed Analysis of Rocky Sites

For the subdivision of the R and G types, the aim was to review the classification of Havel (1975a,b) and provide additional indicators of the various shallow soils and rock outcrop areas within the Northern Jarrah Forest. This was considered necessary as Havel (1975 a,b) only defined these types in broader terms, with a limited range of species (72-130), most of which do not occur on the outcrops. More recent studies by Heddle for Worsley Alumina Pty. Ltd. (Worsley Alumina Pty. Ltd., 1985) indicated the range of communities which may occur on shallow soils and outcrops.

The data collected on these rocky sites was extracted for the four project sites and reanalysed using the Minimum Spanning Tree (M.S.T.) programme EM420, which is based on the published work of Rohlf (1973). The techniques associated with the delineation of clusters or groups of entities with similar composition have been reviewed by other workers (Sneath and

Sokal, 1973; Anderberg, 1973). The distance measure used in the Q-mode analyses (to create a matrix of similarity coefficients between samples or plots) was one minus cosine theta (1-cosine θ). The results were summarized in the form of Minimum Spanning Trees and Single Linkage Dendrograms. Such an approach was adopted by Heddle in earlier studies carried out at Boddington for Worsley Alumina Pty. Ltd. (Worsley Alumina Pty. Ltd., 1985).

The data matrices for the various proposed alternative project sites differed significantly. This related to the variations in structural and floristic composition of the communities, thereby reflecting the differences in underlying topography soils and climate at the four project sites. Therefore the R and G types were initially reviewed for each area as follows:

a) Each Project Area - All R and G Sites x all plant species.
Mundaring - 71 sites x 252 plant species
Canning - 34 sites x 194 plant species
South Canning - 29 sites x 173 plant species
North Dandalup - 34 sites x 179 plant species.

b) Each Project Area - All R and G sites x all species which were present in more than 5% of the sites for each project area.
Mundaring - 71 sites x 177 plant species
Canning - 34 sites x 161 plant species
South Canning - 29 sites x 144 plant species
North Dandalup - 34 sites x 150 plant species.

c) Each Project Area - All R and G sites x all species which were present in more than 5% of all sites for the project areas. This excluded species which might only have occurred at one project area.
Mundaring - 71 sites x 119 plant species
Canning - 34 sites x 109 plant species
South Canning - 29 sites x 99 plant species
North Dandalup - 34 sites x 103 plant species.

These results were then reviewed and summarized by site. The large geographical variation between the four project areas was reflected in the decrease of species in the last series of analyses. The final series of runs then extracted these groupings and compared findings between the four areas. These will be discussed in greater detail in the following sections.

5.3.2.2 Broad Analysis of the Entire Data Base

For the data base as a whole, the aim was basically the survey of the area, classification of the observations in terms of existing ecological classifications, and the correlation of all observations, whether of individual species or of whole plant communities, to the proposed engineering works so that their impact could be assessed. The following steps were taken.

(a) Establishment of a register of all species, giving their scientific, common names (if available) and field descriptions, the family to which they belonged, their code for computer analysis, the collector, the collection number, and the location where the species was collected (Appendix A.). This was based on the adaptation of the programme OMNIS, and could be retrieved on either scientific name, species code or family code. The species register was built up as identification of the specimens in the herbarium proceeded. The first eighteen code numbers were allotted to trees known to occur in the four survey areas, and a further 73 numbers to species identified by Havel and Heddle in their earlier studies as reliable indicators of site conditions. The remaining 400 code numbers were allocated in course of the herbarium studies.

(b) Establishment of a register of observations, giving the code number and location in terms of damsite, transect, transect segment and location along the transect, again using a modification of programme OMNIS. Information could be retrieved either on code or on location (Appendix F1.).

(c) The two registers were then used to build up an integrated geographic, taxonomic and ecological data base, again using the programme OMNIS, in which each occurrence of a given species could be retrieved in terms of the location, and each location could be described in terms of the species occurring on it (Appendix F3.). A separate data base was built for each of the four alternative dam sites. By further cross referencing of stored data it is also possible to determine the physical environment for each location and natural and man-made events such as wildfires or logging, which were likely to have influenced the occurrence of the various species at that location. For rapid evaluation of the rarity or frequency of all the species, provision is made for the summary of observations in terms of the number of times within each damsite that the species was observed.

For the less common species (that is those observed less than 10 times per damsite) provision was made for the ennumeration of all locations in which each was found.

(d) As the next step, each location was provisionally classified in terms of Havel's (1975a,b) classification, using not only the original 21 site-vegetation types, but also an additional type defined subsequently by Mattiske & Associates, (1983) and all the relevant combinations of these, eg. AC. As Havel's classification is really an economic subdivision of a multi-dimensional continuum, such combinations are quite appropriate where finer ecological definition is needed.

(e) This provisional allocation made it possible to describe each primary or derived (combination) type found in a damsite, by summing up observations for all locations falling into the same type, using yet another modification of the OMNIS programme (Appendix F6.). Each type is described in terms of the component species, giving the number of locations in which that species has occurred. As the description comprises all species and not merely the indicators, much broader description of the type is possible. Some recombination of the less common types became necessary at this stage.

(f) By using the valley profiles, each location was also related to the various engineering options such as the raising of an existing dam wall, or the building of a new dam, to various levels (App. C). This has made it possible to define the impact of the various options in terms of the site-vegetation types inundated by them (Appendix F4.). Yet another modification of OMNIS provided for the summation of the impact over all the locations affected by a particular engineering option in terms of the individual species.

(g) Although the comparison of the various outputs of the OMNIS programme makes possible some assessment of the ecological patterns, eg. by comparing the number of times that a species occurs in a given site-vegetation type with the total number of occurrences of that species in the data base as a whole, it is essentially a broadscale summation approach. To obtain a finer definition of the ecological patterns, the OMNIS data base programme was combined with a modified EXCEL spreadsheet programme (Appendix G.). This combination is capable of refining the ecological gradients observed along a transect by combining previous studies with the new data sets, and expanding the known ecological relationships by inclusion of the new and rarer species. The process is similar to the European Zurich-Montpellier system for the study of plant communities, as used locally by Bridgewater (1981). This makes it possible to assess the vulnerability of a rare species to inundation, not merely directly through its location on the survey transects, but also indirectly through its association with site-vegetation types subject to inundation. It provides linkage between the detailed observations along a limited number of transects and the broadscale coverage of the area in-between transects by photo interpretation, which in itself is incapable of providing information on individual species.

In this stage of data analysis, which is much more labour intensive and time consuming than that based on OMNIS alone, the indicator species with known ecological behaviour are used as condensation nuclei around which the less common and less known species are aggregated. The result is a set of ecological groupings of varying amplitudes, from groups with narrower amplitudes than Havel's indicators, to species of very broad amplitudes. It is the species which have narrow amplitudes and are limited in their occurrence to those types, and those positions of the landscape most affected by inundation, which are of greatest concern.

5.4 Assessment of Impacts

By the use of the reports produced by the OMNIS programme it is possible to examine the impact of the various levels of inundation on the individual plant species and on site vegetation-types. This can be further refined by using the tables produced by the EXCEL programme. It is, however possible that a particular species has not been recorded on any of the survey transects, or during the initial reconnaissance, even though it does occur within the survey area. In such a case no refinement of analysis would help. Given the extent of the field work the probability of this occurring is not great, though it cannot be dismissed entirely.

The comparison of impact at the broader level of vegetation complexes was achieved by computer-based overlay of the maps of the proposed dams and the maps of vegetation complexes of Heddle et al. (1980a), at the full supply level of inundation only. (Table 6a).

6. RESULTS

6.1 Landforms and Soils

In the western part of the Darling Plateau, including areas affected by the four different dam options, it has been shown (Havel, 1975a,b; Heddle et al., 1980a) that native vegetation is closely related to soils, topography and hydrology. It is therefore relevant to consider the pattern of soils as a framework for vegetation studies.

Since the project involves inundation, attention has been focussed on the valleys and, as shown by mapping in the Darling System (Churchward and McArthur, 1980), these have an orderly change in form with distance downstream. The valleys in the head waters are broad and shallow and become more deeply entrenched westward and are deepest where they pass through the Darling Scarp onto the coastal plain. Each unit has characteristic soils which vary in response to slope, relief and lithology. Figure 6 and 7 shows generalised sequences of soils based on detailed studies in the Wungong Brook catchment (Churchward and Batini, 1975). Similar soil-topographic relationships have been shown for the Murray River catchment (McArthur et al., 1977).

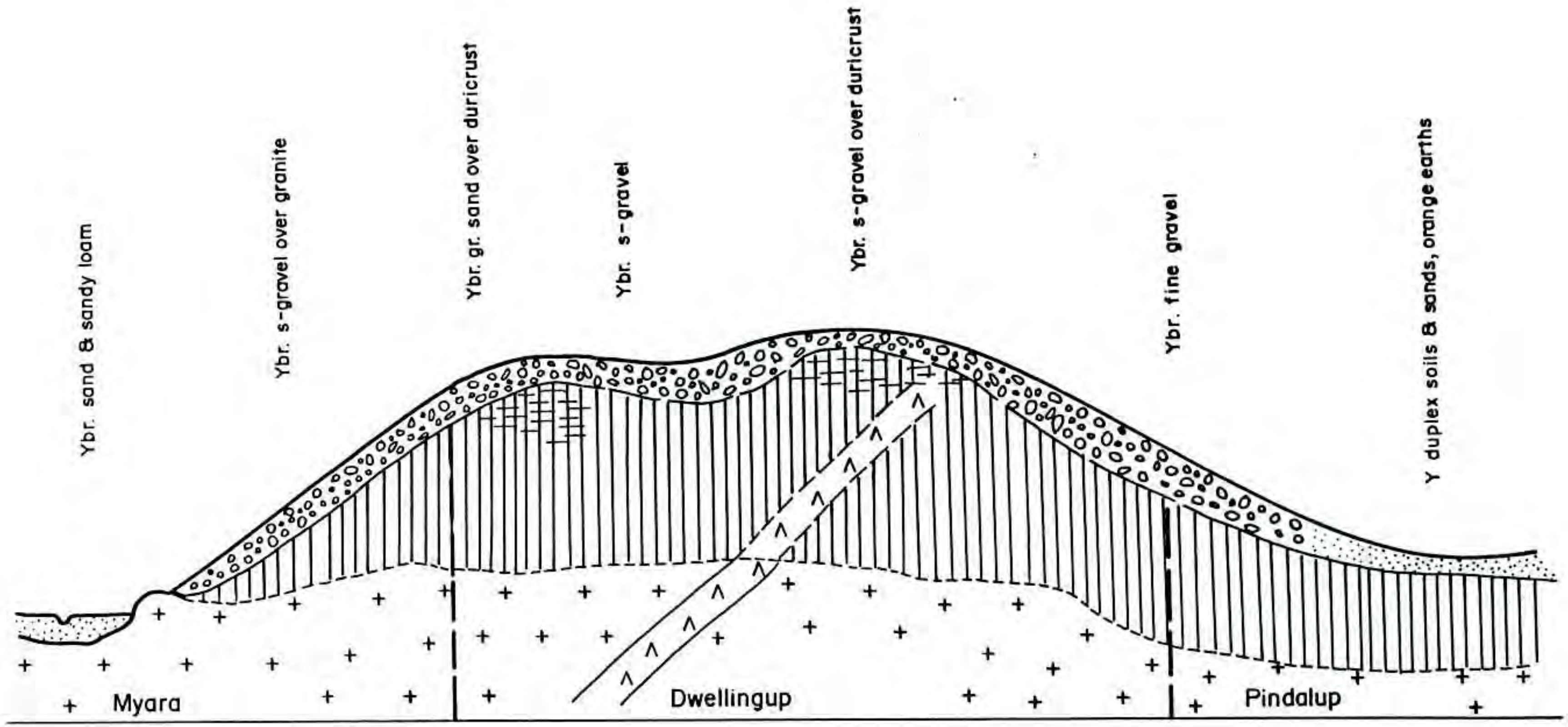
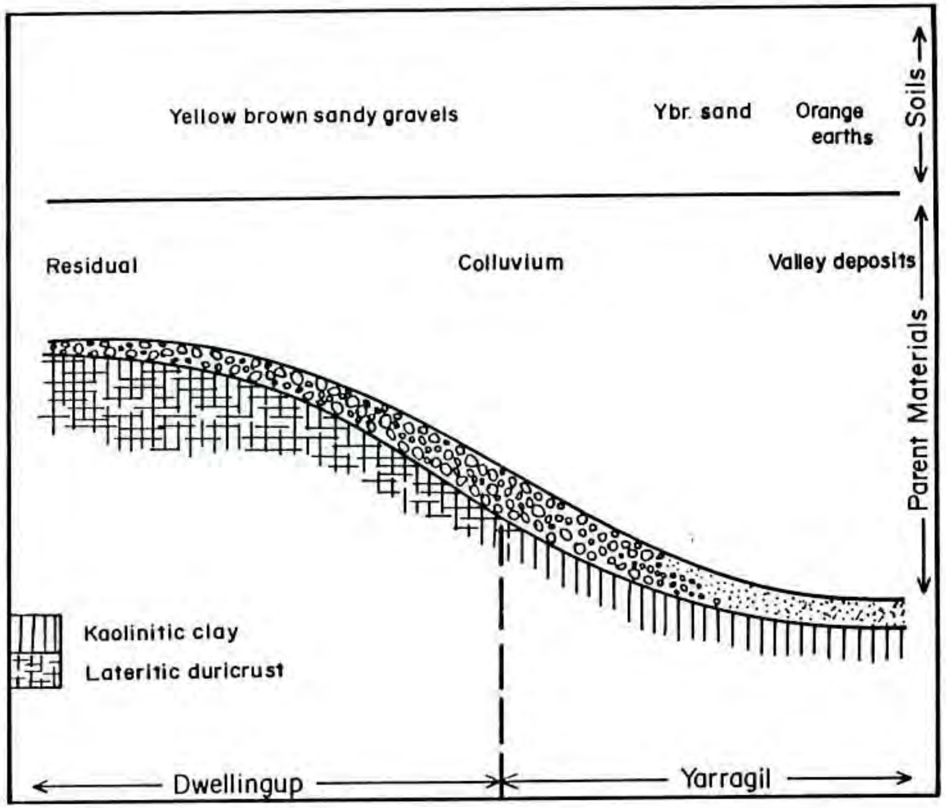


Figure 6

Sequence of Soils on the Myara, Dwellingup and Pindalup units



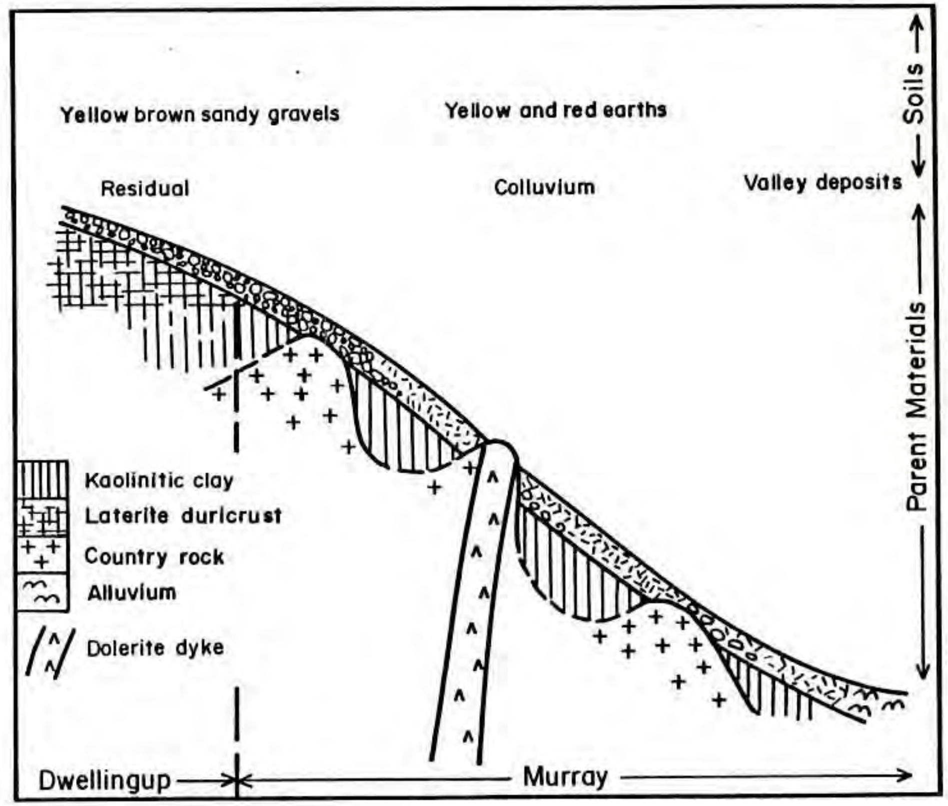


Figure 7

Sequence of Soils on the Dwellingup and Yarragil units

Sequence of Soils on the Dwellingup and Murray units

From these studies it is evident that the soil changes with relative elevation above the valley floor and, since vegetation and soils are related, different communities will be sequentially affected depending on depth of inundation. Therefore, the valleys have been sub-divided into component parts; these are shown in Table 1 together with details of soils. The Murray and Myara Valley types are the main ones involved and, while Table 1 gives general characteristics, each of the valleys considered for water storage has variations and these are discussed in more detail below.

The Mundaring Dam Extension occupies Murray type valleys but differs in having much more rock outcrop and generally lower relief and more gentle slopes than the Canning. The Helena River valley tends to be very open with much rock outcrop; soils are mainly shallow yellow earths. The valley floor is generally narrow but occasionally widens where remnants of a high terrace are preserved. The Darkin and Little Darkin River valleys tend to have steeper slopes, probably because the valleys pass between high hills; in some instances the valleys are asymmetric. There is a small but significant valley floor consisting of terraces and some rock. In Mann's Gully the slopes are very steep and the stream is cut into rock with no development of terraces; there are some areas of yellow earths on the slopes.

The Canning Dam Extension involves Murray type valleys but with the different tributaries having different characteristics.

The East Canning River valley has very extensive rock outcrop just above the present full supply level but, upstream rock decreases and the slopes are generally smooth indicating deep red or yellow earths. The South Canning River valley slopes are mainly occupied by deep red or yellow earths with only sporadic rock outcrops; occasionally a laterite spur extends downslope. The valley floor is mainly narrow but sometimes broadens where there is a remnant of a former high terrace.

The other valleys of the two tributaries, Death Adder Creek and Poison Gully, are very rocky but generally are broad with gently sloping irregular flanks; soils on the slopes are mainly shallow red or yellow earths.

TABLE 1 : RELATIONSHIPS BETWEEN TOPOGRAPHY AND SOILS IN COMPONENT PARTS OF BROAD-SCALE MAP UNITS OF THE DARLING PLATEAU.

Broad-scale Units	Landform	Component parts	Soils
Dwellingup (D)	Undulating Lateritic Upland	(i) Broad smooth crests	Sandy gravels; some block laterite
		(ii) Broad shallow depressions	Deep, sandy gravels
Yarragil (Yg)	Broad, swampy minor valleys	(i) Smooth gentle slopes	Sandy gravel; some block laterite
		(ii) Flat swampy floor	Orange silty loam over bag iron ore
Pindalup (Pn)	Broad, flat minor valleys.	(i) Smooth gentle slopes	Sandy gravels;some block laterite & rock
		(ii) Flat valley floor	Yellow duplex soils, sands, & orange earths
Murray (My)	Deeply incised major valleys	(i) Steep irregular flanks	Red or yellow earths, same gravel & stones
		(ii) Rock outcrop	Bare rock or shallow gritty soils over rock
		(iii) Upper terrace (discontinuous)	Gravelly earth, yellow duplex soils & sands
		(iv) Lower terrace with channel	Sand or sandy loam
Myara (Ma)	Steeply profiled major valleys	(i) Steep irregular flanks of lower reaches	Red or yellow earths; some gravel & stone
		(ii) Rock outcrop	Bare rock or shallow gritty soils on rock
		(iii) Gently sloping smooth flanks of upper reaches	Gravelly sand; some block laterite
		(iv) Narrow swampy terrace with channel	Brown sand or sandy loam
Helena (H)	Very deeply incised major valleys	(i) Steep irregular flanks	Red or yellow earths; some gravel and stone
		(ii) Rock outcrop	Bare rock or shallow gritty soils on rock

The South Canning Dam option occupies much of the upper reaches of the Canning River system. For this reason the area of maximum inundation is very broad. The total fall of the stream is only about 40 m over a direct distance of about 20 km; most of this fall is accounted for in the lower reaches of the inundated area, with about 60 m relief, steep rocky slopes, and shallow stony red or yellow earths.

From just above the confluence of the Canning River and Four-Ways Creek, the valley broadens and relief decreases. In particular the valley floor unit, including the upper and lower terraces, increases in width and, in the event of inundation, this entire landscape would be lost. With distance upstream from the confluence the character of the valley continues to change, becoming broader and shallower. The red or yellow earths and rock outcrops are less common and lateritic soils extend down the gentle slopes almost to the valley floor. This gradually gives way to the Yarragil and Pindalup valley types in the upper-most parts of the area of inundation.

The North Dandalup River valley has been classed as a Myara type, which is defined as a very steeply profiled system. It is a relatively small system and changes quickly from Yarragil type valleys to a deeply entrenched rocky gorge (Helena type) where it passes through the scarp. The area of inundation extends only about 6 km from the dam wall and, over this distance, the valley bottom falls at about 1:100.

Although the two main branches of the system are different in form, the rate of fall is fairly constant in both. The main (southern) branch is mainly steep-sided, with much rock outcrop, but with extensive areas of red or yellow earth which grade up-slope into lateritic soils of the Dwellingup unit. The valley has a narrow floor consisting of the lower colluvial slopes, a narrow sandy loam terrace with an incised channel, and some rock outcrop. Thus, apart from its steep profile, it resembles the Murray valley type and has been so-named on the map. This distinguishes it from the northern branch, Cronin Brook, which has been designated the Myara type. Cronin Brook has similar relief and gradient but is very broad with the area of inundation being more than twice the width of that in the main branch. The valley has a narrow swampy terrace, flanked on either side by a narrow zone of red or yellow earths and some rock outcrop, grading into gravelly sands and duricrust on the gentle slopes.

Much of the valley of the North Dandalup system is mantled by ancient alluvial material, probably similar to that described by Churchward and Bettenay (1973) in the Harvey River valley. It consists of a clay matrix with many cobbles and boulders in various stages of weathering. The sediment apparently pre-dates laterite formation since it makes up the mottled and pallid zones below duricrust and gravels. It is well shown in the saddle dam area, but also evident on some lower flanks where the clay matrix apparently causes impeded drainage with resultant characteristic vegetation. The occasional water-worn pebble on this soil surface indicates that this sediment is widespread in the catchment.

6.2 Flora

A total of 70 families and 466 vascular plant species were recorded in the study area (see Appendix A). In addition, 8 Bryophytes belonging to 6 families were also recorded. Dominant families were Proteaceae (53 species), Papilionaceae (43 species), Myrtaceae (34 species), Cyperaceae (27 species), Liliaceae (27 species), Mimosaceae (21 species) and Stylidiaceae (21 species).

A total of eight introduced species were recorded, although collections were not made of all introduced species. In general introduced species were restricted to the more disturbed sites near roads, tracks and pine plantations.

6.3 Rare and Restricted Flora

Any review of the rare and restricted flora of a particular area is limited by the adequacy of previous studies and coverage in sampling of the study area. Irrespective of the recognized paucity of information on distribution details and population records for rare and restricted flora at the project sites it is possible to highlight several species that require assessment (Appendix F2.).

Prior to summarizing the findings, it should be noted that species which are gazetted rare under Section 23F of the Wildlife Conservation Act, 1950-1979, cannot be removed without the consent of the Minister administering that Act.

A list of rare or restricted species expected in the study area was compiled from the following publications:

Rye and Hopper, 1981
Patrick and Hopper, 1982
Rye, 1982
Barrett, 1982
Gillen, 1982
Anon, 1985

Reference was not made to Leigh et. al (1981) or Marchant and Keighery (1979), as following discussions with Dr S. Hopper (Department of Conservation and Land Management) and a review of the Herbarium records, the information in these articles was considered to be out of date.

The compiled list was then revised after checking existing herbarium records at the Western Australian Herbarium and consultation with Herbarium staff. Selected species were removed from the list due to taxonomic reclassifications. The species removed from the list of rare and restricted are summarized in Table 2.

Table 2: Summary of Species deleted from Rare and Restricted List

Species	Comments
Adenanthos cygnorum ssp. chamaephyton	Not Poorly Collected
Boronia defoliata	Not Restricted
Comesperma virgatum	Not Restricted
Danthonia pilosa	Not Poorly Collected
Dodonaea ericoides (syn. D. cryptandroides)	Not Restricted because of reclassification
Hibbertia rhadinopoda	Not Restricted
Lomandra hermaphrodita	Not Restricted
Pericalymma ellipticum (syn. Leptospermum ellipticum)	Not Restricted because of reclassification
Pimelea sylvestris (syn. P. graciliflora)	Not Restricted because of reclassification
Wahlenbergia multicaulis (syn. W. simplicicaulis)	Not Poorly Collected because of reclassification

Results for the rare and restricted species for the four alternative project sites are summarized in Appendix B and Table 3.

Acacia barbinervis :

This species was recorded 8 times in the botanical survey, but no change to its geographical range was observed.

Aotus cordifolia :

This species was recorded once at Canning, although its known geographical range is greater. The lack of occurrence in the botanical survey suggests that this species may be relatively uncommon.

Billardiera drummondiana var. collina :

This species was recorded twice at Mundaring. No change in its geographical range was recorded.

Boronia crenulata var. gracilis :

This species was recorded twice at North Dandalup, which is within its known geographical range.

Calothamnus rupestris :

This species was recorded nine times at Canning, which is within its known geographical range.

Conospermum huegelii :

This species was recorded twice at Mundaring, which is within its known geographical range.

Conostylis setosa :

This species was recorded 44 times within all project sites with the exception of Canning. This study has extended its range, but not changed its restricted category of 100-160km. This study has also shown that it is a common species within its range.

Dryandra praemorsa :

This species was recorded 10 times throughout all project sites. No change to its geographical range was observed.

Eucalyptus laeliae :

This species was recorded 11 times, within the Canning and North Dandalup project sites, which is within its known geographical range.

TABLE 3. RARE AND RESTRICTED SPECIES

(Based on Appendix F3.)

KEY

+ : species recorded during this study.

Geographical Range - The named places indicate the approximate end points of the longest distance across the species' known range. The figures in the next two columns give this distance in kilometres.

x : known only from one locality.

Conservation status -

G : gazetted as rare

C : species occurs on a conservation reserve.

- : species does not occur on a conservation reserve.

Representation within catchments

"4" : number of site occurrences

- : not recorded.

Species	Geographical Range	Geographical Range <100km	Geographical Range 100-160km	Conservation Status	Catchments M	Catchments C	Catchments SC	Catchments ND
Acacia anomala	Chittering Valley - Bickley			G-				
Acacia aphylla	Helena Valley - Spencers Brook			G-				
+ Acacia barbinervis	Bullsbrook - Coolup		120	C	-	1	6	1
Acacia horridula	Helena Valley - Serpentine	60		-				
Acacia subflexuosa	Jarrahdale- W of Cuballing		105	-				
Anthocercis gracilis	Mundaring	x		-				
+ Aotus cordifolia	Gidgegannup - Dwellingup		105	-	-	1	-	-
Astroloma foliosum	Carmel	x		-				

TABLE 3. RARE AND RESTRICTED SPECIES

Species	Geographical Range	Geographical Range <100km	Geographical Range 100-160km	Conservation Status	Catchments M	C	SC	ND
Baumea arthrophylla	Chidlow - Bayswater	45		-				
Beaufortia purpurea	Kalamunda - Toodyay	30		C				
+ Billardiera drummondiana var. collina	Kalamunda - Mundaring	10		C	2	-	-	-
Billardiera parviflora var. guttata	Serpentine	x		C				
+ Boronia crenulata var. gracilis	Mundaring - Banksiadale	85		C	-	-	-	2
Boronia tenuis	Helena Valley-Oakley Dam above Pinjarra	20		G-				
+ Calothamnus rupestris	Red Hill - Boyagin Rock		105	C	-	9	-	-
Centrolepis inconspicua	Armadale - SE of Pingelly		140	C				
+ Conospermum huegelii	Mogumber - Serpentine Falls		155	-	2	-	-	-
+ Conostylis setosa	Bindoon - Jarrahdale		105	C	3	-	20	21
Craspedia pleiocephala	Wooroloo - Guildford	35		-				
Darwinia pimelioides	Red Hill	10		C				
Diplolaena andrewsii	Helena Valley	x		C				
Drakaea elastica	Lesmurdie - Mahogany Creek	20		-				
+ Dryandra praemorsa	Clackline - Dwellingup		120	-	3	1	5	1
+ Eucalyptus laeliae	Helena Valley - Harvey		135	-	-	1	-	10

TABLE 3. RARE AND RESTRICTED SPECIES

Species	Geographical Range	Geographical Range		Conservation Status	Catchments			
		<100km	100-160km		M	C	SC	ND
Gastrolobium acutum	Helena Valley - Armadale	30		-				
+ Gastrolobium epacridoides	Moore River - Helena Valley		105	-	1	-	-	-
Gastrolobium tricuspidatum	Boddington - Cannington		145	C				
+ Grevillea drummondii	Bolgart - Shannon River		>160	G-	-	-	-	-
var. pimelioides					13	-	-	-
Hakea crassinervia	Bickley - York	65		-				
Hakea cristata	Helena Valley - Wooroloo	30		-				
Hakea myrtoides	Helena Valley	5		-				
Halgania corymbosa	Gidgegannup - Gosnells	35		-				
Haloragis tenuifolia	Midland - Wooroloo	35		-				
Hibbertia lasiopus	New Norcia - Kalamunda		115	-				
+ Hibbertia nymphaea	Helena River - Serpentine River	50		-	-	-	8	-
+ Hibbertia pilosa	Dwellingup; Margaret River		155	-	17	3	54	13
Jacksonia gracilis	Perth - E of Mandurah	70		-				
+ Lasiopetalum bracteatum	Helena Valley	10		G-	-	4	-	-
Lasiopetalum cardiophyllum	Boddington	40		-				
+ Lasiopetalum glabratum	Mt. Cooke - York	80		-	-	-	11	-
Lasiopetalum membranaceum	Dwellingup - Capel		115	C				
Lepyrodia heleocharoides	Helena Valley	x		-				
+ Lepyrodia sp. A.	W of Beverley - Harvey area		120	-	-	1	-	-

TABLE 3. RARE AND RESTRICTED SPECIES

Species	Geographical Range	Geographical Range <100km	Geographical Range 100-160km	Conservation Status	Catchments M	C	SC	ND
Lhotskya acutifolia	Helena Valley - Popanyinning		125	-				
Lomandra spartea	Armadale	x		C				
+ Microcorys longifolia	Mogumber - Helena Valley		105	-	1	-	-	-
Parsonsia diaphanophleba	Coolup	x		-				
Patersonia babianoides	Carmel	x		-				
+ Petrophile biloba	Red Hill - Gosnells	30		-	1	-	-	-
Pithocarpa achilleoides	E of Wannamal - Wooroloo	75		-				
Restio stenostachyus	Gingin - Canning River	80		-				
Senecio gilbertii	Bindoon - York	90		-				
+ Senecio leucoglossus	Perth - Harvey		130	-	-	-	-	4
Stylidium rigidifolium	Helena Valley - Lesmurdie	10		-				
Synaphea acutiloba	Helena Valley - Cannington	25		-				
Synaphea pinnata	Millendon - Gosnells	35		GC				
Templetonia drummondii	Bindoon - Kalamunda	60		-				
+ Tetratheca nuda	Wooroloo - Canning River	45		C	1	-	3	-
Tetratheca pilifera	Helena Valley - York	70		C				
Tetratheca similis	E of Bindoon - W of Brookton		105	-				

TABLE 3. RARE AND RESTRICTED SPECIES

Species	Geographical Range	Geographical Range <100km	Geographical Range 100-160km	Conservation Status	Catchments M	C	SC	ND
Thomasia glutinosa	Clackline - Gosnells	70		C				
Thysanotus fastigiatus	Kalamunda	x		C				
Trymalium angustifolium	Muchea - Helena Valley	45		-				
Verticordia fimbrilepis	E of Canning River	x		-				
Wahlenbergia stricta	Mt. Cooke area	x		-				
Xanthosia sp. (aff. fruticulosa)	Chittering - Serpentine		105	C				

Gastrolobium epacridoides :

This species was recorded once at Mundaring, near a transect. This represents an extension of its known range, but does not change its restricted category of 100-160km. . This also suggests that it is relatively uncommon.

Grevillea drummondii var. pimelioides :

There are two varieties, but only one is considered rare, with the variety collected in this botanical survey (var. pimelioides) not being considered rare. However, as the species as a whole appears on the gazetted rare list, and hence is covered by legislation, it is still recognized as rare.

This species was recorded 13 times, although only within the Mundaring project site. This number of occurrences would suggest that this variety is not rare, but may have a restricted distribution.

Hibbertia nymphaea :

This species occurred eight times at South Canning, which is within its known geographical range.

Hibbertia pilosa :

This species was recorded 87 times, and occurred in all project sites. This species is currently undergoing taxonomic revision, so it is difficult to comment on its geographical range. The entity currently called Hibbertia pilosa now has a range of >160 km because of recordings made during this botanical survey.

Lasiopetalum bracteatum :

This species was recorded four times at Canning. This represents a geographical extension of this rare species, but does not change its restricted category of <100 km.

Lasiopetalum glabratum :

This species occurred 11 times within the South Canning site. No change to its geographical range occurred as a result of this survey.

Lepyrodia sp. (A) :

This species was only recorded once in this study, at Canning. Although this species has a geographical range of 100-160 km it appears to be relatively uncommon.

Microcorys longifolia :

This species occurred once in the botanical survey, at Mundaring. The current study has extended its range, but not changed its restricted category of 100-160 km.

Petrophile biloba :

This species was recorded once at Mundaring. Observations appear to indicate that it is relatively uncommon within its restricted range of < 100 km.

Senecio leucoglossus :

This species occurred four times in the botanical survey at North Dandalup, which is within its known geographical range. This species resembles an introduced species, so that its status may relate to inadequate collections.

Tetratheca nuda :

This species occurred four times within the Mundaring and South Canning project sites. No change to its geographical range was observed as a result of this survey.

As a result of the botanical survey the geographical distribution of a range of species has been extended (Table 4).

Table 4: Summary of Geographical Distribution Changes Noted as a Result of Botanical Survey

Species	Conservation Status	Comments
Boronia defoliata	-	Extension in range
Conostylis setosa	Restricted	Extension in range
Dodonaea coccinea	-	May have been planted
Gastrolobium epacridoides	Restricted	Extension in range
Hibbertia pilosa	Restricted	Extension in range
Hypocalymma cordifolium	-	Extension in range
Lasiopetalum bracteatum	Gazetted Rare	Extension in range
Microcorys longifolia	Restricted	Extension in range
Platysace tenuissima	-	Extension in range

A review of Western Australian Herbarium records and literature indicated that a total of 66 rare or restricted species could be expected in the region. A review of the results indicated 20 of these were recorded and observed during the botanical survey (Table 5). The differences in expected and observed is predictable as not all of the landscape and resulting plant communities were sampled (as they are not all likely to be influenced by the proposed projects), while others would not be expected to occur in the project site areas (e.g. the species which are known to be restricted to the Darling Scarp).

Table 5: Summary of Rare and Restricted Species Recorded in Botanical Survey

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2 Gazetted Rare Species were recorded:

- Grevillea drummondii (see comments above regarding varieties)
- Lasiopetalum bracteatum

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6 Geographically Restricted Species (<100 km) were recorded:

- Billardiera drummondiana var. collina
- Boronia crenulata var. gracilis
- Hibbertia nymphaea
- Lasiopetalum glabratum
- Petrophile biloba
- Tetratheca nuda

---

12 Geographically Restricted Species (>100 km, <160km) were recorded:

- Acacia barbinervis
- Aotus cordifolia
- Calothamnus rupestris
- Conospermum huegelii
- Conostylis setosa
- Dryandra praemorsa
- Eucalyptus laeliae
- Gastrolobium epacridoides
- Hibbertia pilosa
- Lepyrodia sp. (A)
- Microcorys longifolia
- Senecio leucoglossus

6.4 Site-vegetation Types

The evaluation of the impact of the four alternative water resource developments on the vegetation complexes has been done on a regional level, and in fact, would not have been sufficiently precise at a more detailed level, as most of them contain only two to four vegetation complexes.

At the next level of detail, when the site-vegetation types comprising the vegetation complexes are considered, examination of a single proposal at a time became imperative for two reasons:

a) There is no map of site-vegetation types for the whole region.

b) Parallel evaluation of all four alternative proposals at several levels of inundation would be too complex.

For these reasons, each of the four main options will be examined separately to determine if the site-vegetation types contained within it differ significantly from the standard types described by Havel (1975 a,b) and used subsequently in the delineation and description of reserves within the forested region by Heddle et al. (1980b). This will be followed by the asssessment of the various levels of inundation on the site-vegetation types, again separately for each main option. Ultimately the impacts will be summarized at the regional level.

In view of the applied nature of this study, its clearly defined objectives and the finite resources made available for it, the expansion of Havel's definition of site-vegetation types has been limited to those types most likely to be affected by the four engineering options, namely the lowland types A, B, C, E, Q, W, X and Y and their derivatives. In addition, as the level of information on the rocky slopes and outcrops is generally poorly covered in the literature, a series of analyses were undertaken to characterize and expand the definition of the R and G site-vegetation types defined by Havel (1975 a,b).

As virtually the only published information on the floristic classification of the vegetation of the region is that of Heddle et al. (1980a) and Havel (1975a,b), Havel's indicator species, together with some additional species and one additional type (X) were built into the field recording sheet. The first step in the analysis of data was the allocation of the observations made along the transects into Havel's site-vegetation types. It can be viewed as the extension of identification from individual species to a set of species occupying a site. In order to assess to what degree the allocation reflected the data, the observations belonging to a type, or group of types, were summed up across the entire damsite using a modification of the OMNIS programme (App. F6). This gave the summation of the occurrence of each species within a type within a damsite. The number of occurrences could then be compared with the total number of observations within the particular group (class), to give an assessment of how well the preliminary allocation reflected the survey data. On the whole the correspondence was very good at the level of the common indicator species, whose number of occurrence closely matched the number of observation within the group. This approach however proved less appropriate to the rarer species, whose total number of occurrences on the whole damsite was often less than the number of observations falling within a single grouping. A supplementary approach, based on the EXCEL programme, was used for a number of representative transects in a way that closely approximates the Zurich-Montpellier approach to vegetation classification, namely progressive restructuring of the species record to obtain maximum similarity in the species grouping, and hence the finest possible definition of the association and ecological amplitude of individual species.

The following patterns emerge at regional level.

Type A

As defined by Havel, site-vegetation type A is characteritic of broad, sandy valley heads in medium to low rainfall areas. Within the scope of the present survey it occurs only in the South Canning area, as the Mundaring project area is too dissected, and the North Dandalup and Canning areas are confined to the high rainfall zone near the Darling Scarp. However a variant, AQ, is important though not extensive in the Mundaring area. Within the South Canning area, the type occurs in the original form, as well as in the variant AY, already described by Havel (1975b) and the variants AB, AC, AW and AX. The latter was defined by Mattiske and Associates (1983) in a study of valley systems in the Northern Jarrah Forest. Of these AY, AC, AQ, AW and AB are merely intermediates between the parent types, but AX is a new, and more extreme type requiring in-depth treatment.

Havel's original list of indicators for type A can be expanded by Conostylis serrulata, Petrophile longifolia, Kunzea recurva, Verticordia huegelii, Hakea prostrata, and Elythranthera emarginata.

For type AX, associated with depressions and drainage lines within the broad flats, the additional species are Melaleuca viminea, Melaleuca polygaloides, Eucalyptus rudis, Leptocarpus aristatus, Drosera gigantea, Polypompholyx tenella, Philydrella pygmaea, Hakea incrassata, Hakea sulcata, Stylidium emarginatum, Stylidium pulchellum, Schoenus nanus, Chrysocoryne pusilla and Restio tremulus.

In addition to the indicators of types A and B, the following species are associated with, but not necessarily confined to type AB; namely - Hibbertia stellaris, Eriostemon spicatus, Tetraria octandra, Drosera menziesii, Stylidium junceum, Gompholobium aristatum, Sphaerolobium scabriusculum, Conostylis psyllium, Drosera leucoblasta, Drosera platystigma and Hibbertia aurea.

The most significant additions to the list of species for type AC are Eucalyptus rudis, Caesia parviflora, Acacia divergens, Hibbertia nymphaea, Melaleuca viminea, Melaleuca polygaloides, Leucopogon australis, Velleia trinervis, Stylidium canaliculatum, Viminara juncea and Baumea vaginalis.

Types AW and AY, occurring at the transition between the swampy flats and the adjacent lower slopes, have in addition to indicators of types A, W and Y, the following species: Xanthorrhoea preissii, Loxocarya fasciculata, Dryandra nivea, Drosera gigantea, Kunzea recurva, Melaleuca polygaloides, Neurachne alopecuroidea and Hakea prostrata. Many of these species have a wide ecological amplitude, but the overall combination is quite distinct.

Type W

Type W was defined as a transitional type between the wet valley floors and the drier slopes, developed on sandy loam with a tendency for waterlogging in winter. In this survey it has been recorded not only in its normal form, but also in combination with the types that occur both below and above it, such as AW, CW, HW, PW, WG, WQ, WR, WS, WY and WZ.

Type W has a solid group of species which have a high level of occurrence in all four project sites. These are Eucalyptus calophylla, Eucalyptus marginata, Eucalyptus patens, Baeckea camphorosmae, Xanthorrhoea preissii, Macrozamia riedlei, Hypocalymma angustifolium, Lepidosperma tenue, Acacia pulchella, Tetraria octandra and Hakea lissocarpha. Most of these are indicators of the type as defined by Havel (1975a). However, some of Havel's indicators, such as Lepidosperma angustatum, Synaphea petiolaris and Mesomelaena tetragona were found less consistently, particularly in the Mundaring and Canning areas, reflecting the paucity of sandy soils in these strongly dissected landscapes. Numerous other species were found to be associated, though not necessarily restricted to this type, such as Stylidium bulbiferum, Phyllanthus calycinus, Acacia pulchella, Neurachne alopecuroidea, Scaevola striata, Hibbertia hypericoides, Conostylis setigera, Lechenaultia biloba, Hakea prostrata, Bossiaea ornata and Loxocarya flexuosa. Other species are locally but not regionally associated with the type, such as Acacia saligna, Hibbertia huegelii, Conostylis setosa, Stylidium junceum, Ptilotus manglesii, Helipterum cotula, Leucopogon nutans, Petrophile squamata, Eucalyptus megacarpa, Hibbertia amplexicaulis, Gastrolobium calycinum, Dillwynia sp. (A), Cryptandra arbutiflora, Stackhousia huegelii, Gonocarpus cordiger, Xanthosia huegelii, Xanthosia candida, Hemiandra pungens, Hibbertia pilosa and Astroloma pallidum.

The more significant variants of type W are:

a) WG in the Helena (M/H) complex in North Dandalup, with Eucalyptus laeliae.
b) WQ and WP in the Murray-Bindoon (L/M) complex at Mundaring with the variety of Grevillea drummondii.
c) WS, which is strongly developed on the margins of the Yarragil (Max. Swamp) complex in South Canning.
d) WP in the Yarragil (Min. Swamp) complex in the North Dandalup with Boronia crenulata var. gracilis.

Type Y

Type Y is the main site-vegetation type of the Pindalup-Yarragil (L/M) vegetation complex in the South Canning project area. It occupies the floors and lower slopes of mildly sloping broad valleys. It generally contains within it the phreatic and swampy vegetation of types AC, AX and AY. It also occurs, to a much lesser extent, on the terraces and lower slopes within the Murray-

Bindoon (L/M) complex in the Mundaring project area, and is completely absent from the Canning and North Dandalup areas.

It is dominated by Eucalyptus wandoo, with some admixture of Eucalyptus patens. In addition to the indicators defined by Havel (1975a), the following species also occur at high to moderate levels within it: Grevillea bipinnatifida, Hibbertia commutata, Synaphea petiolaris, Xanthorrhoea preissii, Dryandra nivea, Gompholobium marginatum, Cryptandra arbutiflora, Pimelea imbricata var. piligera, Stylidium bulbiferum, Neurachne alopecuroidea, Lechenaultia biloba, Tetraria octandra and Hakea prostrata. Locally but not regionally common species are Ptilotus manglesii, Macrozamia riedlei, Phyllanthus calycinus, Patersonia juncea, Calytrix depressa, Trachymene pilosa, Lobelia rhytidosperma, Velleia trinervis, Podolepis gracilis, Waitzia paniculata, Danthonia setacea, Drosera gigantea and Hibbertia rhadinopoda (formerly Hibbertia lineata).

Because of its central position in the eastern valleys, type Y forms many combinations with adjacent types, such as CY and AY near the streams and YM, YQ, YL and WY on the lower slopes.

Type E

Type E is a transitional type between the mild laterite-mantled slopes and swampy valley floors of the Yarragil (Max. Swamps) and Pindalup-Yarragil (L/M) vegetation complexes. As such it shares some of the features of both complexes. This is reflected in the set of indicator species and in the underlying soils, which are generally sandy gravels or gravelly sands, wet in winter but dry in summer. Within this survey it was only found on the periphery of the South Canning project area, as the other areas are too strongly dissected.

The main species found within this type and its derivatives (CE, EH) are Eucalyptus marginata, Eucalyptus patens, Baeckea camphorosmae, Grevillea wilsonii, Hakea ruscifolia, Lepidosperma angustatum, Patersonia rudis, Synaphea petiolaris, Pericalymma ellipticum, Xanthorrhoea preissii, Loxocarya fasciculata, Styphelia tenuiflora, Conostylis psyllium, Patersonia pygmaea, Dryandra nivea, Pimelea suaveolens, Dampiera linearis, Neurachne alopecuroidea, Tetraria octandra, Daviesia decurrens, Daviesia rhombifolia, Grevillea synapheae, Ptilotus manglesii, Laxmannia sessiflora and Haemodorum laxum. Some of these are the indicators as defined by Havel, others are additional species defined through the present study.

Type E has been strongly affected by the dieback disease, as it combines the presence of many susceptible species with edaphic and topographic conditions favouring the pathogen (Phytophthora cinnamomi).

Type Q

Type Q is the most characteritic site-vegetation type of the Murray (M/H) vegetation complex. It occupies the valley floors and lower slopes of valleys in the high rainfall zone, particularly on red earths developed from basic rocks. It is absent, in its original form, from the south-eastern section of South Canning, and occurs mainly in the form of drier derivatives such as MQ, QZ and YQ in the Mundaring project area.

Not all of Havel's (1975a) indicators occur throughout the full range of occurrence of type Q. Acacia extensa, Chorizema ilicifolium, Leucopogon propinquus and Pteridium esculentum are largely absent from the drier eastern projects areas (Mundaring, eastern South Canning). On the other hand a considerable number of additional species is associated with the type, such as Clematis pubescens, Hibbertia hypericoides, Xanthorrhoea preissii, Boronia fastigiata, Acacia pulchella, Xanthorrhoea gracilis, Hibbertia pilosa, Pentapeltis peltigera, Stylidium amoenum, Tetrarrhena laevis, Dryandra nivea, Hibbertia commutata and Hibbertia amplexicaulis. Species locally but not regionally associated with the type are the variety of Grevillea drummondii, Diplolaena drummondii var. microcephala, Logania serpyllifolia and Tetratheca hirsuta.

The drier eastern derivatives (MQ, YQ and QZ) have a strong development of such indicators as Macrozamia riedlei, Phyllanthus calycinus and Trymalium floribundum, as well as Diplolaena drummondii var. microcephala and Lechenaultia biloba.

Type C

The type C was described by Havel (1975a) primarily from Yarragil and Murray type valleys. It occurs within the western project areas (Canning and North Dandalup) primarily as types CQ and CR. The former is associated with non-rocky valley floors and lower slopes, the latter with rocky sites. In the South Canning area the CQ and CR are confined to the north-western section, being replaced by AC, CW and CY in the south-eastern sector. Havel's list of indicator species for type C can be expanded by the inclusion of Melaleuca rhaphiophylla, Acacia extensa, Acacia alata, Lepidosperma tetraquetrum, Lepidosperma longitudinale, Gahnia trifida, Grevillea diversifolia, Oxylobium linarifolium, Acacia divergens, Baumea vaginalis, Thomasia paniculata, Billardiera variifolia and Paraserianthes lophantha. The additional species for type CR are summarized in Appendix D.

Type CQ, which is the most common variant in this study contains the additional species: Xanthorrhoea preissii, Acacia pulchella, Acacia divergens, Asterolasia pallida, Billardiera variifolia, Aotus cordifolium, Gonocarpus benthamii, Dampiera hederacea, Hypocalymma cordifolium, Paraserianthes lophantha, Conostylis aculeata, Lepidosperma leptostachyum, Xanthosia candida and in case of North Dandalup River, Banksia littoralis var. seminuda.

Types CW and CY, which mainly occur in central and south-eastern portion of the South Canning project area, are not so much true intermediates as narrow phreatic bands next to the streams surrounded by broader bands of type W and Y.

Enclosed within the vegetation type C is the aquatic vegetation of the streams and pools, such as Villarsia albiflora and Triglochin procera. The only observed occurrence of the liverwort (Anthoceros sp.) can also be placed here, as it was found under an overhanging bank in North Dandalup River.

Types R and G

The analyses separated out a range of R and G types. The results for each project area are summarized in Appendix D. Several trends became apparent from the analyses between results at the four project areas.

A range of communities were defined on the granite outcrops and associated shallow soils from herbfields, through heaths to woodlands. It was of interest to note that the heaths and woodlands reflected regional trends. For example, the Rock Sheoak (Allocasuarina huegeliana) was recorded on the rocky slopes in the Mundaring project area; while the Eucalyptus laeliae occurred on the dissected steeper slopes in the North Dandalup project area, although it is known to spread northwards and eastwards through the Canning catchment onto the Mt. Cooke monadnock. Similarly the Wandoo dominated the R and G types at Mundaring, so reflecting the Murray-Bindoon (M/L) vegetation complex as defined by Heddle et al. (1980a).

The eastern rock outcrops were separated from the western types by the differences in composition of the shrub storey. The indicators of Darling Scarp and Helena surface are lacking in the drier intermediate rainfall zone covering the proposed South Canning project area. Further, some of the species recorded in the eastern section of the Northern Jarrah Forest are only represented in the South Canning project area. Consequently it was necessary to subdivide types of G and R (and their derivatives) primarily on floristic differences, rather than the obvious structural differences. These results are expanded in the sections for specific project areas.

The remaining types of R and G tended to be intermediates of nearby communities (e.g. WR, DR, LG, MG, RS). These are summarized in Appendix D for the respective project areas.

6.5 Vegetation Complexes

The only published detailed vegetation maps covering the entire region are the maps of the vegetation complexes prepared by Heddle, et al. (1980a) for the Atlas of Natural Resources Darling System Western Australia. These were published at the scale of 1:250,000 but the original drafts of the maps were prepared and subsequently digitized by the Darling Range Study Group, at the scale of 1:50,000. It is at this scale that the comparison of the alternative proposals will be made, as it is at this scale that the evaluation of representation of various vegetation complexes was originally quantified by the Darling Range Study Group and subsequently updated by the Forests Department for the Reserves Review Committee (1984). The most recent updating of the data base was carried out by Mr G. Mauger of the Water Authority of Western Australia, giving the various vegetation complexes affected by the four alternative dam proposals at the maximum levels (Table 6a).

The significance of the impact will be assessed by establishing an index of the adequacy of representation of the various vegetation complexes within the existing system of reserves (Table 6b), and using this to adjust the absolute impact in terms of the area of each vegetation complex that would be inundated (Fig. 10). Finally an assesssment will be made of the degrees of disturbance, and hence the quality of preservation, of the areas to be inundated, using the information collected during the surveys and that provided by the Department of Conservation and Land Management.

6.6 Assessment of Impact on Vegetation Complexes

6.6.1 Absolute Impact.

The main vegetation complexes to be affected by the four dam proposals are summarized in Table 6.

Table 6a: Impact Assessment of Proposed Dams on Vegetation Complexes

	Percentage Land Surface of Proposed Dams			
Vegetation Complexes	Mundaring	Canning	South Canning	North Dandalup
Murray (M/H)	-	98.9	37.4	80.7
Murray-Bindoon (L/M)	98.5	-	-	-
Yarragil (Max.Swamp)	-	-	26.7	-
Swamp	-	-	18.6	-
Yarragil (Min. Swamp)	-	-	-	12.4
Pindalup-Yarragil (L/M)	-	-	10.7	-
Dwellingup-Hester (H)	-	-	-	6.8
Dwellingup (M/H)	Minor	Minor	6.1	-
Helena (L/M)	0.6	-	-	-
Dwellingup-Yalanbee (L/M)	0.9	-	-	-
Helena (M/H)	-	-	-	Minor
Cooke			Minor	

Note: H = High Rainfall, M/H = Medium to High Rainfall, L/M = Low to Medium Rainfall,

In terms of the number of vegetation complexes affected by the four proposals, South Canning has the greatest impact. At the lowest level under consideration, it affects mainly Murray (M/H) ad to a lesser degree Yarragil (Max. Swamp), Swamp and Dwellingup (M/H). At lower optimum, the impact extends to Pindalup-Yarragil (L/M) and at the maximum level it extends slightly to Cooke and, if the powerline relocation is considered, to Dwellingup-Yalanbee (L/M).

The next highest impact in terms of number of vegetation complexes is that of Mundaring and North Dandalup. At small rising level, the main impact of Mundaring is on Murray-Bindoon (L/M), and to a lesser degree on Helena (L/M) and Dwellingup (M/H). At maximum level Dwellingup-Yalanbee (L/M) will also be affected. The relocation of roads, which will be a prominent feature of this proposal, will affect all four complexes. The impact of the North Dandalup dam includes Murray (M/H) and Yarragil (Min. Swamp) at the lowest level, rising to include Dwellingup-Hester (H) at maximum level. The construction of the spillway will affect Helena (M/H) to a minor degree.

The impact of the raising of the Canning Dam is the lowest, being restricted to the Murray (M/H) and Dwellingup (M/H) complexes, though one of the transects suggest that at maximum level inundation may just begin to affect Yarragil (Min. Swamp).

6.6.2 Representation of Vegetation Complexes in Existing Reserves

The only quantitative information available (Darling Range Study Group, Reserves Review Committee, Department of Conservation and Land Management) covers the main forested region, that is the areas originally designated as Management Priority Areas for the Conservation of Flora and Fauna, and the Serpentine National Park. This appears adequate for the Canning and South Canning catchments, but in the cases of North Dandalup and Mundaring additional consideration will need to be given to other National Parks and Reserves occurring on the periphery of the region, using information contained in the System 6 Report (Environmental Protection Authority, 1983).

The coding scale for the adequacy of represenatation has been developed as an amplification of international standards, which consider 5-10% of the total area represented in reserves as just adequate. A significant proportion of the vegetation complexes fall below this level and some have very low levels of representation. The lower end of the range has therefore been halved and then halved again, e.g. 5% to 2.5%, 2.5% to 1.25 and below 1.25%. At the other end of the scale, the range has been obtained by doubling, e.g. 10-20%, and above 20%.

Table 6b: Coverage of Vegetation Complexes within Reserves

Vegetation Complex	% Representation in Reserves	
1. 0-1.25% Completely inadequate representation		
Helena (L/M)	-	
Williams River	-	
Loudon	0.23	
Cardiff	-	
Forrestfield	-	
2. 1.25-2.5% Minimal representation		
Darling Scarp	1.53	
3. 2.5-5% Less than adequate		
Michibin	3.49	
Wilga (L/M)	3.81	
Muja	4.32	
4. 5-10% Just adequate		
Yarragil Min Swamps (M/H)	5.74	
Collie	5.88	
Dwellingup (H)	6.03	
Coolakin (L)	7.49	
Murray (L/M)	8.70	
Murray (M/H) before Ministerial ruling	8.95	*
5. 10-20% Ample		
Yarragil Max Swamps (M/H)	12.45	
Dwellingup-Yalambee (LM)	13.72	
Dwellingup (M/H)	13.99	
Pindalup/Yarragil (L/M)	17.35	
Yalambee-Dwellingup (L)	18.75	
6. >20% Generous to Excessive		
Murray (M/H) after Ministerial ruling	26	(* approx.)
Yalambee (L)	23.66	
Swamp	25.60	
Helena (M/H)	26.84	
Cooke	31.86	
Goonaping	56.81	

* Representation has been greatly enlarged by recent Ministerial ruling on the Lane-Poole Reserve.

6.6.3 Relative Impact

In considering to what degree the significance of this may be modified by the adequacy of representation in reserves, the main weighting has been given to the fact that Helena (L/M) is least adequately represented, and that Cooke, Swamp and Helena (M/H) are represented at 20% + level, as is the Murray (M/H) complex following the recent ministerial decision on the Lane-Poole Reserve. The exclusion of water resources development from the recreational zone of the Reserve increases the de-facto coverage of the Murray (M/H) complex by approximately 13,000 ha, or from 8.95 to approximately 26% of the total area.

On the qualitative basis, the most significant impact in terms of vegetation complexes is that of the proposed raising of the Mundaring Weir. Most of the vegetation complexes affected by the South Canning proposal are amply or excessively represented. However in strictly quantitative terms the impact of the South Canning proposal is the most serious even when allowance is made for this factor, due to the large area affected by it.

6.7 Assessment of Impact on Site-vegetation Types

For the purpose of assessing the impact of inundation it is necessary to agglomerate the vegetation types into larger groups, the most logical being into those characteristic of valley floors and lower slopes (category 1) and those characteristic of steeper mid and upper slopes and uplands (category 2). The third category of intermediate types will also be necessary.

In view of the expected strongly biased impact of the inundation on the low lying site-vegetation types, it is important to assess how adequately the various types are represented in the existing system of Reserves, National Parks and Management Priority Areas for the Conservation of Flora, Fauna and the Landscape. This is only possible qualitatively, as maps at this level of detail are only available for some of the reserves. The source for the information is primarily the ennumeration of reserves in the Northern Jarrah Region by Heddle et al., (1980b). This is reassessed in Table 7.

TABLE 7: ASSESSMENT OF REPRESENTATION OF SITE-VEGETATION TYPES

Site-Vegetation Type	Main Forms Found in WAWA Surveys	Reserves, National Parks and Conservation MPAs in which the Type is found as a Dominant Type	Minor Type	Adequacy of Representation
A	A,AC,AB,AQ	Goonapin, Sullivan Lane-Poole	Russell, Dale, Monadnock, Lupton, Gyngoorda, Duncan	ample, very widespread eastern type
B	B,AB.BE	Lane-Poole	Gunapin, Sullivan, Monadnock.	adequate, but very dieback susceptible
C	C,CQ,CR,AC, CW,CY	Lane-Poole	Monadnock, Serpentine.	adequate
D	D,DG,DS	Monadnock, Duncan, Lane-Poole	Russell, Dale, Serpentine.	inadequate - very susceptible to dieback.
E	E,EH,CE,BE		Russell, Dale, Monadnock, Gyngoorda, Lane-Poole	inadequate - very susceptible to dieback.
F	not found in survey		Gunapin, Sullivan, Dale, Monadnock, Lane-Poole	overall rare, but adequately represented.
G	G,CG,DG,HG,LG, MG,RG,UG,YG	Dale, Monadnock, Serpentine, Kalamunda NP, John Forrest NP,Walyunga NP.	Russell, Serpentine, Duncan, parts of Lane-Poole.	ample, very variable.

TABLE 7: ASSESSMENT OF REPRESENTATION OF SITE-VEGETATION TYPES

Site-Vegetation Type	Main Forms Found in WAWA Surveys	Reserves, National Parks and Conservation MPAs in which the Type is found as a Dominant Type	Minor Type	Adequacy of Representation
H	H,EH,ZH, YH,WH,PH.	Gunapin, Sullivan, Russell, Dale, Monadnock, Lupton, Duncan, Lane-Poole.	Gunapin, Sullivan, Russell, Dale, Gyngoorda, Lane-Poole.	ample, very widespread eastern type.
J	AJ		Gunapin, Sullivan, Dale, Russell, Monadnock, Gyngoorda, Lane-Poole.	ample, mainly in Gunapin vegetation complex.
L	L,CL,LQ,ML,YL		Russell, Dale, Lane-Poole, Kalamunda NP.	overall rare but adequately represented.
M	M,MG,WM,ZM, YM,QM	Gunapin, Russell, Dale, Lupton, Gyngoorda, Lane-Poole.	Monadnock, Duncan.	adequate to ample.
O	O,OS	Lane-Poole		overall restricted, but probably adequately represented.

TABLE 7: ASSESSMENT OF REPRESENTATION OF SITE-VEGETATION TYPES

Site-Vegetation Type	Main Forms Found in WAWA Surveys	Reserves, National Parks and Conservation MPAs in which the Type is found as a		Adequacy of Representation
		Dominant Type	Minor Type	
P	P,PH,PQ,PS,WP	Monadnock, Serpentine, Lane-Poole.	Duncan.	adequate but strongly dieback affected.
Q	Q,AQ,CQ,RQ, WQ,QT	Serpentine, Lane-Poole.	Monadnock	adequate, common in Lane-Poole.
R	R,CR,RG,RS, RT,WR	Monadnock.	Dale, Lane-Poole.	adequate - widespread on Monadnock & valleys.
S	S,DS,OS,PS, RS,ST,WS,ZS.	Monadnock, Serpentine, Lane-Poole.		adequate - very widespread on western uplands.
T	T,ST,OT,QT,ZT.	Serpentine, Lane-Poole.	Monadnock	adequate - common in Lane-Poole.
U	U,UG		Lane-Poole, on very small scale in Serpentine	adequate - rare type but dieback resistant.
W	W,AW,CW,WG,WH, WQ,WR,WP,WS,WZ.		Monadnock, Serpentine, Lane-Poole.	inadequate - strongly affected by dieback.

TABLE 7: ASSESSMENT OF REPRESENTATION OF SITE-VEGETATION TYPES

Site-Vegetation Type	Main Forms Found in WAWA Surveys	Reserves, National Parks and Conservation MPAs in which the Type is found as a Dominant Type	Minor Type	Adequacy of Representation
Y	Y,AY,CY,GY, LY,MY,YZ.	Sullivan, Russell, Lupton, Duncan, Lane-Poole.	Dale, Monadnock.	ample - common in eastern valleys.
Z	Z,HZ,ZQ,ZS, ZT.	Monadnock, Lane-Poole.	Russell, Duncan.	ample - common in eastern uplands.

P.S. Lane-Poole Reserve has been formed by the amalgamation of Murray, Teesdale, Bell, Federal, Samson, Plavins, Surface, Nalyerin, Stene and Trees. Monadnock has been formed by the amalgamation of Eagle Hill, Cooke & Windsor. Serpentine has been formed by the amalgamation of Serpentine, Karnet and Gooralong.

In view of the complexity of the task the impact of the proposed engineering options on site-vegetation types will be initially examined separately in chapters 7 to 10, and subsequently summarized in Chapter 11.

6.8 Assessment of Impact on Individual Species

Although some assessment of the impact of the various engineering options is feasible given the establishment of a comprehensive data base, the detailed examination of all species is out of question within the present time and financial constraints. The effort has therefore been concentrated on the rare and restricted species, which are dealt with separately for the four options in chapters 7 to 10 and summarized in chapter 11.

6.9 Condition of Plant Communities

In assessing the condition of the vegetation, the data sheets were structured to give simple answers to such questions as:

a) What is the condition of the vegetation at present?
b) What has been the cause of disturbance?
c) How long ago did the most recent disturbance take place?

The former was assessed on a scale of 1 to 4 (see Section 5.1.3), The assessment of the disturbance was chiefly made in terms of the trees, although in the case of dieback disease, understorey species were also included.

The time since disturbance was only roughly assessed by the preservation of dead trees and stumps, i.e. whether there was time first for the bark, and then wood, to be destroyed by fires or rot. In Mundaring, an excellent check was provided by extensive felling and ringbarking of trees which took place in the early 1900's.

The outstanding impression is the resilience of most of the valley vegetation types. Although evidence remains in many areas of very severe disturbances, the recovery, compared to lateritic uplands, has been very good. The impact of the dieback disease (*Phytophthora cinnamomi*) has, by comparison to shallow valleys and depressions in the uplands, been relatively minor. This is attributed to better drained and more fertile soils of the valley slopes and a high proportion of species not susceptible to the disease. It is only on the periphery of the area to be inundated, in the Yarragil (M/H) vegetation complex and on the edges of the Dwellingup (M/H) complex, that the disease has had a serious impact.

By contrast, fire and drought damage has been much more severe on the steep valley slopes with shallow soils than on the lateritic uplands with deep soils. Most severe fire damage is datable to the 1950's and 1960's, between the breakdown of the total fire protection and the establishment of the present system of periodic prescribed burning.

The invasion of the disturbed forest by exotic weeds has been relatively mild, roughly in proportion to the fertility of a given site. It tends to be highest on fertile red earths developed from basic rocks such as dolerite, and least on infertile grey sands and lateritic gravels.

In terms of the more recent man-made disturbances, the north-western half of the South Canning proposal is most severely disturbed, having been heavily logged-over when the construction of the dam was considered imminent in the early 1980's. However the south-eastern half of the proposed dam is relatively undisturbed, chiefly because of the poor form and low yield of trees characteristic of the valleys, such as Eucalyptus rudis, E. patens, E. wandoo and E. calophylla. Logging is currently in progress at North Dandalup, particularly on uplands and slopes south of the river. The eastern bank of the Canning Basin was logged in the late 1970's, but the steep banks leading to the waterline were generally not affected. The Mundaring proposal has had by far the greatest degree of past disturbance in the form of clearing for agriculture and exotic pine plantations and ring-barking to increase the water yield, but there are significant areas that have not been disturbed recently and have had the chance to recover. As the man-made disturbances are not uniformly distributed over the areas under construction, only a very rough ranking of the four project sites is feasible. The Canning proposal is considered to have the least disturbance, followed by North Dandalup, Mundaring and South Canning. This reduces the severity of the additional potential impact of the South Canning Dam.

6.10 Off-site Impacts of Dam Construction

The off-site impacts of the dam construction fall chiefly into two categories -

a) lateral impact of road and power line relocation
b) downstream impact on aquatic and phreatic vegetation below the dam.

The impact of the former would be quite considerable. This problem has been incorporated into the sampling design for Mundaring (road) and South Canning (powerline) options, but the road relocations would be a feature of all four options. Generally, the effect would be to move the roads and powerlines from the valleys to be inundated to the adjacent uplands. Where the existing road system runs parallel to the long axis of the dam, the roads would need to be moved upslopes. Where the slopes are steep, as in the case of Mundaring, this would cause considerable problem, and would increase the impact on species with good vertical distributions, eg. Grevillea drummondii var pimelioides. Dryandra praemorsa and Conospermum huegelii, and on the site-vegetation types typical of these slopes such as G and R. Where the roads are currently orientated across the valley, considerable detours through upland types P, S and T would be involved, with the accompanying risk of spreading Phytophthora cinnamomi, the pathogen causing the jarrah dieback disease. The effect would then possibly gravitate to types O, D and W in shallow upland valleys and depressions.

The main effect of powerline relocation in the South Canning option would be to extend the impact on to the Dwellingup-Yalanbee (L/M) complex and its main component types H and Z.

The downstream effect on aquatic and phreatic vegetation has, in some past studies, been assumed to arise out of disruption of normal flow patterns. The flow pattern over the past two decades has been so erratic that it is doubtful if any species dependent on consistent flows could have survived this period.

During the course of the surveys, between reconnaissance and the final check, many of the streams and pools have dried up and the common aquatic species, such as Villarsia albiflora and Triglochin procera, have completed their flowering and fruiting cycle and are aestivating. In the deeper and more permanent pools these species remain active.

Secondly, the assumption that damming a stream could prevent the periodic refilling of the pools ignores the fact that most streams have tributaries below the dam which, although not capable of maintaining summer flows, are capable of filling the pools and replenishing the subsoil water storage on which the phreatic vegetation of type C depends. Even on the streams that have more than one impoundment, such as Serpentine and Harvey or an impoundment that requires number of years to be filled, such as South Dandalup, aquatic and phreatic vegetation persists downstream from the dams. Without quantitative observations over a considerable period it is impossible to say whether there has been a partial reduction, but there has not been total elimination. Generally downstream from dams, in the steep sided Helena-type valleys, the phreatic vegetation forms a very narrow zone of type CR even in the natural state.

6.11 Effects of Periodic Inundation

In the course of surveys, particularly those carried out with the aid of boats, there were numerous opportunities to observe vegetation on areas subject only to periodic inundation, such as in the upper reaches of the Canning and Mundaring dams. On the whole, the capacity of vegetation to persist or return to areas inundated only infrequently is disappointing. Even species with a proven capacity to cope with periodic natural flooding, such as Eucalyptus rudis and Melaleuca rhaphiophylla, have not persisted below the level of maximum inundation. However they have, to a considerable degree, recolonized some areas of shallow inundation, normally associated with the original river terraces and flood plains. It is on these areas that there has also been reinvasion by other species, often not indigeneous. The most successful woody invaders have been the legumes Viminaria juncea and Acacia saligna, which in the more favourable areas form dense thickets. The associated herbaceous species vary according to location, and again include some legumes such as the Kennedia, as well as the species of moist disturbed sites such as Dampiera and Velleia spp. There is also a high proportion of exotics. The re-vegetation of the steeper slopes has been very poor, suggesting that during the period of inundation there is drastic leaching of nutrients, and downslope movement of clay and silt. This is also indicated by leached appearance of the soils below the maximum level of inundation, and by the success of genera capable of generating their own nitrogen supply, such as Viminaria, Acacia and Kennedia.

Aerial photographs from the upper reaches of South Dandalup Dam, characterized by slow filling capacity (estimated average of 7 years) and recent construction, suggest that similar patterns are developing there. A dense line of the regeneration has developed at maximum inundation level. Immediately downslope from it, there is a bare zone on the steeper slopes which suggest that the original vegetation, which would have had very poor tolerance to flooding has been eliminated even by the once-off event. On the mildest slopes where gullies enter the dam, the original swamp vegetation of types A and C has persisted. There is a second line of regeneration downslope, which is less dense and less continuous. Some moderately large trees have persisted between the two levels, but the shrub layer has been strongly reduced down to the lower level, indicative of more prolonged inundation. As in the case of Canning and Mundaring, there has been reinvasion of the shallow mildly sloping flats even below the lower level, but there are considerable areas between that level and the February 1986 water level, which remain bare even on the flats.

It is therefore reasonable to predict that dynamic patterns of death through inundation of the original vegetation, and its partial replacement on the more favourable sites by invasive species more tolerant of inundation, would also characterize the South Canning dam. As full flooding would be a rare event, longer persistence of the original vegetation may be expected. However eventually considerable areas with little or no vegetation would develop.

6.12 Effects of Increased Recreational Use

Dam construction has, in the past, tended to attract public interest and lead to increased recreational usage of the area at and below the dam wall. The impact of such increased recreational activity would, in the case of South Canning and North Dandalup options, be complicated by the fact that reserves for the conservation of flora and fauna occurs immediately below the dam. In view of the vulnerability of the Murray and Helena Vegetation Complexes to heavy recreational use, recreational activity should be, as far as possible, be confined to lateritic uplands adjacent to the dam wall, and only access on foot permitted to the valley below the dam. It should not be facilitated by provision of footpaths, and all motorized recreation should be excluded entirely.

7. MUNDARING

7.1 Site-vegetation Types

Mundaring differs from the other project sites in the lower rainfall and distinctive geology (the occurrence of large body of migmatite rock). This is reflected in the distribution of site-vegetation types. For instance, type T characteristic of the transition between the dissected and lateritic landscape in the high rainfall zone is absent, as are its derivatives such as ST and QT, which are so prominent in Canning and North Dandalup. Type Q rarely occurs in its typical high rainfall form, tending to be replaced by drier derivatives such as MQ, PQ, UQ, YQ and in particular QZ and WQ. Similarly CQ is largely replaced by type AQ. Type S, characteristic of the lateritic surfaces in medium to high rainfall areas, is relaced here by type Z, occupying a similar position in the landscape. Types L and M, which are absent from other survey areas, and Type Y, which elsewhere only occurs at the south-eastern extremity of the South Canning project site, are strongly developed here.

Due to the unusual geology of the area, the proportion of types with higher fertility and fine texture (derivatives of U, L, Q, and to a lesser degree Y, W) is very high, whereas those types with low fertility and coarse texture (B, H, E, F, P and D) are virtually absent from the area surveyed. This tendency is reflected in the strong intermixing of type Q with the types more characteristic of this lower rainfall zone, such as A, M, Z and Y and in the occurrence of WQ at much higher levels than seen elsewhere.

As in other areas surveyed, the distribution of site-vegetation types within the landscape is strongly influenced by the degree of dissection. The unusual feature of Mundaring is the combination of steep, strongly eroded and rocky slopes and mildly sloping lower slopes and terraces, which are often lateritized. Due to the scattered and asymmetrical distribution of these lateritized surfaces, the pattern is very complex. This is particularly evident where the Darkin and Helena Rivers enter the dam.

Where the dam is surrounded by uplands, the pattern is relatively simple - the site-vegetation types of the slopes are determined by the underlying geology and the steepness of the slopes. The steepest slopes, generally with heavy rock exposures, are occupied by type R in the moister north-west, and by type G in the south-east, with various degrees of mixing in between. There is also asymmetry in the distribution of the two types due to aspect, the west and north facing slopes tending to carry type G, whereas the south and east facing slopes more frequently carry type R. Because exfoliation of granite and migmatite results in greater areas of bare rock then the progressive breakdown along joints of the dolerite dykes, the sites over dolerite dykes frequently have deeper soils, with some development of type U and its derivatives, whereas types R and G are more common over granite and migmatite. The less steep slopes, which generally are covered with some lateritic gravel, either developed in situ or brought down from the lateritic surfaces above and not fully removed by erosion, mostly carry types Z and M. The proportion of type Z, dominated by Eucalyptus marginata is greater on the western side of the dam, whereas type M, with greater proportion of Eucalyptus wandoo, is greater on the eastern side. On aerial photographs it is difficult to distinguish type R from type G, and type Z from type M, as in their structure and position in the landscape they are very similar.

The mildly sloping lower slopes and terraces carry either site-vegetation types W and its derivatives WP and WQ, where soils are deeper and better drained, or type Y where the soil profile is shallower, with drainage impeded by clayey subsoil. The vegetation of the stream-lines and narrow alluvial plains is mainly of the type AQ in the case of the two main streams, and CY in the case of the minor tributaries.

Several subdivisions of type G were defined:

- The first includes the mosaic of herbfields and heaths which occur on the massive granite outcrops (G1); this community is generally devoid of a tree layer (Appendix D1), with the exception of a few pockets of Allocasuarina huegeliana (Rock Sheoak). In fact the Rock Sheoak occurs in a range of groupings, where the soils are deep enough over the outcropping to support the sheoak stands.

- The second includes stands of Rock Sheoak and a range of Eucalypts, including Jarrah, Marri and Flooded Gum (G2); this community type has affinities with a transitional type UG (Appendix D1) and occurs on the dolerite dykes.

- The dominance of Wandoo in the Mundaring catchment is reflected in the range of types recorded (MG, GM, GL and LG), Appendix D1. All these differ slightly in the species that reflect the massive outcrops (G) types and derivatives. These Wandoo types reflect the differences in geology and climate, as noted in earlier studies by Heddle et al. (1980a).

The other types defined by the R and G analyses were transitional types or derivatives of Havel's types (1975a,b), Appendix D1.

7.2 Assessment of Impact on the Site-vegetation Types

Some simplification of the complex vegetation patterns in the Mundaring area is essential for the quantitative evaluation of the impact. The grouping most appropriate to Mundaring is:

Category 1 - comprises all site-vegetation types of valley floors, lower slopes and depressions, namely A, C, Q, W and Y and their derivatives (Appendix E1).

Category 2 - comprises types of mid and upper slopes, and lateritic uplands, namely G, L, M, R, U and Z and their derivatives (Appendix E1).

The lateritic uplands of the Dwellingup and Yalanbee surfaces largely remain unaffected by even the highest inundation. The types characteristic of them , such as S and P in the north-west, and H and E in the east, are virtually absent, although P occurs on two occassions in intermediate types WP and PQ. The comparison of the two main categories in terms of the various levels of inundation are summarized in Table 8.

Table 8: Summary of Effect of Progressive Inundation on Site-vegetation Types at Mundaring

a) Effect of Progressive Inundation Levels

Category	SR	SR-LO	LO-UO	UO-ML	>ML
1	13	5	6	4	1
2	7	7	12	7	18

b) Effect of Progressive Inundation Levels In Cummulative, Absolute Terms

Category	SR	LO	UO	ML	Total
1	13(43%)	18(62%)	24(83%)	28(97%)	29(100%)
2	7(14%)	14(27%)	26(51%)	33(65%)	51(100%)

Note: SR = Small Rising, LO = Lower Optimum, UO = Upper Optimum
ML = Maximum Level

This means that the Category 1 is strongly affected even at the lowest level, and would be virtually eliminated at the maximum level of inundation. By contrast Category 2 is barely affected until the upper optimum level, and to only 65% even at the maximum level. Even this impact is exaggerated, as the types comprising Category 2 (M, G, R, U and Z) continue well above the limits of the survey. The impact on Category 1 is aggravated by the fact that above the upper limit of inundation the vegetation of the valley floors and lower slopes has been largely replaced by exotic plantations in both the Helena and the Darkin Rivers. All the minor streams descend into the dam very rapidly in the form of cascades and rapids over rocky outcrops, so that the stream-line vegetation is poorly developed. The impact of inundation on the site-vegetation types comprising this category, especially AQ, YQ, CY and WQ would therefore be particularly severe. It is further accentuated by the absence of types AQ, YQ and WQ from other areas surveyed. The only comparable combination of environmental conditions and of vegetation is in the Bell Section of the Lane-Poole Reserve.

The relocation of roads that would be made necessary by the raising of the dam wall would mainly affect types L, M, R and G, characteristic of the Helena (L/M) vegetation complex. The relocation of roads made necessary by the inundation of section of Reservoir and Allen Roads would mainly affect types M, Z, R and G, characteristic of higher levels within the Murray-Bindoon (L/M) complex.

7.3 Assessment of Impact on Individual Rare and Restricted Species

Considering the relatively small area of inundation even at the maximum level, the number of rare or restricted species affected by it is high (Appendix B1). The severity of the impact is largely determined by their dependence on Category 1 site-vegetation types.

For most of the rarer species in the Mundaring area, the dependence is fortunately not complete.

Billardiera drummondiana var. collina :
The variety of this species was only recorded from below the optimum level of inundation, but the types within which it was found (CR, R) have considerable vertical distribution, so that the impact is unlikely to be total. Nevertheless it is severe.

Conospermum huegelii :
This species occurs on type G. It was found once below and once above the maximum level of inundation. Type G has considerable vertical distribution, and the impact is therefore only partial.

Dryandra praemorsa :
This species is primarily found in types R and G, which occur both below and above the maximum level of inundation.

Gastrolobium epacridoides :
This species was only found once, in type G, above the maximum level of inundation.

Grevillea drummondii var. pimelioides :
This variety was found mainly in types W and Q and their derivatives below, and in types R and G and their derivatives above the maximum level of inundation.

Hibbertia pilosa :

This species occurs in a wide range of sites of average or better fertility (Y, W, Q, R, G and Z) from below the lowest level of inundation to above the maximum level.

Microcorys longifolia :

This species only occurred once during reconnaissance in type CQ on Little Darkin River, below the maximum level of inundation. On the present level of information it would be severely affected.

Petrophile biloba :

This species was found only once in type G above the maximum level of inundation.

Tetratheca nuda :

This species was only found once, in type G, above the maximum level of inundation.

Therefore in summary, there is only one species (Microcorys longifolia) which would be severly affected by raising the level of inundation at Mundaring. In all the other species, the inundation would result in only partial reduction of populations, or have no affect at all.

Several rare species known to occur in the Helena (L/M) complex, such as Synaphea pinnata, Acacia anomala, A. aphylla, Darwinia pimelioides and Lasiopetalum bracteatum were searched for but not found in the north-western portion of the surveyed area.

8. CANNING

8.1 Site-vegetation Types

The range of vegetation types in the Canning option is relatively narrow, because it is restricted to the high rainfall zone and does not contain any major geological features not present elsewhere. In addition it is ecologically well known, as it is here that Havel (1975b) and Kaeshagen (1978) carried out detailed ecological mapping. The chief source of variation is the degree of dissections of the lateritic plateau, and the dominance of either granitic or doleritic basement rock within the dissection. The river system is strongly asymmetrical. The western half is drained by the deeply entrenched South Canning branch, which appears to follow a geological line of weakness and contains an exceptionally high proportion of basic doleritic rock in its dissection. The dominant vegetation types in this context are CQ along the streamline, flanked by Q on lower and mid slopes, T on upper slopes and S on the plateau. On residual terraces in the upper reaches of the dam there is strong development of type W and where the river breaks through a zone of granitic rocks, there is a strong development of types R and G. The East Canning branch and its former tributaries enter the existing dam in a granitic zone and are less deeply incised into the lateritic plateau. This means that the stream line vegetation tends to be mainly of C or CR type, and that there is much greater development of types WR, R, G and SR. It is within this ecological context that some of the rare or restricted species, such as Lasiopetalum bracteatum, Calothamnus rupestris and Lepyrodia sp. (A), occur.

One of the variants of G type (G1) occurs on the massive areas of outcrops and supports a range of herbfields and heaths with only the occasional emergent Marri (G1), Appendix D2.

In the peninsula between the two river branches there is a restricted, almost anomalous vegetation type, which for want of better name has been named DR. Its outstanding feature is the occurrence of multi-stemmed Kingia australis. Normally this species occurs on the lower slopes and valley floors as a single stemmed grass tree (Appendix D2). Adjacent to it is a restricted occurrence of types GR and GM dominated by Eucalyptus laeliae and Eucalyptus wandoo, whose nearest occurrences are in the Helena (M/H) complex downstream or in the Cooke complex upstream. Here it is associated with an outcropping of a basic (doleritic) dyke. With the exception of the types described above, the vegetation types occurring here approximate very closely Havel's (1975a,b) types.

8.2 Assessment of Impact on Site-vegetation Types

In the Canning option, category 1 contains vegetation types C, W, Q and D and their derivatives and category 2 contains S, T, R and G and their derivatives (Appendix E2). Intermediate types containing elements of 1 and 2 have been placed into a separate category 3. The evaluation of the impact is summarized in Table 9.

Table 9: Summary of Effect of Progressive Inundation on Site-vegetation Types at Canning

a) Effect of Progressive Inundation Levels

Category	<SR	SR-LO	LO-ML	>ML
1	9	3	3	0
2	7	6	6	29

b) Effect of Progressive Inundation Levels In Cummulative, Absolute Terms

Category	<SR	LO	ML	TOTAL
1	9(60%)	12(80%)	15(100%)	15(100%)
2	7(15%)	13(27%)	19(40%)	48(100%)

Note: SR = Small Rising, LO = Lower Optimum, ML = Maximum Level

This means that inundation has a similar effect on both categories in absolute terms, up to maximum level, but whereas at this stage the Category 1 vegetation types C, W, and Q, would be entirely eliminated, the bulk of Category 2 would continue above the maximum inundation levels.

This is an exageration, as types C, W and Q continue on the South Canning branch right up to the proposed South Canning dam site. This portion of the river was not covered by the current survey, but was partly covered by Havel's (1975b) survey. Types C and W also occur within the Yarragil (M/H) complex, the bulk of which is above the highest level of inundation considered.

8.3 Assessment of Impact on Individual Rare and Restricted Species

The range of rare and restricted species which may be affected by the proposed development are summarized in Appendix B2.

Of those observed, not all are equally affected.

Acacia barbinervis :

This species was recorded here only once, but in other areas it was collected more extensively, generally on slopes. Consequently it is unlikely to be severly affected by the proposed raising of the dam.

Aotus cordifolia :

This species was recorded in this project site only. Although one occurrence is insufficient to assess its ecological amplitude, it is known from herbarium records to occur in swamps and streamline vegetation (Type C). It would therefore be strongly affected by any dam extension.

Calothamnus rupestris :

This species was only recorded at this project site. It occurs here in a range of site-vegetation types, on different sections of the landscape. It would be partially affected by dam extension.

Dryandra praemorsa :

This species was recorded at all project sites, often quite extensively and generally on slopes, therefore would be affected to a lesser degree.

Eucalyptus laeliae :

Although this species was recorded only once in this project site, there have been numerous observations at the North Dandalup site. In addition, the main occurrence of the species is in the Cooke vegetation complex on the monadnocks, high above any inundation. The inundation of the one occurrence here would therefore be of lesser consequence.

Hibbertia pilosa :

This species was recorded in significant numbers at most sites, often quite extensively and generally on slopes and would therefore be affected to a lesser degree.

Lasiopetalum bracteatum :

This species has been recorded from several transects, on granite outcrops near the East Branch. Only one of the four observations was above the lower optimum and maximum level of inundation. In the herbarium (Gillen, 1982) it is recorded as occuring on granitic outcrops near streams, which is supported by this survey. The impact of the inundation would therefore be considerable particularly as most of the earlier observations came from areas now affected by suburban growth (Darlington, Kalamunda, Lesmurdie, Helena Valley).

Lepyrodia sp.(A) :

This species has been collected only once on this survey, and its ecological amplitude is poorly documented, but it appears to have preference for water gaining sites low in the landscape. It would be therefore strongly affected by inundation.

In addition to the known restricted or rare species there is a large number of species which have been mostly recorded from below the maximum level of inundation. In many cases, as in the earlier quoted example of Eucalyptus laeliae, this is purely an artifact created by the survey, as the species is known to be relatively well distributed above and outside the inundation. There still remains a considerable number of these species recorded only from site vegetation types C, Q & W, normally the first to be affected by inundation. Some of these have been collected only once or twice, eg. Baumea vaginalis, Thomasia paniculata, Dampiera hederacea and Hemigenia ramosissima, and they may require future study on regional scale. A fuller list of these species is given in Appendix B2.

9. SOUTH CANNING

9.1 Site-vegetation Types

The great geographical extent of the South Canning proposal is reflected not only in the greatest number of vegetation complexes affected by it, but also in the very wide range of site-vegetation types. Of the 22 types defined by Havel (1975 a,b) only two relatively rare types F and U, are not represented here, either directly or by their derivatives. An additional type identified by Mattiske & Associates (1983) and labelled here as X, is also quite extensively developed within this area. Whereas in other areas surveyed climatic variation is relatively small, here it is considerable and ranks second only to the degree of dissection as the determinant of vegetation patterns. The climatic and geomorphological gradients reinforce one another, producing a very strong East-West ecological gradient from the tall Jarrah-Marri-Yarri forest of types Q and T in the deeply dissected valleys of the western high rainfall zone, to relatively low open Wandoo woodlands of type Y and treeless swamps of type A in the flat, poorly drained valleys in the eastern low rainfall zone.

The vegetation pattern is further complicated by the very strong asymmetry of the South Canning catchment, whose western boundary is strongly defined by a line of high monadnocks, whereas the north-eastern boundary is very poorly defined by a low, swampy divide. At the wall of the proposed dam, where the river closely abutts Eagle Hill, the deep, steeply sloping valley slopes carry mainly site-vegetation types R and G where granitic parent rock outcrops, and types T and Q where the soils are somewhat deeper red earths.

Further upstream, where the river swings away from the line of monadnocks and its gradient slackens, the valley broadens, its slopes become milder and retain much greater proportion of the deep lateritic mantle. This is reflected in markedly increased occurrence of type W and its derivatives and reduced occurrence of type Q and its derivatives. In some portions of the valley asymmetrical development has led to mild slopes with type SP on one side, and much steeper rocky slopes with types WR and R on the other side. The streamside vegetation is still largely C or CQ. It is this combination of slopes, soils and vegetation that does not fit neatly into either the Murray (M/H) or Pindalup-Yarragil (L/M) complexes. This is not surprising when one considers the scale of interpretation for the vegetation complexes (initially

1:50,000 and then a reduction to 1:250,000 for publication).

The true development of the Pindalup-Yarragil (L/M) complex occurs further upstream, where the valleys flatten out and broaden still further, generally impeding drainage on the valley floor, leading to replacement of types C and CQ by types A, AX and AW. The vegetation of the slopes begins to change here from ST and WS to ZT, ZS, WZ and Z, reflecting the decrease in rainfall. Localized development of type O also occurs sometimes, probably associated with truncation of the lateritic profile.

With further progression eastward type W of the lower slopes begins to be replaced by type Y. On slopes of asymmetrical valleys types M and G appear, reflecting the broad-scale climatic change associated with localized reduction in soil depth. Derivatives of type T persist longest on soils developed over dolerite dykes, which provide the best combination of moisture and nutrients.

The ultimate stage of the eastward, upstream progression are the broad, mildly sloping valleys, with type Y on the lower slopes and valley floors, separated by low gravelly-sandy divides carrying type H.

There are two main departures from this major trend. The western tributary valleys draining from the monadnocks reflect the combination of somewhat higher rainfall and greater deposition of sandy detritus in the appearance of types B, D, E and P.

The northern tributaries draining the low divide between Canning and Darkin River begin in very broad, sand-filled swampy depressions whose central position is covered by shrubby vegetation of types A and AX. The steeper transition zone to the lateritic uplands is occupied by type WS, the milder, sandier transition by types B, E and J. The adjacent uplands are of types P and S.

Several subdivisions of type G were defined:

- The first includes the mosaic of herbfields and heaths which occur on the massive granite outcrops (G3); this community is devoid of a tree layer and therefore is similar in some aspects to G1 (Appendix D3). However in the last series of analyses between sites these eastern intermediate rainfall granite outcrops were separated out from the western heath and herbfield types (G1). These difference are apparent from the list of indicator and associated species summarized in Appendix D3. For example, the eastern Gastrolobium spinosum was recorded in G3 but did not appear in the western equivalent type G1. Similarly Grevillea endlicheriana, which is known to occur in significant numbers on the Darling Scarp and Helena surfaces, was not recorded in these eastern heaths on granites (Appendix D1 as compared with D3).

- A similar trend was evident in the definition of G4 (or CR), where the species were associated with shallow soils in the valleys and gullies. For example, the Melaleuca rhaphiophylla and M. viminea were not present in the similar heaths at either Mundaring (possibly a reflection of past flooding) or North Dandalup (where the soils and consequently swamp species differ, as noted by Mattiske and Associates, 1983). Therefore it is not surprising that in the comparison of R and G types (and their derivatives) between the four options this split was highlighted in the extreme site-vegetation types and their derivatives.

Although Wandoo was widespread in the South Canning option it tended to occur on the valley floors and was not associated with rock outcrops. The latter also reflects the differences between the Pindalup-Yarragil(L/M) and Murray-Bindoon (L/M) complexes as defined by Heddle et al. (1980a).

The other types defined by the R and G analyses were transitional types or derivatives of Havel's types (1975a,b) (Appendix D3). For example, at the margin of the lateritic uplands, dominated by type S, intermediate types RS and RT occur. The narrow valley floor carries mainly streambank vegetation of types C, CQ and CR.

9.2 Assessment of Impact on Site-vegetation Types

As would be expected from the description of site-vegetation types in South Canning (Section 9.2), a wide range of site-vegetation types would be affected by inundation caused by the proposed South Canning Dam.

As in preceeding chapters, they have been broken up into three categories.

Category 1 - comprises all site-vegetation types of valley floors, lower slopes and depressions, namely A, B, C, D, E, Q, W and Y and their derivatives (Appendix E3).

Category 2 - comprises types of mid and upper slopes, lateritic uplands, namely G, H, L, M, O, P, R, S, T and Z and their derivatives (Appendix E3).

Category 3 - comprises intermediate types between 1 and 2, such as WS, QT and EH (Appendix E3).

The effect of progressive inundation is summarized in Table 10.

Table 10: Summary of Effect of Progressive Inundation on Site-vegetation Types at South Canning

a) Effect of Progressive Inundation Levels

Category	LL	LL-LO	LO-ML	>ML
1	35	21	15	7
2	17	44	14	45

b) Effect of Progressive Inundation Levels In Cummulative, Absolute Terms

Category	LL	LL-LO	LO-ML	>ML
1	35(45%)	56(72%)	71(91%)	78(100%)
2	17 (14%)	61(51%)	75(62%)	120(100%)

Note: LL = Lowest Level , LO = Lower Optimum , ML = Maximum Level

The results illustrate that at the lowest level of inundation, nearly half of the lowland types would already be affected, rising to 91% at the maximum level. However, in contrast to other alternatives, a proportion of lowland sites would escape inundation. Closer analysis indicates that the types in this category are mainly derivatives of the eastern types Y and E. Types C, Q, CQ, CW and W would, to a large degree, be already inundated at the lower levels, and completely inundated at the lower optimum level.

The types chiefly remaining unaffected by inundation to maximum level are G, H, M, P, R, S, T and Z, their mutual derivatives, especially ST, and intermediate types EH, WH and YH.

9.3 Assessment of Impact on Individual Rare and Restricted Species

Despite the large extent of the proposed South Canning Dam, the number of rare and restricted species is relatively small (Appendix B3). This may be an artifact, as the eastern part of the catchment has not been considered in the recent compilation of the flora in the Perth Metropolitan Regional Flora (Marchant et al., 1987), and the conservation status of the species within it may be less adequately known.

Those species recorded on the South Canning project site are as follows:

Acacia barbinervis :

This species was recorded 6 times in types M, H, Z, S and their derivatives SZ and ZH. Four out of the six times it was recorded above the maximum level of inundation. All occurrences were in the extreme south-east. As the types in which it occurs are upland types, the impact is not likely to be severe.

Dryandra praemorsa :

This was recorded 5 times in types Z, M, H, G and R; in each case above the maximum level of inundation. Three of these were contiguous, part of a larger population drifting down from a high granitic outcrop. The remaining two were also associated with granitic outcrops. Inundation is not considered likely to have a severe impact.

Hibbertia nymphaea :

This species was recorded 8 times, six times below the lowest level of inundation, and twice below the lower optimum level. All occurrences were in streamline or flood-plain types A and C and their derivatives. The impact of inundation on this species would therefore be very severe, if not total. However, the species has been collected in neighbouring river systems (Helena and Serpentine).

Hibbertia pilosa :

This species was recorded 54 times, in a wide range of site-vegetation types. It occurred 14 times above the maximum level of inundation. Given its common occurrence in this survey, its classification as a restricted species needs to be questioned. Impact of inundation is not considered likely to be severe.

Lasiopetalum glabratum :

This species was recorded 11 times, in derivatives of types Z, H, W, Y, L, S, T, E, but most commonly in upland types Z and ST. It occurred 6 times below the maximum level of inundation and 5 times above it. The impact of inundation would thus be only partial.

Tetratheca nuda :

This species occurred 3 times in types W and M, in a contiguous pattern indicative of one large population. All occurrences were below the lower optimum level of inundation, and therefore the impact of inundation is likely to be severe.

10. NORTH DANDALUP

10.1 Site-vegetation Types

Because of the limited geographic extent of this option, which is entirely confined to the high rainfall zone, the range of site-vegetation types within it is relatively narrow. The chief source of variation is the degree of dissection of the lateritic plateau by the North Dandalup River and its tributaries. As described in the geomorphological section, the river system is strongly asymmetrical. The northern half, drained by the Cronin Brook, is markedly less dissected than the southern half, drained by the North Dandalup River itself.

At and below the damsite, the degree of dissection is greatest, resulting in steep rocky slopes. The site-vegetation types found here are chiefly type C and its variants on the stream-line, types Q, R and G and their variants on the slopes, and types T and S on the upper slopes and the plateau. There is a localized development of type W on a mildly sloping terrace, and an even more restricted occurrence of type U in association with dolerite outcrop. To improve the precision of definition, several transitional types such as QT, RT, ST, CG, WG and UG have been described, (Appendix D4).

In the upstream portion of the main river valley, up to the limit of inundation, there is continuation of the same vegetation types with the exception of G. The chief difference is that as the floor of the valley rises, the difference in height between it and the adjacent lateritic uplands decreases, the slopes become milder, resulting in greater proportion of types Q, S and T, and smaller proportion of R.

In the northern half, drained by Cronin Brook, the milder dissection and hence greater retention of the laterized slopes results in an entirely different set of site-vegetation types in the valleys. In the least dissected portion of the landscape, stream-line vegetation of type C is flanked by type W on lower slopes, which in turn is flanked by type P, characterized by sandy-gravels. In slightly more dissected position of the landscape types W and P are missing and the stream-line vegetation is flanked by upland types S and T. Yet another variant, associated with a confluence of two broad gullies, is the flanking of the stream-line vegetation of type C by type D (sandy colluvium on lower slopes) and type O. The latter, which lacks clear-cut indicators of any of the main trends shaping the vegetation of the region, is associated with gravels with loamy matrix, probably indicative of truncated lateritic profiles. In the main valley of the Cronin Brook, lateritic influences persist virtually down to the stream resulting in the flanking of the stream-line vegetation of type C by upland types S, T and their derivatives.

Several subdivisions of type G were defined:

- The first includes the mosaic of herbfields and heaths which occur on the massive granite outcrops (G5); this community is devoid of a tree layer (Appendix D4). It is closer to the G1 at Canning and Mundaring (although it lacks some of the shrub species and Rock Sheoak), but differs substantially from the G3 at South Canning.

- The second includes a mixed stand of Eucalypts on the massive rock outcrops, including Eucalyptus laeliae (G6) (Appendix D4). In general reviews this is referred to as WG, although the presence of the Eucalyptus laeliae distinguishes it from other areas.

- The third (G7) appears as a variant of the previous G6 type, with a mixed stand of Eucalypts and heaths, but with species representative of the transitional type RG; the latter reflecting the less frequent outcropping (Appendix D4).

- The other group of interest (G8) is the stand of Eucalyptus laeliae associated with Wandoo and moisture indicators (CG), such as Agonis linearifolia, Astartea fascicularis and Baumea vaginalis (Appendix D4).

The three variants of G with Eucalyptus laeliae are not represented in the other four project areas with the exception of the one community studied at Canning. The other types defined by the R and G analyses were transitional types or derivatives of Havel's types (1975a,b), Appendix D4.

10.2 Assessment of Impact on Site-vegetation Types

For the purpose of assessing the impact of inundation it is necessary to agglomerate the types of the valley floors and lower slopes (C, W, Q, D) and those of mid and upper slopes (G, R, S, T, O, U). The former will be referred to as category 1, the latter as Category 2. Intermediate types that contain elements of both categories (eg. WP, QT,), will be placed in Category 3, Appendix E4.

The first two categories can then be compared at the various levels on inundation in terms of the number of occurrences (Table 11.)

Table 11: Summary of the Effect of Progressive Inundation of Site-vegetation Types at North Dandalup

a) Effect of Progressive Inundation Levels

Category	<SR	SR-LO	LO-ML	>ML
1	5	11	2	0
2	7	16	8	12

b) Effect of Progressive Inundation Levels In Cummulative, Absolute Terms

Category	<SR	<LO	<ML	TOTAL
1	5(28%)	16(89%)	18(100%)	18(100%)
2	7(16%)	23(53%)	31(72%)	43(100%)

Note: SR = Small Rising, LO = Lower Optimum, ML = Maximum Level

This means that inundation to lowest level has a similar absolute impact, but much greater relative impact, on Category 1 than on Category 2. The types most affected at this level are CQ and WG.

The greater relative impact on Category 1 is accentuated at the next higher level of inundation (lower optimum), when the bulk of Category 1, but only half of Category 2 is affected. The impact is most severe on vegetation types C, D, Q and W. At the maximum level of inundation the elimination of types C, D, Q and W is complete within the area surveyed, though types C and W, and possibly D, continue outside in the Yarragil (M/H) complex. It is unlikely, that type Q, confined to the Murray (M/H) and Helena (M/H) complexes, goes much beyond the maximum level of inundation.

Although the impact of inundation is relatively less severe in the case of category 2, even at the lowest level most of the vegetation types begin to be affected. The only exception is type O, which begins to be strongly affected at the lower optimum level. The least affected are types P, S and T, characteristic of the lateritic uplands.

The construction of the spillway chiefly affects vegetation type G of the Helena (M/H) complex.

10.3 Assessment of Impact on Individual Rare and Restricted Species

The rare and restricted species recorded at North Dandalup are summarized in Appendix B4. They tend to have clearly defined ecological preferences. This facilitates the evaluation of the impact of inundation upon them.

Acacia barbinervis:

This species was found above maximum inundation level in site-vegetation type SP, which is characteristic of lateritic uplands. The impact is therefore assessed to be minimal.

Boronia crenulata var. gracilipes :

This species was found twice, in both cases near the upper limit of inundation, but still within it, in type WP. As type WP is characteristic of valley floors and lower slopes, considerable impact of inundation can be anticipated. However the type WP extends to minor valleys and depressions in the lateritic uplands, beyond the level of inundation, where the species may remain unaffected.

Dryandra praemorsa :

This species was recorded only once, in type RG on the proposed spillway. It extends to the bulk of the RG type not affected by the spillway. It has been also found in type RG in all other surveys.

Eucalyptus laeliae :

This species occurs in the North Dandalup area on derivatives of type G. Two of these variants of G (on the rocky streamlines - G8 or CG and the low terraces - G6 or WG), will be fully affected even at the lowest level of inundation. The third variant of G (G7 or RG) of the steep rocky slopes west of the proposed dam wall, would be affected by the spillway, but occurs extensively in the Helena (M/H), Scarp and Cooke vegetation complexes. The impact would therefore be localized.

Senecio leucoglossus :

This species was recorded four times from type T and its derivatives (ST, QT). One of the occurrences would be affected at lower optimum level, another at upper optimum level, whilst two are above the maximum. The impact is therefore certain to be only partial.

11. COMPARISON OF CATCHMENTS

11.1 Review of Key Factors

Before summarizing the impact of the four engineering options of four alternative dam sites on geomorphology, vegetation and flora, it is perhaps worthwhile to briefly recapitulate their key features.

South Canning is by far the largest potential dam site (Figure 8), and because of that extends over the greatest range of valley types and vegetation complexes. It contains the bulk of the site-vegetation types enumerated for the region, and the greatest number of species.

The remaining three dam sites are less extensive and in the case of two of them (Mundaring, Canning) the impact is in the form of extension of the impact already caused by existing dams. In all three cases, the bulk of the area affected fell within one valley type and one vegetation complex. The Mundaring site is quite distinct in geology and climate, and hence in vegetation. It is also floristically richer than Canning and North Dandalup, which are rather similar except for a slight climatic and hence, ecological north-south gradient.

11.2 Impact at the Level of Geomorphological Units and Minor Features

Of the four options, the North Dandalup option conforms least to the pattern of orderly succession of valley forms described for the

IMPACT IN TERMS OF AREA INUNDATED

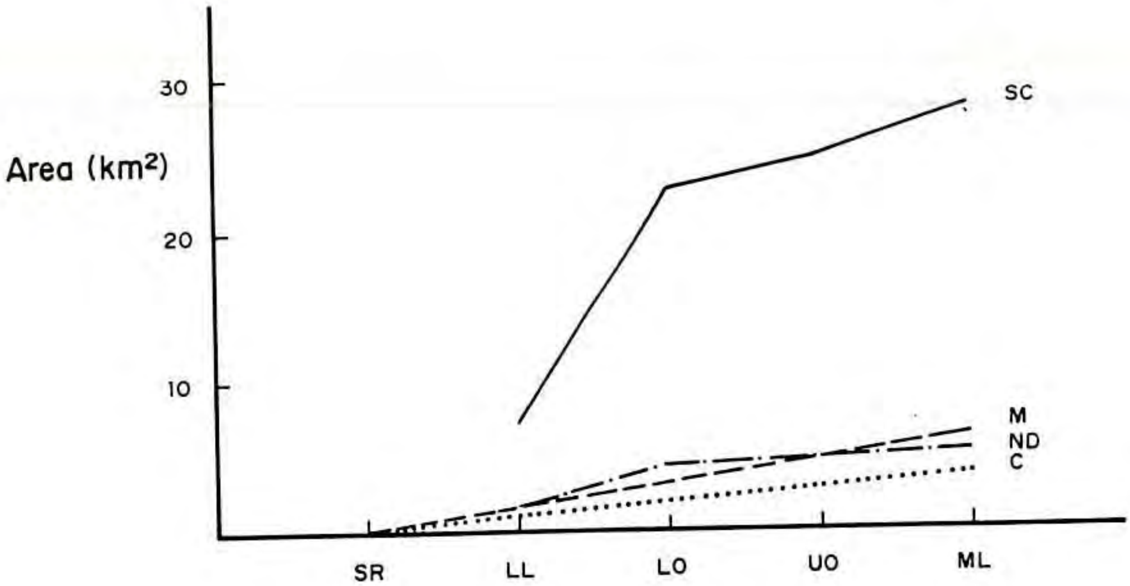

Fig. 8

CONFLICT WITH EXISTING RESERVES

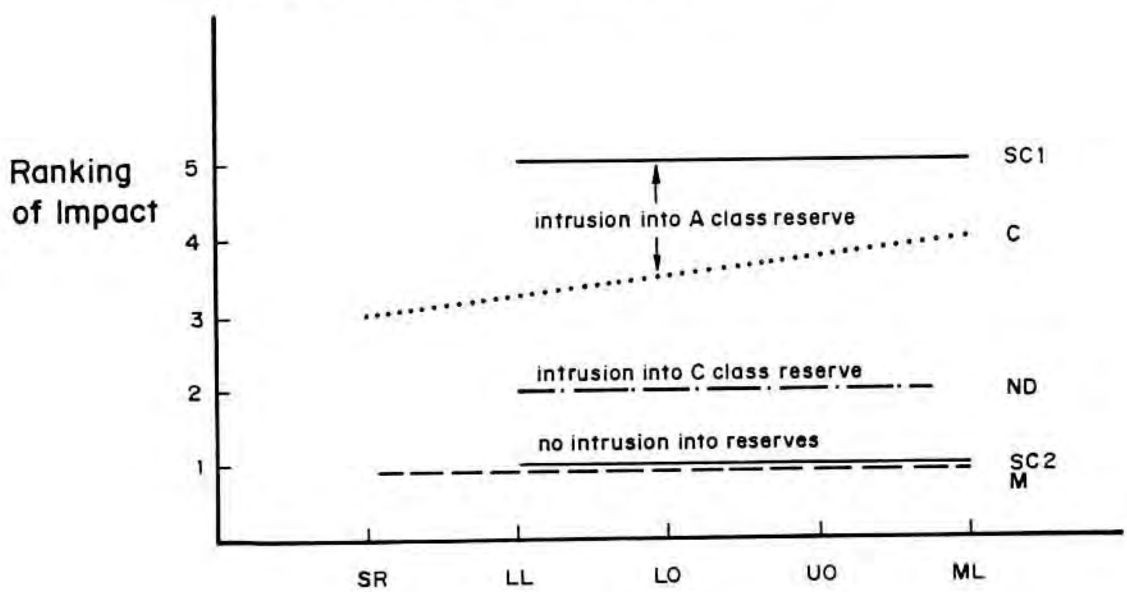

Fig. 9

IMPACT IN TERMS OF NUMBER OF VEGETATION COMPLEXES INUNDATED

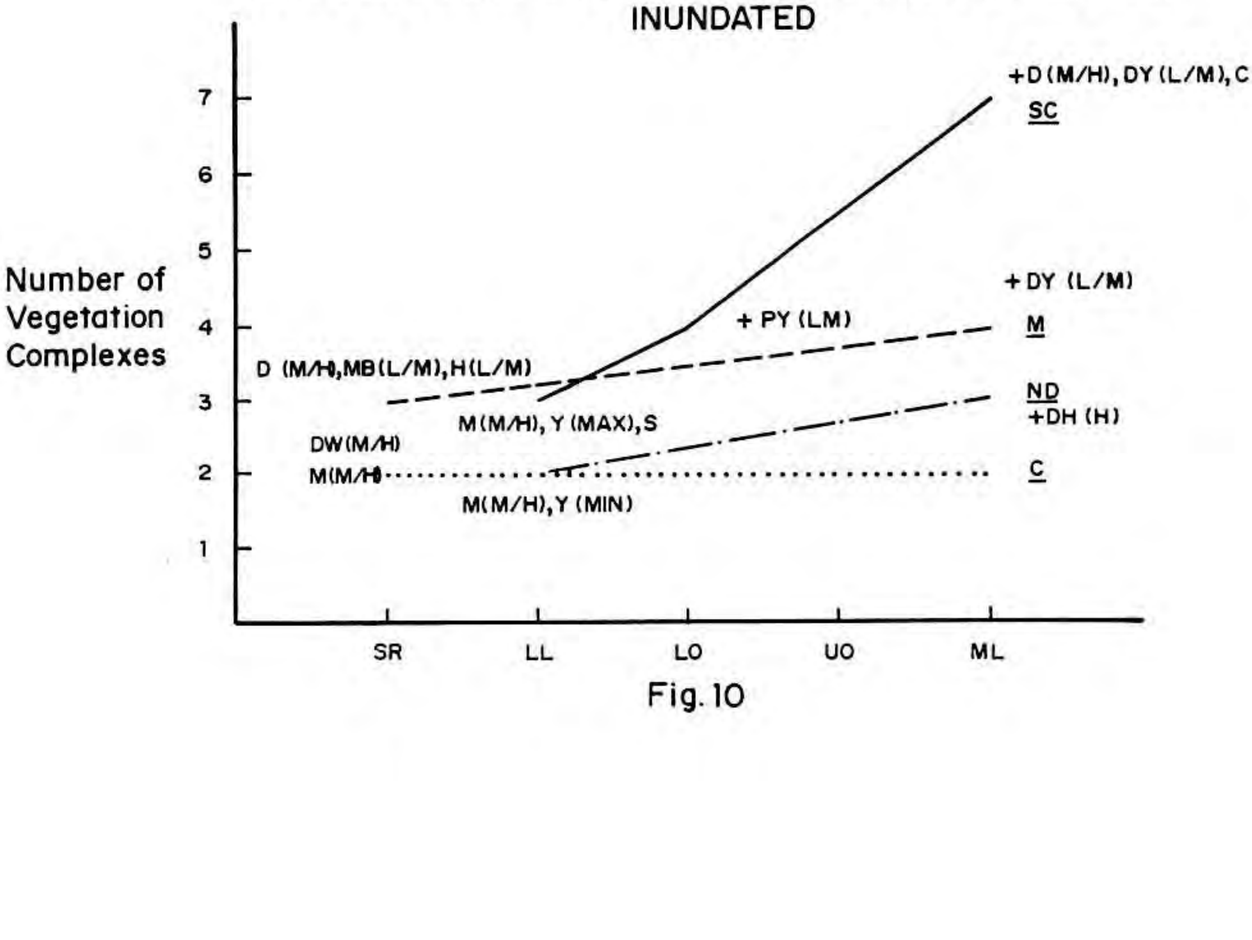

Fig. 10

region by Churchward and McArthur (1980). This is accentuated by the occurrence of ancient alluvial materials at the site of the saddle dam. However, the particular valley form (Myara) and the alluvial deposits are not confined to this option, occurring in other drainage systems.

11.3 Impact at the Level of Vegetation Complexes

The South Canning option affects the greatest number of vegetation complexes (Figure 10.), particularly at upper optimum and maximum level of inundation when seven vegetation complexes would be affected. However, those vegetation complexes not represented in Canning and North Dandalup, namely Yarragil (Max. Swamp), Pindalup-Yarragil (L/M), Cooke and Swamp are amply represented within the regional system of reserves. The Murray (M/H) complex, potentially most affected by the Canning, South Canning and North Dandalup options, is amply represented in the Lane-Poole Reserve. By contrast the Murray-Bindoon (L/M) and Helena (L/M) complexes, affected by the Mundaring option, are less adequately represented in the reserves of the northern jarrah region. Their occurrence in the John Forrest, Avon and Walyunga National Park to the north is subject to heavy recreational pressures. In qualitative terms the Mundaring option is therefore considered to have the most severe impact, followed by South Canning, North Dandalup and finally Canning. In strictly quantitative terms, the relative positions of South Canning and Mundaring are reversed, the former having the heaviest impact.

11.4 Impact at the Level of Site-vegetation Types

In comparing the effect of four options, each with several possible levels of inundation, the most significant criterion is the complete inundation of a lowland site-vegetation type, or a group of such types. Even the lowest level of inundation begins to affect most of the primary types or their derivatives, one to two-thirds of the occurrences becoming inundated (Figure 11.). In the case of existing dams (Canning, Mundaring) the raising of the wall leads to a steady increase until at maximum level considered, 97-100% of the lowland type occurrences are affected. In the case of new dams, the main impact takes place between lowest level and lower optimum. This is particularly so in the case of North Dandalup, where the proportion of lowland types inundated rises from 33% to 93%, and the process is completed at maximum level. In the case of South Canning the rise is from 43% at lowest level through, 72% at lower

IMPACT IN TERMS OF VEGETATION TYPES
(PERCENTAGE OF LOWLAND TYPES AFFECTED)

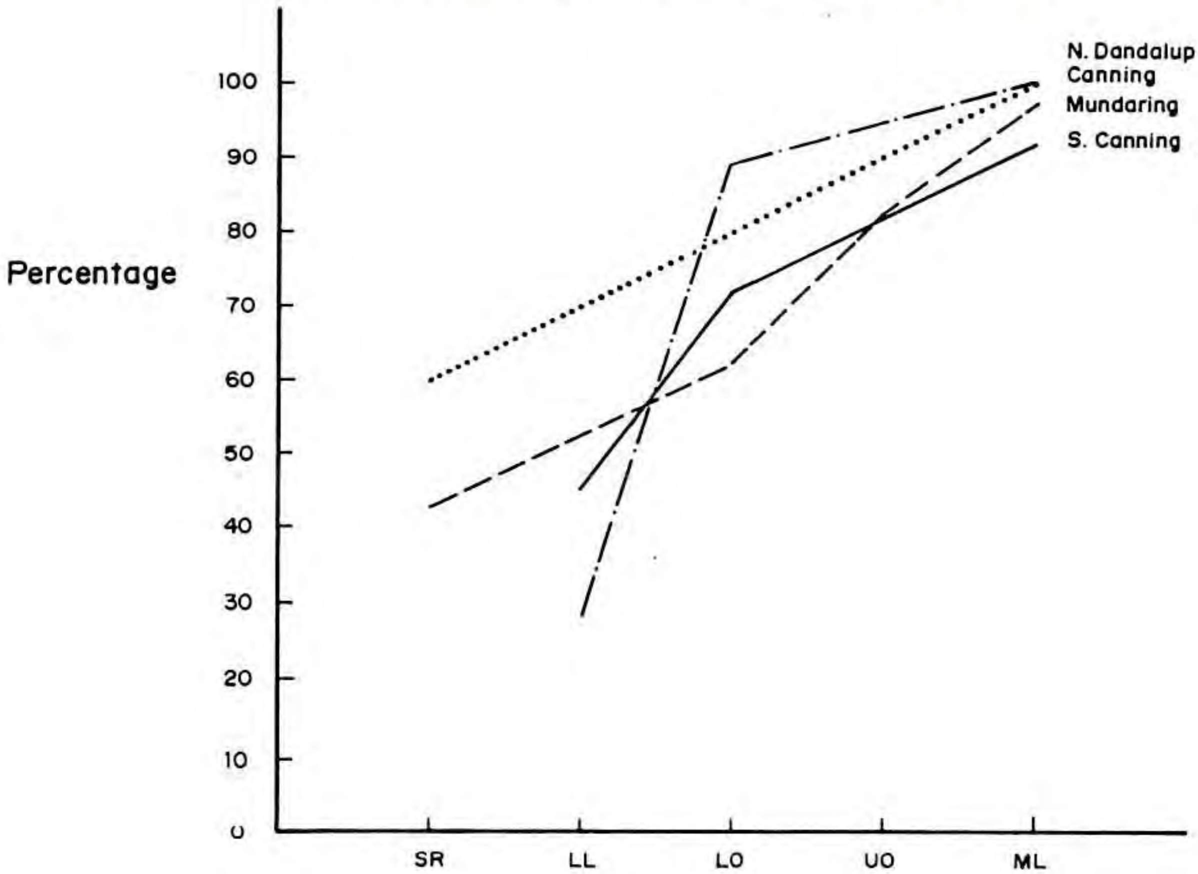

Fig. 11

IMPACT IN TERMS OF NUMBER OF SPECIES AFFECTED

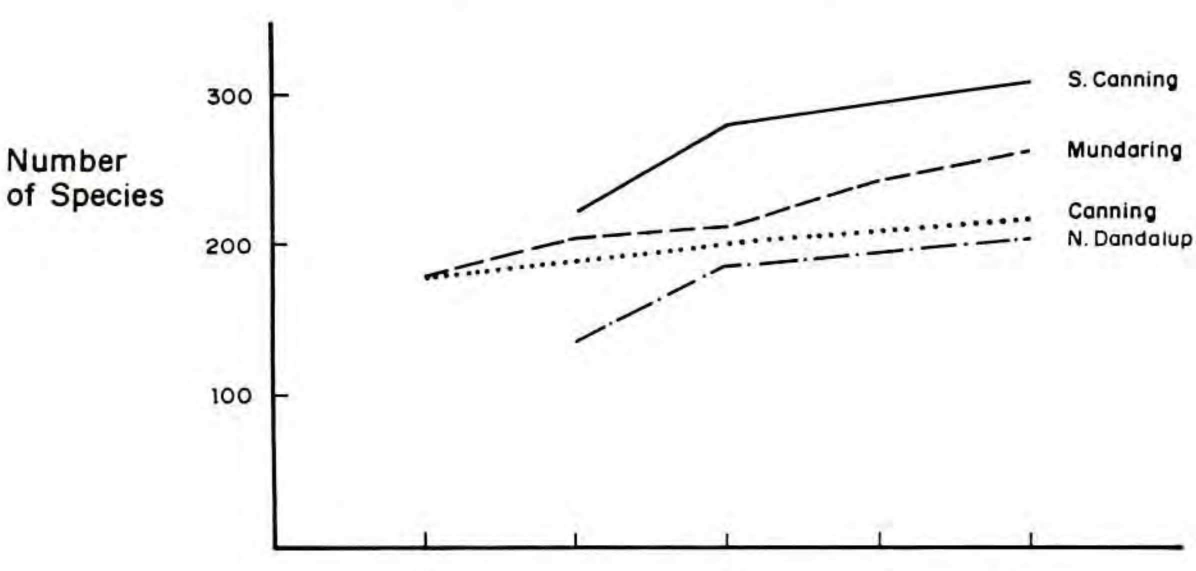

Fig.12

optimum to 91% at maximum level. However, the lowland types that remain unaffected at maximum level are derivatives of eastern types A, E and Y, rather than of western types C, D and Q, which would be affected by the other proposed dams. The impact of the South Canning Dam on types C, D and Q is therefore just as severe as that of other dams. Types A and Y are adequately represented in existing reserves.

The number of site-vegetation types affected is greatest in case of South Canning, followed by Mundaring, North Dandalup and finally Canning. The site-vegetation types on the Mundaring dam site conform least to the regional classification system because of geological and climatic differences. In quantitative terms the impact would therefore be most severe in the case of South Canning, where as in qualitative terms, Mundaring would be of greatest concern.

11.5 Impact on the Flora in General

The greatest impact in terms of total number of species affected by inundation to maximum level would be that of South Canning, with 306 species, followed by Mundaring with 261 species. The impact of Canning is lower still at 219 species, with North Dandalup lowest at 201 species (Figure 12.). For most of the species the impact would be only partial, as they occur both below and above the maximum level of inundation.

11.6 Impact on Individual Rare or Restricted Species

The Mundaring and Canning options affect slightly greater number of species (7 and 6 respectively) currently placed in the rare and restricted category than South Canning and North Dandalup (5 each). However some of these species were found to be quite common and only partially affected. If legally protected (gazetted) species are considered, the species of greatest concern is *Lasiopetalum bracteatum*, which would be strongly affected by raising of the Canning Dam, and otherwise occurs mainly in localities affected by urban spread. The second gazetted species, *Grevillea drummondii* var. *pimelioides* partially affected by the raising of Mundaring Weir, is only a variant of the truly rare *Grevillea drummondii*, and was found to be relatively common both below and above the level of maximum inundation. Several other species with restricted range of occurrence but not gazetted would also be strongly affected eg. *Aotus cordifolia*, *Calothamnus rupestris* and *Lepyrodia* sp. (A) in

Canning, Hibbertia nymphaea and Tetratheca nuda in South Canning, Billardiera drummondii var. collina and Microcorys longifolia in Mundaring and Boronia crenulata var. gracilis in North Dandalup. Overall, raising of the Canning Dam would be of greatest concern, followed by Mundaring, South Canning and North Dandalup.

11.7 Quality of Vegetation Likely to be Affected by Inundation

The impact of the South Canning Dam would be reduced by the recent heavy logging of its north western sector. However the south eastern sector is relatively intact. Severe disturbance has occurred in and around the Mundaring dam early in the century, but there has been a good subsequent recovery. The areas likely to be inundated in the Canning and North Dandalup damsite have been logged in past, but recovery has been good. The past impact of dieback has been most severe in North Dandalup, followed by South Canning, Canning and Mundaring. It is, however of less consequence in the area affected by the inundation than in the surrounding lateritic uplands and minor valleys.

The additional impact of inundation would therefore be most severe in Canning and least in South Canning, with Mundaring and North Dandalup intermediate.

11.8 Impact on Land Set Aside for Conservation

The raising of Canning Dam would significantly affect the proposed Monadnock Reserve, an A-class reserve with vesting for conservation. This reserve would also be strongly affected if the access to South Canning site were to be developed via the Scenic Drive.

Neither the Mundaring nor the South Canning options would have a direct impact on any Reserves, National Parks or Management Priority Areas for Conservation, except as a possible consequence of subsequent road relocation or redevelopment. Construction of the North Dandalup option would intrude into a C-class reserve with dual purpose vesting. The raising of the Canning option would therefore have the most severe impact, followed by North Dandalup (Figure 9.).

11.9 Simplified Tabular Summary of Impact Assessment

A simplified summary of the above findings is given in Table 12.

TABLE 12: RANKING OF THE FOUR OPTIONS WITH RESPECT TO THE SEVERITY OF THEIR IMPACT ON LANDSCAPE AND VEGETATION.
(1 - lightest impact, 4 - heaviest impact)

	Attribute or Criterion	Mundaring Extension	Canning Extension	South Canning	North Dandalup
1.	Geomorphological and geological rarity	3	1	2	4
2.	Vegetation complexes				
	(a) Number of complexes affected	2	1	4	2
	(b) Impact on qualitative basis (adequacy of representation in reserves)	4	1	3	2
	(c) Impact on quantitative basis (area affected x adequacy of representation)	3	1	4	2
3.	Site-vegetation types				
	(a) Completeness of inundation of lowland types	4	1	3	2
	(b) Number of site-vegetation types affected	3	1	4	2
	(c) Rarity of site-vegetation types affected	4	1	3	2
4.	Flora diversity				
	(a) Number of species affected at max level of inundation	3	2	4	1
5.	Rare and restricted flora				
	(a) Impact on gazetted rare species	3	4	1	1
	(b) Impact on restricted species	4	3	2	1
6.	Absence of, or recovery from, disturbance	2	4	1	2
7.	Impact on existing reserves for the conservation of flora and fauna	1	4	2	3

(Havel Land Consultants February 1987)

12. FURTHER WORK REQUIRED

The highest priority is considered to be the dynamic aspects of the ecological balance, such as the long term effects of infrequent inundation and downstream reduction of flows. As these are relevant to virtually every dam that has, or will be built, it would seem to be desirable to establish permanent observation quadrats or transects on which the changes could be quantified over a period of years, rather than inferred from once-off observations.

Ideally, these should be established before a dam is filled, so that an absolute datum point is available (Harris River), but a reasonable approximation would be obtained by sampling the more recently constructed dams in which change is still in progress (Wungong, South Dandalup). Unless this is done, the impact will always be subject to speculation.

As the studies reported above had a strong time constraint, within which four alternative sources of water supply had to be each evaluated at several levels of inundation, no single alternative could be studied in depth. This was particularly significant in preparation of maps, and in the evaluation of information on individual species and their interrelationships.

When the final choice of a particular dam site and full supply level for that dam has been made, some additional work will be needed for the second stage of environmental assessment.

This would include additional transects to reduce the gaps between the currently widely spaced transects to the point where mapping can be done at the level of recognized mapping units, such as soil types and site-vegetation types. These cannot be confidently mapped from aerial photos.

In view of the continually changing status of the species considered to be rare or restricted, revision will be needed for the second stage of environmental assessment. As the data base has been specifically designed to carry out such a task the revision would be only a minor undertaking.

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APPENDIX A1:

FLORA LIST - FLORA & VEGETATION OF FOUR ALTERNATIVE WATER RESOURCE DEVELOPMENT SITES IN THE NORTHERN JARRAH FOREST OF W.A.

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FAMILY CODE	FAMILY NAME	SPECIES SCIENTIFIC NAME	SPECIES CODE
1	Dicranaceae	Campylopus bicolor	451
2	Clathrinaceae	Cladia aggregata	454
		Cladia ferdinandii	453
3	Parmeliaceae	Parmelia spodochroa	452
		Parmelia verrucella	476
4	Siphulaceae	Siphula coriacea	455
5	Teloschistaceae	Caloplaca cinnabarina	268
6	Anthoceraceae	Anthoceros sp.	222
7	Adiantaceae	Cheilanthes austrotenuifolia	92
		Cheilanthes distans	93
11	Dennstaedtiaceae	Lindsaea linearis	94
		Pleurosorus rutifolius	95
		Pteridium esculentum	81
16	Zamiaceae	Macrozamia riedlei	75
26	Juncaginaceae	Triglochin procera	96
31	Poaceae	*Aira caryophyllea	459
		*Briza maxima	458
		*Vulpia myuros	456
		Danthonia caespitosa	97
		Danthonia setacea	98
		Microlaena stipoides	99
		Neurachne alopecuroidea	414
		Stipa campylachne	100
		Tetrarrhena laevis	101
32	Cyperaceae	*Cyperus tenellus	105
		Baumea ? vaginalis	438
		Baumea articulata	102
		Baumea juncea	103
		Baumea riparia	104
		Caustis dioica	32
		Cyathochaeta avenacea	417
		Gahnia ancistrophylla	106
		Gahnia trifida	107
		Isolepis cyperoides	108
		Isolepis nodosa	481
		Lepidosperma angustatum	63
		Lepidosperma drummondii	109
		Lepidosperma gracile	110
		Lepidosperma leptostachyum	111
		Lepidosperma longitudinale	112
		Lepidosperma pruinosum	113
		Lepidosperma pruinosum var. rigidulum	114

APPENDIX A1 : FLORA LIST - FLORA & VEGETATION OF FOUR ALTERNATIVE WATER RESOURCE DEVELOPMENT SITES IN THE NORTHERN JARRAH FOREST OF W.A.

FAMILY CODE	FAMILY NAME	SPECIES SCIENTIFIC NAME	SPECIES CODE
32	Cyperaceae	Lepidosperma scabrum	480
		Lepidosperma sp. (1)	117
		Lepidosperma sp. (E)	116
		Lepidosperma tenue	64
		Lepidosperma tetraquetrum	65
		Lepidosperma tuberculatum	115
		Mesomelaena graciliceps	118
		Mesomelaena tetragona	77
		Schoenus aff. unispiculatus	120
		Schoenus clandestinus	119
		Schoenus nanus	475
		Schoenus sp. (1)	121
		Tetraria octandra	419
39	Restionaceae	Lepidobolus preissianus	122
		Leptocarpus aristatus	123
		Leptocarpus coangustatus / scariosus	66
		Lepyrodia sp. (A)	124
		Loxocarya ? flexuosa	127
		Loxocarya fasciculata	126
		Loxocarya sp.	125
		Lyginia barbata	74
		Restio tremulus	130
40	Centrolepidaceae	Aphelia cyperoides	128
		Centrolepis aristata	129
50	Philydraceae	Philydrella pygmaea	131
54	Liliaceae	Agrostocrinum scabrum	139
		Borya sphaerocephala	140
		Burchardia umbellata	149
		Caesia parviflora	141
		Corynotheca micrantha	430
		Dasypogon bromeliifolius	37
		Dianella revoluta	422
		Kingia australis	61
		Laxmannia sessiflora	142
		Laxmannia squarrosa	143
		Lomandra caespitosa	132
		Lomandra collina	464
		Lomandra hermaphrodita	133
		Lomandra odora	134
		Lomandra preissii	135
		Lomandra purpurea	136
		Lomandra sonderi	137
		Sowerbaea laxiflora	431
		Stypandra glauca	138
		Thysanotus dichotomous	144
		Thysanotus multiflorus	145
		Thysanotus patersonii	146
		Thysanotus thyrsoideus	147
		Tricoryne elatior	148

APPENDIX A1 : FLORA LIST - FLORA & VEGETATION OF FOUR ALTERNATIVE WATER RESOURCE DEVELOPMENT SITES IN THE NORTHERN JARRAH FOREST OF W.A.

FAMILY CODE	FAMILY NAME	SPECIES SCIENTIFIC NAME	SPECIES CODE
54	Liliaceae	Xanthorrhoea gracilis	90
		Xanthorrhoea preissii	91
		Xanthorrhoea reflexa	482
55	Haemodoraceae	Anigozanthos manglesii	429
		Conostylis aculeata	150
		Conostylis psyllium	151
		Conostylis serrulata	152
		Conostylis setigera	153
		Conostylis setosa	154
		Haemodorum laxum	155
		Haemodorum paniculatum	433
60	Iridaceae	Orthrosanthos laxus	156
		Patersonia juncea	157
		Patersonia occidentalis	78
		Patersonia pygmaea	158
		Patersonia rudis	79
66	Orchidaceae	Caladenia flava	447
		Caladenia huegelii	159
		Caladenia marginata	160
		Diuris laxiflora	161
		Elythranthera brunonis	162
		Elythranthera emarginata	472
		Microtis orbicularis	163
		Microtis unifolia	164
		Prasophyllum macrostachyum	165
		Pterostylis vittata	418
		Thelymitra antennifera	166
		Thelymitra crinita	167
		Thelymitra nuda	168
70	Casuarinaceae	Allocasuarina fraseriana	15
		Allocasuarina huegeliana	16
		Allocasuarina humilis	439
90	Proteacae	Adenanthos bargbigerus	24
		Adenanthos obovata	25
		Banksia attenuata	8
		Banksia grandis	9
		Banksia littoralis	10
		Banksia littoralis var. seminuda	11
		Bossiaea linophylla	463
		Conospermum ciliatum	169
		Conospermum huegelii	170
		Conospermum stoechadis	35
		Dryandra armata	171
		Dryandra bipinnatifida	432
		Dryandra nivea	172
		Dryandra praemorsa	173
		Dryandra sessilis	468
		Grevillea bipinnatifida	42

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FAMILY CODE	FAMILY NAME	SPECIES SCIENTIFIC NAME	SPECIES CODE
90	Proteacae	Grevillea diversifolia	43
		Grevillea drummondii var. pimelioides	174
		Grevillea endlicheriana	175
		Grevillea glabrata	176
		Grevillea pilulifera	177
		Grevillea pulchella	178
		Grevillea quercifolia	179
		Grevillea synapheae	44
		Grevillea wilsonii	45
		Hakea amplexicaulis	180
		Hakea ceratophylla	47
		Hakea cyclocarpa	46
		Hakea erinacea	326
		Hakea incrassata	181
		Hakea lissocarpha	48
		Hakea marginata	182
		Hakea petiolaris	50
		Hakea prostrata	437
		Hakea ruscifolia	49
		Hakea stenocarpa	183
		Hakea sulcata	184
		Hakea trifurcata	425
		Hakea undulata	185
		Hakea varia	51
		Isopogon asper	186
		Isopogon buxifolius	187
		Isopogon dubius	59
		Isopogon sphaerocephalus	188
		Persoonia angustiflora	189
		Persoonia elliptica	18
		Persoonia longifolia	17
		Persoonis saccata	461
		Petrophile biloba	82
		Petrophile longifolia	190
		Petrophile serruriae	462
		Petrophile squamata	191
		Petrophile striata	83
		Stirlingia latifolia	85
		Stirlingia simplex	192
		Synaphea aff. gracillima	194
		Synaphea gracillima	193
		Synaphea petiolaris	87
92	Santalaceae	Exocarpos sparteus	195
		Leptomeria cunninghamii	67
		Santalum acuminatum	196
95	Olacaceae	Olax benthamiana	197
97	Loranthaceae	Nuytsia floribunda	12
103	Polygonaceae	Muehlenbeckia adpressa	198

APPENDIX A1 : FLORA LIST - FLORA & VEGETATION OF FOUR ALTERNATIVE WATER RESOURCE DEVELOPMENT SITES IN THE NORTHERN JARRAH FOREST OF W.A.

FAMILY CODE	FAMILY NAME	SPECIES SCIENTIFIC NAME	SPECIES CODE
106	Amaranthaceae	Ptilotus declinatus	199
		Ptilotus manglesii	444
		Ptilotus polystachyus	200
113	Caryophyllaceae	*Silene gallica	201
119	Ranunculaceae	Clematis pubescens	34
		Ranunculus colonorum	202
131	Lauraceae	Cassytha racemosa	203
143	Droseraceae	Drosera erythrorhiza	421
		Drosera gigantea	204
		Drosera leucoblasta	205
		Drosera menziesii	206
		Drosera neessii	207
		Drosera platystigma	208
		Drosera stolonifera ssp. stolonifera	209
152	Pittosporaceae	Billardiera candida	210
		Billardiera coeruleo-punctata	211
		Billardiera drummondiana var. collina	212
		Billardiera floribunda	213
		Billardiera variifolia	214
		Sollya heterophylla	479
161	Rosaceae	*Acaena echinata	215
163	Mimosaceae	Acacia alata	19
		Acacia barbinervis	216
		Acacia browniana	435
		Acacia dentifera	217
		Acacia divergens	218
		Acacia drummondii ssp. drummondii	219
		Acacia ephedroides	220
		Acacia extensa	20
		Acacia lateriticola	221
		Acacia leptoneura	223
		Acacia nervosa	224
		Acacia obovata	225
		Acacia oncinophylla	226
		Acacia preissiana	21
		Acacia pulchella	227
		Acacia pulchella var. goadbyi	228
		Acacia saligna	22
		Acacia stenoptera	229
		Acacia urophylla	23
		Acacia willdenowiana	230
		Paraserianthes lophantha	27
[illegible]4	Caesalpiniaceae	Labichea punctata	231
[illegible]5	Papilionaceae	Aotus cordifolia	232

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FAMILY CODE	FAMILY NAME	SPECIES SCIENTIFIC NAME	SPECIES CODE
165	Papilionaceae	Bossiaea aquifolium	30
		Bossiaea eriocarpa	233
		Bossiaea ornata	31
		Bossiaea spinescens	234
		Chorizema dicksonii	235
		Chorizema ilicifolium	33
		Chorizema rhombeum	236
		Daviesia cordata	428
		Daviesia decurrens	38
		Daviesia hakeoides	237
		Daviesia horrida	238
		Daviesia longifolia	239
		Daviesia preissii	240
		Daviesia rhombifolia	420
		Dillwynia sp. (A)	40
		Eutaxia aff. densifolia	241
		Eutaxia virgata	242
		Gastrolobium calycinum	41
		Gastrolobium epacridoides	243
		Gastrolobium spinosum	470
		Gastrolobium villosum	244
		Gompholobium ? venustum	251
		Gompholobium aristatum	245
		Gompholobium knightianum	246
		Gompholobium marginatum	247
		Gompholobium polymorphum	248
		Gompholobium preissii	249
		Gompholobium shuttleworthii	250
		Hardenbergia comptoniana	478
		Hovea chorizemifolia	56
		Hovea pungens	448
		Hovea trisperma	252
		Jacksonia alata	253
		Jacksonia furcellata	254
		Kennedia coccinea	60
		Kennedia prostrata	424
		Mirbelia dilatata	413
		Mirbelia spinosa	255
		Oxylobium capitatum	256
		Oxylobium linarifolium	257
		Sphaerolobium medium	84
		Sphaerolobium scabriusculum	258
		Viminaria juncea	426
167	Geraniaceae	Pelargonium ? littorale	259
170	Linaceae	Linum marginale	260
175	Rutaceae	Asterolasia pallida	261
		Boronia busselliana	262
		Boronia crenulata var. gracilis	263
		Boronia defoliata	264
		Boronia fastigiata	265

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FAMILY CODE	FAMILY NAME	SPECIES SCIENTIFIC NAME	SPECIES CODE
175	Rutaceae	Boronia ramosa ssp. ethifolia	266
		Boronia viminea	267
		Diplolaena microcephala var. drummondii	39
		Eriostemon spicatus	269
182	Tremandraceae	Tetratheca hirsuta	270
		Tetratheca nuda	271
183	Polygalaceae	Comesperma calymega	272
		Comesperma ciliatum	273
		Comesperma virgatum	423
185	Euphorbiaceae	Amperea ? protensa	274
		Calycopeplus ephedroides	275
		Monotaxis grandiflora	276
		Phyllanthus calycinus	80
		Poranthera microphylla	277
202	Stackhousiaceae	Stackhousia huegelii	278
		Stackhousia huegelii / pubescens	279
		Tripterococcus brunonis	280
207	Sapindaceae	Dodonaea ceratocarpa	281
		Dodonaea concinna	282
		Dodonaea pinifolia	283
215	Rhamnaceae	Cryptandra arbutiflora	284
		Cryptandra nutans	285
		Spyridium sp. (1)	286
		Trymalium floribundum	89
		Trymalium ledifolium	88
223	Sterculiaceae	Lasiopetalum bracteatum	287
		Lasiopetalum floribundum	62
		Lasiopetalum glabratum	288
		Thomasia foliosa	289
		Thomasia paniculata	290
226	Dilleniaceae	Hibbertia acerosa	291
		Hibbertia aff. aurea	441
		Hibbertia aff. serrata	299
		Hibbertia amplexicaulis	292
		Hibbertia aurea	440
		Hibbertia commutata	54
		Hibbertia enervia	293
		Hibbertia huegelii	294
		Hibbertia hypericoides	52
		Hibbertia nymphaea	295
		Hibbertia ovata	296
		Hibbertia perfoliata	297
		Hibbertia pilosa	298
		Hibbertia polystachya	55
		Hibbertia rhadinopoda	53

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FAMILY CODE	FAMILY NAME	SPECIES SCIENTIFIC NAME	SPECIES CODE
226	Dilleniaceae	Hibbertia stellaris	442
		Hibbertia subvaginata	300
243	Violaceae	Hybanthus debilissimus	301
		Hybanthus floribundus ssp. floribundus	302
263	Thymelaeaceae	Pimelea angustifolia	303
		Pimelea argentea	304
		Pimelea ciliata	305
		Pimelea imbricata var. piligera	306
		Pimelea preissii	307
		Pimelea spectabilis	308
		Pimelea suaveolens	309
		Pimelea sylvestris	310
273	Myrtaceae	Agonis linearifolia	26
		Astartea fascicularis	28
		Baeckea camphorosmae	29
		Calothamnus quadrifidus	311
		Calothamnus rupestris	312
		Calytrix depressa	313
		Darwinea aff. citriodora	315
		Darwinea citriodora	314
		Darwinea thymoides	316
		Eucalyptus calophylla	1
		Eucalyptus drummondii	317
		Eucalyptus laeliae	2
		Eucalyptus marginata	4
		Eucalyptus megacarpa	3
		Eucalyptus patens	5
		Eucalyptus rudis	6
		Eucalyptus wandoo	7
		Hypocalymma angustifolium	57
		Hypocalymma cordifolium	58
		Kunzea recurva	318
		Leptospermum erubescens	319
		Melaleuca aff. scabra	325
		Melaleuca lateritia	320
		Melaleuca pauciflora	321
		Melaleuca polygaloides	322
		Melaleuca preissiana	13
		Melaleuca radula	323
		Melaleuca rhaphiophylla	14
		Melaleuca scabra	324
		Melaleuca viminea	76
		Pericalymma ellipticum	68
		Verticordia acerosa	327
		Verticordia huegelii	328
		Verticordia plumosa	329
276	Haloragaceae	Glischrocaryon aureum var. angustifolium	330
		Glischrocaryon aureum var. aureum	331
		Gonocarpos benthamii	332

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FAMILY CODE	FAMILY NAME	SPECIES SCIENTIFIC NAME	SPECIES CODE
276	Haloragaceae	Gonocarpos cordiger	333
281	Apiaceae	Actinotus leucocephalus	334
		Eryngium rostratum	450
		Homalosciadium homalocarpum	335
		Pentapeltis peltigera	412
		Platysace compressa	336
		Platysace tenuissima	337
		Trachymene pilosa	338
		Xanthosia atkinsoniana	466
		Xanthosia candida	339
		Xanthosia huegelii	471
288	Epacridaceae	Andersonia aristata	436
		Andersonia lehmanniana	340
		Astroloma ciliatum	416
		Astroloma glaucescens	473
		Astroloma humifusum	465
		Astroloma pallidum	341
		Leucopogon australis	342
		Leucopogon capitellatus	69
		Leucopogon cordatus	70
		Leucopogon nutans	71
		Leucopogon propinquus	72
		Leucopogon pulchellus	427
		Leucopogon sp. (1)	445
		Leucopogon sp. (2)	446
		Leucopogon sprengeliodes	343
		Leucopogon strictus	344
		Leucopogon verticillatus	73
		Styphelia tenuiflora	86
293	Primulaceae	*Anagallis arvensis	457
302	Loganiaceae	Logania serpyllifolia	345
303	Menyanthaceae	*Centaurium spicatum	467
		Villarsia albiflora	346
313	Lamiaceae	Hemiandra pungens	347
		Hemigenia incana	348
		Hemigenia ramosissima	349
		Hemigenia sericea var. parviflora	350
		Hemigenia sericea var. sericea	351
		Microcorys longifolia	352
316	Scrophulariaceae	*Bellardia trixago	353
323	Lentibulariaceae	Polypompholyx multifida	354
		Polypompholyx tenella	355
		Utricularia inaequalis	356
331	Rubiaceae	Opercularia echinocephala	357

APPENDIX A1 : FLORA LIST - FLORA & VEGETATION OF FOUR ALTERNATIVE WATER RESOURCE DEVELOPMENT SITES IN THE NORTHERN JARRAH FOREST OF W.A.

FAMILY CODE	FAMILY NAME	SPECIES SCIENTIFIC NAME	SPECIES CODE
331	Rubiaceae	Opercularia hispidula	443
		Opercularia vaginata	358
339	Campanulaceae	Wahlenbergia preissii	359
340	Lobeliaceae	Isotoma hypocrateriformis	360
		Lobelia alata	361
		Lobelia rhytidosperma	362
341	Goodeniaceae	Brunoniana australis	434
		Dampiera alata	36
		Dampiera hederacea	363
		Dampiera lavendulacea	364
		Dampiera linearis	365
		Dampiera trigona	366
		Goodenia aff. helmsii	370
		Goodenia caerulea	367
		Goodenia fasciculata	368
		Lechenaultia biloba	415
		Olearia paucidentata	449
		Scaevola glandulifera	369
		Scaevola lanceolata	371
		Scaevola pilosa	469
		Scaevola striata	372
		Velleia trinervis	373
343	Stylidiaceae	Levenhookia pusilla	374
		Levenhookia stipitata	375
		Stylidium affine	376
		Stylidium amoenum	377
		Stylidium breviscapum	378
		Stylidium brunonianum	379
		Stylidium bulbiferum	380
		Stylidium calcaratum var. calcaratum	381
		Stylidium canaliculatum	382
		Stylidium carnosum	383
		Stylidium emarginatum	384
		Stylidium hispidum	385
		Stylidium junceum	386
		Stylidium lineatum	387
		Stylidium piliferum	388
		Stylidium pubigerum	390
		Stylidium pulchellum	391
		Stylidium pychnostachyum	389
		Stylidium repens	392
		Stylidium roseo-alatum	393
		Stylidium schoenoides	394
345	Asteraceae	*Ursinia anthemoides	410
		Brachycome iberidifolia	395
		Brachycome pusilla	396
		Chrysocoryne ? pusilla	477
		Craspedia sp. (A)	397

APPENDIX A1 : FLORA LIST - FLORA & VEGETATION OF FOUR ALTERNATIVE WATER RESOURCE DEVELOPMENT SITES IN THE NORTHERN JARRAH FOREST OF W.A.

FAMILY CODE	FAMILY NAME	SPECIES SCIENTIFIC NAME	SPECIES CODE
345	Asteraceae	Gnaphalium sphaericum	398
		Helichrysum bracteatum	399
		Helipterum cotula	400
		Helipterum manglesii	401
		Lagenifera huegelii	402
		Podolepis canescens	403
		Podolepis gracilis	404
		Podolepis lessonii	405
		Senecio cahillii	460
		Senecio hispidulus	406
		Senecio leucoglossus	407
		Siloxerus humifusus	408
		Trichocline spathulata	409
		Waitzia paniculata	411
400	Not Applicable	~No species name for 474	474

TOTAL NUMBER OF RECORDS = 482

APPENDIX B:

EVALUATION OF SPECIES CURRENTLY CONSIDERED

TO BE RARE OR GEOGRAPHICALLY RESTRICTED

B1: MUNDARING
B2: CANNING
B3: SOUTH CANNING
B4: NORTH DANDALUP

APPENDIX B1: EVALUATION OF RARE AND RESTRICTED SPECIES - MUNDARING

Species Name	Species Code	Total Occur.	Location Code	Location Transect	Effect of Flooding	Site-Veg. Type
Acacia barbinervis	216	0	-	-	-	-
Aotus cordifolia	232	0	-	-	-	-
Billardiera drummondiana var. collina	212	2	38	8A 0	UO	CR
			39	8A 50	UO	R
Boronia crenulata var. gracilis	263	0	-	-	-	-
Calothamnus rupestris	312	0	-	-	-	-
Conospermum huegelii	170	2	21	3A 250	AM	G
			113	2C 0	ML	G
Conostylis setosa	154	3	87	17A 100	LO	M
			52	11B 50	UO	LG
			76	15A 100	SR	YQ
Dryandra praemorsa	173	3	23	3B 100	AM	QR
			21	3A 250	AM	G
			113	2C 0	UO	G
Eucalyptus laeliae	2	-	-	-	-	-
Gastrolobium epacridoides	243	1	-	above 4B50	AM	G
Grevillea drummondii var. pimelioides	174	13	-	23B 50	LO	W
			-	23B 100	ML	WG
				23B 150	AM	WG
				3A 50	UO	WQ
				3A 100	ML	WP
				3A 150	ML	PQ
				3A 250	AM	G
				3B 100	AM	QR
				7A 0	SR	W
				7A 50	SR	Q
				7A 100	UO	WG
				7A 150	AM	RG
				7A 200	AM	RG
Hibbertia nymphaea	295	-	-	-	-	-
Hibbertia pilosa	298	17	-	24A 0	SR	W
			-	2A 100	UO	Z
			-	2A 150	AM	Z
			-	3A 150	ML	PQ

APPENDIX B1: EVALUATION OF RARE AND RESTRICTED SPECIES - MUNDARING (Cont.)

Species Name	Species Code	Total Occur.	Location Code	Location Transect	Effect of Flooding	Site-Veg. Type
Hibbertia pilosa (cont)			-	3B 50	UO	QR
			-	3B 100	AM	QR
			-	13A 100	LO	WQ
			-	13A 150	UO	WQ
			-	13A 200	ML	WQ
			-	13A 250	AM	WQ
			-	13B 50	SR	WQ
			-	13B 150	UO	YQW
			-	13B 250	AM	WG
			-	7A 50	SR	Q
			-	13B 100	LO	YQ
			-	7A 150	AM	RG
			-	7A 200	AM	RG
Lasiopetalum bracteatum	287	0	-	-	-	-
Lasiopetalum glabratum	288	0	-	-	-	-
Lepyrodia sp. (A)	124	0	-	-	-	-
Microcorys longifolia	352	1	-	Near 2A 100	SR	CQ
Petrophile biloba	82	1	-	1A 350	AM	G
Senecio leucoglossus	407	0	-	-	-	-
Tetratheca nuda	271	1	-	1A 350	AM	G

APPENDIX B2: EVALUATION OF RARE AND OR RESTRICTED SPECIES - CANNING

Species Name	Species Code	Total Occur.	Location Code	Location Transect	Effect of Flooding	Site-Veg. Type
Acacia barbinervis	216	1	371	16B 100	AM	SP
Aotus cordifolia	232	1	341	10A 0	At SR	C
Billardiera drummondiana var. collina	212	0	-	-	-	-
Boronia crenulata var. gracilis	263	0	-	-	-	-
Calothamnus rupestris	312	9	310	2B 100	AM	RG
			311	2B 150	AM	RG
			320	4A 0	SR	R
			359	15A 0	SR	CR
			360	15A 50	SR	R
			361	15A 100	SR	WR
			364	15B 100	ML	SR
			366	16A 50	LO	WR
			370	16B 50	ML	R
Conospermum huegelii	170	0	-	-	-	-
Conostylis setosa	154	0	-	-	-	-
Dryandra praemorsa	173	1	362	15A 150	AM	SR
Eucalyptus laeliae	2	1	375	19A 0	SR	GR
Gastrolobium epacridoides	243	0	-	-	-	-
Grevillea drummondii var. pimelioides	174	0	-	-	-	-
Hibbertia nymphaea	295	0	-	-	-	-
Hibbertia pilosa	298	3	332	7A 100	AM	T
			338	9A 50	SR	T
			348	12A 50	LO	ST
Lasiopetalum bracteatum	287	4	306	2A 0	SR	C
			361	15A 100	SR	WR
			366	16A 50	LO	WR
			371	16B 100	AM	SP
Lasiopetalum glabratum	288	0	-	-	-	-
Lepyrodia sp. (A)	124	1	1	16B 0	SR	CR
Microcorys longifolia	352	0	-	-	-	-
Petrophile biloba	82	0	-	-	-	-
Senecio leucoglossus	407	0	-	-	-	-
Tetratheca nuda	271	0	-	-	-	-

APPENDIX B3: EVALUATION OF RARE AND RESTRICTED SPECIES - SOUTH CANNING

Species Name	Species Code	Total Occur.	Location Code	Location Transect	Effect of Flooding	Site-Veg. Type
Acacia barbinervis	216	6	-	1A 100	AM	M
				1A 150	AM	H
				1B 100	ML	H
				1B 200	AM	ZH
				3A 100	ML	SZ
				3A 150	AM	SZ
Aotus cordifolia	232	0	-	-	-	-
Billardiera drummondiana var. collina	212	0	-	-	-	-
Boronia crenulata var. gracilis	263	0	-	-	-	-
Calothamnus rupestris	312	0	-	-	-	-
Conospermum huegelii	170	0	-	-	-	-
Conostylis setosa	154	20	-	-	(11 AM)	O,P,S,T
Dryandra praemorsa	173	5	-	1B 200	AM	ZH
				3A 200	AM	Z
				3A 300	AM	M
				3A 450	AM	MG
				8A 250	AM	R
Eucalyptus laeliae	2	0	-	-	-	-
Gastrolobium epacridoides	243	0	-	-	-	-
Grevillea drummondii var. pimelioides	174	0	-	-	-	-
Hibbertia nymphaea	295	8	-	4A 0	LL	CR
				6A 0	LL	C
				11A 0	LL	AC
				11A 50	LL	AC
				11A 100	LL	AC
				11B 50	LL	AX
				15A 0	LO	AC
				16A 0	LO	CQ
Hibbertia pilosa	298	54	-	-	(14 AM)	S,T,W,Z
Lasiopetalum bracteatum	287	0	-	-	-	-
Lasiopetalum glabratum	288	11	-	2A 200	AM	HZ
				2B 550	AM	Y
				3A 100	LO	SZ
				5B 50	LO	WS

APPENDIX B3: EVALUATION OF RARE AND RESTRICTED SPECIES - SOUTH CANNING (Cont.)

Species Name	Species Code	Total Occur.	Location Code	Location Transect	Effect of Flooding	Site-Veg. Type
Lasiopetalum glabratum (Cont)				5B 100	ML	WY
				12B 400	ML	ST
				12B 500	AM	ST
				15B 150	AM	EH
				16A 150	LO	Z
				16B 200	LO	ZW
				18B 100	AM	Z
Lepyrodia sp. (A)	124	0	-	-	-	-
Microcorys longifolia	352	0	-	-	-	-
Petrophile biloba	82	0	-	-	-	-
Senecio leucoglossus	407	0	-	-	-	-
Tetratheca nuda	271	3	-	3B 150	LO	M
				3B 200	LO	M
				3B 250	LO	W

APPENDIX B4: EVALUATION OF RARE AND RESTRICTED SPECIES - NORTH DANDALUP

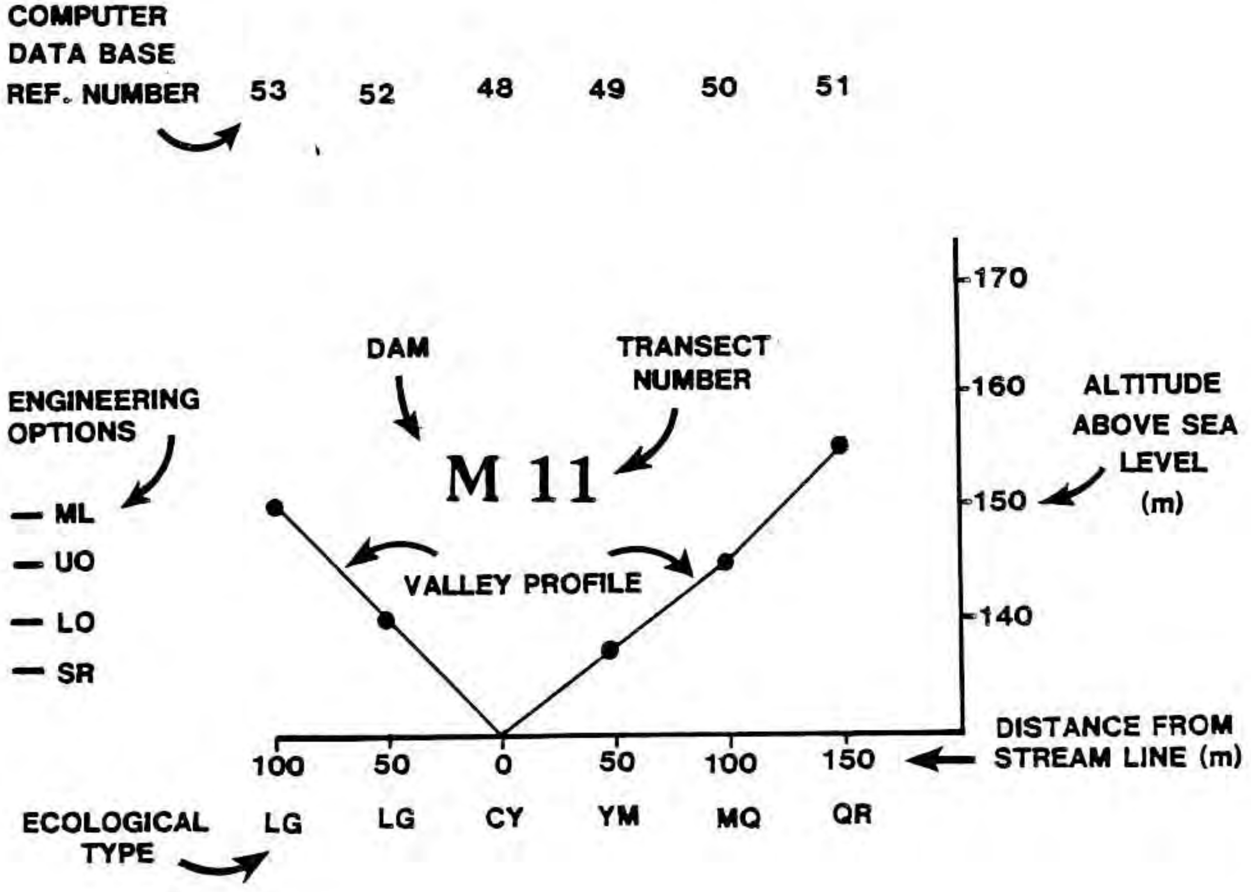
Species Name	Species Code	Total Occur.	Location Code	Location Transect	Effect of Flooding	Site-Veg. Type
Acacia barbinervis	216	1	155	1B 100	AM	SP
Aotus cordifolia	232	0	-	-	-	-
Billardiera drummondiana var. collina	212	0	-	-	-	-
Boronia crenulata var. gracilis	263	2	152	1A 50	ML	WP
			154	1B 50	ML	WP
Calothamnus rupestris	312	0	-	-	-	-
Conospermum huegelii	170	0	-	-	-	-
Conostylis setosa	154	21	-	-	(For Details See Text)	
Dryandra praemorsa	173	1	164	3A 100	SPILLWAY	RG
Eucalyptus laeliae	2	10	162	3A 0	SPILLWAY	CG
			163	3A 50	SPILLWAY	RG
			164	3A 100	SPILLWAY	RG
			166	3A 200	SPILLWAY	RG
			167	3A 250	SPILLWAY	RG
			168	4A 0	LL	CG
			169	4A 50	LL	WG
			170	4A 100	LL	WG
			171	4A 150	LL	WG
			172	4A 200	LL	WG
Gastrolobium epacridoides	243	0	-	-	-	-
Grevillea drummondii var. pimelioides	174	0	-	-	-	-
Hibbertia nymphaea	295	0	-	-	-	-
Hibbertia pilosa	298	13	-	-	(For Details See Text)	
Lasiopetalum bracteatum	287	0	-	-	-	-
Lasiopetalum glabratum	288	0	-	-	-	-
Lepyrodia sp. (A)	124	0	-	-	-	-
Microcorys longifolia	352	0	-	-	-	-
Petrophile biloba	82	0	-	-	-	-
Senecio leucoglossus	407	4	158	2A 50	ML	TQ
			159	2A 100	AM	T
			179	4B 150	LO	ST
			217	8A 100	AM	T
Tetratheca nuda	271	0	-	-	-	-

APPENDIX C :

INTEGRATION OF THE GEOGRAPHICAL, ENGINEERING AND ECOLOGICAL FEATURES OF THE DATA BASE.

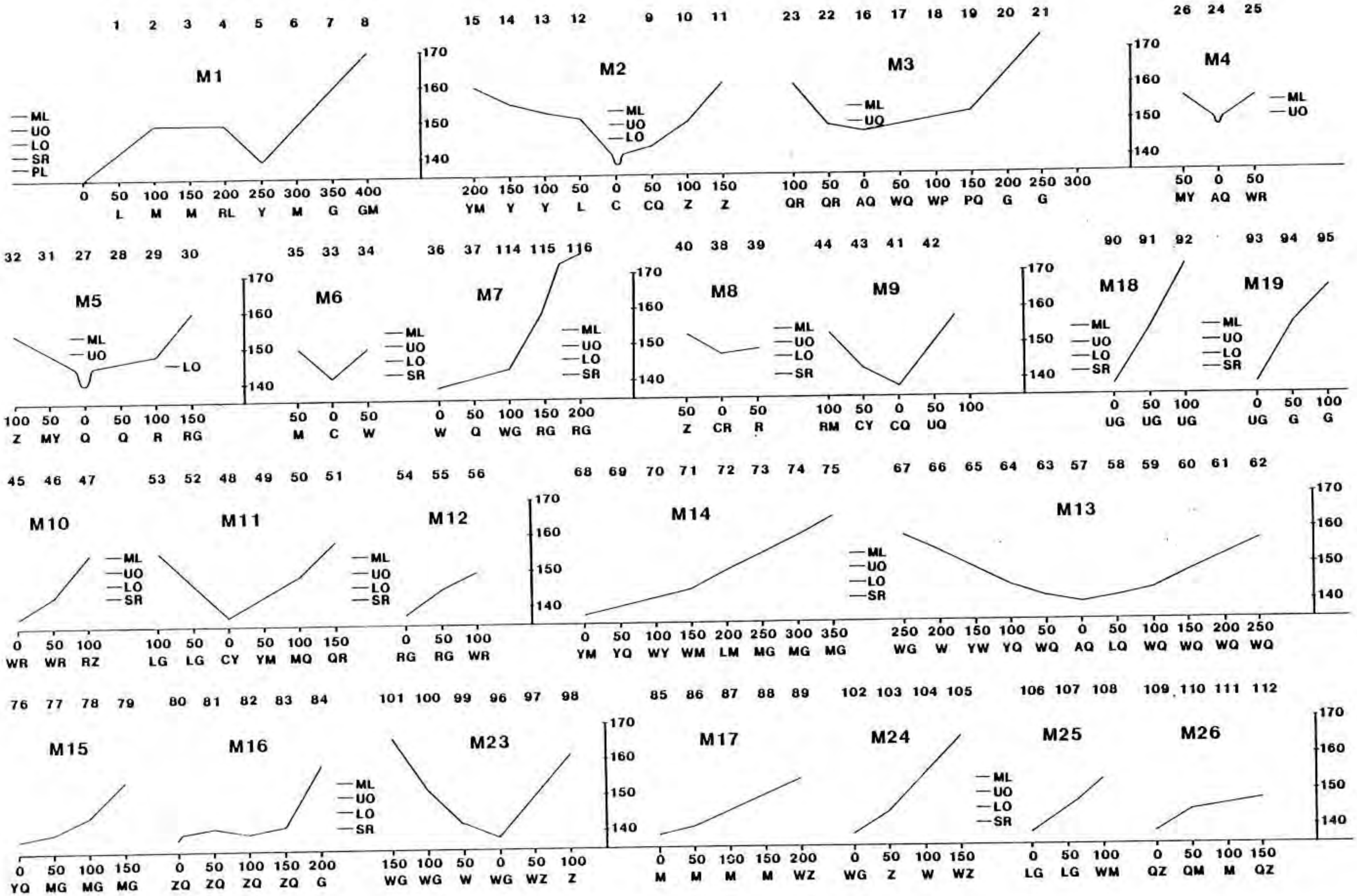
APPENDIX C : INTEGRATION OF THE GEOGRAPHICAL, ENGINEERING AND ECOLOGICAL FEATURES OF THE DATA BASE.

INTEGRATION OF THE DATA BASE

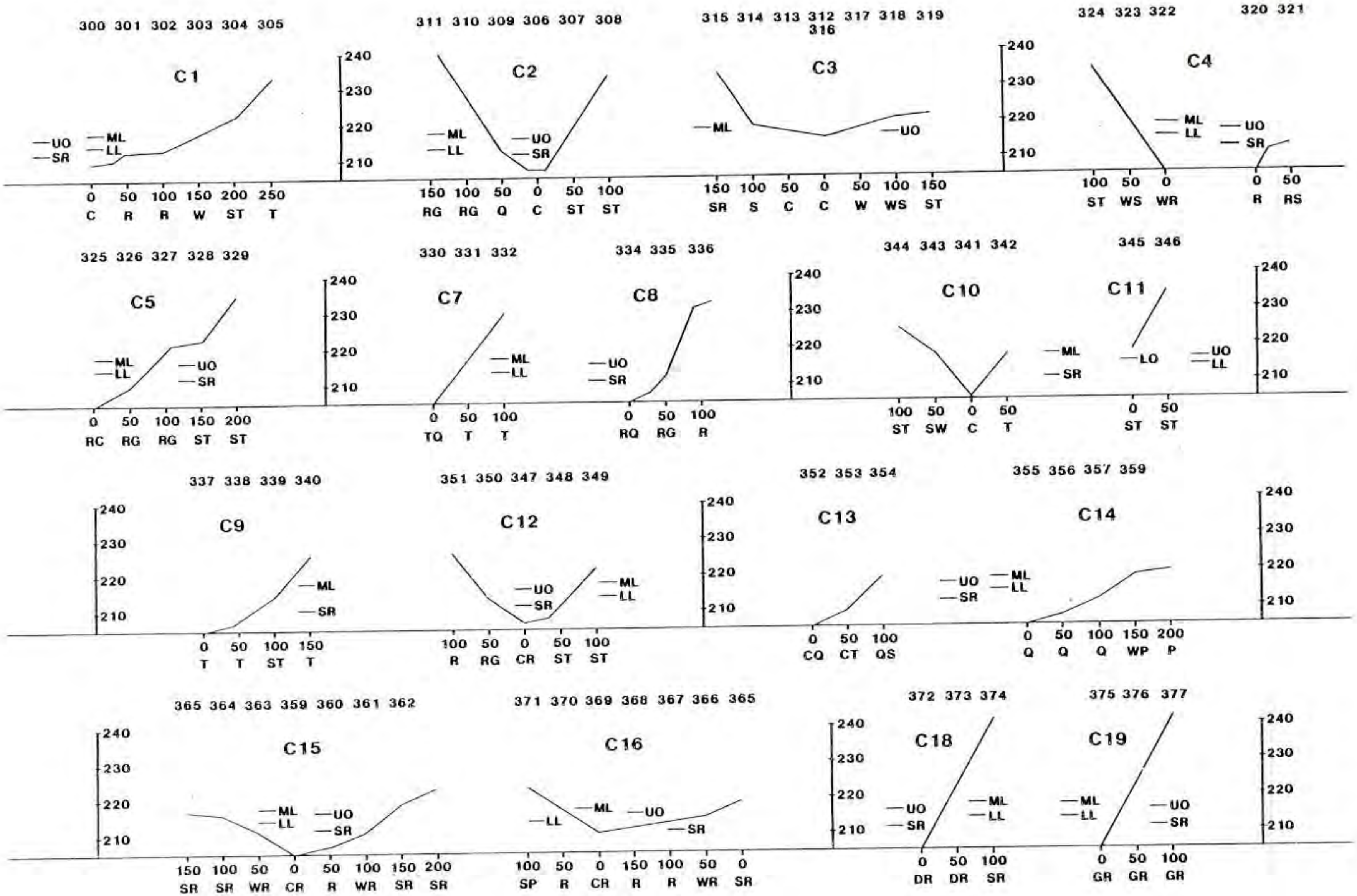


KEY TO INTERPRETATION

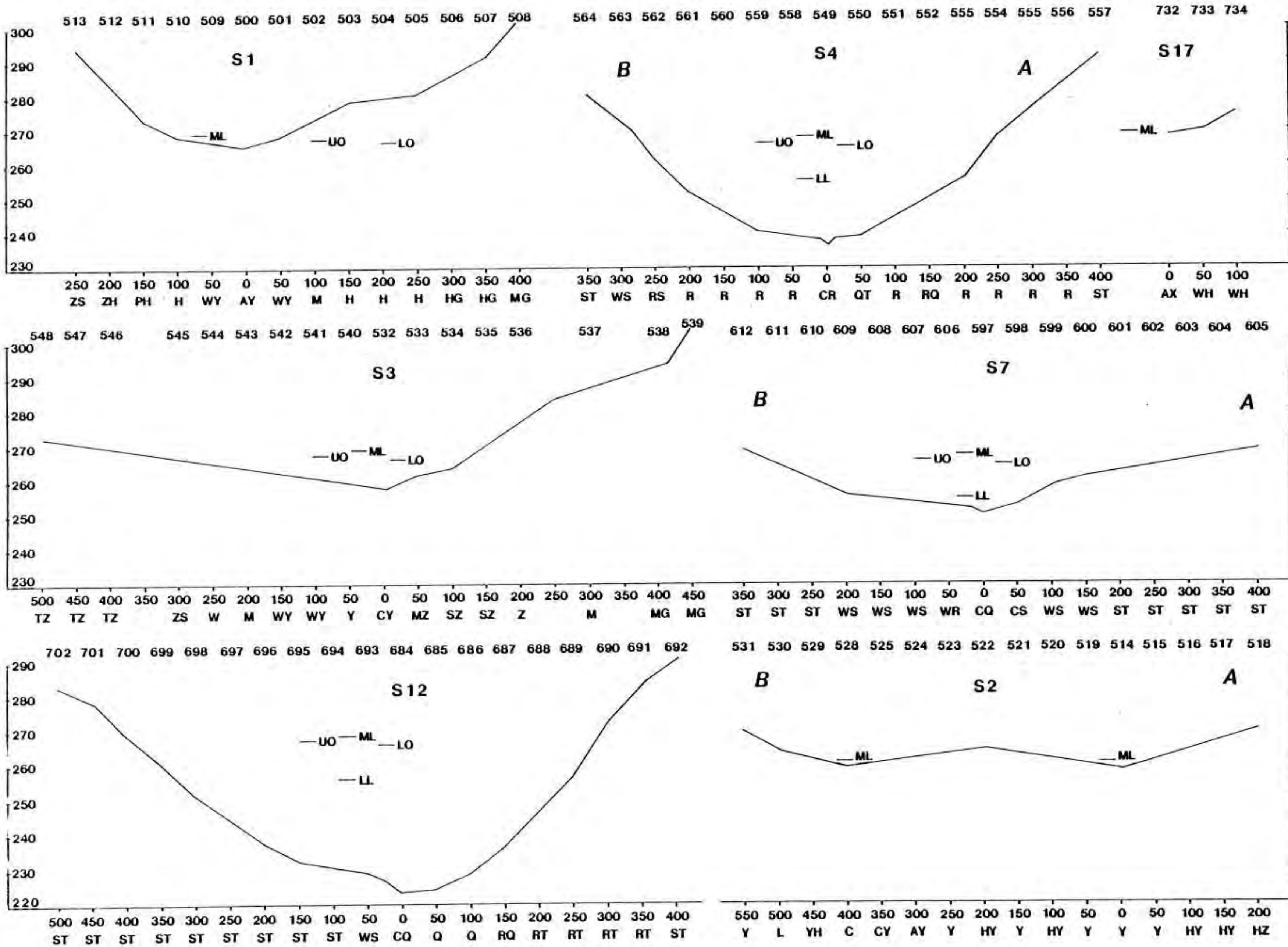
APPENDIX C : INTEGRATION OF THE GEOGRAPHICAL, ENGINEERING AND ECOLOGICAL FEATURES OF THE DATA BASE.



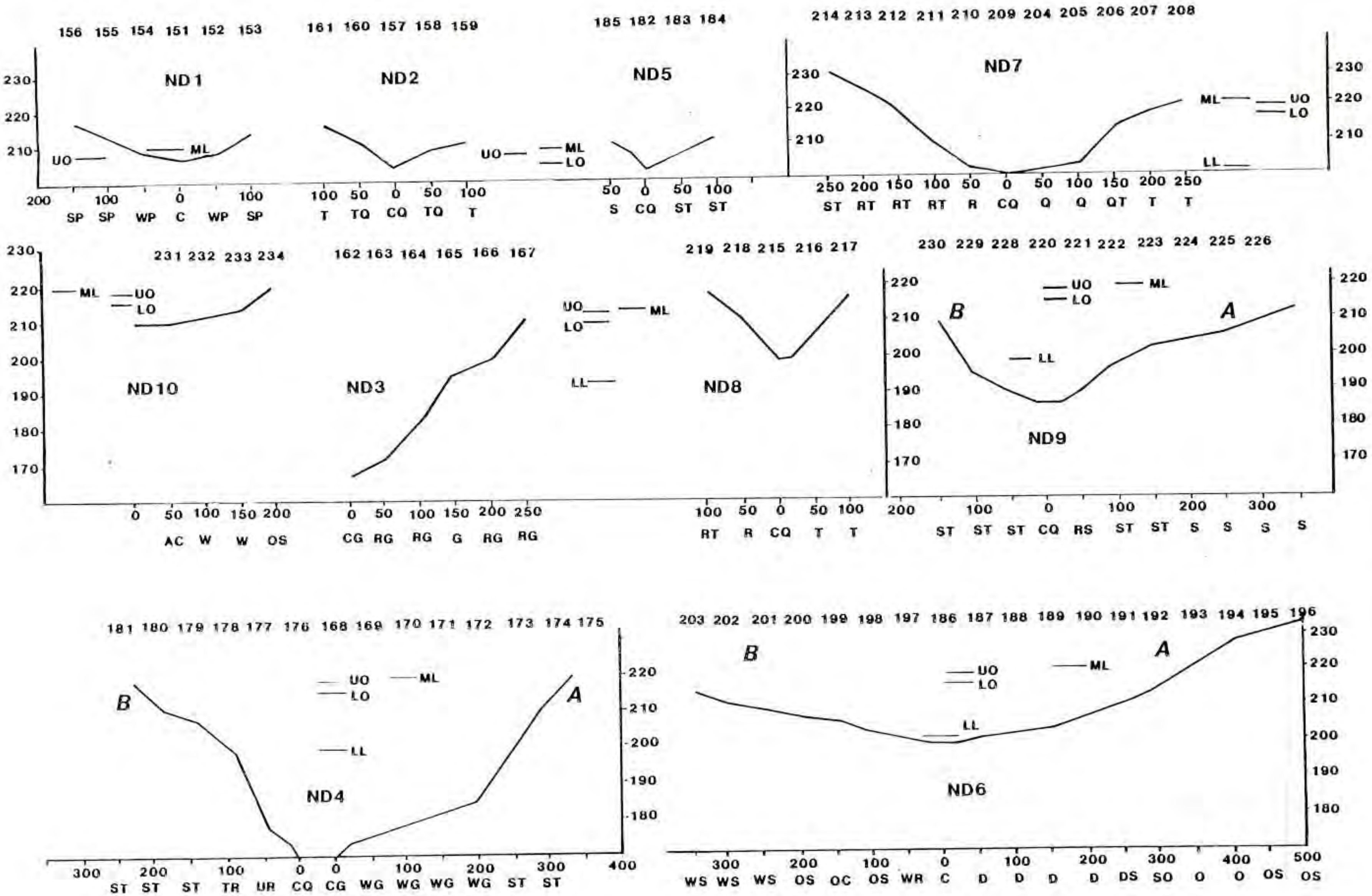
APPENDIX C : INTEGRATION OF THE GEOGRAPHICAL, ENGINEERING AND ECOLOGICAL FEATURES OF THE DATA BASE.

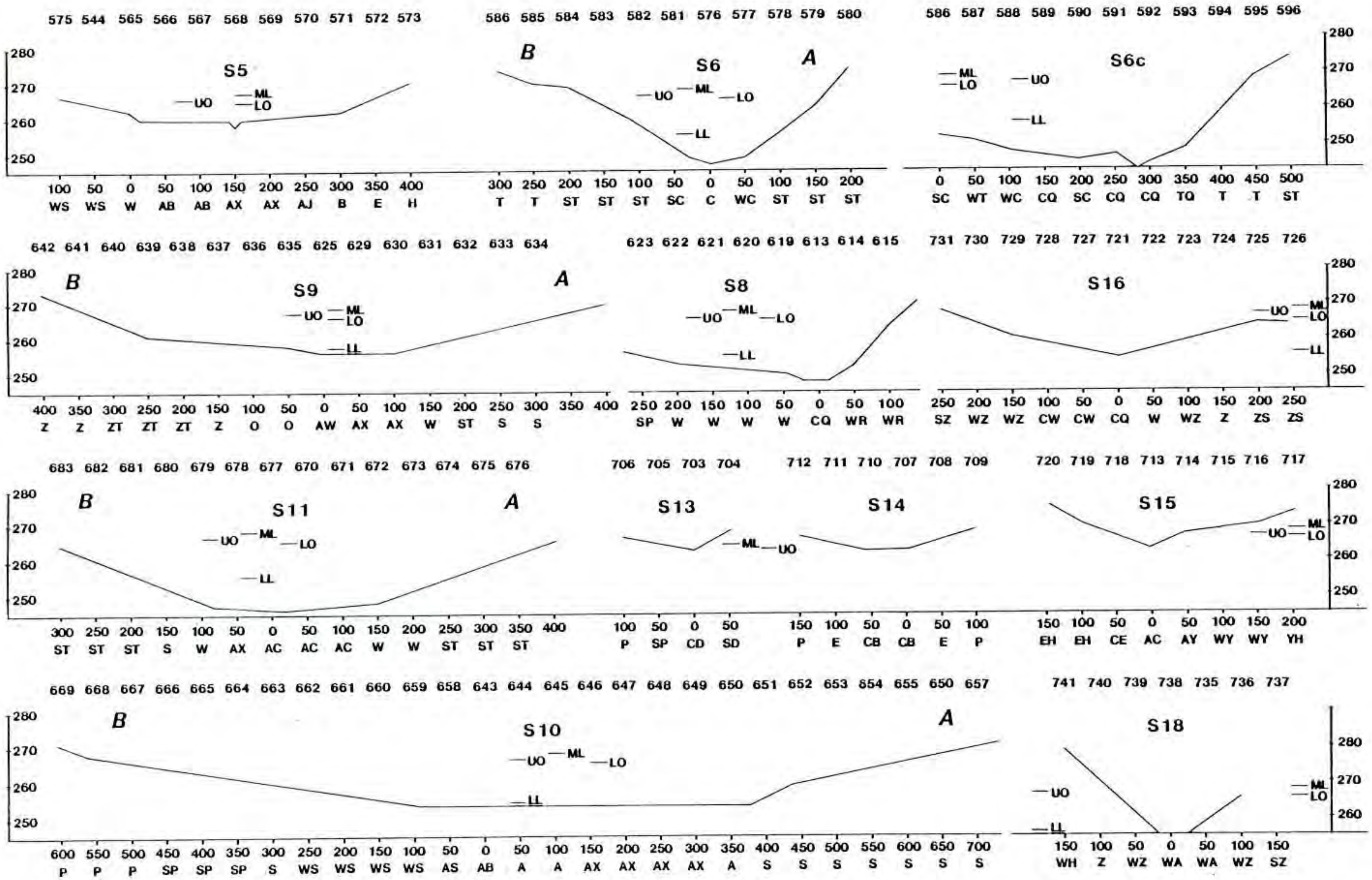


APPENDIX C : INTEGRATION OF THE GEOGRAPHICAL, ENGINEERING AND ECOLOGICAL FEATURES OF THE DATA BASE.



APPENDIX C : INTEGRATION OF THE GEOGRAPHICAL, ENGINEERING AND ECOLOGICAL FEATURES OF THE DATA BASE.





APPENDIX C : INTEGRATION OF THE GEOGRAPHICAL, ENGINEERING AND ECOLOGICAL FEATURES OF THE DATA BASE.

APPENDIX D:

SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES

D1: MUNDARING
D2: CANNING
D3: SOUTH CANNING
D4: NORTH DANDALUP

APPENDIX D1: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT MUNDARING

Species Code	Species	G1	GW WG	G2 UG	GL	GM	MG	LR	MR	WR DR
16	Allocasuarina huegeliana	*	*	*	+	+	-	+	-	+
54	Hibbertia commutata	*	-	*	+	+	-	*	-	*
64	Lepidosperma tenue	*	-	-	-	+	-	+	+	-
138	Stypandra glauca	*	*	+	*	+	-	-	-	+
140	Borya sphaerocephala	*	*	+	+	+	+	-	-	+
204	Drosera gigantea	*	-	-	-	-	-	-	-	-
300	Hibbertia subvaginata	*	-	-	-	+	-	-	-	-
313	Calytrix depressa	*	-	+	-	+	-	-	-	+
451	Campylopus sp.	*	*	+	*	+	-	-	+	-
455	Siphula coriacea	*	*	+	+	+	-	-	-	-
39	Diplolaena microcephala var. drummondii	+	+	-	+	-	-	-	-	-
42	Grevillea bipinnatifida	+	-	-	-	-	-	-	-	-
53	Hibbertia rhadinopoda	+	-	-	-	+	-	*	-	-
88	Trymalium ledifolium	+	*	-	*	*	*	+	-	*
92	Cheilanthes austrotenuifolia	+	*	+	*	+	+	+	-	-
112	Lepidosperma longitudinale	+	-	-	-	-	-	-	-	-
143	Laxmannia squarrosa	+	-	-	-	-	-	-	-	-
175	Grevillea endlicheriana	+	-	-	-	-	-	-	-	-
176	Grevillea glabrata	+	-	-	-	-	-	-	-	-
234	Bossiaea spinescens	+	*	-	-	-	-	-	-	-
255	Mirbelia spinosa	+	-	+	-	-	-	-	-	-
278	Stackhousia huegelii	+	-	-	-	-	-	-	-	-
324	Melaleuca scabra	+	+	-	-	+	-	-	-	-
380	Stylidium bulbiferum	+	*	-	*	*	-	*	-	*
476	Parmelia verrucella	+	*	-	-	-	-	-	-	-
1	Eucalyptus calophylla	-	*	*	+	*	+	+	*	*
4	Eucalyptus marginata	-	+	+	+	+	-	+	*	+
5	Eucalyptus patens	-	*	*	-	+	-	+	-	+
29	Baeckea camphorosmae	-	*	-	-	*	*	*	-	*
48	Hakea lissocarpha	-	+	-	+	*	-	*	*	*
52	Hibbertia hypericoides	-	+	-	-	*	*	*	*	*
57	Hypocalymma angustifolium	-	+	+	+	*	*	+	-	*
75	Macrozamia riedlei	-	+	*	+	*	-	*	*	*
78	Patersonia occidentalis	-	+	-	-	+	-	+	-	-
80	Phyllanthus calycinus	-	*	*	*	*	+	-	-	*
91	Xanthorrhoea preissii	-	*	*	*	*	-	*	*	*
141	Caesia parviflora	-	+	-	+	-	-	-	-	-
148	Tricoryne elatior	-	+	-	+	+	-	-	-	-

APPENDIX D1: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT MUNDARING

Species Code	Species	G1	GW WG	G2 UG	GL	GM	MG	LR	MR	WR DR
172	Dryandra nivea	-	*	-	+	*	+	*	*	*
174	Grevillea drummondii var. pimelioides	-	*	-	-	-	-	-	-	+
227	Acacia pulchella	-	*	-	+	-	+	-	*	+
248	Gompholobium polymorphum	-	+	-	-	-	-	-	-	-
298	Hibbertia pilosa	-	+	-	-	-	-	-	-	-
306	Pimelea imbricata var. piligera	-	+	-	-	-	-	-	-	-
319	Leptospermum erubescens	-	*	-	-	-	-	-	-	-
334	Actinotus leucocephalus	-	+	-	-	-	-	-	-	-
405	Podolepis lessonii	-	*	-	-	-	-	-	-	-
414	Neurachne alopecuroidea	-	+	+	*	*	-	+	-	+
6	Eucalyptus rudis	-	-	+	-	-	-	-	-	-
22	Acacia saligna	-	-	*	+	-	-	-	-	*
304	Pimelea argentea	-	-	*	-	-	-	-	-	-
217	Acacia dentifera	-	-	+	-	-	-	-	-	+
452	Parmelia spodochroa	-	-	+	+	+	-	-	-	-
7	Eucalyptus wandoo	-	-	-	*	*	+	*	+	-
155	Haemodorum laxum	-	-	-	*	+	-	-	-	-
247	Gompholobium marginatum	-	-	-	*	*	-	+	-	-
316	Darwinia thymoides	-	-	-	*	-	-	-	-	-
87	Synaphea petiolaris	-	-	-	+	-	-	-	-	-
127	Loxocarya ?flexuosa	-	-	-	+	-	+	+	-	-
177	Grevillea pilulifera	-	-	-	+	*	+	-	-	-
305	Pimelea ciliata	-	-	-	+	-	-	-	-	-
444	Pilotus manglesii	-	-	-	*	*	-	*	-	-
19	Acacia alata	-	-	-	-	+	-	-	+	-
36	Dampiera alata	-	-	-	-	+	-	-	-	-
41	Gastolobium calycinum	-	-	-	-	+	-	-	-	+
71	Leucopogon nutans	-	-	-	-	+	-	+	-	-
90	Xanthorrhoea gracilis	-	-	-	-	+	+	-	*	+
98	Danthonia setacea	-	-	-	-	+	-	*	-	-
100	Stipa campylachne	-	-	-	-	+	-	*	-	+
167	Thelymitra crinita	-	-	-	-	+	-	-	-	-
291	Hibbertia acerosa	-	-	-	-	+	-	-	-	-
339	Xanthosia candida	-	-	-	-	+	-	-	-	-

APPENDIX D1: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT MUNDARING

Species Code	Species	G1	GW WG	G2 UG	GL	GM	MG	LR	MR	WR DR
381	Stylidium calcaratum var. calcaratum	-	-	-	-	+	-	-	-	-
400	Helipterum cotula	-	-	-	-	+	-	-	-	-
403	Podolepis lessonii	-	-	-	-	+	-	-	-	-
415	Lechenaultia biloba	-	-	-	-	+	-	-	-	-
238	Daviesia horrida	-	-	-	-	-	*	-	-	-
325	Melaleuca aff. scabra	-	-	-	-	-	*	-	-	-
69	Leucopogon capitellatus	-	-	-	-	-	-	+	*	-
192	Stirlingia simplex	-	-	-	-	-	-	+	-	-
360	Isotoma hypocrateriformis		-	-	-	-	-	+	+	*
372	Scaevola striata	-	-	-	-	-	-	-	*	-
443	Opercularia hispidula	-	-	-	-	-	-	-	*	-
333	Gonocarpus cordiger	-	-	-	-	-	-	-	-	+
379	Stylidium brunonianum	-	-	-	-	-	-	-	-	+
437	Hakea prostrata	-	-	-	-	-	-	-	-	+

APPENDIX D2: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT CANNING

Species Code	Species	AR AX	WG	CR	G1	SR	GR GM	DR	R
6	Eucalyptus rudis	*	-	-	-	-	-	-	-
50	Hakea petiolaris	*	-	-	*	-	-	-	-
57	Hypocalymma angustifolium	*	*	-	*	-	*	*	-
80	Phyllanthus calycinus	*	-	-	+	*	*	+	-
88	Trymalium ledifolium	*	-	+	*	*	*	+	-
138	Stypandra glauca	*	-	-	+	-	-	-	-
204	Drosera gigantea	*	-	-	+	-	-	-	+
280	Tripterococcus brunonis	*	-	-	+	-	-	-	-
413	Mirbelia dilatata	*	-	-	-	-	-	-	-
227	Acacia pulchella	+	*	-	+	*	*	*	+
5	Eucalyptus patens	-	*	+	-	-	-	+	-
68	Pericalymma ellipticum	-	*	-	-	-	-	-	-
143	Laxmannia squarrosa	-	*	-	-	-	+	-	-
148	Tricoryne elatior	-	*	-	+	-	-	-	-
179	Grevillea quercifolia	-	*	-	-	-	-	-	-
220	Acacia ephedroides	-	*	+	*	-	-	-	-
255	Mirbelia spinosa	-	*	-	-	-	-	-	-
264	Boronia defoliata	-	*	-	-	-	-	-	-
373	Velleia trinervis	-	*	+	+	+	-	+	-
19	Acacia alata	-	+	-	-	-	-	+	-
20	Acacia extensa	-	+	-	-	-	-	-	-
26	Agonis linearifolia	-	+	+	-	-	-	-	-
29	Baeckea camphorosmae	-	+	+	+	-	-	+	-
33	Chorizema ilicifolium	-	+	-	-	-	-	-	-
43	Grevillea diversifolia	-	+	-	-	-	-	-	-
53	Hibbertia rhadinopoda	-	+	-	-	-	+	-	-
64	Lepidosperma tenue	-	+	-	+	*	+	*	-
66	Leptocarpus coangustatus/ scariosus	-	+	-	-	-	-	-	-
75	Macrozamia riedlei	-	+	+	+	*	*	*	-
79	Patersonia rudis	-	+	-	-	-	-	-	-
89	Trymalium floribundum	-	+	-	-	+	-	-	-
91	Xanthorrhoea preissii	-	+	+	+	*	*	*	-
92	Cheilanthes austrotenuifolia	-	+	-	*	-	-	-	-
101	Tetrarrhena laevis	-	+	-	-	-	+	-	-
122	Lepidobolus preissianus	-	+	-	-	-	-	-	-
140	Borya sphaerocephala	-	+	+	*	-	-	-	+
149	Burchardia umbellata	-	+	-	-	-	-	-	*
153	Conostylis setigera	-	+	+	+	+	+	-	-

APPENDIX D2: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT CANNING

Species Code	Species	AR AX	WG	CR	G1	SR	GR GM	DR	R
172	Dryandra nivea	-	+	+	+	*	+	*	-
185	Hakea undulata	-	+	+	*	*	*	+	+
247	Gompholobium marginatum	-	+	+	+	*	*	-	+
278	Stackhousia huegelii	-	+	-	*	-	-	-	-
284	Cryptandra arbutiflora	-	+	-	-	-	-	-	-
313	Calytrix depressa	-	+	*	*	-	-	-	-
314	Darwinia citriodora	-	+	-	*	-	-	-	-
318	Kunzea recurva	-	+	-	-	-	-	-	-
364	Dampiera lavandulacea	-	+	-	-	-	-	-	-
370	Goodenia aff. helmsii	-	+	-	*	-	-	-	-
395	Brachycome iberidifolia	-	+	-	*	-	-	-	-
414	Neurachne alopecuroidea	-	+	-	+	-	-	-	-
451	Campylopus sp.	-	+	*	*	-	+	-	-
455	Siphula coriacea	-	+	+	*	-	-	-	-
1	Eucalyptus calophylla	-	-	*	+	*	*	*	+
4	Eucalyptus marginata	-	-	*	-	*	-	*	+
312	Calothamnus rupestris	-	-	*	*	-	-	-	-
319	Leptospermum erubescens	-	-	*	-	-	-	-	-
400	Helipterum cotula	-	-	*	*	+	+	-	-
411	Waitzia paniculata	-	-	+	-	-	-	-	-
412	Pentapeltis peltigera	-	-	+	-	-	-	-	-
425	Hakea trifurcata	-	-	*	-	-	-	+	-
439	Allocasuarina humilis	-	-	*	+	-	+	-	-
12	Nuytsia floribunda	-	-	+	-	-	-	-	*
15	Allocasuarina fraseriana	-	-	+	-	-	-	-	-
62	Lasiopetalum floribundum	-	-	+	-	-	-	-	+
88	Trymalium ledifolium	-	-	+	-	-	-	-	-
90	Xanthorrhoea gracilis	-	-	+	-	+	-	-	-
124	Lepyrodia sp. (A)	-	-	+	-	-	-	-	-
126	Loxocarya fasciculata	-	-	+	-	-	-	-	-
141	Caesia parviflora	-	-	+	+	-	-	-	*
144	Thysanotus dichotomous	-	-	+	+	-	-	-	-
208	Drosera platystigma	-	-	+	-	-	-	-	-
281	Dodonaea ceratocarpa	-	-	+	-	-	+	-	-
452	Parmelia spodochroa	-	-	+	*	-	-	-	-
328	Verticordia huegelii	-	-	+	*	-	-	-	-
329	Verticordia plumosa	-	-	+	*	-	-	-	-
340	Andersonia lehmanniana	-	-	+	+	-	-	-	-
347	Hemiandra pungens	-	-	+	-	-	-	-	-
470	Gastrolobium spinosum	-	-	+	*	-	-	-	-

APPENDIX D2: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT CANNING

Species Code	Species	AR AX	WG	CR	G1	SR	GR GM	DR	R
476	Parmelia verrucella	-	-	+	-	-	-	-	-
42	Grevillea binpinnatifida	-	-	-	*	-	*	-	-
52	Hibbertia hypericoides	-	-	-	*	*	-	*	-
325	Melaleuca aff. scabra	-	-	-	*	-	*	-	-
330	Glischrocaryon aureum var. angustifolium	-	-	-	*	-	-	-	-
360	Isotoma hypocrateriformis	-	-	-	*	+	+	+	-
453	Cladia ferdinandii	-	-	-	*	-	-	-	-
48	Hakea lissocarpha	-	-	-	+	*	*	*	-
54	Hibbertia commutata	-	-	-	+	-	+	+	-
171	Dryandra armata	-	-	-	+	-	-	-	-
175	Grevillea endlicheriana	-	-	-	+	-	-	-	-
203	Cassytha racemosa	-	-	-	+	*	*	+	-
244	Gastrolobium villosum	-	-	-	+	+	-	-	-
305	Pimelea ciliata	-	-	-	+	*	*	*	-
306	Pimelea imbricata var. piligera	-	-	-	+	-	*	+	-
344	Leucopogon strictus	-	-	-	+	-	-	-	-
348	Hemigenia incana	-	-	-	+	+	*	-	-
358	Opercularia vaginata	-	-	-	+	-	-	+	-
374	Levenhookia pusilla	-	-	-	+	-	-	-	-
380	Stylidium bulbiferum	-	-	-	+	-	+	-	-
392	Stylidium repens	-	-	-	+	-	-	-	-
7	Eucalyptus wandoo	-	-	-	-	+	*	-	-
31	Bossiaea ornata	-	-	-	-	*	-	-	-
69	Leucopogon capitellatus	-	-	-	-	*	-	*	-
443	Opercularia hispidula	-	-	-	-	*	-	+	-
377	Stylidium amoenum	-	-	-	-	+	+	-	-
341	Astroloma pallidum	-	-	-	-	+	+	-	-
73	Leucopogon verticillatus	-	-	-	-	+	-	-	-
87	Synaphea petiolaris	-	-	-	-	+	-	-	-
173	Dryandra praemorsa	-	-	-	-	+	-	-	-
270	Tetratheca hirsuta	-	-	-	-	+	*	-	-
2	Eucaluyptus laeliae	-	-	-	-	-	+	-	-
369	Scaevola glandulifera	-	-	-	-	-	*	-	-
139	Agrostocrinum scabrum	-	-	-	-	-	+	-	-
155	Haemodorum laxum	-	-	-	-	-	+	-	-
238	Daviesia horrida	-	-	-	-	-	+	-	-
252	Hovea trisperma	-	-	-	-	-	+	-	-

APPENDIX D2: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT CANNING

Species Code	Species	AR AX	WG	CR	G1	SR	GR GM	DR	R
17	Persoonia longifolia	-	-	-	-	-	-	+	-
23	Acacia urophylla	-	-	-	-	-	-	*	-
60	Kennedia coccinea	-	-	-	-	-	-	*	-
61	Kingia australis	-	-	-	-	-	-	+	-
248	Gompholobium polymorphum	-	-	-	-	-	-	+	-
293	Comesperma ciliatum	-	-	-	-	-	-	+	-
292	Hibbertia amplexicaulis	-	-	-	-	-	-	*	-
308	Pimelea spectabilis	-	-	-	-	-	-	*	-
339	Xanthosia candida	-	-	-	-	-	-	+	-

APPENDIX D3: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT SOUTH CANNING

Species Code	Species	G3	G4 CR	CR	WR	RT	RS
204	Drosera gigantea	*	-	-	-	-	+
313	Calytrix depressa	*	-	-	-	+	*
318	Kunzea recurva	*	*	-	*	+	*
329	Verticordia plumosa	*	-	-	-	-	-
344	Leucopogon strictus	*	-	-	-	-	+
381	Stylidium calcaratum var. calcaratum	*	-	+	+	*	+
400	Helipterum cotula	*	+	-	+	+	*
419	Tetraria octandra	*	-	-	+	-	-
20	Acacia extensa	+	+	+	-	-	-
53	Hibbertia rhadinopoda	+	-	-	-	-	-
122	Lepidobolus preissianus	+	-	-	-	-	-
140	Borya sphaerocephala	+	-	-	-	+	*
176	Grevillea glabrata	+	-	-	-	-	-
178	Grevillea pulchella	+	-	-	-	+	+
185	Hakea undulata	+	+	+	-	-	-
255	Mirbelia spinosa	+	-	-	-	-	-
273	Comesperma ciliatum	+	-	-	-	-	-
350	Hemigenia sericea var. parviflora	+	-	-	+	-	-
380	Stylidium bulbiferum	+	*	-	+	+	*
395	Brachycome iberidifolia	+	+	*	+	-	-
413	Mirbelia dilatata	+	+	-	+	-	-
451	Campylopus sp.	+	-	-	-	*	+
470	Gastrolobium spinosum	+	-	-	+	+	+
305	Pimelea ciliata	-	*	-	*	-	+
5	Eucalyptus patens	-	+	*	*	-	-
6	Eucalyptus rudis	-	+	-	-	-	-
14	Melaleuca rhaphiophylla	-	+	-	-	-	-
28	Astartea fascicularis	-	+	-	-	-	-
43	Grevillea diversifolia	-	+	-	-	-	-
48	Hakea lissocarpha	-	+	*	*	*	+
54	Hibbertia commutata	-	+	-	-	-	+
66	Leptocarpus coangustatus/ scariosus	-	+	-	-	-	-
75	Macrozamia riedlei	-	+	*	*	*	+
76	Melaleuca viminea	-	+	-	-	-	-
80	Phyllanthus calycinus	-	+	-	-	+	+
88	Trymalium ledifolium	-	+	-	*	-	-
89	Trymalium floribundum	-	+	+	-	-	+

APPENDIX D3: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT SOUTH CANNING

Species Code	Species	G3	G4 CR	CR	WR	RT	RS
91	Xanthorrhoea preissii	-	+	*	*	*	*
92	Cheilanthes austrotenuifolia	-	+	-	-	-	-
112	Lepidosperma longitudinale	-	+	-	-	-	-
141	Caesia parviflora	-	+	*	+	-	+
227	Acacia pulchella	-	+	*	*	-	+
247	Gompholobium marginatum	-	+	-	-	-	-
257	Oxylobium linarifolium	-	+	-	-	-	-
270	Tetratheca hirsuta	-	+	*	+	*	+
280	Tripterococcus brunonis	-	+	-	-	-	-
295	Hibbertia nymphaea	-	+	-	-	-	-
330	Glischrocaryon aureum var. angustifolium	-	+	-	-	-	-
424	Kennedia prostrata	-	+	-	-	-	-
425	Hakea trifurcata	-	+	-	-	-	-
438	Baumea ?vaginalis	-	+	-	-	-	-
454	Cladia aggregata	-	+	-	-	-	-
473	Astroloma glaucescens	-	+	-	-	+	-
64	Lepidosperma tenue	-	-	*	*	*	-
292	Hibbertia amplexicaulis	-	-	*	-	+	+
298	Hibbertia pilosa	-	-	*	*	-	-
339	Xanthosia candida	-	-	*	+	-	-
447	Caladenia flava	-	-	*	+	-	-
10	Banksia littoralis	-	-	+	-	-	-
17	Persoonia longifolia	-	-	+	-	+	+
69	Leucopogon capitellatus	-	-	+	-	*	+
202	Ranunculus colonorum	-	-	+	-	-	-
345	Logania serpyllifolia	-	-	+	-	+	-
365	Dampiera linearis	-	-	+	-	-	-
417	Cyathochaeta avenacea	-	-	+	+	-	-
1	Eucalyptus calophylla	-	-	-	*	*	*
4	Eucalyptus marginata	-	-	-	*	*	*
29	Baeckea camphorosmae	-	-	-	*	-	+
31	Bossiaea ornata	-	-	-	*	*	+
42	Grevillea bipinnatifida	-	-	-	*	-	*
68	Pericalymma ellipticum	-	-	-	*	-	+
78	Patersonia occidentalis	-	-	-	*	-	-
126	Loxocarya fasciculata	-	-	-	*	-	+
172	Dryandra nivea	-	-	-	*	-	+

APPENDIX D3: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT SOUTH CANNING

Species Code	Species	G3	G4 CR	CR	WR	RT	RS
373	Velleia trinervis	-	-	-	*	-	-
167	Thelymitra crinita	-	-	-	+	+	+
284	Cryptandra arbutiflora	-	-	-	+	-	+
388	Stylidium piliferum	-	-	-	+	-	-
439	Allocasuarina humilis	-	-	-	+	-	-
19	Acacia alata	-	-	-	-	*	+
23	Acacia urophylla	-	-	-	-	*	-
73	Leucopogon verticillatus	-	-	-	-	*	-
63	Lepidosperma angustatum	-	-	-	-	+	+
67	Leptomeria cunninghamii	-	-	-	-	+	-
90	Xanthorrhoea gracilis	-	-	-	-	+	+
147	Thysanotus thyrsoideus	-	-	-	-	+	-
238	Daviesia horrida	-	-	-	-	+	+
265	Boronia fastigiata	-	-	-	-	+	+
328	Verticordia huegelii	-	-	-	-	+	+
330	Glischrocaryon aureum var. angustifolium	-	-	-	-	+	-
336	Platysace compressa	-	-	-	-	+	-
372	Scaevola striata	-	-	-	-	+	-
412	Pentapeltis peltigera	-	-	-	-	+	+
428	Daviesia cordata	-	-	-	-	+	-
443	Opercularia hispidula	-	-	-	-	+	-
34	Clematis pubescens	-	-	-	-	+	-
56	Hovea chorizemifolia	-	-	-	-	+	-
71	Leucopogon nutans	-	-	-	-	+	-
74	Lyginia barbata	-	-	-	-	+	-
278	Stackhousia huegelii	-	-	-	-	+	-
306	Pimelea imbricata var. piligera	-	-	-	-	+	-
348	Hemigenia incana	-	-	-	-	+	-
358	Opercularia vaginata	-	-	-	-	+	-
415	Lechenaultia biloba	-	-	-	-	+	-
452	Parmelia spodochroa	-	-	-	-	+	-
455	Siphula coriacea	-	-	-	-	+	-

APPENDIX D4: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT NORTH DANDALUP

Species Code	Species	G5	G6 WG	G7 RG	G8 CG	CR	TR	GT	RT	RS
92	Cheilanthes austrotenuifolia	*	-	-	-	-	-	*	-	-
140	Borya sphaerocephala	*	-	-	-	-	-	-	-	-
146	Thysanotus patersonii	*	+	*	-	-	-	+	-	-
185	Hakea undulata	*	+	-	-	-	-	-	-	-
278	Stackhousia huegelii	*	+	-	-	-	-	+	-	-
281	Dodonaea ceratocarpa	*	*	-	-	-	-	-	-	-
314	Darwinia citriodora	*	*	-	*	*	-	-	-	-
380	Stylidium bulbiferum	*	+	+	-	-	-	*	-	-
29	Baeckea camphorosmae	+	+	+	-	-	-	-	-	-
42	Grevillea bipinnatifida	+	+	+	-	-	-	-	-	-
64	Lepidosperma tenue	+	+	*	-	-	-	+	+	+
110	Lepidosperma gracile	+	+	-	-	-	-	-	-	+
167	Thelymitra crinita	+	+	-	-	-	-	+	+	-
227	Acacia pulchella	+	*	*	+	-	-	*	-	*
255	Mirbelia spinosa	+	+	-	-	-	-	-	-	-
307	Pimelea preissii	+	-	+	-	-	-	-	-	-
311	Calothamnus quadrifidus	+	+	-	-	-	-	-	-	-
348	Hemigenia incana	+	+	-	-	-	-	+	-	-
381	Stylidium calcaratum var. calcaratum	+	+	-	-	-	-	-	-	-
400	Helipterum cotula	+	-	-	-	-	-	-	-	-
414	Neurachne alopecuroidea	+	-	-	-	+	-	-	-	-
451	Campylopus sp.	+	+	-	-	-	-	*	-	-
452	Parmelia spodochroa	+	-	-	-	-	-	+	-	-
1	Eucalyptus calophylla	-	*	*	+	*	*	*	*	*
2	Eucalyptus laeliae	-	*	*	*	-	-	-	-	-
31	Bossiaea ornata	-	*	*	-	-	-	-	+	-
36	Dampiera alata	-	*	*	-	-	-	+	-	-
52	Hibbertia hypericoides	-	*	*	+	-	*	+	*	*
57	Hypocalymma angustifolium	-	*	*	+	-	+	-	-	-
80	Phyllanthus calycinus	-	*	+	-	-	*	*	+	*
87	Synaphea petiolaris	-	*	*	-	-	-	-	-	+
172	Dryandra nivea	-	*	*	-	-	-	-	-	+
305	Pimelea ciliata	-	*	*	-	+	-	+	-	+
315	Darwinia aff. citriodora	-	*	*	+	-	-	*	-	+
372	Scaevola striata	-	*	*	-	-	-	-	+	-
425	Hakea trifurcata	-	*	*	+	-	-	-	-	-

APPENDIX D4: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT NORTH DANDALUP

Species Code	Species	G5	G6 WG	G7 RG	G8 CG	CR	TR	GT	RT	RS
48	Hakea lissocarpha	-	+	+	-	-	*	+	+	+
77	Mesomelaena tetragona	-	+	-	-	-	-	-	-	-
91	Xanthorrhoea preissii	-	+	*	-	-	*	*	*	*
186	Isopogon asper	-	+	*	-	-	-	-	-	-
235	Chorizema dicksonii	-	+	+	-	-	-	-	-	-
247	Gompholobium marginatum	-	+	-	-	-	-	+	-	+
292	Hibbertia amplexicaulis	-	+	*	-	-	*	-	+	-
365	Dampiera linearis	-	+	+	-	-	-	-	+	+
4	Eucalyptus marginata	-	-	*	-	+	*	+	*	*
54	Hibbertia commutata	-	-	*	-	-	+	-	-	-
69	Leucopogon capitellatus	-	-	*	-	-	*	*	*	+
75	Macrozamia riedlei	-	-	*	-	+	*	*	*	*
139	Agrostocrinum scabrum	-	-	*	-	-	-	-	-	-
183	Hakea stenocarpa	-	-	*	-	-	-	-	-	-
188	Isopogon sphaerocephalus	-	-	*	-	-	-	-	-	-
224	Acacia nervosa	-	-	*	-	-	-	-	-	-
377	Stylidium amoenum	-	-	*	-	-	-	-	+	-
385	Stylidium hispidum	-	-	*	-	-	-	-	-	-
419	Tetraria octandra	-	-	*	-	-	-	-	-	*
433	Haemodorum paniculatum	-	-	*	-	-	-	-	-	-
101	Tetrarrhena laevis	-	-	+	-	-	-	-	-	-
221	Acacia lateriticola	-	-	+	-	+	*	-	*	-
309	Pimelea suaveolens	-	-	+	-	-	-	-	-	-
416	Astroloma ciliatum	-	-	+	-	-	-	-	-	-
432	Dryandra bipinnatifida	-	-	+	-	-	-	-	-	-
20	Acacia extensa	-	-	-	*	-	+	*	*	+
26	Agonis linearifolia	-	-	-	*	*	-	+	-	-
28	Astartea fascicularis	-	-	-	*	*	-	+	-	-
43	Grevillea diversifolia	-	-	-	*	*	-	+	-	-
66	Lepidosperma coangustatus/ scariosus	-	-	-	*	*	-	+	-	-
438	Baumea ? vaginalis	-	-	-	*	-	-	+	-	-

APPENDIX D4: SUMMARY OF INDICATOR SPECIES AND ASSOCIATED SPECIES IN R & G TYPES AND THEIR DERIVATIVES AT NORTH DANDALUP

Species Code	Species	G5	G6 WG	G7 RG	G8 CG	CR	TR	GT	RT	RS
7	Eucalyptus wandoo	-	-	-	+	-	-	-	-	-
65	Lepidosperma tetraquetrum	-	-	-	+	*	-	+	-	-
203	Cassytha racemosa	-	-	*	+	-	-	-	*	-
217	Acacia dentifera	-	-	-	+	-	-	*	-	-
413	Mirbelia dilatata	-	-	-	+	+	-	-	-	-
5	Eucalyptus patens	-	-	-	-	*	*	+	-	-
81	Pteridium esculentum	-	-	-	-	*	+	-	-	-
56	Hovea chorizemifolia	-	-	-	-	+	-	-	-	-
298	Hibbertia pilosa	-	-	-	-	+	-	*	+	-
17	Persoonia longifolia	-	-	-	-	-	*	-	-	-
23	Acacia urophylla	-	-	-	-	-	*	*	*	*
270	Tetratheca hirsuta	-	-	-	-	-	*	-	+	-
33	Chorizema ilicifolium	-	-	-	-	-	+	+	-	-
34	Clematis pubescens	-	-	-	-	-	+	*	*	-
62	Lasiopetalum floribundum	-	-	-	-	-	+	-	-	-
67	Leptomeria cunninghamii	-	-	-	-	-	+	-	*	*
72	Leucopogon propinquus	-	-	-	-	-	+	-	-	*
73	Leucopogon verticillatus	-	-	-	-	-	+	+	*	-
90	Xanthorrhoea gracilis	-	-	-	-	-	+	-	+	+
180	Hakea amplexicaulis	-	-	-	-	-	+	-	-	+
236	Chorizema rhombeum	-	-	-	-	-	+	-	*	-
301	Hybanthus debilissimus	-	-	-	-	-	+	-	-	-
127	Loxocarya ? flexuosa	-	-	-	-	-	-	+	-	-
177	Grevillea pilulifera	-	-	-	-	-	-	*	-	+
238	Daviesia horrida	-	-	-	-	-	-	*	-	-
306	Pimelea imbricata var. piligera	-	-	-	-	-	-	+	-	-
339	Xanthosia candida	-	-	-	-	-	-	+	-	-
357	Opercularia echinocephala	-	-	-	-	-	-	+	-	-
395	Brachycome iberidifolia	-	-	-	-	-	-	+	-	-
428	Daviesia cordata	-	-	-	-	-	-	+	-	-
60	Kennedia coccinea	-	-	-	-	-	-	-	+	-
63	Lepidosperma angustatum	-	-	-	-	-	-	-	+	-
265	Boronia fastigiata	-	-	-	-	-	-	-	*	-
310	Pimelea sylvestris	-	-	-	-	-	-	-	*	-
153	Conostylis setigera	-	-	-	-	-	-	-	-	*

APPENDIX E:

SUMMARY OF IMPACTS AT THE LEVEL OF SITE-VEGETATION TYPES

E1: MUNDARING
E2: CANNING
E3: SOUTH CANNING
E4: NORTH DANDALUP

APPENDIX E1: SUMMARY OF IMPACTS AT THE LEVEL OF SITE-VEGETATION TYPES - MUNDARING

Level of Inundation	Types on Valley Floor, Depressions and Lower Slopes	Types on Intermediate Positions	Types on Steeper Mid and Upper Slopes
Raising to SR	AQ-3	QZ-1	LG-1
	CQ-1	WG-2	M-2
	CY-2	WR-1	MG-1
	QC-1	ZQ-4	RG-1
	W-1		UG-2
	WQ-1		
	Y-1		
	YM-1		
	YQ-2		
To LO Level	W-1	LQ-1	L-1
	WQ-1	QM-1	LG-1
	WY-1	WG-1	M-2
	YC-1	WM-1	MG-1
	YQ-1	WR-1	RG-1
		YM-1	Z-1
To UO Level	AQ-2	CR-1	L-1
	Q-1	MQ-1	LG-1
	W-1	QR-1	LM-1
	WQ-1	QZ-1	M-5
	Y-1	WP-1	R-2
		WZ-1	RL-1
			Z-1
To ML Level	W-2	MY-2	MG-2
	WQ-1	PQ-1	RM-1
	Y-1	UQ-1	RZ-1
		WG-1	UG-1
		WM-1	Z-2
		WR-2	
		WZ-1	
		YM-1	

APPENDIX E1: SUMMARY OF IMPACTS AT THE LEVEL OF SITE-VEGETATION TYPES - MUNDARING

Level of Inundation	Types on Valley Floor, Depressions and Lower Slopes	Types on Intermediate Positions	Types on Steeper Mid and Upper Slopes
Above ML Level (AM)	WQ-1	QR-1	G-6
		WG-2	GM-1
		WZ-1	LG-1
			MG-2
			R-2
			RG-3
			UG-1
			Z-2

APPENDIX E2: SUMMARY OF IMPACTS AT THE LEVEL OF SITE-VEGETATION TYPES - CANNING

Level of Inundation	Types on Valley Floor, Depressions and Lower Slopes	Types on Intermediate Positions	Types on Steeper Mid and Upper Slopes
Raising to SR	C-5 CQ-1 Q-3	CR-3 DR-1 RC-1 RQ-1 WR-2	R-2 RG-2 ST-1 T-2
To LO Level	C-1 Q-1 W-1	CR-1 SW-1 WR-1	R-2 RG-1 RS-1 ST-1 T-1
To ML Level	C-1 W-2	QS-1 WP-1	R-2 RG-1 SR-1 ST-1 T-1
Above ML Level (AM)	-	DR-1 QS-1 WR-1 WS-2	R-3 RG-5 S-1 SP-1 SR-5 ST-10 T-4

APPENDIX E3: SUMMARY OF IMPACTS AT THE LEVEL OF SITE-VEGETATION TYPES - SOUTH CANNING

Level of Inundation	Types on Valley Floor, Depressions and Lower Slopes	Types on Intermediate Positions	Types on Steeper Mid and Upper Slopes
To LL Level	A-3	AS-1	R-5
	AA-1	CR-1	RT-1
	AB-1	CS-5	S-1
	AC-3	QT-1	SP-1
	AW-2	RQ-2	ST-9
	AX-6	TQ-1	
	C-2	WR-2	
	CQ-6	WS-5	
	Q-2	WT-1	
	W-7		
	WC-2		
To LO Level	AB-2	WR-1	M-1
	AC-1	WS-6	MZ-1
	AJ-1	WZ-5	O-2
	AX-2		P-1
	AY-1		RS-1
	B-1		RT-1
	CW-2		S-7
	CY-1		SP-7
	Q-1		ST-13
	W-4		T-1
	WA-1		Z-2
	WY-3		ZS-4
	Y-1		ZT-3
To ML Level	AX-1	WS-1	H-1
	AY-1		P-1
	C-1		R-1
	CB-2		S-2
	CD-1		ST-4
	CE-1		SZ-2
	CY-1		T-1
	E-2		TZ-1
	WY-3		Z-1
	Y-2		

APPENDIX E3: SUMMARY OF IMPACTS AT THE LEVEL OF SITE-VEGETATION TYPES - SOUTH CANNING

Level of Inundation	Types on Valley Floor, Depressions and Lower Slopes	Types on Intermediate Positions	Types on Steeper Mid and Upper Slopes
Above ML Level (AM)	AY-1	EH-2	H-4
	E-1	HY-6	HG-2
	WY-1	SD-1	HZ-2
	Y-4	WH-3	L-1
		WR-1	M-2
		WS-1	MG-3
			P-4
			PH-1
			R-4
			RT-2
			S-1
			SP-1
			ST-9
			SZ-2
			T-2
			TZ-2
			Z-3

APPENDIX E4: SUMMARY OF IMPACTS AT THE LEVEL OF SITE-VEGETATION TYPES - NORTH DANDALUP

Level of Inundation	Types on Valley Floor, Depressions and Lower Slopes	Types on Intermediate Positions	Types on Steeper Mid and Upper Slopes
To LL Level	C-1 CQ-3 D-1	CG-1 WG-4 WR-1	RS-1 ST-4 TR-1 UR-1
To LO Level	AC-1 CQ-3 D-3 Q-2 W-2	DS-1 QT-1 WS-3	OS-3 R-1 RT-1 S-4 SO-1 ST-5 T-1
To ML Level	C-1 Q-1	WD-2	OS-1 R-1 RT-1 ST-3 T-2
Above ML Level (AM)	-	-	O-1 OS-2 RT-2 S-1 SP-3 ST-2 T-1

APPENDIX F :

EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS

F1. Cross Referencing of Survey Location to Computer Sequence and Reverse.

F2. Species Rate Summary Report, Used to Establish Rarity or Abundance of Species.

F3. Species Occurrences Report, Used to Locate Rare Species and Define their Ecological Affinities.

F4. Species Flooding Impact Report, Used to Define the Impact of Inundation on Individual Species.

F5. Location Group Report, Used to Cross Reference Geographical and Ecological Data.

F6. Location Class Species Report, Used to Broaden Definition of Site-vegetation Types.

APPENDIX F1 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS CROSS REFERENCING OF SURVEY LOCATION TO COMPUTER SEQUENCE AND REVERSE

LOCATION TO SEQUENCE NUMBER

LOCATION				SEQUENCE
DAM	TRANSECT	SEGMENT	DISTANCE	NUMBER
ND	1	A	0	151
ND	1	A	50	152
ND	1	A	100	153
ND	1	B	50	154
ND	1	B	100	155
ND	1	B	150	156
ND	2	A	0	157
ND	2	A	50	158
ND	2	A	100	159
ND	2	B	50	160
ND	2	B	100	161
ND	3	A	0	162
ND	3	A	50	163
ND	3	A	100	164
ND	3	A	150	165
ND	3	A	200	166
ND	3	A	250	167
ND	4	A	0	168
ND	4	A	50	169
ND	4	A	100	170
ND	4	A	150	171
ND	4	A	200	172
ND	4	A	250	173
ND	4	A	300	174
ND	4	A	350	175
ND	4	B	0	176
ND	4	B	50	177
ND	4	B	100	178
ND	4	B	150	179
ND	4	B	200	180
ND	4	B	250	181
ND	5	A	0	182
ND	5	A	50	183
ND	5	A	100	184
ND	5	B	50	185
ND	6	A	0	186
ND	6	A	50	187
ND	6	A	100	188
ND	6	A	150	189
ND	6	A	200	190
ND	6	A	250	191
ND	6	A	300	192
ND	6	A	350	193
ND	6	A	400	194
ND	6	A	450	195
ND	6	A	500	196
ND	6	B	50	197
ND	6	B	100	198
ND	6	B	150	199
ND	6	B	200	200
ND	6	B	250	201

APPENDIX F1 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS
CROSS REFERENCING OF SURVEY LOCATION TO COMPUTER SEQUENCE AND REVERSE

LOCATION TO SEQUENCE NUMBER

LOCATION				SEQUENCE
DAM	TRANSECT	SEGMENT	DISTANCE	NUMBER
ND	6	B	300	202
ND	6	B	350	203
ND	7	A	50	204
ND	7	A	100	205
ND	7	A	150	206
ND	7	A	200	207
ND	7	A	250	208
ND	7	B	0	209
ND	7	B	50	210
ND	7	B	100	211
ND	7	B	150	212
ND	7	B	200	213
ND	7	B	250	214
ND	8	A	0	215
ND	8	A	50	216
ND	8	A	100	217
ND	8	B	50	218
ND	8	B	100	219
ND	9	A	0	220
ND	9	A	50	221
ND	9	A	100	222
ND	9	A	150	223
ND	9	A	200	224
ND	9	A	250	225
ND	9	A	300	226
ND	9	A	350	227
ND	9	B	50	228
ND	9	B	100	229
ND	9	B	150	230
ND	10	A	50	231
ND	10	A	100	232
ND	10	A	150	233
ND	10	A	200	234

TOTAL NUMBER OF SEGMENTS = 84

APPENDIX F1 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS
CROSS REFERENCING OF SURVEY LOCATION TO COMPUTER SEQUENCE AND REVERSE

SEQUENCE NUMBER TO LOCATION

SEQUENCE	DAM	TRANSECT	SEGMENT	DISTANCE
151	ND	1	A	0
152	ND	1	A	50
153	ND	1	A	100
154	ND	1	B	50
155	ND	1	B	100
156	ND	1	B	150
157	ND	2	A	0
158	ND	2	A	50
159	ND	2	A	100
160	ND	2	B	50
161	ND	2	B	100
162	ND	3	A	0
163	ND	3	A	50
164	ND	3	A	100
165	ND	3	A	150
166	ND	3	A	200
167	ND	3	A	250
168	ND	4	A	0
169	ND	4	A	50
170	ND	4	A	100
171	ND	4	A	150
172	ND	4	A	200
173	ND	4	A	250
174	ND	4	A	300
175	ND	4	A	350
176	ND	4	B	0
177	ND	4	B	50
178	ND	4	B	100
179	ND	4	B	150
180	ND	4	B	200
181	ND	4	B	250
182	ND	5	A	0
183	ND	5	A	50
184	ND	5	A	100
185	ND	5	B	50
186	ND	6	A	0
187	ND	6	A	50
188	ND	6	A	100
189	ND	6	A	150
190	ND	6	A	200
191	ND	6	A	250
192	ND	6	A	300
193	ND	6	A	350
194	ND	6	A	400
195	ND	6	A	450
196	ND	6	A	500
197	ND	6	B	50
198	ND	6	B	100
199	ND	6	B	150
200	ND	6	B	200
201	ND	6	B	250
202	ND	6	B	300

APPENDIX F1 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS
CROSS REFERENCING OF SURVEY LOCATION TO COMPUTER SEQUENCE AND REVERSE

SEQUENCE NUMBER TO LOCATION

SEQUENCE	DAM	TRANSECT	SEGMENT	DISTANCE
203	ND	6	B	350
204	ND	7	A	50
205	ND	7	A	100
206	ND	7	A	150
207	ND	7	A	200
208	ND	7	A	250
209	ND	7	B	0
210	ND	7	B	50
211	ND	7	B	100
212	ND	7	B	150
213	ND	7	B	200
214	ND	7	B	250
215	ND	8	A	0
216	ND	8	A	50
217	ND	8	A	100
218	ND	8	B	50
219	ND	8	B	100
220	ND	9	A	0
221	ND	9	A	50
222	ND	9	A	100
223	ND	9	A	150
224	ND	9	A	200
225	ND	9	A	250
226	ND	9	A	300
227	ND	9	A	350
228	ND	9	B	50
229	ND	9	B	100
230	ND	9	B	150
231	ND	10	A	50
232	ND	10	A	100
233	ND	10	A	150
234	ND	10	A	200

TOTAL NUMBER OF SEGMENTS = 84

APPENDIX F2 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS SPECIES RATE SUMMARY REPORT USED TO ESTABLISH RARITY OR ABUNDANCE OF SPECIES

North Dandalup

SPECIES CODE	SPECIE SCIENTIFIC NAME	OCCURRENCES RATE-1	RATE-2	RATE-3	RATE-4	RATE-5	TOTAL
1	Eucalyptus calophylla	1	7	29	20	21	78
2	Eucalyptus laeliae	4	4		1	1	10
3	Eucalyptus megacarpa			1	1	1	3
4	Eucalyptus marginata	5	5	8	10	39	67
5	Eucalyptus patens	2	6	4	5	3	20
7	Eucalyptus wandoo		1				1
9	Banksia grandis	1	2	8			11
10	Banksia littoralis	1	1				2
11	Banksia littoralis var. semi-nuda	1					1
13	Melaleuca preissiana					1	1
15	Allocasuarina fraseriana	2	1	1	1		5
17	Persoonia longifolia	9	10	1			20
18	Persoonia elliptica	3					3
19	Acacia alata	2	3	1	2		8
20	Acacia extensa	1	14	3	2		20
21	Acacia preissiana			1			1
23	Acacia urophylla	3	19	10	3	1	36
24	Adenanthos bargbigera	2	8	1			11
26	Agonis linearifolia			4	4	3	11
27	Paraserianthes lophantha		2				2
28	Astartea fascicularis	1	1	6	1		9
29	Baeckea camphorosmae	4	3	2	6		15
31	Bossiaea ornata	3	14	15	5		37
32	Caustis dioica		1				1
33	Chorizema ilicifolium	1	1	5	1		8
34	Clematis pubescens	1	9	7	2		19
36	Dampiera alata	1	9	5	1		16
38	Daviesia decurrens	4	3				7
42	Grevillea bipinnatifida	2		3			5
43	Grevillea diversifolia	3	1	1	8		13
45	Grevillea wilsonii	1		4	2		7
48	Hakea lissocarpha	4	6	21	6		37
50	Hakea petiolaris	1		1			2
52	Hibbertia hypericoides		5	17	26	2	50
53	Hibbertia rhadinopoda	3	6	8	2		19
54	Hibbertia commutata	4	13	1	1		19
56	Hovea chorizemifolia	8	3	1			12
57	Hypocalymma angustifolium	2	6	12	5		25
58	Hypocalymma cordifolium		1	1	1	1	4
60	Kennedia coccinea	5	10	1	1		17
62	Lasiopetalum floribundum	1	4	2	5	5	17
63	Lepidosperma angustatum	3	7	4	3		17
64	Lepidosperma tenue		15	15	5		35
65	Lepidosperma tetraquetrum		2	4	3		9
66	Leptocarpus coangustatus / scariosus	1	3	5	2		11
67	Leptomeria cunninghamii	2	19	4			25
68	Pericalymma ellipticum					1	1
69	Leucopogon capitellatus	2	15	16	7		40
71	Leucopogon nutans	2	6	3			11
72	Leucopogon propinquus	6	7	3			16
73	Leucopogon verticilatus	1	11	7	3		22
75	Macrozamia riedlei	5	22	22	11		60

APPENDIX F3 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS SPECIES OCCURRENCE REPORT USED TO LOCATE RARE SPECIES AND DEFINE THEIR ECOLOGICAL AFFINITIES

SPECIE CODE	SPECIE SCIENTIFIC NAME	SPECIE RATE	LOCATION DAM	TRANSECT	SEGMENT	DISTANCE
2	Eucalyptus laeliae	2	ND	3	A	0
		5	ND	3	A	50
		2	ND	3	A	100
		4	ND	3	A	200
		1	ND	3	A	250
		1	ND	4	A	0
		2	ND	4	A	50
		2	ND	4	A	100
		1	ND	4	A	150
		1	ND	4	A	200
3	Eucalyptus megacarpa	3	ND	1	A	0
		4	ND	1	A	50
		5	ND	2	A	0
7	Eucalyptus wandoo	2	ND	3	A	0
10	Banksia littoralis	1	ND	7	B	0
		2	ND	8	A	0
11	Banksia littoralis var. semi-nuda	1	ND	9	A	0
13	Melaleuca preissiana	5	ND	10	A	50
15	Allocasuarina fraseriana	4	ND	1	B	50
		1	ND	1	B	100
		1	ND	5	A	0
		2	ND	9	A	300
		3	ND	9	A	350
18	Persoonia elliptica	1	ND	4	B	150
		1	ND	4	B	250
		1	ND	6	A	450
19	Acacia alata	3	ND	1	A	0
		4	ND	1	A	50
		2	ND	4	B	0
		2	ND	5	A	0
		1	ND	6	A	0
		2	ND	9	A	0
		1	ND	9	B	150
		4	ND	10	A	50
21	Acacia preissiana	3	ND	10	A	200
27	Paraserianthes lophantha	2	ND	8	A	0
		2	ND	8	A	0
28	Astartea fascicularis	4	ND	1	A	0
		2	ND	2	A	0
		1	ND	2	B	50

APPENDIX F4 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS SPECIES FLOODING IMPACT REPORT USED TO DEFINE THE IMPACT OF INUNDATION ON INDIVIDUAL SPECIES

NORTH DANDALUP: IMPACT INNUNDATION TO L.O. LEVEL

SPECIE CODE	SPECIE SCIENTIFIC NAME	OCCURRENCES
1	Eucalyptus calophylla	47
2	Eucalyptus laeliae	5
3	Eucalyptus megacarpa	1
4	Eucalyptus marginata	41
5	Eucalyptus patens	12
9	Banksia grandis	5
10	Banksia littoralis	2
11	Banksia littoralis var. semi-nuda	1
13	Melaleuca preissiana	1
15	Allocasuarina fraseriana	2
17	Persoonia longifolia	10
18	Persoonia elliptica	1
19	Acacia alata	5
20	Acacia extensa	12
21	Acacia preissiana	1
23	Acacia urophylla	22
24	Adenanthos bargbigera	2
26	Agonis linearifolia	8
27	Paraserianthes lophantha	2
28	Astartea fascicularis	6
29	Baeckea camphorosmae	13
31	Bossiaea ornata	24
32	Caustis dioica	1
33	Chorizema ilicifolium	6
34	Clematis pubescens	7
36	Dampiera alata	11
38	Daviesia decurrens	2
42	Grevillea bipinnatifida	2
43	Grevillea diversifolia	9
48	Hakea lissocarpha	28
50	Hakea petiolaris	1
52	Hibbertia hypericoides	31
53	Hibbertia rhadinopoda	10
54	Hibbertia commutata	10
56	Hovea chorizemifolia	8
57	Hypocalymma angustifolium	16
58	Hypocalymma cordifolium	4
60	Kennedia coccinea	7
62	Lasiopetalum floribundum	4
63	Lepidosperma angustatum	16
64	Lepidosperma tenue	22
65	Lepidosperma tetraquetrum	7
66	Leptocarpus coangustatus / scariosus	7
67	Leptomeria cunninghamii	14
69	Leucopogon capitellatus	23
71	Leucopogon nutans	6
72	Leucopogon propinquus	9
73	Leucopogon verticilatus	12
75	Macrozamia riedlei	35

APPENDIX F4 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS SPECIES FLOODING IMPACT REPORT USED TO DEFINE THE IMPACT OF INUNDATION ON INDIVIDUAL SPECIES

76	Melaleuca viminea	1
77	Mesomelaena tetragona	15
78	Patersonia occidentalis	2
79	Patersonia rudis	2
80	Phyllanthus calycinus	24
81	Pteridium esculentum	6
83	Petrophile striata	2
84	Sphaerolobium medium	7
87	Synaphea petiolaris	8
88	Trymalium ledifolium	12
89	Trymalium floribundum	12
90	Xanthorrhoea gracilis	21
91	Xanthorrhoea preissii	40
92	Cheilanthes austrotenuifolia	3
101	Tetrarrhena laevis	2
107	Gahnia trifida	1
110	Lepidosperma gracile	13
111	Lepidosperma leptostachyum	2
114	Lepidosperma pruinosum var. rigidulum	1
125	Loxocarya aspera	1
126	Loxocarya fasciculata	11
127	Loxocarya ? flexuosa	3
133	Lomandra haemaphrodita	1
135	Lomandra preissii	2
136	Lomandra purpurea	1
137	Lomandra sonderi	2
139	Agrostocrinum scabrum	7
140	Borya sphaerocephala	2
141	Caesia parviflora	1
142	Laxmannia sessiflora	1
144	Thysanotus dichotomous	3
145	Thysanotus multiflorus	1
146	Thysanotus patersonii	7
147	Thysanotus thyrsoideus	2
148	Tricoryne elatior	2
149	Burchadia umbellata	4
150	Conostylis aculeata	8
152	Conostylis serrulata	2
153	Conostylis setigera	12
154	Conostylis setosa	15
155	Haemodorum laxum	4
167	Thelymitra crinita	21
172	Dryandra nivea	24
177	Grevillea pilulifera	13
180	Hakea amplexicaulis	14
183	Hakea stenocarpa	6
185	Hakea undulata	1
186	Isopogon asper	6
188	Isopogon sphaerocephalus	7
202	Ranunculus colonorum	3
203	Cassytha racemosa	13
204	Drosera gigantea	1
206	Drosera menziesii	1
214	Billardiera varifolia	3

APPENDIX F4 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS SPECIES FLOODING IMPACT REPORT USED TO DEFINE THE IMPACT OF INUNDATION ON INDIVIDUAL SPECIES

217	Acacia dentifera	2
218	Acacia divergens	2
220	Acacia ephedroides	1
221	Acacia lateriticola	24
224	Acacia nervosa	11
227	Acacia pulchella	16
229	Acacia stenocarpa	2
235	Chorizema dicksonii	3
236	Chorizema rhombeum	14
238	Daviesia horrida	3
247	Gompholobium marginatum	13
248	Gompholobium polymorphum	2
249	Gompholobium preissii	1
251	Gompholobium ? venustum	4
252	Hovea trisperma	1
253	Jacksonia alata	2
255	Mirbelia spinosa	1
257	Oxylobium linarifolium	1
265	Boronia fastigiata	10
269	Eriostemon spicatus	7
270	Tetratheca hirsuta	11
273	Comesperma ciliatum	2
277	Poranthera microphylla	2
278	Stackhousia huegelii	5
280	Tripterococcus brunonis	2
281	Dodonaea ceratocarpa	4
290	Thomasia paniculata	2
292	Hibbertia amplexicaulis	14
294	Hibbertia huegelii	1
298	Hibbertia pilosa	9
301	Hybanthus debilissimus	2
305	Pimelea ciliata	10
306	Pimelea imbricata var. piligera	3
307	Pimelea preissii	3
309	Pimelea suaveolens	5
310	Pimelea sylvestris	1
311	Calothamnus quadrifidus	2
314	Darwinea citriodora	7
315	Darwinea aff. citriodora	6
316	Darwinea thymoides	1
324	Melaleuca scabra	2
336	Platysace compressa	1
337	Platysace tenuissima	1
339	Xanthosia candida	3
340	Andersonia lehmanniana	1
341	Astroloma pallidum	7
345	Logania serpyllifolia	2
348	Hemigenia incana	2
349	Hemigenia ramosissima	1
357	Opercularia echinocephala	3
358	Opercularia vaginata	1
360	Isotoma hypocrateriformis	2
361	Lobelia alata	1
365	Dampiera linearis	15

APPENDIX F4 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS SPECIES FLOODING IMPACT REPORT USED TO DEFINE THE IMPACT OF INUNDATION ON INDIVIDUAL SPECIES

372	Scaevola striata	21
374	Levenhookia pusilla	2
377	Stylidium amoemum	14
380	Stylidium bulbiferum	7
381	Stylidium calcaratum var. calcaratum	12
385	Stylidium hispidium	3
386	Stylidium junceum	9
387	Stylidium lineatum	2
395	Brachycome iberidifolia	1
397	Craspedia sp. (A)	2
400	Helipterum cotula	1
406	Senecio hispidulus	1
407	Senecio leucoglossus	1
412	Pentapeltis peltigera	15
413	Mirbelia dilatata	5
414	Neurachne alopecuroidea	11
415	Lechenaultia biloba	8
416	Astroloma ciliatum	11
417	Cyathochaeta avenacea	5
418	Pterostylis vittata	1
419	Tetraria octandra	27
421	Drosera erythrorhiza	1
422	Dianella revoluta	2
423	Comesperma virgatum	3
424	Kennedia prostrata	10
425	Hakea trifurcata	5
428	Daviesia cordata	3
429	Anigozanthos manglesii	5
431	Sowerbaea laxiflora	4
432	Dryandra bipinnatifida	3
433	Haemodorum paniculatum	4
434	Brunoniana australis	1
436	Andersonia aristata	1
437	Hakea prostrata	1
438	Baumea ? vaginalis	3
443	Opercularia hispidula	6
451	Moss	3
452	Parmelia	1

Total number of species impacted = 195

APPENDIX F5 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS LOCATION GROUP REPORT, USED TO CROSS REFERENCE GEOGRAPHICAL AND ECOLOGICAL DATA

GROUP	SEQUENCE NUMBER	LOCATION DAM	TRANSECT	SEGMENT	DISTANCE
Q	204	ND	7	A	50
Q	205	ND	7	A	100
Number of locations in the group =				2	
QT	160	ND	2	B	50
QT	206	ND	7	A	150
Number of locations in the group =				2	
R	210	ND	7	B	50
R	218	ND	8	B	50
Number of locations in the group =				2	
RG	163	ND	3	A	50
RG	164	ND	3	A	100
RG	166	ND	3	A	200
RG	167	ND	3	A	250
Number of locations in the group =				4	
RS	221	ND	9	A	50
Number of locations in the group =				1	
RT	211	ND	7	B	100
RT	212	ND	7	B	150
RT	213	ND	7	B	200
RT	219	ND	8	B	100
Number of locations in the group =				4	
S	156	ND	1	B	150
S	185	ND	5	B	50
S	224	ND	9	A	200
S	225	ND	9	A	250
S	226	ND	9	A	300
S	227	ND	9	A	350
S	229	ND	9	B	100
Number of locations in the group =				7	
SO	192	ND	6	A	300
Number of locations in the group =				1	
SP	153	ND	1	A	100
SP	155	ND	1	B	100
Number of locations in the group =				2	

APPENDIX F6 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS LOCATION CLASS SPECIES REPORT USED TO BROADEN DEFINITION OF SITE-VEGETATION TYPES

ND: TYPE CQ/ 157,176,182,209,215,220.

SPECIE CODE	SPECIE SCIENTIFIC NAME	OCCURRENCES
1	Eucalyptus calophylla	5
3	Eucalyptus megacarpa	1
4	Eucalyptus marginata	2
5	Eucalyptus patens	5
10	Banksia littoralis	2
11	Banksia littoralis var. semi-nuda	1
15	Allocasuarina fraseriana	1
19	Acacia alata	3
20	Acacia extensa	1
23	Acacia urophylla	1
26	Agonis linearifolia	6
27	Paraserianthes lophantha	2
28	Astartea fascicularis	5
33	Chorizema ilicifolium	4
36	Dampiera alata	1
43	Grevillea diversifolia	6
48	Hakea lissocarpha	1
52	Hibbertia hypericoides	1
56	Hovea chorizemifolia	1
58	Hypocalymma cordifolium	2
60	Kennedia coccinea	1
63	Lepidosperma angustatum	1
64	Lepidosperma tenue	1
65	Lepidosperma tetraquetrum	6
66	Leptocarpus coangustatus / scariosus	4
69	Leucopogon capitellatus	1
75	Macrozamia riedlei	4
80	Phyllanthus calycinus	1
81	Pteridium esculentum	4
89	Trymalium floribundum	6
91	Xanthorrhoea preissii	1
111	Lepidosperma leptostachyum	1
127	Loxocarya ? flexuosa	1
144	Thysanotus dichotomous	1
146	Thysanotus patersonii	1
148	Tricoryne elatior	1
150	Conostylis aculeata	1
177	Grevillea pilulifera	1
214	Billardiera varifolia	1
217	Acacia dentifera	1
218	Acacia divergens	2
221	Acacia lateriticola	1
227	Acacia pulchella	1
238	Daviesia horrida	1
257	Oxylobium linarifolium	1
290	Thomasia paniculata	2
298	Hibbertia pilosa	2
305	Pimelea ciliata	2
314	Darwinea citriodora	2

APPENDIX F6 : EXAMPLE OF OUTPUT FROM PROGRAMME OMNIS LOCATION CLASS SPECIES REPORT USED TO BROADEN DEFINITION OF SITE-VEGETATION TYPES

315	Darwinea aff. citriodora	1
339	Xanthosia candida	1
380	Stylidium bulbiferum	1
412	Pentapeltis peltigera	2
413	Mirbelia dilatata	3
414	Neurachne alopecuroidea	1
431	Sowerbaea laxiflora	1
438	Baumea ? vaginalis	3
443	Opercularia hispidula	1
451	Moss	1

Total number of species in class = 59

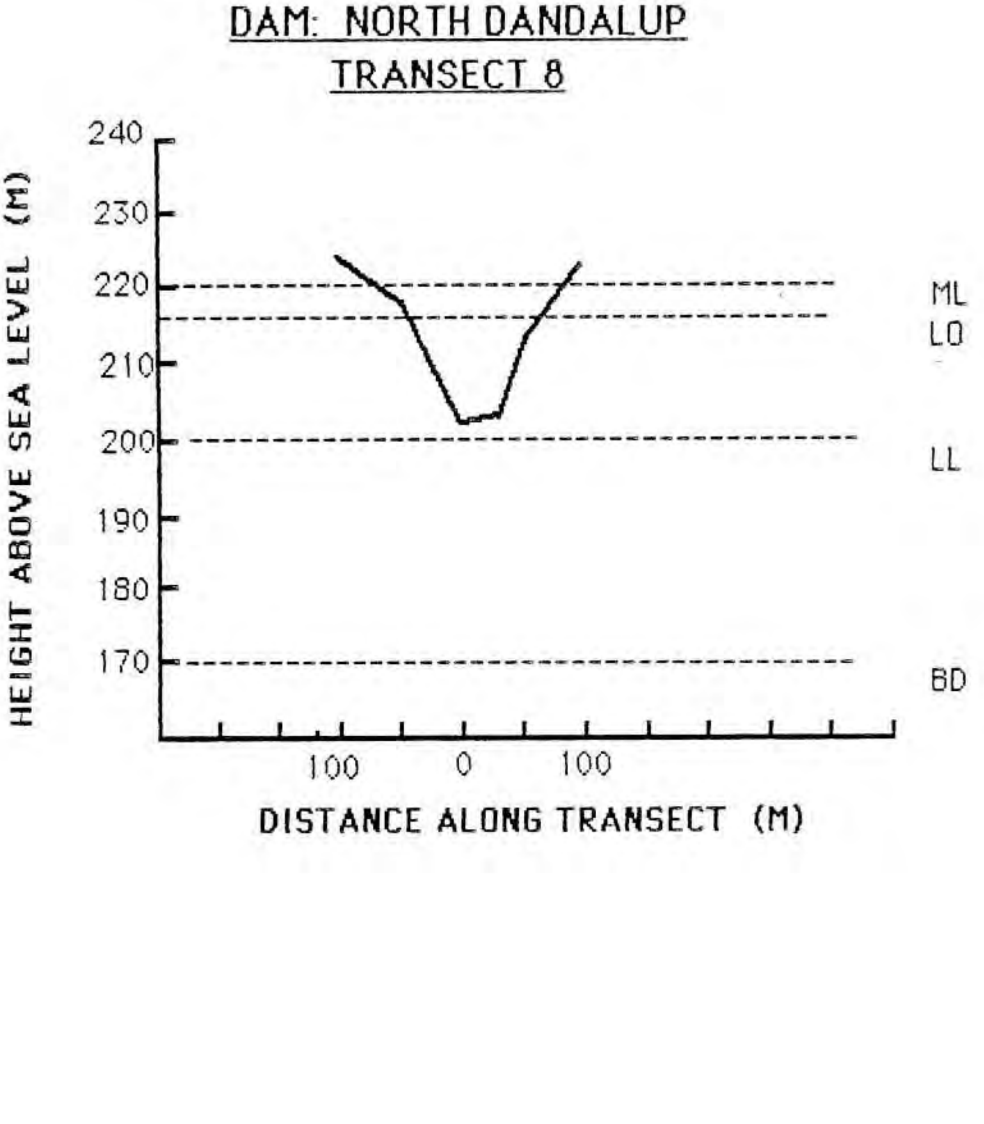
APPENDIX G :

EXAMPLE OF OUTPUT FROM PROGRAMME EXCEL

Used to Refine Ecological Relationships and Impact of Inundation

APPENDIX G : EXAMPLE OF OUTPUT FROM PROGRAMME EXCEL USED TO REFINE ECOLOGICAL RELATIONSHIPS AND IMPACT OF INUNDATION

IMPACT OF INUNDATION



APPENDIX G : EXAMPLE OF OUTPUT FROM PROGRAMME EXCEL USED TO REFINE ECOLOGICAL RELATIONSHIPS AND IMPACT OF INUNDATION

ND 8

Code						
	Sequence Number for location	219	218	215	216	217
	Dam	ND	ND	ND	ND	ND
	Transect	8	8	8	8	8
	Segment	B	B	A	A	A
	Distance	100	50	0	50	100
	Bearing	266	266	86	86	86
	Topographical Position	4	3	1	3	4
	Topographical Steepness	2	3	1	3	3
	Rock Outcrop Composition	2	2	2	1	1
	Rock Outcrop Extent	1	1	3	3	3
	Soil Colour	4	45	45	4	45
	Soil Texture	36	3	3	46	46
	Tree Canopy Height	2	3	1	1	1
	Tree Density	3	3	1	1	1
	Condition of Vegetation	3	2	2	2	2
	Cause of Disturbance	5	5	5	3	3
	Time since disturbance	4	4	4	1	1
	Class	RT	R	CQ	T	T
Code	**Species Scientific Name**	***	***	***	***	****
10	Banksia littoralis	0	0	2	0	0
26	Agonis linearifolia	0	0	4	0	0
27	Paraserianthes lophantha	0	0	2	0	0
28	Astartea fascicularis	0	0	3	0	0
43	Grevillea diversifolia	0	0	4	0	0
56	Hovea chorizemifolia	0	0	3	0	0
65	Lepidosperma tetraquetrum	0	0	4	0	0
66	Leptocarpus coangustatus / scariosu:	0	0	3	0	0
111	Lepidosperma leptostachyum	0	0	2	0	0
150	Conostylis aculeata	0	0	2	0	0
214	Billardiera varifolia	0	0	1	0	0
218	Acacia divergens	0	0	4	0	0
5	Eucalyptus patens	0	3	5	0	0
20	Acacia extensa	0	2	0	4	0
89	Trymalium floribundum	0	0	4	3	0
203	Cassytha racemosa	0	0	0	1	0
221	Acacia lateriticola	0	0	1	2	0
298	Hibbertia pilosa	0	0	2	3	0
305	Pimelea ciliata	0	1	2	0	0
377	Stylidium amoemum	0	0	0	3	0
412	Pentapeltis peltigera	0	0	2	2	0
423	Comesperma virgatum	0	0	0	1	0
81	Pteridium esculentum	0	0	2	2	4
4	Eucalyptus marginata	3	0	0	5	5
9	Banksia grandis	0	0	0	2	3
17	Persoonia longifolia	0	0	0	1	2
23	Acacia urophylla	2	0	0	4	4
34	Clematis pubescens	2	0	0	3	3
54	Hibbertia commutata	2	0	0	0	2
60	Kennedia coccinea	0	0	0	2	3
62	Lasiopetalum floribundum	0	0	0	5	4
67	Leptomeria cunninghamii	0	0	0	0	2
69	Leucopogon capitellatus	3	2	0	2	2
72	Leucopogon propinquus	0	0	0	0	1

APPENDIX G : EXAMPLE OF OUTPUT FROM PROGRAMME EXCEL USED TO REFINE ECOLOGICAL RELATIONSHIPS AND IMPACT OF INUNDATION

ND 8

73	Leucopogon verticilatus	0	0	0	3	4
80	Phyllanthus calycinus	3	0	0	0	3
84	Sphaerolobium medium	0	0	0	0	1
90	Xanthorrhoea gracilis	0	0	0	0	3
91	Xanthorrhoea preissii	4	0	0	4	4
149	Burchadia umbellata	0	0	0	2	1
180	Hakea amplexicaulis	0	0	0	3	3
236	Chorizema rhombeum	2	0	0	2	2
265	Boronia fastigiata	0	0	0	3	3
270	Tetratheca hirsuta	0	0	0	0	2
292	Hibbertia amplexicaulis	2	0	0	2	3
301	Hybanthus debilissimus	0	0	0	2	2
336	Platysace compressa	0	0	0	1	3
357	Opercularia echinocephala	0	0	0	0	2
407	Senecio leucoglossus	0	0	0	0	2
42	Grevillea bipinnatifida	3	3	0	0	0
48	Hakea lissocarpha	3	0	0	0	0
52	Hibbertia hypericoides	4	3	0	0	0
57	Hypocalymma angustifolium	3	3	0	0	0
64	Lepidosperma tenue	2	0	0	0	0
88	Trymalium ledifolium	4	3	0	0	0
92	Cheilanthes austrotenuifolia	0	3	0	0	0
101	Tetrarrhena laevis	0	3	0	0	3
140	Borya sphaerocephala	0	3	0	0	0
146	Thysanotus patersonii	2	0	0	0	0
167	Thelymitra crinita	1	1	0	0	0
172	Dryandra nivea	3	3	0	0	0
177	Grevillea pilulifera	2	0	0	0	0
185	Hakea undulata	2	4	0	0	0
206	Drosera menziesii	1	0	0	0	0
227	Acacia pulchella	3	0	0	0	0
238	Daviesia horrida	2	2	0	0	0
252	Hovea trisperma	1	0	0	0	0
255	Mirbelia spinosa	0	3	0	0	0
277	Poranthera microphylla	0	2	0	0	0
279	Stackhousia huegelii / pubescens	0	1	0	0	0
306	Pimelea imbricata var. piligera	0	2	0	0	0
314	Darwinea citriodora	2	4	1	0	0
329	Verticordia plumosa	0	3	0	0	0
374	Levenhookia pusilla	0	1	0	0	0
380	Stylidium bulbiferum	0	2	0	0	0
381	Stylidium calcaratum var. calcaratu	0	2	0	0	0
395	Brachycome iberidifolia	3	3	0	0	0
400	Helipterum cotula	3	3	0	0	0
418	Pterostylis vittata	0	1	0	0	0
451	Moss	0	3	0	0	0
452	Parmelia	0	3	0	0	0
1	Eucalyptus calophylla	5	5	2	4	3
75	Macrozamia riedlei	3	3	3	4	4