

**AN EVALUATION OF THE LAND USE POTENTIAL  
OF THE BLACK-LIESBEECK RIVER CONFLUENCE  
AREA**

**BY**

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Submitted in partial fulfilment for the Master of Philosophy Degree in the Department of  
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## EXECUTIVE SUMMARY

### Purpose of this report

- \* to assess and evaluate the land use potential of the Black-Liesbeeck River Confluence Area based on the limitations imposed by the biophysical, social, economic and developmental factors operating in the area.
- \* to make general recommendations on which types of land use activities are appropriate for the Confluence Area.

### Background

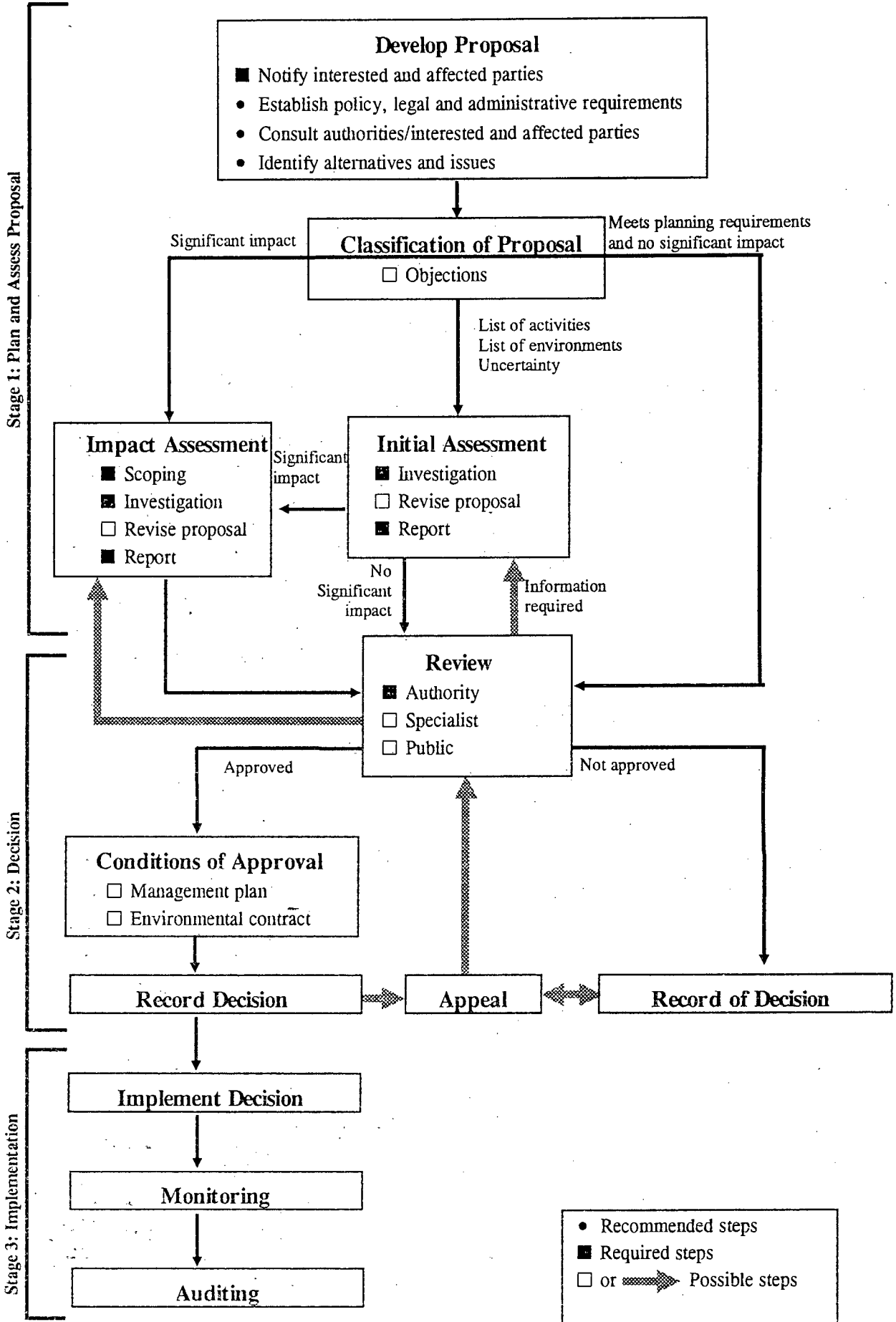
The Interim Metropolitan Development Framework (IMDF) identifies intensification of existing residential and industrial areas as a possible solution to the current trend of urban sprawl in Greater Cape Town. Furthermore, this document states that intensification of existing urban areas should not occur at the expense of maintaining the green open spaces in the city. To achieve this aim a proactive, holistic and integrated approach to environmental planning will be required. This study presents the ideal opportunity to test this planning approach. The Confluence Area is unusual in that it contains large, unutilized open spaces that are surrounded by suburbs with medium to high residential densities. In addition, the Confluence Area is located near one of the largest business centres (the CBD-Salt River-Woodstock-Maitland-Epping-Ndabeni complex) in Greater Cape Town.

This study forms part of a planning initiative underway in the Culemborg-Black River (CBR) Area that is adjacent to the northern boundary of the Confluence Area. The aim of this planning initiative undertaken by the Cape Town City Council (CCC) and South African Transport Services (SATS) is to investigate the land use potential of the CBR area. The findings of this study of the Confluence Area will be incorporated into the final planning proposals for the Culemborg-Black River Area.

### Approach to this study

The first phase of this study was conducted by a multidisciplinary team and involved the investigation of those environmental factors that were relevant to potential land use activities in the Confluence Area. The process followed in the first phase of this study was in accordance with the broad principles of Integrated Environmental Management (IEM), and was comparable to the "Develop Proposal" stage in the IEM procedure (see Figure 1). Interested and Affected Parties (I&APs) were consulted about their views on the future development of the Confluence Area, and alternative land use activities were evaluated using the environmental factors operating in this area. No formal developments were proposed and, therefore, this study was not an Environmental Impact Assessment (EIA). The result of the first phase was the production of a baseline report by the multidisciplinary team. The second phase of the study required each team member to assess and evaluate the baseline data collected in the first phase.

Figure 1: The IEM Procedure



The method used to assess and evaluate the baseline data consisted of four discrete stages. The first stage involved the division of the Confluence Area into land units based on the natural features (e.g. geology, hydrology and vegetation) of the area.

Seven land use activities were selected, and included open space, conservation, active and passive recreation, housing, light industry and agriculture. These land uses were selected on the basis that they were compatible with those set out in the Cape Metropolitan Guide Plan as suitable urban land use activities. The environmental factors operating in the Confluence Area were divided into biophysical, social, economic and developmental factors.

The second and third stage involved the evaluation of the biophysical, social, economic and developmental factors. The biophysical factors were evaluated using a quantitative approach while the social, economic and developmental factors were evaluated using a qualitative approach.

Each biophysical factor was assigned a significance rating and importance weighting based on the physical and financial limitations that it imposed on the land use activity. The biophysical factor with the highest combined rating and weighting score in each land unit was termed the primary biophysical controlling factor. The financial costs involved in overcoming the limitations imposed by the primary biophysical factor result in certain land use activities being financially unfeasible and, therefore, unsuitable in the designated area. For example, flooding is the primary biophysical controlling factor in three of the four land units in the Confluence Area. Flooding imposes very severe physical limitations on the construction of houses or buildings. The financial costs of overcoming the flooding problems are sufficiently high to render this type of structural development unfeasible and, therefore, unsuitable in areas that are prone to flooding.

Biophysical factors with lower combined ratings and weightings are termed secondary biophysical controlling factors. These factors control land use activities in areas that are not influenced by the primary biophysical factor. If secondary biophysical controlling factors do impose physical limitations on a specific land use activity, these can be overcome without incurring considerable expense. Therefore, secondary biophysical factors do not render particular land use activities unsuitable. For example, certain soil types in the Confluence Area have low bearing capacities, and this imposes physical limitations on the types of structures that can be built on these soils. However, relatively inexpensive engineering solutions are available to overcome these limitations and, therefore, bearing capacity does not render structural development unsuitable in areas where these soil types occur.

As with the biophysical factors the social and developmental factors were evaluated in terms of the limitations they imposed on each land use activity. The social factors include the concerns, with respect to future development of the Confluence Area, voiced by I&APs during interviews that took place in the first phase of this study. The developmental factors include all the development proposals and policies relevant to the Confluence Area. Each social and developmental factor is evaluated in terms of its importance to particular land units. The economic factors were not evaluated in terms of their relevance to particular land units but rather in terms of the entire Confluence Area. It was not feasible to evaluate the economic factors in isolation but rather as part of the larger economic zone that surrounds the Confluence Area.

Therefore, the suitability of the selected land use activities in each land unit in the Confluence Area were evaluated in terms of:

- (1) the primary and secondary biophysical controlling factors, and
- (2) the social and developmental factors operating in these areas.

The fourth stage of the study involved drawing conclusions and making recommendations on the most suitable suite of land uses for the various land units in the Confluence Area.

### **Land use potential**

This section should be read in conjunction with Table 1 (pg v).

Open space is an unsuitable land use activity in Land Unit Three because of the limitations imposed by the current land activity, the South African Astronomical Observatory (SAAO), in this area. In Land Unit One and Two open space is a suitable land use option because these areas are prone to seasonal flooding that renders most of the remaining land uses unsuitable. The possibilities for open space in Land Unit Four are very limited because this area is already quite developed.

Conservation is a highly suitable land use activity in the wetlands of Land Unit One because of the high proportion of indigenous species of fauna and flora in these areas. Conservation is unsuitable in Land Unit Two and Three because these areas are biologically degraded and the costs of improving these areas render this land use activity financially unfeasible. Conservation has limited suitability in Land Unit Four because of the current land uses in this area. The exception to this is the Pallotti field where an opportunity exists to combine conservation, open space and recreation in this area.

Structural development (housing, light industry and structures needed for active recreation) is unsuitable in areas that are prone to flooding because of the physical and financial limitations imposed by this biophysical factor. This includes the whole of Land Unit One and Two, and a small section of Land Unit Three. Structural development is suitable in areas that are not prone to flooding in Land Unit Three as long as it conforms with the requirements of the SAAO. Land Unit Four has the greatest potential for intensification of residential and urban development. This includes housing and light industry.

Passive recreation is a suitable land use activity in all four of the land units of the Confluence Area. Passive recreation (e.g. birdwatching) is a suitable land use activity in Land Unit One because of the more natural character of the wetland areas in this land unit. The current recreational facilities in Land Unit Two make it suitable for passive recreation. Active recreation, which involves structural development, is suitable in Land Unit Three and Four because these areas are largely free from flooding.

Agriculture has limited suitability in the Confluence Area because of the flooding problems experienced in Land Unit One and Two, and the current land use in Land Unit Three. However, there are certain areas in Land Unit Four where this land use activity is appropriate.

**Table 1:** Key decision-making framework for land use potential in the Confluence Area.

LAND USE	LAND UNIT 1		LAND UNIT 2		LAND UNIT 3		LAND UNIT 4	
	S*	UNS*	S	UNS	S	UNS	S	UNS
Open space	✓		✓			✓	✓	
Conservation	✓			✓		✓	✓	
Active Recreation		✓		✓	✓		✓	
Passive Recreation	✓		✓		✓		✓	
Housing		✓		✓	✓		✓	
Light Industry		✓		✓		✓	✓	
Agriculture		✓		✓		✓	✓	

S = SUITABLE  
UNS = UNSUITABLE

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## ABBREVIATIONS

a.s.l.	above sea level
AR	Active Recreation
A	Agriculture
C	Conservation
CBD	Central Business District
CBR	Culemborg-Black River
CCC	Cape Town City Council
CMGP	Cape Metropolitan Guide Plan
EES	Environmental Evaluation System
EIA	Environmental Impact Assessment
FRD	Foundation for Research Development
GP	Fill Material
H	Housing
ha	hectare
IMDF	Interim Metropolitan Development Framework
IEM	Integrated Environmental Management
I&AP's	Interested & Affected Parties
JIM	Judgemental Impact Matrix
kN/m <sup>2</sup>	kilo Newtons per square metre
LSA	Land Suitability Analysis
LA	Landscape Assessment
LI	Light Industry
M.Phil	Master of Philosophy

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m	metres
m <sup>3</sup>	cubic metres
ML	shale soils
MRC	Medical Research Council
MOSS	Metropolitan Open Space System
NMC	National Monuments Council
N2	National Road Two
nutr. avail.	nutrient availability
OS	Open Space
PR	Passive Recreation
P.U.C.E.	Pattern-Unit-Component-Evaluation
<i>pers.comm.</i>	personal communication
R	Rand
RBS	Raapenberg Bird Sanctuary
SAAO	South African Astronomical Observatory
SM	Light Grey sandy Soils
SP	Alluvium
<i>spp.</i>	species
SW	Greywacke and Quartzitic sands
UCS	United Classification System
UCT	University of Cape Town
WCEDF	Western Cape Economic Development Forum

**CHAPTER ONE: INTRODUCTION**

**1.1 Background . . . . .1**

**1.2 Purposes of the study . . . . .1**

**1.3 Terms of reference . . . . .1**

**1.4 Report structure . . . . .2**

**1.5 Scope of the dissertation . . . . .3**

**1.6 Assumptions and limitations . . . . .6**

**1.7 Approach to the dissertation . . . . .6**

# CHAPTER ONE

## INTRODUCTION

### 1.1 Background

The Cape Town City Council (CCC), along with South African Transport Services (SATS), is involved in investigating the land use potential of the Culemborg-Black River (CBR) area of Cape Town. This substantial piece of land is currently used as shunting and repair yards by the railways. The Black-Liesbeeck confluence area (hereafter Confluence Area) lies adjacent to the CBR and is largely owned by the CCC. The CCC, as a signatory to the Interim Metropolitan Development Framework (IMDF), ascribes to one of its central tenets *viz.*, that to limit urban sprawl, densification of existing urban areas must occur. In order to realise this aim proactive, holistic and integrated planning must take place. The Confluence Area presents an opportunity to test this approach, and the appropriateness of the concept of densification of existing urban areas, while simultaneously enhancing the green open space character of the city. As part of the planning process underway in the CBR, the CCC requested Masters students from the Department of Environmental and Geographical Science, University of Cape Town, to investigate the land use possibilities for the Confluence Area. The findings of these reports will ultimately be taken into consideration in the final planning proposals for the area.

### 1.2 Purposes of the study

The purposes of this study are:

- to assess and evaluate the suitability of various land uses for the Confluence Area based on the biophysical, social, economic and developmental limitations of the area.
- to make general recommendations on which types of land use activities are appropriate for Confluence Area.

This study aims to assist the decision-maker with regard to the optimal land uses for the Confluence Area.

### 1.3 Terms of reference

The CCC is currently involved in a planning exercise for the CBR area but has recognised a gap in their information regarding the Confluence Area. Consequently, the CCC supported the idea that the 1993/4 Master of Philosophy (M.Phil) class of the Department of Environmental and Geographical Science at the University of Cape Town undertake a study on the area. This study was divided into two parts. The first part required the class, working as a team, to produce a baseline document on all relevant environmental factors and characteristics operating in the study area. The second part requires each individual class member to assess and evaluate the information in the baseline document and produce their own interpretation of the data. The entire study is in partial fulfilment of the academic requirements of the M.Phil degree.

This dissertation was undertaken with the following objectives in mind:

- to divide the Confluence Area into land units based on the pattern of natural characteristics (geology, hydrology, flora, fauna) and current land uses of the area;
- to provide an integrated, holistic assessment and evaluation of the relevant environmental factors that influence the suitability of selected land uses in the Confluence Area;
- to provide recommendations that will be of assistance to a decision-making authority when producing planning proposals for the Confluence Area.

## **1.4 Report structure**

This report is divided into five chapters.

Chapter One provides an introduction to the study and includes background information; purposes of the study; report structure; scope of the study; assumptions and limitations; and the general approach to the study.

Chapter Two outlines the various methods used in the study to assess and evaluate the different categories of information. This dissertation does not have a particular chapter that deals solely with theory that is relevant to this study. Rather, theory is interspersed in amongst the various sections in this dissertation. For example, theory that relates to the types of methods available in land suitability analyses appears in Chapter Two.

Chapter Three contains a descriptive account of the assessment and evaluation of those environmental factors (biophysical, social, economic and developmental) that impose restrictions or provide opportunities for various land uses in the Confluence Area. To this end, the Confluence Area is explicitly divided into smaller land units based on the geological, hydrological, floral, faunal and current land use features of the area (see Map 2). A summary section appears at the end of each section on a particular land unit and draws together the main conclusions with respect to land use suitability each land unit.

Chapter Four outlines the major conclusions pertaining to the suitability of various land uses, after all environmental factors have been considered. Land use suitability maps follow directly after Chapter Four. The scale of these maps is 1:7000 (i.e. 1cm = 70m). These maps illustrate the optimal placement of the land use activities in the Confluence Area. It is important the maps are viewed while reading Chapter Four. Rather than illustrating the suitability of each land use activity within each land unit, these maps illustrate the suitability of each land use activity in terms of the whole Confluence Area. For example, Map 6 illustrates the suitability of open space in the Confluence Area rather than in each of the land units. This procedure is repeated for each of the land use activities.

## 1.5 Scope of the dissertation

Map 1 delineates the boundary of the study area, which is 232ha in extent. Many of the biophysical factors (e.g. hydrology) that affect the suitability of particular land uses are themselves parts of more complex systems. For example, the section of the Black River that runs through the study area is a small part of the entire Vygekraal/Black River catchment area. Thus, much of the effluent and pollution that affects the suitability of various land uses in the Confluence Area enters the river system further upstream in the catchment area. It would be very difficult, if not impossible, to distinguish between the contribution of local and 'metropolitan' pollution in the study area. For this reason the spatial scope of this study is not restricted to the Confluence Area but, where relevant, deals with the study area as part of larger systems.

Certain environmental factors, such as the economic and developmental factors, did not lend themselves to evaluation in isolation from surrounding areas and conditions. For this reason both the economic and developmental analyses are undertaken with regard to the broader metropolitan context.

In the baseline report the social concerns (pertaining to future land use in the Confluence Area) of approximately sixty Interested & Affected Parties (I&APs) were gauged by means of a questionnaire administered during an interview. It was not possible, due to financial and time constraints, to extend the scope of this social survey to full public participation (e.g. public meetings). Notwithstanding this limitation, the views of I&APs expressed in this dissertation are those of identified leading I&APs who have the most direct involvement in the Confluence Area. The process of identifying lead I&APs was undertaken by the CCC as part of the CBR study. This information was then made available to the students for the purposes of their study.



Map 1: The Confluence Area

## 1.6 Assumptions and limitations

Many of the assumptions and limitations that pertain to the baseline study are also of relevance to this dissertation because the evaluation is based on data collected in the previous study. Further assumptions or limitations pertaining to specific environmental factors are stated in the course of this dissertation.

Additional assumptions include:

- each biophysical factor is assigned a significance rating and importance weighting according to the physical and financial limitations they impose on the land use activities. The biophysical factor with the highest combined rating and weighting score is termed the primary biophysical controlling factors (also referred to as "primary factor"), while those biophysical factors with lower combined scores are termed secondary biophysical controlling factors (also referred to as "secondary factors"). It is assumed that the financial costs of overcoming the limitations imposed by the primary biophysical controlling factors are sufficiently high to render specific land uses unsuitable in the designated land unit. For example, flooding is the primary biophysical controlling factor in three of the four land units in the Confluence Area. Flooding imposes strict physical limitations on the types of structures (e.g. houses) that can be built in areas that are prone to flooding. The financial costs of overcoming these limitations are high enough to ensure that structural development is unsuitable in areas that are prone to flooding in the Confluence Area.
- the soil categories set out in this study are adequately representative of those on the ground.

Additional limitations include:

- insufficient funds and time to utilise a panel evaluation to rate and weigh the environmental factors and thus remove any possibility of author subjectivity. Thus, while the process of rating and weighing of environmental factors may be duplicated it may not necessarily produce exactly the same results when attempted by another author.
- no geotechnical report was available to assist in the evaluation of the engineering capabilities of the soils in the study area. The information concerning engineering capabilities in this report are speculative and should be verified by a specialist geotechnical investigation of the area.

## 1.7 Approach to the dissertation

The term Assessment and Evaluation in this study have the following definitions:

**Assessment:** the process of collecting, organising, analyzing, interpreting and communicating data relevant to some decisions, and;

**Evaluation:** the act of making value judgements or ascribing subjective values to data in order to determine their importance to some goal or their significance to some decision (Stauth *et al.*, 1993).

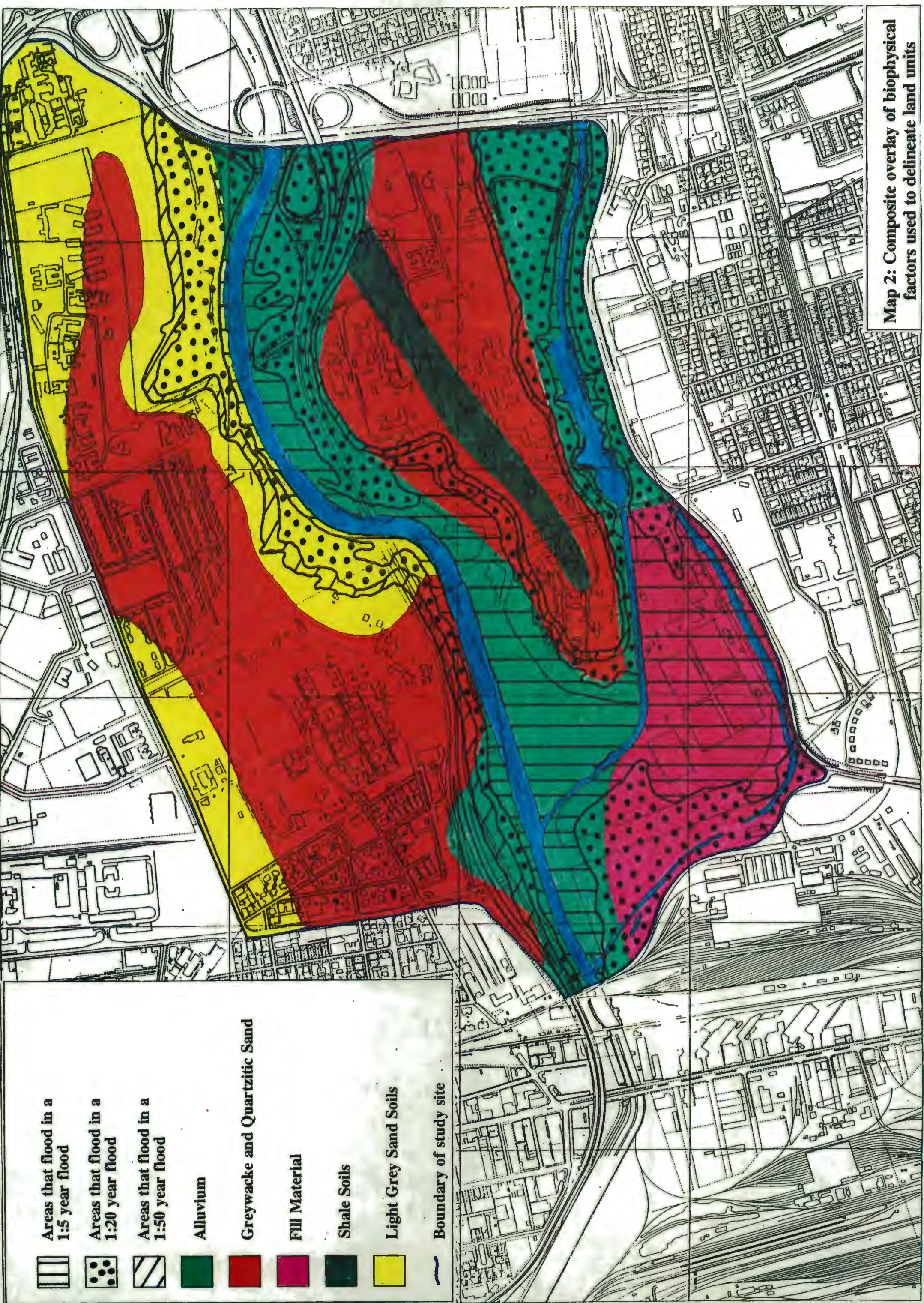
The first phase of this study was conducted by a multidisciplinary team and involved the investigation of the environmental factors relevant to land use activities in the Confluence Area. The process followed in the first phase of this study was in accordance with the broad principles of Integrated Environmental Management (IEM; Department of Environment Affairs, 1992), and was comparable to the "Develop Proposal" stage in the IEM procedure (see Figure 1). Interested and Affected Parties (I&APs) were consulted about their views on the future development of the Confluence Area, and alternative land use activities were evaluated using the environmental factors operating in this area. No formal developments were proposed and, therefore, this study was not an Environmental Impact Assessment (EIA). The result of the first phase was the production of a baseline report by the multidisciplinary team. This report contained primary and secondary data on various biophysical, social, developmental and economic factors. A descriptive account followed by a brief evaluation of each factor concluded each chapter. The baseline report did not attempt an integrated evaluation of the environmental factors acting in the Confluence Area. The second phase of the study required each member of the team to assess and evaluate the data in the baseline report.

This dissertation is effectively a land suitability analysis. A central aim is to relate all relevant environmental factors to particular, pre-selected land uses. The environmental factors operating in and around the study site are divided into biological, physical, socio-economic and developmental factors. Six land use categories are selected, representing a broad spectrum of current urban land uses in Greater Cape Town. These categories are open space, conservation, recreation, light industry, housing and agriculture. These categories were selected on the basis that they are compatible with those set out in the Cape Metropolitan Guide Plan. The only category omitted from this evaluation was heavy industry. The reason for this is that it was the only land use category that was deemed completely unsuitable for the Confluence Area by all I&APs.

The approach taken in this dissertation consists of four discrete stages.

### Stage 1

The study area was subdivided into "naturally occurring" land units ("land facets"; Mitchell, 1991) using an explicit method. The land units in the study area were explicitly determined using environmental factors that clearly demarcated land regions. These units were derived by overlaying the geological, hydrological, floral, faunal and current land use features. A composite map of these features was used to depict the land units (see Map 2 and 3).



- Areas that flood in a 1:5 year flood
- Areas that flood in a 1:20 year flood
- Areas that flood in a 1:50 year flood
- Alluvium
- Greywacke and Quartzitic Sand
- Fill Material
- Shale Soils
- Light Grey Sand Soils
- Boundary of study site

Map 2: Composite overlay of biophysical factors used to delineate land units



- Land Unit One
- Land Unit Two
- Land Unit Three
- Land Unit Four

Map 3: Boundaries of the land units in the Confluence Area

### Stage 2

The significance of each biophysical component was rated according to the physical limitations it imposed on the seven selected land uses. This rating system utilised specific criteria obtained through literature appraisal, consultation with various experts and the experience of the author obtained during the baseline analysis of the Confluence Area.

### Stage 3

Each biophysical factor was assigned an importance weighting according to the financial costs of overcoming restrictions imposed by that factor. Based on the combined ratings and weightings the biophysical factors were divided into primary and secondary biophysical controlling factors. For example, the biophysical factors with the highest combined rating and weighting were assigned the status of primary biophysical controlling factors. Primary biophysical controlling factors are those in which considerable expenditure is involved in overcoming the technical problems presented by the biophysical component. This factor results in particular land uses being unsuitable in areas in which the factor is dominant. For example, as flooding imposes serious physical limitations on certain land uses, and as considerable expenditure is needed to overcome these problems this parameter is assigned a high overall score (significance rating and importance weighting) and is assigned the status of a primary biophysical controlling factor in areas where flooding occurs. Secondary factors are those that can be overcome by imposing conditions upon the design of a proposed development, or modifying the influence of the controlling factor. As such, secondary factors do not render a particular land use unsuitable for the specific area in which they occur.

### Stage 4

Recommendations are made as to the most suitable suite of land uses for each land unit, based on the biophysical controlling factors, social, developmental and economic factors.

**CHAPTER TWO: METHODS**

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## CHAPTER TWO

### METHODS

#### 2.1 Introduction

This chapter outlines the approach and methods adopted in this dissertation. The first section is a discussion of the merits of adopting a quantitative and/or qualitative approach in any research project. The second section outlines the general approach to the assessment and evaluation of the information in this study.

This is followed by a detailed account of various landscape classification methods, one of which was used to divide the Confluence Area into land units. A critique of each of these methods is included, followed by an account of why a particular method was chosen.

Section three provides a brief description of each of the biophysical factors and components in the Confluence Area. This is followed by detailed account of the rating and weighting scheme adopted in this study.

#### 2.2 Qualitative vs quantitative methods of evaluation

*"The issue is not objectivity or subjectivity, but how well the subjective judgments are substantiated" (Lawrence, 1993).*

Two types of evaluation are identified in Stauth *et al.* (1993). The first, informal evaluation, tends to be qualitative and holistic and consists of a relatively casual and personal evaluation in which subjective value judgments are not clearly articulated. The second approach, formal evaluation, which is a quantitative and additive approach, consists of a systematic process of significance measurement in which subjective value judgments are clearly stated (McAllister, 1980; Stauth *et al.*, 1993).

##### 2.2.1 Qualitative methods

Given the fact that environmental considerations are becoming more important in planning exercises, it is desirable that a sound basis for decision-making be provided. Hence, there is a need for systematic evaluation procedures if sound decision-making is to occur (Lawrence, 1993). However, qualitative methods of evaluation often fall short of what is required and have been criticised for their lack of rigour (Alston & Freeman, 1975; Bisset, 1978; Hollick, 1981; Prasartseree, 1982; Lawrence, 1993). Criticisms of qualitative methods include:

- (a) a limited ability to manage large data sets,
- (b) being biased, subjective and laden with implicit values,
- (c) being deliberately misrepresentative,
- (d) lacking in theoretical vigour, and
- (e) being ill-equipped to deal with uncertainty and risk.

Furthermore, qualitative evaluation has been described as inconsistent and unsystematic in its treatment of alternatives and values. Such methods also lack repeatability and traceability, thus the conclusions that are drawn cannot be reproduced (Lawrence, 1993).

### 2.2.2 Quantitative methods

To resolve the above difficulties, formal quantitative evaluation procedures have been suggested as an alternative. These methods commence with the assumption that there exists a single best alternative, that alternatives can be ordered from best to worst, and choices amongst alternatives can be made by decision-makers on the basis of a decision rule. The assumption is made that weighed and scaled attributes can be amalgamated mathematically by means of a decision rule. This assumption presupposes that everything is tradeable; that trade-offs can be assessed and described in commensurate units, and that choice amongst alternatives is a purely methodological problem (Lawrence, 1993). These methods supposedly eliminate all the shortcomings of qualitative evaluation processes in that they produce systematic, consistent, flexible and reproducible results.

There are, however, several problems with quantitative methods that have thus far not been resolved. These methods cannot address impacts that cannot be predicted with precision. Indirect and induced impacts which do not have established linkages in the existing system cannot be assessed. Quantitative methods seldom consider inter-relationships or cumulative impacts. In addition, the treatment of items with irreplaceable values (e.g. ecosystems) or values that are difficult to quantify (e.g. species) present problems for the wider application of these methods. Quantitative methods are not essential to rational decisions and may even impede them (Hollick, 1981). There are fundamental problems of goal setting, evaluation, prediction and aggregation that make a satisfactory quantitative decision-making method difficult to achieve. The assertion that formal evaluation methods are objective and free from bias is simply not true. Science in impact assessment is concerned with identification, prediction and explanation of change (Beanlands and Duinker, 1983). As soon as the orientation shifts to interpretation and evaluation, impact assessment moves from the realm of science to the value-laden realm of personal, social and political preference and decision-making (Lawrence, 1993). As long as the scientific pretence is maintained, there remains the potential for hidden bias in the results of a study. The data available in a study does not always lend itself to quantitative evaluations. Application of inappropriate techniques can be more damaging than the subjectivity inherent in qualitative evaluation.

The prevalence of psychological biases in environmental problem solving and decision-making, suggests that the notion of objective judgment is an illusion. More attention should be paid to recognition of biases and finding ways to alleviate their detrimental effects (Miller, 1985). Impartiality in both seeking and weighing of evidence is considered a crucial element of professional competence in scientific and technical fields but is a particularly elusive quality (Miller, 1983). There is a considerable "grey area" of unwitting bias where personal factors influence thought, apparently unknown to the individual concerned. Innumerable personal factors influence professional judgments, including kinds of knowledge, beliefs, attitudes, motives and defences (Miller, 1983). Environmental decision makers are inevitably guided by some set of assumptions and values that influence the outcome of policy decisions (Caldwell, 1987). Science specialists, engineers, economists, lawyers and various sectors of the public are guided by differing logic, expressing differing values. There are two broad categories of personal bias:

- (a) an attitude which is a value-laden belief, and;
- (b) cognitive style which refers to the characteristic way in which people approach problems, and reflects individual consistencies in style of thinking and reasoning.

Therefore, even in quantitative methods of evaluation there is still considerable bias. For example, bias may enter in the choice of environmental factors to be evaluated or in the choice of delimiting categories of significance.

This study employs a combination of the quantitative and qualitative approach to evaluation. The biophysical factors are evaluated using a quantitative model while the social, economic and developmental factors are evaluated using a qualitative approach. In this study these two approaches contain several subjective judgments but where this does occur the assumptions inherent in the approach are clearly stated.

### **2.3 Land suitability analysis**

McAllister (1980) identifies four types of landscape analysis: land suitability analysis (LSA), landscape assessment (LA), environmental evaluation systems (EES), and judgmental impact matrix (JIM). LSA is not a single methodology but represents a group of related methods focusing on a particular evaluation scheme. LSA represents a class of methodologies for evaluating land use potential based on the natural characteristics of alternative sites (McAllister, 1980). This method concentrates on evaluating the suitability of each site for each of several land use options based on the land characteristics, such as topography, soils, geology, hydrology, fauna and flora. Expert judgment by natural scientists plays an important role in this method.

The quantitative approach to LSA is one in which numerical ratings are assigned to "subclasses" of each land characteristic and aggregated for each land parcel into a grand index of land suitability for a particular use. In addition to ratings, each land characteristic is assigned a special numerical value (referred to as a multiplier), which reflects the relative importance of that characteristic in determining overall suitability (McAllister, 1980).

The qualitative approach to LSA utilises methods that are suitable to that particular study and may involve a large degree of subjectivity. This approach classifies land into ecological types

to which land use principles are applied for determining suitability of particular uses (McAllister, 1980).

There are several disadvantages to the LSA approach, namely:

- (a) It focuses primarily on the natural characteristics of the land and evaluates how these characteristics influence land use potential. Social and economic characteristics are not included in the evaluation;
- (b) The LSA method does not provide any fixed guidelines for evaluators to set ratings or importance weightings;
- (c) The use of expert judgment to evaluate the significance or importance of environmental characteristics is inappropriate in a fully democratic society;
- (d) Land characteristics often fail to reveal important impacts of a particular land use that are not location specific. For example, industrial activity in the Confluence Area will not only affect air and water quality within the area but will have an impact on air and water quality in Greater Cape Town;
- (e) An important shortcoming of the LSA method is its failure to establish any systematic procedure for expert judgment. If the LSA approach is to be used for many different analyses then there needs to be a common, repeatable "method" for experts to follow when assigning ratings.

Notwithstanding these disadvantages LSA is the most suitable approach for this dissertation. While it is not a comprehensive evaluation method, it does fulfil a central aim of the study, to evaluate alternative sites within the Confluence Area for particular land uses based on the environmental characteristics of these sites. The normal LSA approach concentrates on the natural characteristics of the land and does not include the socio-economic factors. In this dissertation the LSA approach is modified to include the social, economic and developmental factors. A quantitative LSA method is used to evaluate the biophysical factors, while a qualitative LSA method is adopted to evaluate the social, economic and developmental factors operating in the Confluence Area. The result is a more holistic, comprehensive and integrated evaluation of these factors.

## **2.4 Landscape classification**

The first stage in the evaluation process involves the division of the Confluence Area into land units. To divide the study area into land units a repeatable, reproducible, efficient method is required. This method must be explicit and facilitate evaluation of those environmental components that are relevant to each section of land, rather than to the Confluence Area as a whole. Several methods of landscape classification were researched.

There are three principal approaches to landscape classification: the parametric approach, the genetic approach, and the landscape or physiographic approach (Mabbutt, 1968; Brink *et al.*, 1982; Mitchell, 1991). The parametric approach seeks to establish land units by quantifying selected attributes of selected environmental factors. In the genetic approach land is subdivided into natural regions on the basis of environmental factors. The land units of the

landscape approach are components of the landscape with similar landforms, soils and vegetation (Mabbutt, 1968). More detail on each of these three approaches follow.

## 2.4.1 Landscape classification methods

### 2.4.1.1 Parametric approach

Parametric land classification is the subdivision of land on the basis of selected attribute values. The landscape is described in terms of the values of selected parameters such as slope, drainage and soil properties. Values of the parameters are measured in the field or from contour maps or remote sensing imagery. The range of values is subdivided into specific classes (e.g. vegetation cover of 0-20%, 20-40%, etc). Class intervals for each parameter are usually selected in relation to the specific constraints they impose on different types of development (Brink *et al.*, 1982). For example, if maps to identify optimal areas for development are the end result, then different factors can be divided into classes at certain critical values and isopleths can be drawn around them, to indicate suitable areas based on the selected criteria (Mitchell, 1991).

An advantage of the parametric approach is that the class intervals and attached parameter values lend themselves to quantitative, statistical analysis. The main disadvantage is that there are problems with the location of boundaries, for example, parametric soil classes are difficult to determine without a large number of field observations. There are also difficulties in finding a flexible sampling system which takes into account local variations in the complexity of the terrain (Brink *et al.*, 1982).

Additional quantitative parameters such as isohyets or isotherms can be contoured to yield complex maps that indicate 'suitable' areas based on an 'overlay' of factors. Terrain attributes in a parametric map must be recognisable and measurable in the field, and must define the land units at scales relevant to the land uses (Mitchell, 1991).

Proponents of the parametric approach argue that it achieves a greater degree of precision, and avoids the subjectivity of the landscape method. With the advent of computer technology and scanning devices, this has become a favoured method. However, there are several problems associated with the parametric approach. These include:

- (a) the choice of attributes,
- (b) delimitation of attributable classes,
- (c) the variance of attributes in space and time (Mabbutt, 1968).

For detailed surveys in areas without visible internal differentiation, or for quantitative analysis of important features, the parametric approach adds precision and reliability (Mabbutt, 1968; Mitchell, 1991).

The parametric approach to land subdivision is not used in this study because the available data does not lend itself to this type of rigorous, quantitative evaluation. For example, the type and detail of information on the composition and location of each soil type was not adequate for quantitative, computer based analysis. This was mainly due to the lack of a geotechnical survey.

### **2.4.1.2 Genetic approach**

This approach subdivides the landscape into a logical hierarchy of land units based on the environmental components acting on the land, including climate, temperature, rainfall and land structure (Mabbutt, 1968). The hierarchy consists of physiographic land divisions, provinces and sections. This approach was developed to deal with large tracts of land and is appropriate at mapping scales of 1:1 000 000 or smaller. However, these regions are often too large and vague for effective landscape assessment because of the magnitude and extent of the environmental components (Mabbutt, 1968).

The genetic approach has several disadvantages. Firstly, the units are too large (usually hundreds of thousands of square kilometres) to deal with the internal complexity of the systems contained in the areas. Secondly, large areas with complex internal systems often produce land divisions with vague boundaries. For example, if climate was used as the environmental component delineating the boundaries of a region, the characteristic lack of precision in large climatic databases may result in large and unwieldy regions that do not allow for "definitive" analysis. In the genetic approach precision is exchanged for an overall, rationally based, correlative framework in which lower land units are derived from higher units and generalisations are transmitted downwards (Mabbutt, 1968). In addition, the genetic approach fails to deal with the problem of delimiting land types on a scale realistic for land use.

Based on the fact that this method was designed to handle much larger tracts of land and the lack of boundary precision, this method of landscape classification was deemed unsuitable for the subdivision of the study area into land units.

### **2.4.1.3 Landscape approach**

In the 1930s, geographers began to work on a method that would combine small regions into areas of successively higher order (Mabbutt, 1968). This method is not a process of division and subdivision of areas as in the genetic approach, but rather one of combining small regions into successively larger areas. Environmental components such as relief, characteristic land structure, hydrology, plant cover, soils and current land use are suggested starting points for this process (Mabbutt, 1968).

A central premise of this method is not to view the individual land components in isolation, but rather to adopt an integrated approach and research the combined effect of the geographical factors in each of the land units. The integrated view of the land complex is particularly appropriate to the assessment of overall land potential (Mabbutt, 1968). In dividing land into land units, the environmental components operating in the area become the fundamental unit of description.

A recurrent problem in non-parametric landscape analysis, is the reproducibility and reliability of the 'division' of land units (Mabbutt, 1968). Two types of information are needed to ensure that a method is effective: recognition of types of landscape, and knowledge of the properties of these types, i.e. recognisability and reproducibility (Mitchell, 1991). The recognisability of a type of terrain can be defined as the proportion of it which can be recognised, without ground check, out of the total area it covers, with the tools generally available (Mitchell, 1991). These consist of published material, topographic, geologic and soil maps, and aerial photographs. The recognisability of terrain types in this study was

carried out with the use of a 1:50 000 geological map, information on floodlines according to their contour, height and field, and aerial photo surveys of the vegetation cover and current land use.

The reproducibility of a type of terrain is the degree to which it is possible to delimit it in any area (Mitchell, 1991). The more precise the information available on the attributes, the more exact will be the description and delineation of the boundaries. While more detailed information on the environmental components would improve the delineation of the land unit boundaries, the method used is nonetheless repeatable.

The landscape approach is divided into two different approaches. The first method is used to evaluate very large tracts of land (the PUCE classification system), while the second is designed to evaluate smaller tracts of land (the land system/land facet classification system). Both methods make extensive use of airphoto interpretation in recognising terrain units.

### (i) PUCE classification

The Pattern-Unit-Component-Evaluation classification provides an hierarchical terrain classification at four levels: the province, pattern, unit and component (Aitchison and Grant, 1967).

The province is an area of constant geology at group level and may cover several hundreds of thousands of square kilometres. The terrain pattern is defined chiefly in terms of aerial photo patterns at scales in the order of 1:100 000. It is further defined by field sampling. Terrain units are areas occupied by a single physiographic feature, that is a characteristic association of earthen materials with a characteristic vegetative cover (Mabbutt, 1968). These characteristics are largely determined by field survey. Terrain units may be mapped at scales of 1:10 000 - 1:50 000. The terrain component is a unit characterised by a consistent soil profile, vegetation association and a constant change of slope.

### (ii) Land facet classification

The basic unit of land classification in this system is the land facet, which is an area of land with a simple surface form, a specific succession of soil profile horizons (each with reasonably uniform properties and a characteristic groundwater regime). The land facet may be delineated on aerial photographs at scales of 1:10 000 to 1:50 000. A recurrent pattern of genetically linked land facets is known as a land system. Characteristically, land facets are small units and usually correspond to small physiographic features such as outcrops, free rock faces, talus slopes, alluvial fans and alluvial terraces. In this study, the land facet concept is extended to include more than one physiographic feature (e.g. several different soil categories).

The scales of the province and pattern in the PUCE method are too large to be of use in this study. Land units in the study area can best be delineated at the 1:10 000 scale. Therefore, the terrain unit and terrain component (in the PUCE method) are the appropriate levels of classification in this study (the equivalent category in the land facet classification method is the land facet). In this study a single term, the **land unit**, is used and is equivalent to the terrain unit in the PUCE method and the land facet in the land facet classification system.

#### 2.4.1.4 Advantages of landscape approach

The landscape approach distinguishes units of land on their overall character, while the parametric approach ascertains patterns of occurrence of selected attributes. Areas defined by the parametric approach will be of high reliability, but their mapping may present problems unless scanning of attributes is possible (Mabbutt, 1968). The landscape approach offers the possibility of a more rapid survey at lower costs. Its reliability is adequate for reconnaissance and with moderately close sampling, for semi-detailed work (Mabbutt, 1968). With the advent of the parametric approach, an important advantage of the landscape approach disappears, namely the easy recognition of its land components.

Additional advantages of the landscape approach are:

- (a) that it provides information on smaller scale surface features such as slope, moisture, etc;
- (b) that landscape units govern the distribution of other environmental features such as water, soils and other land uses, and can form a useful framework for their survey and representation;
- (c) that landscape units are visible and easily recognisable on the ground or from the air;
- (d) that a physiographic classification is more speedy and economical;
- (e) that physiographic systems make it easier to grade the relative importance of different land attributes. The parametric approach may assign equal ratings to all land attributes even if they are unequal in importance;
- (f) that physiographic systems lend themselves readily to a variety of scales because they are normally both composite and divisible (Mabbutt, 1968).

The landscape approach to 'subdividing' the Confluence Area into land units is the most suitable of the three landscape classification methods. The size of the Confluence Area and the nature of the environmental characteristics of the area are such that the landscape approach is the optimal method. Therefore, the landscape approach to land division is used in this study.

In this study, the process of dividing the Confluence Area into land units was as follows. First, a composite overlay of three biophysical features (soil types, flooding regime and vegetation) and the current land use in the Confluence Area were mapped onto a single A3 base map (see Map 2). The best visual match up of the biophysical factors and current land uses were then obtained. Where the boundaries of the three biophysical factors and property boundaries coincided or were a close match, the area was designated as a land unit. A brief description of each land unit follows.

In Land Unit One the flooding regime, soil type and vegetation are the most obvious biophysical factors to use to delineate this land unit. The reasons for this are: firstly, that the area immediately adjacent to the two river courses is made up of one soil type - alluvium; and secondly, 1:5, 1:20 and 1:50 year floods inundate large portions of land adjacent to the rivers. Consequently the boundaries of Land Unit One coincide with the 1:20 year floodline

in the Liesbeeck Lake area, the 1:5 year floodline on the western side of the Black River and the 1:50 year floodline on the eastern side of the Black River (see Map 2). These boundaries also include approximately 90% of the alluvium that occurs along the river courses. The vegetation that occurs in the Black River wetlands is mostly indigenous and was the third factor used to delineate this land unit. It just so happens that the eastern sector of Land Unit One contains all the indigenous vegetation in the Confluence Area and, therefore, it seemed sensible to include vegetation as a factor when deciding on the boundaries of this land unit.

Land Unit Two forms a natural "island" in the northern part of the Confluence Area (see Map 1). The current land use, flooding regime, soil type and vegetation were the factors used to delineate this land unit. This land unit is prone to 1:5, 1:20 and 1:50 year floods, contains two soil types (fill material and alluvium), is almost completely covered by alien vegetation. The current land use in the area falls into the open space-recreation category and has one owner, South African Transport Services. Therefore, the boundary of the land unit coincides with the boundaries of the two soil types, the 1:20 year floodline and the SATS property boundary.

The boundary of Land Unit Three coincides directly with the property boundary of the SAAO. While small areas within this area is prone to flooding this factor is not used to delineate the boundaries of the land unit.

Unlike Land Unit One, the main feature used to delineate the boundaries of Land Unit Four is the current land use in the area. The boundaries of the western sector of Land Unit Four coincide almost directly with the property boundary of the western campus of Valkenberg Hospital. The eastern sector of this land unit lies adjacent to Land Unit One, and is just above the 1:50 year floodline along the eastern bank of the Black River.

## **2.5 Description of each land unit**

### **2.5.1 Land Unit One**

Land Unit One includes both the water courses in the Confluence Area. For convenience, this land unit is divided into two areas - the eastern and western sector. The western sector comprises the Liesbeeck Lake, surrounding picnic spots, Rosenfontein wetland and lawn, and the canalised and uncanalised sections of the Liesbeeck River (see Map 3). The eastern sector includes the entire Black River and adjacent kikuyu lawns, the Black River Parkway, Raapenberg Bird Sanctuary (RBS) and Pallotti wetlands.

Many parts of the land unit are prone to flooding in the winter months. This land unit contains the only permanent water bodies (Pallotti wetland, Raapenberg South and Liesbeeck Lake) in the study area. Due to the presence of seasonal and permanent water bodies, this area is quite isolated and is generally inaccessible to the public. The only areas of botanical interest in the Confluence Area are found in the wetlands of the eastern sector, where a large proportion of the flora is indigenous. Hereafter, the wetlands in the eastern sector will be referred to as the Black River wetlands. Despite extensive habitat modification and degradation the Black River wetlands are still a rich avifaunal habitat (Turpie, 1994). There are three soil types in this land unit; namely alluvium, greywacke and quartzitic sand, and light grey sandy soils. The dominant soil type in Land Unit One is alluvium. This soil type covers most of the ground adjacent to and underlying the two river courses.

### 2.5.2 Land Unit Two

Land Unit Two is 13ha in size and comprises the Varsvlei-Liesbeeck Sportsgrounds complex. This area is largely open space in the north with the Sportsgrounds in the south. The boundaries of this land unit coincide with Liesbeeck Parkway in the west, the canalised and uncanalised sections of the Liesbeeck River in the east, and the southern boundary of the shunting yards in the north.

This area has been severely degraded and has been used as a dumping site by its owner, South African Transport Services (SATS). Builders' rubble, ash, tyres and dredge material from the rivers have been dumped in this area. Only two soil categories are found in this land unit, alluvium and builders' rubble or fill. The category, in the United Classification System for classification of soils, that best describes the builders' rubble is fill material. The assumption made in placing it into this soil category is that the main component is builders' rubble. The Old Liesbeeck River channel runs adjacent to the western and northern boundary of the land unit and only carries water the winter months. This old river course is largely choked up during the dry months by exotic water weeds (Parrot's feather and water hyacinth). The terrestrial vegetation is completely dominated by alien species, most prominent of which are from the genus *Acacia*, and kikuyu grass. In the northeastern section of Land Unit Two, there is a small wetland (Varsvlei wetland) that supports indigenous reeds.

### 2.5.3 Land Unit Three

Land Unit Three is occupied exclusively by the South African Astronomical Observatory (SAAO). The area contains Observatory buildings, roads and gardens.

The vegetation is dominated by alien trees (*Eucalypts* and *Acacia spp.*) and kikuyu lawns. A small population of the bulb, *Moraeeae aristata* is to be found in the grounds of Dr R.S. Stobie. This is an endangered species, and is reported to be the last wild population (Turpie, 1994). The eastern boundary of the land unit coincides with the boundary of the Raapenberg Bird Sanctuary (see Map 3). The 1:20 and 1:50 year floodlines fall within the physical boundaries the SAAO and this imposes potential problems for structural development in the future.

Three soil types characterise Land Unit Three. Alluvium occurs along the boundary with the RBS, shale soils occur near to the southern boundary of the land unit, and greywacke and quartzitic sand make up the rest.

### 2.5.4 Land Unit Four

As with Land Unit One, Land Unit Four is divided into an eastern and western sector. The eastern sector consists of Maitland Residential Area (adjacent to Berkley Road), Alexandra Care and Rehabilitation Centre (hereafter Alexandra Care), Maitland Garden Village, parts of the Peninsula Golf Driving Range, the Vincent Pallotti Hospital, Medical Research Council (MRC) land, the eastern campus of the Valkenberg Hospital, and Pallotti field. The boundaries of the eastern sector of this land unit stretch from above the 1:50 floodline adjacent to the eastern boundary of Land Unit One to Alexandra Road in the East, to Berkley Road in the north and to the Vincent Pallotti Hospital in the south. The western sector

consists of the western campus of Valkenberg Hospital, UCT Courtyard development, and National Monuments Council land. The boundaries of the western sector coincide directly with the property boundary of the western campus of the Valkenberg Hospital.

This area comprises three soil types; shale soils, greywacke and quartzitic sand, and light grey sandy soils. This land unit is largely unaffected by flooding because its boundaries are beyond the 1:50 year floodline. The only exception to this is the western sector of this land unit. A small margin of land that lies adjacent to the boundary of the western sector is prone to 1:50 year floods. This biophysical factor affects particular land use activities (e.g. structural development) in this margin of land. The vegetation in this land unit is dominated by alien trees (*Acacia spp.* and Eucalypts) and grasses (kikuyu). The only area where a few indigenous sand plain fynbos species are still found is the Pallotti field, which is adjacent to the Pallotti wetland.

Land Unit Four is the most built-up area in the study site with a large number of buildings and houses. Housing densities in this land unit vary quite considerably and range from relatively low densities in the western sector to high density housing developments in Maitland Garden Village and Maitland Residential Area.

## 2.6 Description of each biophysical factor and component

The biophysical factors selected were geology, hydrology, slope, flora, fauna and water quality. Certain components within each of these biophysical factors were selected and are represented in Table 1. Certain factors could not be split into components and in these cases the component is the same as the factor.

**Table 1:** The biophysical components and factors relevant to the Confluence Area.

Factor	Component
Geology	bearing capacity, shear strength, heave
Hydrology	flooding
Slope	1-10° slope angle
Flora	-
Fauna	-
Agriculture	nutrient availability & pH
Water Quality	-

### 2.6.1 Geology

The soil categories applicable to the Confluence Area were obtained from the baseline study. However, the information in this report was not detailed enough to allow for the further breakdown into the respective soil types. Therefore, with the assistance of Mr. P. Holmes and the Unified Classification System (UCS) (in Brink *et al.*, 1982) the soils were arranged into soil groups.

Five soil groups are to be found in the Confluence Area (see Map 2). These are (including their symbols in the UCS):

- (a) poorly graded sands or gravelly sands, little or no fines (SP). This category includes the alluvium that is found mainly along the river courses.
- (b) poorly graded gravels or gravel-sand mixtures, little or no fines (GP). This group is used to incorporate the fill material found in the Varsvlei area. The main assumption in placing the fill into this group is that the major component of the fill is builders' rubble.
- (c) well graded sands or gravelly sands, little or no fines (SW). This group includes the greywacke and quartzitic sands.
- (d) silty sands, sand-silt mixtures (SM). This includes the light grey sandy soils found in the extreme north east and south of the study site on the eastern side of the Black River.
- (e) Inorganic clays and very fine sands, rockflour, silty or clayey fine sands or clayey silts with slight plasticity (ML). This includes the shale soils found running through the middle of the western campus of the Valkenberg Hospital.

The soils in the Confluence Area were categorised into these groupings in order to determine their engineering properties. This would have a direct bearing on their suitability for any type of structural development. In this regard three engineering properties of the soils were investigated, namely bearing capacity, shear strength and heave.

**Bearing capacity** refers to the largest intensity of pressure which may be applied by a structure to the soil without causing foundation failure (Craig, 1974; Brink *et al.*, 1982). Much urban development consists of structures such as houses, schools and water supply schemes, which exert low pressures on the soil (less than 100 kN/m<sup>2</sup>). These structures do not warrant the use of expensive foundations or structural treatment (Brink, *et al.*, 1982). The soil beneath normal foundations must be capable of supporting bearing pressures of about 35 kN/m<sup>2</sup> in the case of single-storey houses, and 100 kN/m<sup>2</sup> in the case of double storey houses, without undergoing excessive consolidation.

**Shear strength** of a soil is important to very heavy structures or structures (Brink *et al.*, 1982). When a soil is subjected to shear or tensile stresses, rupture of the soil occurs. The value of the shear strength is used to assess its ability to support heavy loads without undergoing sudden and catastrophic deformation. It governs the ultimate bearing capacity of the soil. If the foundation pressures exceed the shear strength of the soil, catastrophic tilting and collapse may take place (Brink *et al.*, 1982).

**Heave** is also very important to the establishment of structures. Shrinkage of soils under drought conditions may produce differential settlement in buildings which ultimately causes cracking. Heave is the reverse effect where wetting of soils occur and causes differential expansion. Lightly loaded structures such as houses are particularly vulnerable because maximum heave takes place under the centre of the structure where the greatest buildup of moisture occurs (Brink *et al.*, 1982).

## 2.6.2 Hydrology

The Confluence Area is subject to seasonal flooding when the Black and Liesbeeck Rivers burst their banks. This leads to the inundation of large parts of the study site for 2-3 months

of the year (Bergman *et al.*, 1994). Data on the 1:5, 1:20 and 1:50 year floodlines was obtained from Arnold (*pers. comm.*).

The projected floodlines for the Liesbeeck River are 4.3 metres above sea level (a.s.l.) for the 20 year return period flood, and 4.5 metres a.s.l. for the 50 year flood. Under present conditions, the 5 year floodline is at 3.4 metres a.s.l., the 20 year floodline at 4.0 metres a.s.l. and the 50 year floodline at 4.6 metres a.s.l.. With further catchment hardening, these figures are likely to change quite considerably.

The worst case scenario is that the projected levels increase to 3.8 metres a.s.l. (5 year), 4.6 metres a.s.l. (20 year) and 5.1 metres a.s.l. (50 year floodline). It should be noted that these figures are, at best, speculative. Residents in the Confluence Area report that the areas within the 1:5 floodline already flood every year (Tilanus, *pers. comm.*). Therefore, the validity of these figures is questionable. The worst case scenario is based on the premise of full development of the catchment area. However, "full" development can mean several different things. For example, if "full development" means the development of housing estates, with associated roads and stormwater drains, then an estimate for run off can be calculated on this basis. If, however, full development entails high rise apartment blocks with large parking areas, then the runoff calculation may be different.

These are the types of difficulties that plague estimates of future run off in the city. What is clear is that further catchment hardening will occur. This will have a direct bearing on the areas of the Confluence Area that are currently subject to flooding. If runoff is lower than the estimates, then the scenario will not be as bad for low lying regions of the Confluence Area. If, on the other hand, runoff exceeds projected figures, this will have serious implications for the types of land use that are suitable for the area.

### 2.6.3 Slope

The slope angle in the Confluence Area falls into a single category (1-10°). The gently undulating nature of the Confluence Area imposes very few limitations on the land use activities (Bergman *et al.*, 1994).

### 2.6.4 Flora

The Confluence Area is completely dominated by alien vegetation, mostly alien trees (*Acacia spp.* and *Eucalyptus*) and kikuyu grass. As a result, the floral species diversity is very low. The only exceptions to this are the wetland areas which support a relatively large number of indigenous reed and sedge species. Of the study site the Varsvlei area is perhaps the most degraded and is completely covered by aliens.

### 2.6.5 Fauna

Due to extensive modification and degradation of all habitat types it is unlikely that the study site supports amphibian, reptile, fish and mammal life of conservation significance (Turpie, 1994). In spite of actual bird numbers being low, the species richness and bird densities of the Black River wetlands compare favourably with two other wetland systems in the Peninsula (Rietvlei and Rondevlei). This indicates that despite the extensive habitat modification and degradation, the Black River wetlands are still a rich avifaunal habitat.

Particular areas of biological interest include the Liesbeeck Lake, Rosenfontein wetland, Raapenberg Bird Sanctuary (RBS) and the Pallotti wetlands.

### **2.6.6 Water quality**

The levels of pollution (both organic and inorganic) in the Black and Liesbeeck Rivers are still too high for human contact, despite extensive measures by the CCC to improve the water quality. The sources of pollution in these rivers are varied but the main sources include the Borchers and Athlone Sewage Works and runoff from the catchment areas during seasonal rainstorms. Therefore, combating pollution in the Confluence Area is an especially difficult problem. The water quality of the rivers has implications for the choice of land use activity and this is elaborated on in Chapter Three.

### **2.6.7 Agriculture**

The soil types in the Confluence Area have varying levels of nutrient availability and different pH values. Certain soils are extremely nutrient poor (e.g. fill material) and others are nutrient rich (e.g. greywacke and quartzitic sands). Nutrient poor soils are unable to support crops without the addition of fertiliser. Therefore, in areas that are characterised by nutrient poor soils the potential of agriculture is limited. The opposite is true of areas with nutrient rich soils. The acidity and alkalinity of soils also affects its agricultural potential. For example, acidic soils may be highly unsuitable for certain types of crops or vegetables. Soils can be made more neutral by adding substances with the "opposite" pH value. For example, acidic soils can be made more neutral by adding lime, which is an alkali substance.

The next stage in the process of evaluation is to rate the significance of each biophysical component (e.g. flooding) followed by assigning importance weightings to each biophysical factor (e.g. hydrology). This is effectively a process of separating the important biophysical factors from the unimportant ones. This process is described in the following section.

## **2.7 Method of rating and weighting biophysical components and factors**

The aim of the rating scheme used in this dissertation is to rate the significance and importance of the biophysical factors operating in the study area.

The criteria for rating each biophysical component were obtained from literature research and the expert opinions of various professionals. Where subjective decisions in connection with criteria are made, these are clearly stated.

The criteria for determining the significance of other factors like the economic, social and developmental factors were qualitatively determined. This was carried out based on the personal involvement of the author in the baseline study, available literature, and the social concerns expressed by Interested and Affected Parties. The combination of a quantitative and qualitative technique was chosen because of the nature of the data available. Particular categories in this dissertation (e.g. engineering and flooding specifications) lend themselves to more quantitative analysis, while others (social and economic factors) are more appropriate for qualitative evaluation.

A method was required that would:

- (a) rate the significance of each biophysical component in terms of its effect on the suitability of particular land uses (Stage 2); and
- (b) assign importance weightings to the biophysical factors. This process allows the separation of the important from the unimportant biophysical factors (Stage 3).

The rating and weighting scheme for the biophysical factors is based on the linear combination method described by Hopkins (1977). This method entails rating each biophysical component and then multiplying each component by the importance weighting assigned to the biophysical factor (see Table 2).

**Table 2:** A hypothetical example of the linear combination method of assigning significance ratings and importance weightings to biophysical factors.

Factor	Component	Factor weight	Component Rating		R × W		OR
			LU 1	LU 2	LU 1	LU 2	
Factor 1		3					24
	Component 1		2	3	6	9	
	Component 2		1	2	3	6	

LU 1 = Land Use One; LU 2 = Land Use Two.

R × W = the significance rating of each component × the importance weighting of each factor.

OR = the overall rating for the suitability of the two land uses in the land unit (the sum of the combined rating and weighting scores from land use one and two, 6+3+9+6).

In this method, the overall suitability rating of each land use in particular land units is the sum of the combined rating and weighting scores of each of the biophysical factors (see Table 2). The main problem with combining all the scores into one 'grand total' is that it hides the relative significance of lesser biophysical factors i.e. the method cannot handle the interdependence of factors (Hopkins, 1977).

The rating scheme used in this study deviates slightly from the method outlined in Hopkins (1977). The method of rating and weighting the biophysical components and factors is exactly the same as that described above. The biophysical components are rated according to the physical and financial limitations they impose on the land use activity. An importance weighting is assigned to each factor based on the financial limitations that it imposes on the land use activity. The overall rating of each component is obtained by multiplying the significance rating by the importance weighting, or in mathematical terms, the linear combination.

While the method of rating and weighting is the same as the linear combination method, the method of determining overall suitability of the selected land uses is different (see Table 3). Instead of assigning a single suitability rating to all land uses in a land unit the method used in this study allows the biophysical factors to be divided into factors of primary and secondary importance to land use decisions. Each biophysical component and factor is rated, "weighted" and the factor with the highest combined rating and weighting score is assigned the status of the primary biophysical controlling factor. The physical limitations imposed by this factor require considerable expenditure to overcome because of the technical problems presented by the biophysical component. A central assumption in this dissertation is that the limitations imposed by the primary biophysical controlling factors are too expensive to overcome and, therefore, render the particular land use unsuitable in areas where this factor operates. Biophysical factors with lower combined ratings and weightings are termed secondary biophysical controlling factors. These factors control the choice of land use in areas where the primary factors are not operative. Secondary factors can be overcome by imposing conditions upon the design of a proposed development or modifying the influence of the controlling factor. Unless otherwise specified, secondary factors do not render a particular land use unsuitable for the specific area in which it operates.

**Table 3:** The modifications made in this study to the linear combination method of assigning ratings and weightings to the biophysical factors affecting land use suitability in a hypothetical land unit.

Factor	Component	Factor weight	Component Rating		R × W	
			LU 1	LU 2	LU 1	LU 2
Factor 1	Component 1	3	2	3	6	9 *
	Component 2		2	2	6	6

\* Component 1 has the highest combined rating and weighting score and is, therefore, the primary biophysical controlling factor for Land Use Two. Component 2 is the secondary biophysical controlling factor.

LU 1 = Land Use One; LU 2 = Land Use Two.

R × W = the significance rating of each component × the importance weighting of each factor.

In this hypothetical land unit, component 1 is the single most important factor in determining which land use is suitable in this area. Component 2 is the secondary biophysical controlling factor and will determine which land use is suitable in areas that are not subject to the influence of the primary biophysical controlling factor. For example, land use two is not a suitable land use activity in this land unit because of the limitations (both physical and financial) imposed by component 1, whereas land use one is suitable in this land unit because there are very few limitations imposed by component 1 and 2.

This technique of differentiating between factors of primary and secondary importance is similar to the rules of combination method (Hopkins, 1977). In this method, the rating of each component is done in exactly the same way as in the linear combination method. The factor with the worst rating in a given land unit overrides the rating of all the other factors. In this study, this method is modified so that the factor with the worst rating does not override the ratings of all the other biophysical factors. Rather, each factor retains its own combined score. Therefore, the suitability of particular land uses can be evaluated in terms of all the biophysical factors (both primary and secondary) and not just in terms of the factor with the worst rating.

### 2.7.1 Rating categories

Fuggle & Rabie (1983) state that significance reflects the social importance of a particular impact based on reasonable criteria. The main criteria used to assign significance to each component are the physical limitations it imposes on each of the land uses.

The rating categories are as follows:

- 1 : **Low significance**
  - refers to the situation where the biophysical component poses no physical limitations on the location of that land use activity in the specified area.
- 2 : **Moderate significance**
  - refers to the situation where the biophysical component imposes limited physical limitations on the location of that land use activity in a specified area. These limitations can be overcome through changes in technical design or modifying the effect of the biophysical factor without incurring considerable cost.
- 3 : **High significance**
  - refers to the situation where the biophysical component imposes major physical limitations on the location of that land use activity in a specified area. These limitations can be overcome through changes in technical design or modifying the effect of the biophysical factor but these measures incur considerable expense.

Details of the criteria used to assign significance to the biophysical components are outlined in the following section.

## 2.7.2 Criteria used to assign significance ratings to the biophysical components.

### 2.7.2.1 Factor: Geology

There are five soil groups found in the Confluence Area; alluvium, fill material, greywacke and quartzitic sands, light grey sandy soils and shale soils. Each of these soil types have characteristic engineering properties. The three components within geology (bearing capacity, shear strength, and heave) were selected because they are important soil properties when considering construction as a land use activity.

#### (a) Component: Bearing capacity

In general, the harder the material the greater the bearing capacity. Soft, collapsing soils have a bearing capacity of less than 50 kN/m<sup>2</sup>, while harder soils can range up to 200 kN/m<sup>2</sup> depending on the soil composition. Rock has a capacity well in excess of 200 kN/m<sup>2</sup> (Craig, 1974; Sparks, *pers. comm.*).

Alluvium is a soft, collapsing soil with a low bearing capacity (well below 50 kN/m<sup>2</sup>). As such, there are physical limitations on the types of structures that can be erected on this material. In areas where this soil group occurs (Land Unit One and Two) and the land use involves the construction of structures, the bearing capacity receives a rating of 2: moderate significance. That is, this component imposes physical limitations but these can be overcome through modifications in design. In areas where this soil type occurs and the land use does not involve construction of structures, bearing capacity is irrelevant, and thus receives a significance rating of 1: low significance.

The bearing capacities of the remaining soil groups are high. Grey sandy soils have a bearing capacity of up to 200 kN/m<sup>2</sup> while the bearing capacity of shale soils, fill and greywacke is well in excess of 200 kN/m<sup>2</sup>. These four soil groups do not pose any physical limitations on the types of structures that can be built on them. In areas where these four soil groups occur, bearing capacity receives a rating of 1: low significance.

#### (b) Component: Shear strength

The shear strength of the soils in the Confluence Area ranges from fair (shale soils) to excellent (greywacke). The shear strength of alluvium, greywacke, grey sandy soils and fill does not pose any physical limitations on the types of structures that can be erected on these soil groups. In areas where these soil groups occur and the land use involves the construction of structures the shear strength receives a rating of 1: low significance. Where the land use does not involve construction of structures shear strength is irrelevant and receives a rating of 1: low significance.

#### (c) Component: Heave

Clay elements (e.g. kaolinite and halloysites) in soils cause heave or differential expansion. This causes problems in structures because foundations tilt and shift and eventually crack. Alluvium and shale soils contain differing proportions of these substances and are thus subject to heave (Brink, 1985; Holmes, *pers. comm.*). In areas where alluvium and shale

soils occur and the land use involves construction of structures, heave receives a rating of 2: moderate significance. Conversely, if structures are not part of the land use, heave receives a rating of 1: low importance. Heave does not occur in the other three soil types (grey sandy soils, greywacke, fill), and in areas where these soils occur heave receives a rating of 1: low significance.

There are technical engineering solutions to overcome the problems of insufficient bearing capacity, shear strength failure and heave (see Brink *et al.*, 1982). However, without knowing the exact composition of each of these soil groups it would be premature to suggest mitigation measures to overcome these problems.

The physical limitations imposed by the components within geology are not so serious that they cannot be overcome through fairly minor changes in design. Therefore, the highest rating allocated to any of the components within geology does not exceed 2: moderate significance.

#### **2.7.2.2      Factor: Hydrology**

There is only one component within hydrology, namely flooding (represented by the 1:5, 1:20 and 1:50 year floodlines). The Confluence Area is prone to seasonal flooding due to increased runoff from the catchment area. Several residents report that the areas up to and including the 1:5 year floodline already flood each year (Tilanus, *pers. comm.*). The position of the floodlines are based on a worst case scenario and are projected figures from the CCC (Arnold, *pers. comm.*).

In areas where flooding occurs and the land use involves structural development, flooding receives a rating of 3: high significance. That is, this component imposes major physical limitations on structural development as a land use activity in areas that are prone to flooding. Where a rating of 2: moderate significance is assigned, flooding imposes limitations that can be overcome without incurring considerable expense. Finally, a rating of 1: low significance indicates that flooding is not a significant factor in the location of that particular land use in the designated area.

#### **2.7.2.3      Factor: Slope**

The entire Confluence Area falls into a single slope category, a 1-10° slope angle. This slope category does not affect any of the land uses specified in Table 1. Therefore, this factor is assigned a significance rating of 1: low significance.

#### **2.7.2.4      Factor: Flora**

In areas where alien vegetation dominates, this factor receives a rating of 1: low significance because the occurrence of this vegetation does not impose physical limitations on any of the land uses. It is assumed that alien vegetation is not worthy of preservation and that it is desirable to remove it.

The majority of the indigenous vegetation in the Confluence Area is aquatic and is found in the wetlands (areas that flood). Indigenous vegetation imposes physical limitations on certain land uses by virtue of the fact that it is aquatic and occurs in areas that experience flooding. Therefore, in areas where indigenous flora dominates a significance rating of 3: high

significance is applied to particular land uses (e.g. those which involve structural development).

#### **2.7.2.5      Factor: Fauna**

The Black River wetlands contain a relatively high waterbird species diversity, and a number of rare or endangered species. As with the flora, the wetland fauna imposes physical limitations on certain land use activities by virtue of the fact that it occurs in areas that are prone to flooding, and receives a rating of 3: high significance. In areas where the species diversity is low and no rare or endangered species are to be found, fauna receives a rating of 1: low significance.

#### **2.7.2.6      Factor: Water quality**

This factor is only relevant to the two rivers in the study area. As the water quality of both rivers is poor it imposes physical limitations on certain land uses (especially those that involve water contact). It is assumed that water-contact activities should not occur in a polluted river because of the health hazard such contact would involve. This factor is assigned a rating of 3: high significance in areas where water contact is an inevitable outcome of the land use activity. A rating of 1: low significance is applied in areas where water contact does not result from the land use activity.

#### **2.7.2.7      Factor: Agriculture**

##### **(a)      Components: Nutrient availability & pH**

These two components are only relevant to agriculture. Fill, greywacke and grey sandy soils are all nutrient poor, acidic soil groups and it would be very difficult to grow economically viable crops on these soils. Fertiliser would need to be added in order to facilitate the growing of crops, and lime would be needed to make the soils more neutral. In areas where these soil groups occur a rating of 2: moderate significance is applied because the soils impose physical limitations on agriculture as a land use. Alluvium and shale soils are both adequate for agriculture in terms of nutrient availability and pH. In areas where these soils occur a rating of 1: low importance is applied to these two components. The rating tables for each land unit follow.

**Table 4:** The significance ratings and importance weightings of the biophysical components and factors in **Land Unit One** (western sector).

Factor	Component	Land use categories							Weight		
		OS	C	AR	PR	H	LI	A			
<b>Geology</b>									<b>2</b>		
	Bearing capacity										
	Alluvium	1	1	2	1	2	2	-			
	Shear strength										
	Alluvium	1	1	1	1	1	1	-			
	Heave										
<b>Hydrology</b>									<b>3</b>		
	1:5 floodline	1	2	3	2	3	3	3			
	1:20 "	1	2	3	2	3	3	3			
	1:50 "	1	2	3	2	3	3	3			
<b>Slope</b>		1	1	1	1	1	1	1	<b>1</b>		
<b>Flora</b>		1	1	3	3	3	3	3	<b>2</b>		
<b>Fauna</b>		1	1	3	3	3	3	3	<b>2</b>		
<b>Water quality</b>		1	2	1*	3*	1*	3*	1	1	2	<b>3</b>
<b>Agriculture</b>										<b>2</b>	
	Nutr. Avail.										
	Alluvium	-	-	-	-	-	-	-	1		
	pH										
	Alluvium	-	-	-	-	-	-	-	1		

**Symbols:**

OS = Open Space; C = Conservation; AR = Active Recreation; PR = Passive Recreation; H = Housing; LI = Light Industry; A = Agriculture; Nutr. Avail. = nutrient availability.

\* The first column denotes the rating for recreation activities where no water contact is made, while the second column denotes the rating for water-contact recreational activities.

**Table 5: The significance ratings and importance weightings of the biophysical components and factors in Land Unit One (eastern sector).**

Factor	Component	Land use categories							Weight		
		OS	C	AR	PR	H	LI	A			
<b>Geology</b>									<b>2</b>		
	Bearing capacity										
	Alluvium	1	1	2	1	2	2	-			
	Greywacke	1	1	1	1	1	1	-			
	Grey sandy soils	1	1	1	1	1	1	-			
	Shear strength										
	Alluvium	1	1	1	1	1	1	-			
	Greywacke	1	1	1	1	1	1	-			
	Grey sandy soils	1	1	1	1	1	1	-			
	Heave										
	Alluvium	1	1	2	1	2	2	-			
	Greywacke	1	1	1	1	1	1	-			
	Grey sandy soils	1	1	1	1	1	1	-			
	<b>Hydrology</b>									<b>3</b>	
		1:5 floodline	1	2	3	2	3	3			3
1:20 "		1	2	3	2	3	3	3			
1:50 "		1	2	3	2	3	3	3			
<b>Slope</b>		1	1	1	1	1	1	1	<b>1</b>		
<b>Flora</b>		1	1	3	3	3	3	3	<b>2</b>		
<b>Fauna</b>		1	1	3	3	3	3	3	<b>2</b>		
<b>Water quality</b>		1	2	1 *	3 *	1 *	3 *	1	1	2	<b>3</b>
<b>Agriculture</b>									<b>2</b>		
	Nutr. Avail.										
	Alluvium	-	-	-	-	-	-	1			
	Greywacke	-	-	-	-	-	-	2			
	Grey sandy soils	-	-	-	-	-	-	2			
	pH										
	Alluvium	-	-	-	-	-	-	1			
	Greywacke	-	-	-	-	-	-	2			
	Grey sandy soils	-	-	-	-	-	-	2			

**Symbols:**

OS = Open Space; C = Conservation; AR = Active Recreation; PR = Passive Recreation; H = Housing; LI = Light Industry; A = Agriculture; Nutr. Avail. = nutrient availability.

\* The first column denotes the rating for recreation activities where no water contact is made, while the second column denotes the rating for water-contact recreational activities.

**Table 6:** The significance ratings and importance weightings of the biophysical components and factors in Land Unit Two.

Factor	Component	Land use categories							Weight		
		OS	C	AR	PR	H	LI	A			
<b>Geology</b>									<b>2</b>		
	Bearing capacity										
	Alluvium	1	1	2	1	2	2	-			
	Fill	1	1	1	1	1	1	-			
	Shear strength										
	Alluvium	1	1	1	1	1	1	-			
	Fill	1	1	1	1	1	1	-			
	Heave										
	Alluvium	1	1	2	1	2	2	-			
	Fill	1	1	1	1	1	1	-			
<b>Hydrology</b>									<b>3</b>		
	1:5 floodline	1	2	3	2	3	3	3			
	1:20 "	1	2	3	2	3	3	3			
	1:50 "	1	2	3	2	3	3	3			
<b>Slope</b>		1	1	1	1	1	1	1	<b>1</b>		
<b>Flora</b>		1	1	1	1	1	1	1	<b>2</b>		
<b>Fauna</b>		1	1	1	1	1	1	1	<b>2</b>		
<b>Water quality</b>		1	2	1*	3*	1*	3*	1	1	2	<b>3</b>
<b>Agriculture</b>									<b>2</b>		
	Nutr. Avail.										
	Alluvium	-	-	-	-	-	-	1			
	Fill	-	-	-	-	-	-	2			
	pH										
	Alluvium	-	-	-	-	-	-	1			
Fill	-	-	-	-	-	-	2				

**Symbols:**

OS = Open Space; C = Conservation; AR = Active Recreation; PR = Passive Recreation; H = Housing; LI = Light Industry; A = Agriculture; Nutr. Avail. = nutrient availability.

\* The first column denotes the rating for recreation activities where no water contact is made, while the second column denotes the rating for water-contact recreational activities.

**Table 7:** The significance ratings and importance weightings of the biophysical components and factors in **Land Unit Three**. Water quality is not considered because the rivers do not flow directly through this land unit. Therefore, water quality does not affect the suitability of recreation as a possible land use activity.

Factor	Component	Land use categories							Weight
		OS	C	AR	PR	H	LI	A	
<b>Geology</b>									<b>2</b>
	Bearing capacity								
	Greywacke	1	1	1	1	1	1	-	
	Shale soils	1	1	1	1	1	1	-	
	Shear strength								
	Greywacke	1	1	1	1	1	1	-	
	Shale soils	1	1	1	1	1	1	-	
	Heave								
	Greywacke	1	1	1	1	1	1	-	
Shale soils	1	1	2	1	2	2	-		
<b>Hydrology</b>									<b>3</b>
	1:5 floodline	1	2	3	2	3	3	3	
	1:20 "	1	2	3	2	3	3	3	
	1:50 "	1	2	3	2	3	3	3	
<b>Slope</b>		1	1	1	1	1	1	1	<b>1</b>
<b>Flora</b>		1	1	1	1	1	1	1	<b>2</b>
<b>Fauna</b>		1	1	1	1	1	1	1	<b>2</b>
<b>Agriculture</b>									<b>2</b>
	Nutr. Avail.								
	Greywacke	-	-	-	-	-	-	2	
	Shale soils	-	-	-	-	-	-	1	
	pH								
	Greywacke	-	-	-	-	-	-	2	
Shale soils	-	-	-	-	-	-	1		

**Symbols:**

OS = Open Space; C = Conservation; AR = Active Recreation; PR = Passive Recreation; H = Housing; LI = Light Industry; A = Agriculture; Nutr. Avail. = nutrient availability.

**Table 8:** The significance ratings and importance weightings of the biophysical components and factors in **Land Unit Four**. Water quality is not considered because the rivers do not flow directly through this land unit. Therefore, water quality does not affect the suitability of recreation as a possible land use activity. Flooding does not occur in this land unit, therefore, it is not rated.

Factor	Component	Land use categories							Weight
		OS	C	AR	PR	H	LI	A	
<b>Geology</b>									<b>2</b>
	Bearing capacity								
	Grey sandy soils	1	1	1	1	1	1	-	
	Shale soils	1	1	1	1	1	1	-	
	Greywacke	1	1	1	1	1	1	-	
	Shear strength								
	Grey sandy soils	1	1	1	1	1	1	-	
	Shale soils	1	1	1	1	1	1	-	
	Greywacke	1	1	1	1	1	1	-	
	Heave								
	Grey sandy soils	1	1	1	1	1	1	-	
	Shale soils	1	1	2	1	2	2	-	
	Greywacke	1	1	1	1	1	1	-	
<b>Slope</b>		1	1	1	1	1	1	<b>1</b>	
<b>Flora</b>		1	1	1	1	1	1	<b>2</b>	
<b>Fauna</b>		1	1	1	1	1	1	<b>2</b>	
<b>Agriculture</b>								<b>2</b>	
	Nutr. Avail.								
	Grey sandy soils	-	-	-	-	-	-		2
	Shale soils	-	-	-	-	-	-		1
	Greywacke	-	-	-	-	-	-		2
	pH								
	Grey sandy soils	-	-	-	-	-	-		2
	Shale soils	-	-	-	-	-	-		1
	Greywacke	-	-	-	-	-	-		2

**Symbols:**

OS = Open Space; C = Conservation; AR = Active Recreation; PR = Passive Recreation; H = Housing; LI = Light Industry; A = Agriculture; Nutr. Avail. = nutrient availability.

### 2.7.3 Criteria for assigning importance weightings to each biophysical factor

The process of assigning importance weightings to each biophysical factor separates the important components and factors from the unimportant ones. The importance weightings of each factor are based on the financial costs involved in overcoming the physical limitations imposed by each biophysical component. The categories are as follows:

1. **Low importance**
  - the financial costs involved in overcoming the physical limitations imposed by the biophysical components within each factor are either low or non-existent.
2. **Moderate importance**
  - the financial costs involved in overcoming the physical limitations imposed by the biophysical components are high but not high enough to cause the land use to be unsuitable for the area.
3. **High importance**
  - the financial costs of overcoming the physical limitations imposed by the biophysical components are high enough to cause the land use to be unsuitable for the specified area.

#### 2.7.3.1 Geology

##### 2: Moderate importance

Engineering solutions to overcome the structural limitations imposed by each component within geology are assumed to be expensive but not expensive enough to render this land use activity financially unfeasible. For example, structures with a bearing capacity in excess of 50 kN/m<sup>2</sup> cannot be built on alluvium because of its low bearing capacity. However, there are engineering solutions to overcome these problems. By assigning an importance weighting of 2 to bearing capacity in areas where alluvium is found the author is assuming that if a developer chose to build structures on alluvium, then the expense of incorporating the necessary technical solutions into the cost of the unit would still make it an economically viable option.

#### 2.7.3.2 Hydrology

##### 3: High importance

Engineering solutions to overcome the limitations imposed by flooding are assumed to be expensive enough to render all land use activities that involve structural development, financially unfeasible.

Two important assumptions are made in assigning this weighting. Firstly, it is assumed that flooding imposes such serious physical limitations on structural development that the costs of overcoming these problems render this component of activity unsuitable in flood areas. There are several problems with flood projection data (see section 2.6.2). If these prove to

be unwarranted then areas within the 5.6m contour will only flood every 50 years, as projected. If, on the other hand, the projections are underestimates of the true figures these areas will flood more frequently than every 50 years. In order to avoid severe problems in the future the worst case scenario must be planned for. The second assumption is that the areas earmarked to flood every 50 years will flood more frequently. Consequently, structural development is inappropriate, not only within the 1:5 and 1:20 floodlines, but also in areas within the 1:50 year floodline.

### **2.7.3.3 Slope**

#### **1: Low importance**

Slope does not pose any financial limitations for any of the land uses.

### **2.7.3.4 Flora and Fauna**

#### **2: Moderate importance**

The financial costs of overcoming the physical limitations imposed by vegetation are moderately high. For example, the costs of clearing dense thickets of alien vegetation can be very high. The costs of removing the indigenous fauna and flora that occurs in the wetlands must not only be evaluated in terms of the physical costs but also in terms of non-use values. In the neoclassical economic model, the basis for Western world economies, it is commonplace to undervalue environmental goods because their non-use values are not accurately accounted for. The result is that natural resources are overexploited without taking the full costs of environmental degradation into account (O'Riordan & Turner, 1983; Panayotou, 1987; Common, 1988; Barbour, 1992). Many people derive benefit from the natural resources in the Confluence Area by either engaging in activities such as birdwatching and nature walks or by simply valuing the area as a green open space within an urban environment that is always available to be utilised. The financial costs of removing this resource should take account of its total economic value, including the user value, option value and intrinsic value, and the "willingness-to-pay" (Norton, 1988; Pearce *et al.*, 1989; Bergstrom, 1990) of those people wishing to retain this natural resource.

### **2.7.3.5 Water quality**

#### **3: High importance**

The financial costs of overcoming the pollution in the Confluence Area rivers is enormous because it would require a management plan at the metropolitan scale. For example, the improvement in the Athlone Sewage Works cost the CCC R31 million between 1979 and the present (Lief, *pers. comm.*) The cost of overcoming these physical limitations (abnormally high pollution levels) render certain land uses inappropriate for the study area.

### **2.7.3.6 Agriculture**

#### **2: Moderate importance**

The financial costs of overcoming the limitations imposed by nutrient poor and acidic soils are high enough to restrict the suitability of this land use activity.

**Table 9:** The importance weightings of the biophysical components and factors in Land Unit One (western sector). The weighting of each component was obtained by multiplying the significance rating by the importance weightings found in Table 4.

Factor	Component	Land use categories								
		OS	C	AR	PR	H	LI	A		
<b>Geology</b>	Bearing capacity									
	Alluvium	2	2	4	2	4	4	-		
	Shear strength									
	Alluvium	2	2	2	2	2	2	-		
	Heave									
	Alluvium	2	2	4	2	4	4	-		
<b>Hydrology</b>	1:5 floodline	3	6	9	6	9	9	9		
	1:20 "	3	6	9	6	9	9	9		
	1:50 "	3	6	9	6	9	9	9		
<b>Slope</b>		1	1	1	1	1	1	1		
<b>Flora</b>		2	2	6	6	6	6	6		
<b>Fauna</b>		2	2	6	6	6	6	6		
<b>Water quality</b>		3	6	3*	9*	3*	9*	3	3	6
<b>Agriculture</b>	Nutr. Avail.									
	Alluvium	-	-	-	-	-	-	-	2	
	pH									
	Alluvium	-	-	-	-	-	-	-	2	

**Symbols:**

OS = Open Space; C = Conservation; AR = Active Recreation; PR = Passive Recreation; H = Housing; LI = Light Industry; A = Agriculture; Nutr. Avail. = nutrient availability.

\* The first column denotes the rating for recreation activities where no water contact is made, while the second column denotes the rating for water-contact recreational activities.

**Table 10:** The importance weightings of the biophysical components and factors in **Land Unit One (eastern sector)**. The weighting of each component was obtained by multiplying the significance rating by the importance weightings found in Table 5.

Factor	Component	Land use categories								
		OS	C	AR	PR	H	LI	A		
<b>Geology</b>	Bearing capacity									
	Alluvium	2	2	4	2	4	4	-		
	Greywacke	2	2	2	2	2	2	-		
	Grey sandy soils	2	2	2	2	2	2	-		
	Shear strength									
	Alluvium	2	2	2	2	2	2	-		
	Greywacke	2	2	2	2	2	2	-		
	Grey sandy soils	2	2	2	2	2	2	-		
	Heave									
	Alluvium	2	2	4	2	4	4	-		
	Greywacke	2	2	2	2	2	2	-		
	Grey sandy soils	2	2	2	2	2	2	-		
<b>Hydrology</b>	1:5 floodline	3	6	9	6	9	9	9		
	1:20 "	3	6	9	6	9	9	9		
	1:50 "	3	6	9	6	9	9	9		
<b>Slope</b>		1	1	1	1	1	1	1		
<b>Flora</b>		2	2	6	6	6	6	6		
<b>Fauna</b>		2	2	6	6	6	6	6		
<b>Water quality</b>		3	6	3*	9*	3*	9*	3	3	6
<b>Agriculture</b>	Nutr. Avail.									
	Alluvium	-	-	-	-	-	-	-	2	
	Greywacke									
	Grey sandy soils	-	-	-	-	-	-	-	4	
	pH									
	Alluvium	-	-	-	-	-	-	-	2	
Greywacke										
Grey sandy soils	-	-	-	-	-	-	-	4		

**Symbols:**

OS = Open Space; C = Conservation; AR = Active Recreation; PR = Passive Recreation; H = Housing; LI = Light Industry; A = Agriculture; Nutr. Avail. = nutrient availability.

\* The first column denotes the rating for recreation activities where no water contact is made, while the second column denotes the rating for water-contact recreational activities.

**Table 11:** The importance weightings of the biophysical components and factors in **Land Unit Two**. The weighting of each component was obtained by multiplying the significance rating by the importance weightings found in Tables 6.

Factor	Component	Land use categories								
		OS	C	AR	PR	H	LI	A		
<b>Geology</b>	<b>Bearing capacity</b>									
	Alluvium	2	2	4	2	4	4	-		
	Fill	2	2	2	2	2	2	-		
	<b>Shear strength</b>									
	Alluvium	2	2	2	2	2	2	-		
	Fill	2	2	2	2	2	2	-		
	<b>Heave</b>									
	Alluvium	2	2	4	2	4	4	-		
	Fill	2	2	2	2	2	2	-		
<b>Hydrology</b>	1:5 floodline	3	6	9	6	9	9	9		
	1:20 "	3	6	9	6	9	9	9		
	1:50 "	3	6	9	6	9	9	9		
<b>Slope</b>		1	1	1	1	1	1	1		
<b>Flora</b>		2	2	2	2	2	2	2		
<b>Fauna</b>		2	2	2	2	2	2	2		
<b>Water quality</b>		3	6	3*	9*	3*	9*	3	3	6
<b>Agriculture</b>	<b>Nutr. Avail.</b>									
	Alluvium	-	-	-	-	-	-	-	2	
	Fill	-	-	-	-	-	-	-	4	
	<b>pH</b>									
	Alluvium	-	-	-	-	-	-	-	2	
	Fill	-	-	-	-	-	-	-	4	

**Symbols:**

OS = Open Space; C = Conservation; AR = Active Recreation; PR = Passive Recreation; H = Housing; LI = Light Industry; A = Agriculture; Nutr. Avail. = nutrient availability.

\* The first column denotes the rating for recreation activities where no water contact is made, while the second column denotes the rating for water-contact recreational activities.

**Table 12:** The importance weightings of the biophysical components and factors in **Land Unit Three**. The weighting of each component was obtained by multiplying the significance rating by the importance weightings found in Table 7. Water quality is not considered because the rivers do not flow directly through this land unit. Therefore, water quality does not affect the suitability of recreation as a possible land use activity.

Factor	Component	Land use categories						
		OS	C	AR	PR	H	LI	A
<b>Geology</b>	Bearing capacity							
	Greywacke	2	2	2	2	2	2	-
	Shale soils	2	2	2	2	2	2	-
	Shear strength							
	Greywacke	2	2	2	2	2	2	-
	Shale soils	2	2	2	2	2	2	-
	Heave							
	Greywacke	2	2	2	2	2	2	-
	Shale soils	2	2	4	2	4	4	-
<b>Hydrology</b>	1:5 floodline	3	6	9	6	9	9	9
	1:20 "	3	6	9	6	9	9	9
	1:50 "	3	6	9	6	9	9	9
<b>Slope</b>		1	1	1	1	1	1	1
<b>Flora</b>		2	2	2	2	2	2	2
<b>Fauna</b>		2	2	2	2	2	2	2
<b>Agriculture</b>	Nutr. Avail.							
	Greywacke	-	-	-	-	-	-	4
	Shale soils	-	-	-	-	-	-	2
	pH							
	Greywacke	-	-	-	-	-	-	4
	Shale soils	-	-	-	-	-	-	2

**Symbols:**

OS = Open Space; C = Conservation; AR = Active Recreation; PR = Passive Recreation; H = Housing; LI = Light Industry; A = Agriculture; Nutr. Avail. = nutrient availability.

**Table 13:** The importance weightings of the biophysical components and factors in **Land Unit Four**. The weighting of each component was obtained by multiplying the significance rating by the importance weightings found in Table 8. Water quality is not considered because the rivers do not flow directly through this land unit. Therefore, water quality does not affect the suitability of recreation as a possible land use activity. Flooding does not occur in this land unit, therefore, it is not weighted.

Factor	Component	Land use categories						
		OS	C	AR	PR	H	LI	A
<b>Geology</b>	<b>Bearing capacity</b>							
	Grey sandy soils	2	2	2	2	2	2	-
	Shale soils	2	2	2	2	2	2	-
	Greywacke	2	2	2	2	2	2	-
	<b>Shear strength</b>							
	Grey sandy soils	2	2	2	2	2	2	-
	Shale soils	2	2	2	2	2	2	-
	Greywacke	2	2	2	2	2	2	-
	<b>Heave</b>							
	Grey sandy soils	2	2	2	2	2	2	-
	Shale soils	2	2	4	2	4	4	-
	Greywacke	2	2	2	2	2	2	-
<b>Slope</b>		1	1	1	1	1	1	1
<b>Flora</b>		2	2	2	2	2	2	2
<b>Fauna</b>		2	2	2	2	2	2	2
<b>Agriculture</b>	<b>Nutr. Avail.</b>							
	Grey sandy soils	-	-	-	-	-	-	4
	Shale soils	-	-	-	-	-	-	2
	Greywacke	-	-	-	-	-	-	4
	<b>pH</b>							
	Grey sandy soils	-	-	-	-	-	-	4
	Shale soils	-	-	-	-	-	-	2
Greywacke	-	-	-	-	-	-	4	

**Symbols:**

OS = Open Space; C = Conservation; AR = Active Recreation; PR = Passive Recreation; H = Housing; LI = Light Industry; A = Agriculture; Nutr. Avail. = nutrient availability.

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## CHAPTER THREE

### EVALUATION OF LAND UNITS

#### 3.1 Introduction

The suitability of the selected land use activities in each land unit is evaluated in terms of:

- (a) the primary and secondary biophysical controlling factors, and secondly
- (b) the developmental and social factors.

The final product is an overall analysis that includes a quantitative evaluation of the biophysical factors, and a qualitative evaluation of the social, economic and developmental factors for each individual land unit. The evaluation of each land unit should be read in conjunction with the relevant rating and weighting tables set out in Chapter Two.

An analysis of the potential for economic development in the Confluence Area appears at the end of the chapter. It is more appropriate to evaluate the economic factors operating in the study area in the context of the entire Confluence Area and not by land unit as with the other factors (biophysical and social).

There are four land units in the Confluence Area (see Map 3). The evaluation of each land unit consists of the following subsections:

- (a) a description of the primary and secondary biophysical controlling factors operating in each unit, and
- (b) the evaluation of each land unit by land use activity.

#### 3.2 Land Unit One

##### 3.2.1 Primary and secondary controlling factors

There are two primary biophysical controlling factors in Land Unit One. The first factor, flooding, imposes limitations on particular land use activities (e.g. activities that involve structural development). A central assumption of this dissertation is that the considerable expenditure involved in overcoming flooding problems renders land use activities that involve structural development unsuitable. The second factor, water quality, is only relevant to recreation as a land use activity. More specifically, the poor water quality in the Black and Liesbeeck Rivers will impose limitations on any recreational activity that involves water contact. For land use activities that do not involve water contact water quality is irrelevant and should be considered a secondary biophysical controlling factor.

The secondary biophysical controlling factors in this land unit include geology, slope, flora, fauna, nutrient availability and pH of the soils. Of the secondary biophysical controlling factors, the three that have the greatest influence on land use suitability are the geology, the fauna and the flora. The geological components (bearing capacity, shear strength and heave) impose specific engineering limitations, while the indigenous fauna and flora impose

restrictions by virtue of the fact that they occur in areas that are prone to seasonal flooding (e.g. the Raapenberg Bird Sanctuary).

### 3.2.2 Evaluation of land unit by land use activity

This section should be read in conjunction with Tables 4,5,9 and 10.

#### 3.2.2.1 Open space

Certain key assumptions are made in connection with the open space option. The choice of open space as a land use option is similar to the no-go development option in Environmental Impact Assessments. The choice of this option will result in very little change to the current condition of the open space areas in the study site. These areas will require minimal management and little or no development of public facilities i.e. they will stay as they are now.

The suitability of this land use activity in Land Unit One is unaffected by most of the biophysical factors. The only possible exception is flooding, which might influence the utility value of the area as a walking or picnicking spot. However, even flooding does not greatly influence the suitability of this area for open space.

#### 3.2.2.2 Conservation

The most influential biophysical factors affecting the suitability of conservation for Land Unit One are (1) flooding (a primary biophysical controlling factor), and (2) fauna, flora, and water quality of the rivers (secondary biophysical controlling factor). It is assumed that a central aim of conservation is to return biologically degraded areas in the study site to their former natural states. If this is to be realised measures will need to be instituted to remove alien vegetation and re-instate indigenous flora and fauna in these areas. The suitability of conservation in the western and eastern sectors of Land Unit One are dealt with separately.

##### Western sector

If the conservation of terrestrial habitats is envisaged in the western sector of this land unit, then flooding will be a major problem. A 1:20 flood will inundate all terrestrial vegetation. This could cause mass mortality amongst the indigenous species inhabiting this area.

If conservation is to be a viable option in the western sector then the water quality in the Liesbeeck Lake and River will need to be improved. Even though the water quality has improved in recent years (Pitt, 1989) the levels of pollution are still too high to support a wider diversity of aquatic and terrestrial organisms.

Measures to improve the water quality and, thus, the conservation status of the area, seem unlikely to occur because:

- (a) the costs of removing dense thickets of alien vegetation (like that found in the study site) are extremely high and, as such, impose limitations of the suitability of this land use;

- (b) the problem of poor water quality in the Confluence Area rivers is a metropolitan problem. The main source of trace metal and plastic pollution for the Liesbeeck River is from the Claremont, Rondebosch, Mowbray area during rainstorms in winter. To improve the water quality in the Liesbeeck Lake and the canalised section of the river, measures will need to be taken further upstream to prevent the pollution entering the river. These measures will require considerable expenditure and continuous monitoring.

Therefore, based on the financial difficulties of overcoming the physical limitations imposed by flooding, alien vegetation and poor water quality, it appears as though conservation is not a viable land use activity in the sector. The only exception to this is the Rosenfontein wetland, which supports indigenous vegetation and a relatively high number of waterbird species. As such conservation is a suitable land use activity in this wetland area.

### Eastern sector

The Black River wetlands contain the largest populations of indigenous flora and fauna in the study site. Raapenberg North has the highest overall species diversity of all the wetlands in the Confluence Area (55 recorded species in an area of 6,30 ha). Raapenberg South contains a permanent pool and many of the birds that inhabit the northern section migrate to the southern section when the pool dries up (Turpie, 1994). The third large wetland in this sector, the Pallotti wetlands, also support a high diversity of birds and is the one area where the Little Bittern (status : rare; Brooke, 1984) has been recorded (Turpie, 1994).

Seasonal flooding already occurs in the eastern sector and has little or no effect on the fauna and flora inhabiting the area (see Plate 3). This, together with the fact that there are a high number of indigenous species in this sector, make it an ideal area for the conservation of indigenous aquatic fauna and flora. Therefore, conservation is a highly desirable land use activity in this sector.

Based on the high proportion of indigenous species and high diversity of waterbirds, the wetlands of the eastern sector would be an ideal opportunity to combine conservation and recreational activities. Activities that utilise the natural resources (e.g. birdwatching or nature walks) could be encouraged and promoted in this area. This, in addition to creating environmental awareness, will help to generate revenue that can contribute towards improving the area and the facilities on offer.

#### 3.2.2.3 Recreation

In this dissertation, this land use category takes two forms, active and passive recreation. It is assumed that active recreation involves the development of public facilities (e.g. picnic spots, ablution blocks, wash rooms, recreational halls, community centres, cycleways, walking paths and bird hides). That is, the development of some sort of structure. Passive recreation refers to the situation where no facilities are provided. This is currently the case in the Confluence Area, where very few facilities are offered. Passive recreation would involve the utilisation of the area in an informal manner. These are the assumptions that should be noted when reading through this section.

If any structures for the purposes of active recreation are envisaged for Land Unit One then flooding will be a major limitation. Therefore, active recreational facilities in this land unit

are unsuitable. For additional limitations to structural development in this land unit see section 3.2.2.4. Unlike active recreation, flooding is not likely to be as big a concern in passive recreation, where no structural development is envisaged. For example, even if the area floods it can still be used for various passive recreation activities (e.g. canoeing and birdwatching). The Liesbeeck Lake supports a wide variety of waterbirds that utilise this area as a roosting, nesting and feeding site. Of particular importance is the group of White Pelicans (status: rare; Brooke, 1984) and Greater Flamingo (status: indeterminate; Brooke, 1984) that utilise this area as a feeding site. Similarly, the Black River wetlands support a relatively high waterbird species diversity that is comparable to two other important wetland systems in the Peninsula, Rietvlei and Rondevlei. If passive recreational activities occur in the eastern and western sector, they should occur in a manner that does not impact on the waterbird populations.

A major limitation that applies to both active and passive recreation in Land Unit One is the water quality of the Black and Liesbeeck Rivers. The water quality of the Black River is especially poor, despite the measures undertaken by the CCC to improve it. Currently, the river is not fit for water-contact activities. Where the recreational activity involves water contact the water quality imposes strict limitations on the suitability of this land use type. If, on the other hand, the activity does not involve water contact then water quality is irrelevant and does not affect the suitability of this land use activity in this land unit. However, if the full recreational opportunities of this land unit are to be realised, the water quality of both rivers will need to be improved quite considerably.

Improvement in the water quality of the Black River, to the point where it could be used for water-based recreational activities, is perhaps unrealistic because of the cost involved. As with the Liesbeeck River the sources of pollution for Black River are varied and include not only the Borchers Quarry and Athlone Sewage Works, but, in fact, the entire catchment area. Major pollution events occur after rainstorms when large amounts of debris, faecal matter, trace metals and other pollutants end up in the river. Much of this pollution ends up in the sediments and filters into the water column over long periods of time. To rectify this, a programme at the metropolitan scale would need to be established to combat the pollution before it reached the river (e.g. debris collecting nets in stormwater drains). This would have to be a fairly intensive and ongoing programme to prevent further river pollution.

Therefore, unless the water quality of the Black and Liesbeeck Rivers is improved water based recreational activities in Land Unit One are unsuitable.

#### **3.2.2.4 Housing and Light Industry**

These land use activities are combined in this section because the primary biophysical controlling factor in this land unit - flooding - has the same effect on the suitability of both activities.

Land Unit One, based on its flooding regime, is not suitable for housing or light industry. There are engineering solutions to flooding problems (see Appendix 1) but the cost of initiating and maintaining these measures are likely to cause the unit cost of each house to be much higher than unit prices in suburbs surrounding the Confluence Area. The suburbs surrounding the Confluence Area are characterised by lower cost housing (e.g. Woodstock, Brooklyn and Maitland).

If, for arguments sake, flooding problems could be overcome without inducing considerable expense, there are still problems with the bearing capacity of the alluvium soils in Land Unit One. Problems associated with construction on alluvial deposits arise from the nature and variability of the material (Brink, 1985). Structures built on alluvium are often subject to differential settlement or heave. The soils exhibit high compressibility and low shear strength. Alluvium restricts the construction of buildings due to its low bearing capacity (Bergman *et al.*, 1994). The bearing capacity of this soft, collapsing soil is estimated to be less than 50 kN/m<sup>2</sup> (Sparks, *pers. comm.*). Structures exceeding 50 kN/m<sup>2</sup> will undergo foundation failure. This alone is likely to render 'light industry' unsuitable, assuming that structures housing this activity are relatively large (and thus exceed 50kN/m<sup>2</sup>). Again, engineering solutions are available to alleviate the problem of insufficient loading capacity but these measures are more costly than normal foundations.

The wetland fauna and flora in the eastern and western sector of Land Unit One is mostly indigenous and imposes limitations on structural development by virtue of the fact that it occurs in areas that are prone to seasonal and permanent inundation by water. Even though the terrestrial vegetation in the western and eastern sector is almost exclusively alien vegetation it still receives a high overall rating. The reason for this is that it occurs in areas that are also prone to flooding, albeit for shorter periods of time than the wetland areas.

#### 3.2.2.5 Agriculture

Apart from the fact that flooding is the main limitation to the suitability of agriculture in the area, the nutrient availability of the soils (alluvium, greywacke, and grey sandy soils) is poor (Holmes, *pers. comm.*). Greywacke and quartzitic sand, and the light grey sandy soils would drain very quickly resulting in irrigation being problematic. All three soil types would require lime to make them more alkali, and fertiliser to provide nutrients for crops to grow. Unless fertiliser is applied to these soils very little besides grass, and trees adapted to nutrient poor soils, are able to grow. Other secondary biophysical controlling factors include fauna, flora and water quality. The fauna and flora impose restrictions on agriculture because they occur in areas that are prone to flooding. Poor water quality imposes limitations on agriculture because of the high pollution levels in the sediments and surface water. The high levels of trace metals (especially lead and cadmium) are likely to result in the vegetables or crops being unfit for human consumption. Therefore, Land Unit One is generally unsuitable for agriculture.

### 3.2.3 Developmental factors

The vast majority of Interested and Affected Parties (I&APs) interviewed expressed the view that current ownership and land use in the Confluence Area would be vital to the planning of future land use in this area (Bergman *et al.*, 1994).

Land Unit One is zoned for three purposes, Community Facilities, Public Open Space and Street Purposes. While the zoning of an area is relatively flexible (departures from current zoning schemes are sought from the Administrator), the current scheme is likely to influence future land use suitability decisions.

The area immediately adjacent to the Liesbeeck Parkway is designated for road widening. There are proposals from the CCC to widen this road from a two lane to a four lane conduit. This proposal is subject to the allocation of funds to the project. If the proposal proceeds,

then the specified area will not be available for any other purpose. As such, this proposal is a significant limitation to alternative forms of 'development' (recreation, open space, conservation, housing, etc) along the eastern verge of the Parkway.

A proposal that may influence the land use options in the western sector of Land Unit One is the proposal to remove the berm separating the Rosenfontein lawn and the wetland. This will allow the lawn to return to its former state as a wetland. This proposal has been approved by the CCC but funds to implement it are not available. The main limitation to any other activity occurring in the lawn area is that it floods during the winter months (see Plate 2).

In the eastern sector, the Raapenberg Bird Sanctuary (RBS) was proclaimed a local authority nature reserve by Provincial Notice 142/1986, dated 7 March 1986, and has the protection this status offers (Peterson & Bellas, 1987). In a CCC memorandum dated 28 January 1994, it was recommended that the City Engineer proceed with incorporation of the Pallotti wetlands into the Raapenberg Sanctuary Nature Reserve, pending the alignment of the eastern boundary of the Reserve (see Appendix 2). The legal status of these wetlands impose restrictions on the land for any other use besides conservation. Therefore, if this land were to be used for any other purpose, the status of local authority nature reserve would need to be revoked.

The most serious developmental threat to Land Unit One is the proposed river widening of the Black and Liesbeeck Rivers. River widening is required because of increasing development in the catchment areas of the Vygekraal, Salt, Liesbeeck and Black Rivers (Lief, *pers. comm.*). The development of tar roads, stormwater drains and sewerage pipes to cater for new housing developments increases the runoff into the rivers. This concept is referred to as catchment hardening. The engineering solution to catchment hardening is river widening. It is proposed that river widening of the Black River will occur in two stages:

- (a) from its present width to a width of 45.7 metres in extent. This was to have taken place by 1992/3 (Peterson & Bellas, 1987). This has not yet been undertaken due to the controversial nature of the proposal;
- (b) from 45.7 metres to a maximum width of 121.9 metres in extent, to take place early in the next century (see Map 4).



River widening is a particularly controversial issue, as the proposed widening will 'swallow up' large sections of the Black River wetlands (Peterson & Bellas, 1987). The I&APs were divided on the issue of river widening as a solution flooding problems. Many groups felt that a more long term, environmentally compatible solution should be found. Other groups, including the City Engineer (Drainage) felt that river widening was the optimal solution. Environmentally compatible solutions have been suggested and involve the retention of stormwater in the catchment area through natural flood attenuation devices. These include:

- (a) the development of retention dams in unutilised open grass fields adjacent to the Black River along its course. The 'open areas' surrounding Settlers Way/N2 have been examined for these purposes. The land has natural depressions which could be turned into retention ponds. The storage capacity afforded by these depressions would be approximately 200 000 m<sup>3</sup>. In order to accommodate future runoff needs, 750 000 m<sup>3</sup> would be needed (Lief, *pers. comm.*);
- (b) the development of wetlands along the three rivers in question to absorb peak floods and filter the flood water through; and
- (c) active measures in the catchment area, e.g. fitting houses with rainwater tanks which would decrease runoff into the rivers.

It would be expedient to choose the short term engineering solution before considering alternative methods of flood control. By addressing the causes of increased runoff, a longer term and more sustainable solution may be found. There is merit in investigating the possibilities of rainwater tanks in new housing developments to reduce runoff at the source; or development of new, and protection of existing wetlands that are known to absorb flood waters; or retention dams in appropriate places along the three river courses. These may be the more expensive options, but may produce the best results in the long term.

If river widening to the maximum extent of 121.9 metres does occur in the Black River, most of the land use activities set out in Table 4-8 become academic because river widening will engulf all the land that is currently available for these land use activities. A positive aspect to river widening is that if it does proceed it is possible that areas in the study site that are currently prone to flooding (e.g. the Varsvlei-Liesbeeck Sportsgrounds complex) may become available for alternative land use activities. For example, structural development not previously considered because of seasonal flooding may become a viable land use activity.

River widening proposals are currently under review while the Drainage and Sewage Branch undertakes a study of the Vygekraal-Black-Salt River systems. Widening proposed for the next three years will be confined to the areas running through the Rondebosch Golf Course.

### 3.2.4 Development policies

The Greening the City report is a metropolitan plan that aims to make a more visible and accessible open space system and forms part of the Coast to Coast Greenway concept for Cape Town. This report earmarks the Raapenberg Bird Sanctuary and Black River surrounds for inclusion in the Coast to Coast Greenway. It further suggests that the Pallotti wetland be awarded the status of a Protected Area. While this document favours the open space-conservation option in the Confluence Area, much of the plan (adopted by the CCC in 1984) has not been implemented due to a lack of funds. In addition, it is not a legally binding document and, therefore, is unlikely to influence land use decisions.

The Cape Metropolitan Guide Plan (CMGP) for future spatial development in the Peninsula is a legally binding document with broad guidelines. It is administered by the Physical Planning Act (No. 125 of 1991). This document states that areas adjudged to be a floodplain by the Administrator, shall not be used for urban development. This particular clause is of relevance to certain areas of Land Unit One which are either seasonally or annually inundated by water. The CMGP earmarks the study area for three uses; open space, government use and urban development.

In the Interim Metropolitan Development Framework (IMDF) most of the Confluence Area is earmarked as part of the metropolitan open space system (MOSS). However, compatible with their central aim of densification of activity corridors, more intensive use should be made of existing built areas in the Confluence Area.

The CBR study encourages the open space option in the Confluence Area. With the choice of the open space option these planners aim to include the protection of natural features, linking open space to MOSS and the conservation of wetlands.

A dominant theme in all three of these metropolitan plans is to maintain the open space character of the Confluence Area. In areas where this is still possible (e.g. Land Unit One and Two) this option should be encouraged.

### 3.2.5 Social concerns

Retaining Land Unit One (especially the eastern sector) as an open space-conservation area was the majority view of I&APs interviewed. Many I&APs felt that conservation of the more natural areas in the study site should be a priority, even if these areas are not pristine. Many argued that open space in metropolitan Cape Town was important and due to its strategic location, the Confluence Area was an important link in this system. They cautioned that this open space would have to be managed and benefit the public.

### 3.2.6 Summary

The suitability of the open space option in Land Unit One is largely unaffected by the environmental factors (biophysical, social and developmental). Therefore, in areas that are prone to flooding or in areas that are suitable for conservation, the open space option is ideal. There are several opportunities in the study site to enhance the open space by combining it with either conservation or recreational activities.

The eastern sector of Land Unit One has the highest proportion of indigenous species of fauna and flora in the Confluence Area. As a result of this, and the fact that most of the area is prone to seasonal flooding that does not affect the fauna and flora, this sector is ideal for conservation purposes. Parts of the western sector of this land unit are also ideal for conservation purposes, for example, the Rosenfontein wetland. Other areas in the western sector are not suitable for conservation because of the financial limitations imposed by removing the alien vegetation and improving the water quality of the Liesbeeck Lake and River.

Flooding is the main limitation to structural development in this land unit. As such, any land use activity that involves the construction of houses or buildings is unsuitable in Land Unit One. If flooding problems could be overcome without incurring considerable expense, then

the alluvium soils in Land Unit One would impose restrictions on the types of structures that could be built in this area. Alluvium has a low bearing capacity and a tendency to undergo differential expansion and heave. The terrestrial and wetland fauna and flora in Land Unit One impose restrictions on structural development by virtue of the fact that they occur in areas prone to seasonal or permanent flooding.

The poor water quality of the two rivers in this land unit is the major limiting factor for water-based recreation activities (both active and passive recreation). Where recreational activities do not involve water contact this factor becomes irrelevant and does not affect the suitability of this land use type in this land unit.

Flooding is also the main biophysical limitation to agriculture in this land unit. Secondary biophysical controlling factors include the poor nutrient availability of the soil and the occurrence of wetland fauna and flora.

The main developmental limitation relevant to Land Unit One is the proposed river widening of the Black and Liesbeeck Rivers. If these proposals proceed most of this land unit will be engulfed by the respective river channels. The open space, conservation, housing, light industry and agricultural activities will no longer be possible in this area. Even the recreational opportunities will be more limited if this development proceeds.

More minor proposals that will affect land use options in this land unit include; the widening of the Liesbeeck Parkway into a four lane highway, and the return of the Rosenfontein lawn to its original state as a wetland.

The overwhelming view expressed by I&APs was to maintain Land Unit One as an open space-conservation area. They further expressed the opinion that the area should be well managed and benefit the public.

### **3.3 Land Unit Two**

#### **3.3.1 Primary and secondary controlling factors**

As with Land Unit One, flooding is the primary biophysical controlling factor in this land unit. A 1:5 flood inundates approximately three quarters of the land unit, while a 1:20 flood would cover the area completely.

The only secondary biophysical controlling factor of any importance in this land unit is geology. The engineering properties of the alluvium and fill are relevant to the optimal choice of land use activity. Due to the extensive modification of the biological environment in this area neither the fauna nor the flora are of importance to land use decisions.

### 3.3.2 Evaluation of land unit by land use activity

This section should be read in conjunction with Tables 6 and 11.

#### 3.3.2.1 Open space

The suitability of the open space option is largely unaffected by the biophysical components operating in this land unit. The limitations applicable to the open space option in this land unit are the same as those in Land Unit One (see section 3.2.2.1). While the northern section of this land unit is characterised by dense alien tree thickets it still has value as an open space that can be utilised when money is available to improve it.

#### 3.3.2.2 Conservation

The Varsvlei area is dominated by alien vegetation (both aquatic and terrestrial). This area is biologically degraded and supports very few species. As such, this area has very little potential for conservation, unless active measures are undertaken to improve the area. These measures would include clearing alien vegetation, re-establishing indigenous species and improving water quality. However, these measures would be expensive and this renders conservation an unsuitable land use activity in this area.

#### 3.3.2.3 Recreation

While the possibilities for recreational activities are limited in the wet season because of the flooding problems (see Plate 4), there are several opportunities for improvement of the facilities to cater for recreation in the dry months.

Current facilities in this land unit are more than adequate for a wide range of recreational activities in the dry summer months. The Liesbeeck Sportsgrounds (now 'The River Club') comprises four tennis courts, four bowling greens and six sportsfields (Bergman *et al.*, 1994). Currently these fields are used as a golf driving range and a recreational bar.

#### 3.3.2.4 Housing and Light Industry

Flooding is the primary biophysical controlling factor in this land unit and is the main limitation to structural development in the area (see Plate 4). The limitations imposed by this biophysical factor are the same as for Land Unit One (see section 3.2.2.4).

Land Unit Two is characterised by two soil types, alluvium and fill. The engineering restrictions that apply to alluvium are discussed in section 3.2.2.4. Assuming that the flooding problems in Land Unit Two could be overcome without causing considerable expense the fill material would not impose any limitations on structural development. The fill material has a good shear strength (Brink *et al.*, 1982) and a bearing capacity that can withstand large structures (200-600 kN/m<sup>2</sup>, Craig, 1974).

#### 3.3.2.5 Agriculture

The fill material underlying Land Unit Two is extremely nutrient poor and is slightly acidic (Holmes, *pers. comm.*). For these reasons, and the fact that the area floods, agriculture is not a viable land use option in this land unit.

### 3.3.3 Developmental factors

Land Unit Two has three landowners, SATS, the Foundation for Research Development (FRD) and the CCC. The area is zoned for Community Facilities, Street Purposes and a section adjacent to the railway shunting yards has an Indeterminate zoning.

Several development proposals are currently under consideration for Land Unit Two. These include;

- (a) the CCC proposal to widen the Liesbeeck Parkway from a two lane to a four lane 'highway'. This would entail filling in the Old Liesbeeck River channel. This proposal is subject to funds being available, but it seems at this stage to be a fixed proposal. This would obviously prevent any other land use activity occurring in this area; and
- (b) a section through the Varsvlei area (see Map 1) is zoned for street purposes. There was a 1949 provision for the extension of Berkley Road to connect with Malta Road. This will require a bridge over the Black River and an intersection with Liesbeeck Parkway. Financial constraints have shelved this idea thus far, but it is considered a desirable option (Aberman, 1993). The CCC have even proposed that any company wishing to develop the Varsvlei area, should be responsible for constructing this link. If this proposal sees fruition, then this stretch of land will not be suitable for any other land use activity. Whether this route is eventually constructed or not, is another issue;
- (c) several other, more minor proposals have been tabled, and include:
  - i. the establishment of a recreational lake, which would require extensive excavation (Taylor, 1990);
  - ii. a housing estate (Boddington, *pers. comm.*);
  - iii. a hotel (Boddington, *pers. comm.*);
  - iv. incorporating the area into the Raapenberg Bird Sanctuary (Cape Bird Club, 1992), and
  - v. the establishment of an urban river trail (City Engineers Department, 1982).

In order for developments ii and iii to take place, the flooding problem will need to be addressed. If the costs of overcoming flooding are too great, these land use options are unsuitable.

A possible method of overcoming flooding in this area would be to fill the area beyond the 5.6m contour line (the 1:50 year floodline), and build high density housing to bring down the unit cost of maintaining flood control measures. This would require further investigation to determine whether it would be a cost effective and viable option. Developments i, iv and v are also viable options, but also require further investigation to determine their feasibility.

### 3.3.4 Development policies

The Western Cape Economic Development Forum (WCEDF) document on the proposed guidelines for release of public land is relevant to this land unit. The WCEDF document states that publicly owned land should be used to address issues such as provision of affordable housing, long term needs for recreational and open space, and creation of training and employment opportunities.

A main concern of I&APs was the method of disposal of 'public' land. Certain I&APs argued that land owned by SATS was public land bought with taxpayers' money, and should be available for public use. Many felt that the privatisation of state land was preferable because it improved the potential of the land.

The manner in which SATS land is released will have a direct bearing on the type of land use that is finally selected for this area. If the amount that UCT paid for their property within the Confluence Area (R1 million for 2.5ha) is anything to go by then this sizeable piece of land (13ha) is worth a considerable sum. If the land is sold, at market related prices, to a private developer it is likely that a development with a high financial (e.g. a hotel or high density housing) will need to occur to ensure a respectable profit. If, on the other hand, the land is handed over to the "public" the types of land use activities are not restricted by concerns of profits but rather by what activities are in the interests of the wider community.

### 3.3.5 Social concerns

A strong feeling among many I&APs was that Land Unit Two should be developed for public use. There were also points of departure or conflict amongst I&APs concerning;

- (a) whether the Liesbeeck Sportsgrounds were appropriate for development, and
- (b) whether the Varsvlei area should be used for flood ponds, the re-establishment of wetlands or as a bird sanctuary.

Certain I&APs felt that there was a possibility of developing low cost housing or light industry on the grounds currently occupied by the Sportsgrounds. However, the high cost of overcoming the flooding problems may prohibit the possibility of low cost housing in this land unit. Other I&APs felt that the area was ideal for community recreational facilities.

### 3.3.6 Summary

As with Land Unit One, the primary biophysical controlling factor is flooding. Most of the limitations that apply to the open space, recreation, housing, light industry and agricultural options in Land Unit One apply in Land Unit Two as well.

Conservation is not a viable option in this land unit because of the extensive biological degradation that has already occurred. The Varsvlei area is completely overrun by alien vegetation. Efforts to improve the area for conservation purposes would entail considerable expense. For example, clearing of alien vegetation is an extremely expensive and labour intensive operation. Therefore, based on the financial limitations, conservation is not a viable land use activity in this land unit.

The two road proposals for Land Unit Two will have a strong influence on the land use activities that occur in this area. The widening of the Liesbeeck Parkway will eliminate the possibility of any other land use occurring in the region of the Old Liesbeeck River channel. The Malta-Berkley link, if it ever occurs, will also eliminate any other proposed land uses in the designated area. The other development proposals outlined in section 3.3.3 are only possible if inexpensive solutions can be found to the flooding problems.

The manner in which the SATS owned land in Land Unit Two is disposed of, will have a strong influence on the type of land use activity that is likely to occur there in the future. A strong feeling amongst I&APs was that the land in should be used to address the needs of the wider community and be available for public use.

### **3.4 Land Unit Three**

#### **3.4.1 Primary and secondary controlling factors**

Many I&APs felt that the SAAO was an inappropriate land use for the area. However, the management staff of the Observatory are not considering moving their operations elsewhere (Stobie, *pers. comm.*). Unlike the other land units dealt with thus far, Land Unit Three has two primary controlling factors, current land use and flooding.

Parts of the land unit are prone to 1:5, 1:20 and 1:50 year floods (see Plate 1). This will limit further development, unless engineering measures are instituted (e.g. filling in the area).

On account of the overwhelming importance of the primary controlling factors in this land unit, the secondary controlling factors (e.g. fauna and flora) are unimportant.

#### **3.4.2 Evaluation of land unit by land use activity**

This section should be read in conjunction with Tables 7 and 12.

##### **3.4.2.1 Open space**

This is inappropriate land use option in the light of the current land use in this land unit.

##### **3.4.2.2 Conservation**

The vegetation composition of this land unit comprises almost exclusively of alien species. While the layout of the gardens, lawns and trees in this property are aesthetically pleasing they are not of conservation significance. Due to the high level of alien infestation and the current land use restrictions in this land unit, conservation is not a suitable land use activity.

### 3.4.2.3 Recreation

Active and passive recreation is a suitable land use activity in Land Unit Three. However, active recreation is unsuitable in areas that are prone to flooding because this land use involves the construction of various types of structures. There are several possibilities for improving the recreational facilities in the SAAO grounds. Currently, public access is controlled and this area is only open to the public on the second Saturday of each month for slide and historical presentations. There are possibilities to open the site for more extensive educational and recreational purposes, as it offers a unique opportunity to educate the public about astronomical research. These facilities need not result in further buildings being constructed on the site (Taylor, 1990).

### 3.4.2.4 Housing and Light Industry

Housing and light industry is inappropriate in the light of the current land use in this land unit. Additional structures to house Observatory facilities could be built in the existing grounds if the need arose. There are no biophysical limitations on structural development, except in the areas that are prone to flooding.

The limitations involved in building on alluvium have been dealt in previous sections. Both the greywacke and quartzitic sand, and the shale soils have an adequate shear strength (Brink *et al.*, 1982) and good bearing capacity for the construction of large buildings. While shale soils are subject to heave there are engineering solutions to combat this problem, for example, floating foundations (Bergman, *pers. comm.*).

### 3.4.2.5 Agriculture

In the light of the current land use, agriculture is not an appropriate land use in this land unit.

## 3.4.3 History and Archaeology

Several of the buildings in the SAAO grounds are older than 50 years old (see Map 5), and modification or demolition of any of these buildings requires permission from the National Monuments Council.

## 3.4.4 Developmental factors

This area is owned by the FRD and is zoned Community Facilities. No formal proposals for the site have been developed, but there are possibilities to enhance the Observatory by providing educational facilities and a tea garden.





**Plate 1:** Flood waters in the South African Astronomical Observatory grounds. This occurs every year when the Black River (out of view) bursts its banks.



**Plate 2:** The Rosenfontein lawn (or picnic spot) floods every year during the winter months. The N2 freeway is on the left hand side of this photograph.



**Plate 3:** When the Black River bursts its banks (right hand side of photograph) the Raapenberg Bird Sanctuary (RBS) and the kikuyu lawns adjacent to the river become inundated with flood waters. Here the RBS is shown after such an event.



**Plate 4:** A photograph taken from the eastern bank of a flooding Liesbeeck River canal. In the background is the Liesbeeck Sportsground under flood waters.

### 3.4.5 Summary

Land use possibilities in Land Unit Three are controlled by two primary controlling factors, current land use and flooding. The open space, conservation and agricultural options are inappropriate in light of the current land use in the area. In addition, conservation is inappropriate because of the total dominance of alien vegetation in this land unit.

There are several opportunities to enhance the recreational and educational potential of the Observatory. The engineering properties of the two dominant soil types are such that they do not impose any limitations on the construction of buildings in this area. The exception to this is areas that are prone to flooding. While construction is not impeded by the soils in the area, the types of buildings that are suitable are restricted by the current land use i.e. only buildings or houses catering for the needs of the Observatory are appropriate.

## 3.5 Land Unit Four

### 3.5.1 Primary and secondary controlling factors

The primary controlling factor in Land Unit Four is current land use. As with the SAAO, certain I&APs argued that Valkenberg Hospital and Alexandra Care were inappropriate land uses and should be moved elsewhere. This evaluation does not incorporate this as a consideration, as it is the opinion of the author that it is an unrealistic expectation for these community facilities to move elsewhere. As such, decisions on future land use will be dominated by what is there already.

Secondary biophysical controlling factors in this area include the geology (bearing capacities, shear strength of the soils) and agricultural potential of the soils. However, due to the overwhelming importance of the primary controlling factor these factors are of limited importance.

### 3.5.2 Evaluation of land unit by land use activity

This section should be read in conjunction with Tables 8 and 13.

#### 3.5.2.1 Open space

The possibilities for open space are limited in this land unit because the area is already quite developed. There is the possibility of the Pallotti field being turned into a 'nature park' which would be an ideal open space area (see Map 7 and Appendix 2). This is a proposal currently under review by the CCC.

#### 3.5.2.2 Conservation

Most of the land unit is not suitable for conservation purposes, due to its biologically degraded and modified state. As discussed previously, there are isolated opportunities (e.g. Pallotti field nature park) to enhance conservation in the area.

### 3.5.2.3 Recreation

Active and passive recreation are both suitable land use activities in Land Unit Four. There are many opportunities to improve the recreational facilities in this land unit. At present the two hospitals have a variety of recreational facilities, including a swimming pool, cricket field, volleyball courts and soccer fields. These are used by patients, staff and local communities (Dare, *pers. comm.*). Recreation is not an appropriate land use activity in the Maitland Residential Area because the area already supports a high density housing estate. Therefore, space is not available to develop recreation facilities. However, the people living in this area would benefit greatly from recreational facilities in the Confluence Area.

In the western sector the land unit the barn complex (leased by Rosedale Collection (Pty) Ltd) has a small coffee shop that is currently operating. However, it does not operate anywhere near to its full capacity (Hanson, *pers. comm.*). The Valkenberg Homestead is a national monument but is currently unused and is falling into a state of disrepair. There are plans to renovate the Homestead. If this happens then this complex is bound to attract more visitors and this would have a beneficial effect on the coffee shop. This complex (the Homestead, barn area and coffee shop) has the potential to be converted into a recreational drawcard for foreign and local visitors to the area.

There are other areas in Land Unit Four that lend themselves to the development of better recreational facilities. For example:

- (a) cycleways and 'nature' walks may be appropriate in and around the grounds of the Valkenberg Hospital,
- (b) the Pallotti field is adjacent to a wetland and this makes it an ideal spot for birdwatching, and
- (c) walking and cycling routes may enhance the open spaces in this land unit.

### 3.5.2.4 Housing

Land Unit Four has the most potential for greater residential and urban densification in the entire Confluence Area (see Map 9). The three soil types (grey sandy soils, greywacke and shale soils) all have good bearing capacities and adequate to excellent shear strength. While shale soils are prone to heave there are engineering solutions to combat these problems. Therefore, all the soil groups are suitable for the foundations of single and double-storey houses, and larger buildings.

There are proposals to extend the Maitland Garden Village into the grounds of the Peninsula Driving Range. This does not pose any engineering problems. Densification of the Valkenberg and Alexandra Care grounds is a realistic option because at the moment these areas support a relatively low "housing" density. As current land use is the major limiting factor to all alternative land uses in this land unit this will need to be addressed before proposals for development are put forward. With further housing will come the need for additional infrastructure (roads, water pipes, sewerage pipes, stormwater drains and electricity). Each of these developments are bound to have additional environmental impacts. Therefore, feasibility studies will need to be initiated to investigate the cumulative impacts of such developments.

### 3.5.2.5 Light Industry

In addition to housing there are opportunities for the development of light industry in Land Unit Four. This land use activity will need to be positioned near to transport lines (roads and railways) and existing infrastructure (power lines, water pipes) to reduce the unit cost of production. Therefore, optimal placement of these activities will probably be close to the Alexandra and Voortrekker Road activity linkages in the eastern sector of the Land Unit Four. Map 9 identifies the types of areas that have potential as light industrial sites. These sites were selected on the basis that they are close to existing transport lines (rail and road), and that the land is underutilised by the institutions that own them. This does not mean that these areas will have to be used for this land use activity, but rather that areas near to existing infrastructure are most preferable for light industry. In this regard, the Maitland Residential Area and Maitland Garden Village, while close to existing activity nodes, are unsuitable for light industry because of the high density housing estates that are already in place in these areas.

### 3.5.2.6 Agriculture

Limited agriculture has taken place in this land unit in the past (Bergman *et al.*, 1994). In terms of nutrient availability and pH, only one of the soil types, greywacke and quartzitic sand, is suitable for agriculture (Holmes, *pers. comm.*). The other soil types in this area are nutrient poor and would require the addition of fertiliser to facilitate the production of a crop. A problem with agriculture in this land unit is to find a sufficiently large piece of ground to make agriculture an economically viable option.

## 3.5.3 Developmental factors

The two biggest landowners in Land Unit Four are the Department of Community Development (Valkenberg) and the Department of Community Health and Welfare (Alexandra Care). Other landowners include The Order of Pallotti Sisters (Vincent Pallotti), the CCC (Maitland Garden Village), Transnet and private owners (Maitland Residential Area), Medical Research Council, UCT, and the National Monuments Council (NMC).

This area also has the widest variety of zoning categories, namely Community Facilities, Subdivisional General Residential, General Commercial, Single Dwelling Residential, Public Open Space and General Business.

Several proposals have been put forward for various types of developments in this land unit. Two sections of land in Land Unit Four are not suitable for any other land use as developments are about to proceed (MRC Gateway Park) or are already proceeding (UCT Courtyard development). Many of the I&APs interviewed were very concerned with the manner in which the UCT Courtyard development proceeded. Many criticised the UCT Planning Department for not following the Integrated Environmental Management (IEM) procedure, and for not including the public in the development process (Bergman *et al.*, 1994). One of the arguments of those opposed to this development was that it was inappropriate because it clashed with the more "natural character" of the area.

Other proposals that have been tabled, include:

- (a) incorporation of the Pallotti field into the Raapenberg Bird Sanctuary nature reserve complex,
- (b) extension of the Maitland Garden area into the Peninsula Golf Driving Range (the area zoned for Single Dwelling Residential),
- (c) upgrading of roads within Valkenberg, improving road access to Valkenberg and extending Homestead Road to the N2,
- (d) plans to upgrade and redevelop the Valkenberg Homestead, and
- (e) a UCT plan to buy and develop the land they currently lease from the Department of Community Development (0,52 ha).

A few of these proposals (e.g. c,d) do not directly affect the suitability of a particular land use activity because they are simply proposals to upgrade existing facilities. Other proposals, for example, the UCT plan to develop the area adjacent to the Homestead, will affect the decision-making process and will require feasibility studies to determine their viability.

Perhaps the most common view expressed by I&APs was that public involvement was vital to future planning of the Confluence Area, and that key I&APs should be consulted during future developments. Therefore, feasibility studies of future development in the Confluence Area should follow the IEM process and incorporate public participation in the decision-making process.

### **3.5.4 History and Archaeology**

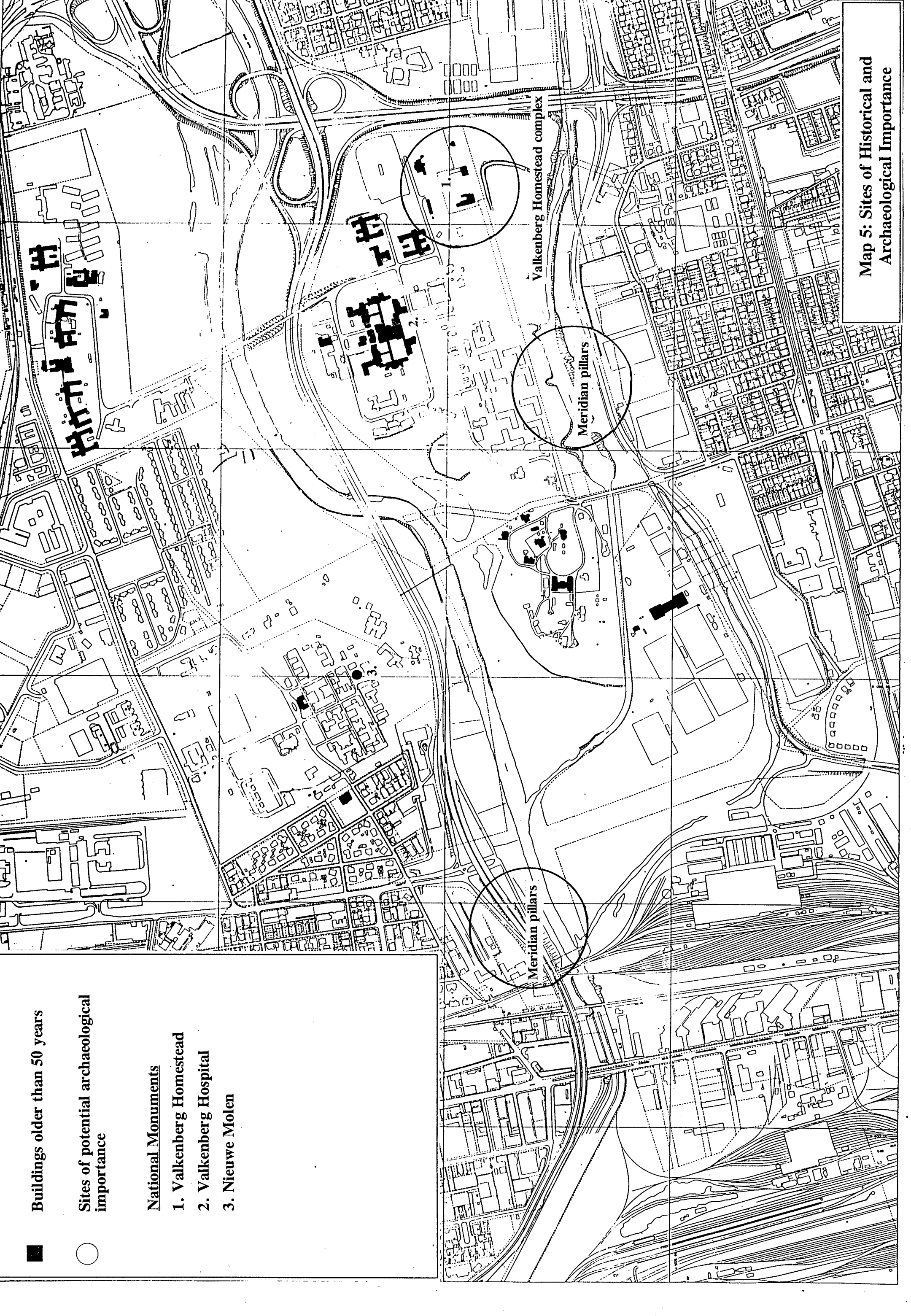
Several national monuments are found in Land Unit Four and include; Valkenberg Homestead, the main administration building of Valkenberg Hospital, and the old mill Nieuwe Molen in Alexandra Care property (see Map 5). These structures are protected by law (the National Monuments Act No. 28 of 1969, as amended). In addition, several buildings that are older than 50 years occur in land unit, and permission is required from the NMC to demolish them. This is a limitation that will need to be borne in mind when selecting suitable land uses because failure to comply with the regulations can result in prosecution.

■ Buildings older than 50 years

○ Sites of potential archaeological importance

National Monuments

1. Valkenberg Homestead
2. Valkenberg Hospital
3. Nieuwe Molen



Valkenberg Homestead complex

Meridian pillars

Meridian pillars

Map 5: Sites of Historical and Archaeological Importance

As a result of extensive modification of the landscape in the recent past, sites of archaeological significance are difficult to ascertain. Potential areas of archaeological significance are noted in Map 5. However, investigation by an archaeologist will be required to verify and pinpoint important archaeological areas. Hall and Hart (1993) pointed out that the areas surrounding Valkenberg Homestead and the barn complex should be considered archaeologically sensitive. Construction in these areas requires the presence of an archaeologist to ensure that potentially sensitive sites are not disturbed.

Many I&APs agreed that features of historical and cultural importance should be conserved where possible. Therefore, the historical and cultural significance of particular sites in this land unit will be an important consideration in the selection of appropriate land uses.

### 3.5.5 Development policies

As mentioned previously, a central idea behind the IMDF is to intensify residential and urban development in and around existing 'activity corridors'. This idea is of particular relevance to Land Unit Four where there is a great potential to 'densify' the area with housing, buildings, or light industry.

The optimal placement of these land use activities will be along existing activity corridors (such as Alexandra Road and the Klipfontein/N2 region), where there is easy access to transport and existing infrastructure (power lines and water pipes).

### 3.5.6 Summary

Unlike any of the other land units, Land Unit Four is not prone to flooding as its boundaries fall above the 1:50 year floodline. The only exception to this is the small margin of land adjacent to the boundary of the western sector of this land unit (see Map 2). The primary controlling factor in this land unit is current land use.

Opportunities for open space and conservation are very limited because the area is built up. The only exception to this is the conversion of the Pallotti field into a nature park. This is an ideal opportunity to combine three land uses - open space, recreation and conservation - and enhance the overall status of this area. Currently the area is in a state of disrepair and requires constructive action to improve it.

Several opportunities exist to improve recreational facilities in the land unit. These possibilities include upgrading and expanding existing facilities in the two hospitals, and the development of new facilities in the appropriate areas (e.g. Pallotti field).

Land Unit Four has the greatest potential to fulfil a central tenet of the Interim Metropolitan Development Framework (IMDF) *viz.*, to intensify residential and urban development in existing built up areas. This densification could take the form of; low, medium or high density housing estates, allocating smaller plots for residential purposes, increasing the number of storeys permissible for each house, or the concentration of a number of small businesses in this land unit. It is important, however, that all developments are subject to feasibility studies that follow the IEM procedure and include public participation in the development process.

The suitability of agriculture in Land Unit Four is limited because of the restrictions imposed by the current land use.

Several sites of historical and archaeological importance are present in this land unit. The national monuments in the area are protected by law and impose limitations on the types of land use activities that are appropriate in these areas. Many I&APs agreed that areas of historical and archaeological importance should be preserved where possible.

## **3.6 Economic analysis**

### **3.6.1 Introduction**

The economic evaluation is not carried out as per land unit like the other biophysical and social factors. The economic potential of the entire Confluence Area should be viewed as part of, and in the context of, the surrounding economic zone (the CBD-Woodstock-Salt River-Maitland-Ndabeni-Observatory-Paarden Eiland area, hereafter referred to as 'the complex').

The areas adjacent to and surrounding the Confluence Area has the highest ratio of jobs:population numbers (3:1) in metropolitan Cape Town (Bergman *et al.*, 1994). This complex has the highest concentration of manufacturing businesses in Greater Cape Town. Many I&APs identified job creation as a problem facing the country, but not a major concern in the Confluence Area. Notwithstanding this, there is a need for employment in Cape Town, with official unemployment rates in the vicinity of 12%. However, this may be an underestimate of the true figure.

The location of the Confluence Area in relation to the concentration of employment and business activity, makes it a highly suitable site for commercial/manufacturing/industrial activity. However, the biophysical and social constraints already dealt with, must be noted when evaluating the suitability of economic activities in the Confluence Area. The existing concentration of economic activity has the added advantage that it provides existing infrastructure and security to establishing businesses in the Confluence Area. The abovementioned concept is one of the central tenets of the theory of agglomeration of economic activity.

### **3.6.2 The theory of economic agglomeration**

Scale economies are normally associated with intrafirm economies, and how the expansion of a single firm can lower unit costs. Scale economies also apply to clusters of firms in the same or related industries (as with the manufacturing industry surrounding the Confluence Area). By clustering together, costs per unit can be lowered for all firms (Foust and de Souza, 1978). Economic units cluster at material sites, transport linkages, cheap labour locations and at focal points of major markets (Lloyd and Dicken, 1972). These are called economies of agglomeration and are a particular kind of external economy of scale. These economies take several forms:

- (a) **Production linkages** : these economies accrue to firms which locate near other producers manufacturing their basic raw materials. The output of one firm becomes the input of another. For example, one firm may produce aircraft parts, the other

- produces aeroplanes. By clustering together, distribution and assembly costs for both types of firms are reduced.
- (b) **Service linkages** : several businesses require specialised services and maintenance activities such as repairs of machinery. No firm is large enough to support the development of a service industry, but collectively they can support an extensive service industry.
  - (c) **Market linkages** : when a cluster is sufficiently large to attract specialised distribution services.
  - (d) **Urbanisation linkages** : firms that locate in urban centres have the advantage over similar firms in more rural areas. The city provides the market, transport links, specialised labour force, service and more extensive industry infrastructure that is not provided in smaller centres.

An agglomeration economy may exist where some or all of these linkages are present within a relatively small area. The concentration of the manufacturing industry in 'the complex' is a localisation economy or an economy in which firms in a single industry are at an advantage by clustering together. The study of agglomeration economies emphasises the connections or linkages between economic activities within a relatively restricted geographic area. By placing manufacturing based industries in and around the Confluence Area, several advantages accrue to new businesses that are characteristic of economies of agglomeration:

- (a) close to sources of labour, where current unemployment rates are high;
- (b) close proximity to major transport links, including rail, roads and a harbour;
- (c) access to existing markets, infrastructure, a service industry, security provided by close proximity to existing manufacturers;
- (d) fast and easy access to communication between businesses in the same industry;
- (e) can lower the production unit cost of goods by externalising costs that would otherwise need to be covered internally if the business established in isolation (e.g. linking up existing transport links).

### 3.6.3 Summary

The Confluence Area is situated adjacent to an area with the highest concentration of employment and manufacturing activity in Greater Cape Town. Establishing manufacturing, commercial and light industrial businesses in this area will result in several benefits that accrue as a result of economies of agglomeration. Therefore, the Confluence Area is an ideal site for economic development. More specifically, Land Unit Four is the most suitable site for this type of economic development. The reasons are that it is already relatively built up and there are no biophysical controlling factors that restrict structural development in this area.

The suitability of the Confluence Area for concentrated economic activity must be weighed against the limitations imposed by the biophysical, developmental and social factors already discussed in this chapter. For example, in areas where flooding is the primary biophysical controlling factor, economic activity is inappropriate. In other areas (e.g. Land Unit Four) there is great potential for these types of economically uplifting activities. As with any other development the feasibility of economic development in this area will require a more detailed analysis.



**CHAPTER FOUR: CONCLUSIONS & RECOMMENDATIONS**

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## CHAPTER FOUR

### CONCLUSIONS & RECOMMENDATIONS

#### 4.1 Introduction

The conclusions in this chapter are set out as per land unit. A key decision-making framework, that sets out the main environmental factors affecting land use suitability in each land unit, accompanies the text in each section. In Chapter Three the economic analysis was evaluated in the context of the entire Confluence Area rather than by land unit. In this chapter, the main conclusions drawn from this analysis are included in section 4.5 - Land Unit Four. The reason for this is that this particular land unit is the most suitable for economic development because of the lack of biophysical controlling factors and the fact that the area is already quite developed.

#### 4.2 Land Unit One

The major biophysical factor that influences land use suitability in this land unit is flooding. Any land use that involves the construction of houses or buildings is unsuitable in this land unit due to the physical and financial constraints imposed by this biophysical factor. This includes the following land use activities; **housing, light industry**, and any structures that are envisaged in **active recreation**. Flooding is also the primary biophysical controlling factor on **agriculture** and, as such, this land use activity is unsuitable in this land unit.

**Conservation** is a highly suitable land use activity in the wetlands of the eastern and western sector of Land Unit One. The reasons for this are:

- (a) that the area is prone to seasonal flooding that does not affect the fauna and flora as the species are aquatic or waterbirds,
- (b) that this area has a high proportion of indigenous species of plant and animal, and;
- (c) that the wetlands in this sector support a high waterbird diversity that is worthy of conservation.

**Conservation** is not a suitable land use activity in the non-wetland areas of the western sector of Land Unit One. The reason for this is that the area is completely dominated by alien vegetation and the water quality of the Liesbeeck Lake and River is poor. For conservation to be a viable land use activity these aliens would need to be removed and the water quality would need to be improved so that a wider range of indigenous species could re-establish in this area. The expense involved in implementing measures to correct the above limitations cause this land use activity to be financially unfeasible and, therefore, unsuitable.

The main **developmental** factor that will influence land use suitability in this area is the proposed river widening of the Black and Liesbeeck Rivers. River widening will engulf most of the ground that is currently unused in the eastern sector of Land Unit One. If these proposals proceed all the abovementioned land use activities will be unsuitable. The other

more minor development proposals are very localised (e.g. road widening of the Liesbeeck Parkway) and affect small areas in the land unit.

The overwhelming view expressed by I&APs was to maintain Land Unit One (especially the eastern sector) as an open space-conservation area. There are several opportunities in this land to realise this aspiration. The eastern sector is an ideal area to combine **open space, conservation and recreation** and will provide the surrounding communities with a valuable natural resource. Recreational activities that utilise the natural resources (e.g. birdwatching and nature walks) in the area should be encouraged. This, in addition to creating environmental awareness, can help to generate funds that can be used for the management and improvement of the area.

The poor water quality of the two rivers is the major controlling factor for recreational activities that involve contact with the water. Therefore, **recreation** that involves water contact is unsuitable in this land unit. Passive 'terrestrial' recreation, for example, picnicking, cycling and walking are appropriate in the western sector where there are existing facilities. As mentioned previously, the eastern sector offers the opportunity to combine recreation (e.g. birdwatching) with open space and conservation activities.

#### 4.2.1 Key decision-making framework for land use suitability in Land Unit One

Land Use	Suitable	Unsuitable	Reason
Open Space	✓		- the high proportion of indigenous species of flora and fauna, and the high waterbird species diversity in the wetlands, make these areas ideal for conservation. There is an opportunity to combine the open space, conservation and recreation options in this area. - conservation is unsuitable in the non-wetland areas of the western sector of this land unit because of the high proportion of alien species and the poor water quality of the Liesbeeck River and Lake.
Conservation	✓		
Passive Recreation	✓		
Active Recreation		✓	- areas that are prone to flooding in this land unit are unsuitable for agriculture, and structural development (including housing, light industry and structures envisaged for active recreation).
Housing		✓	
Light Industry		✓	
Agriculture		✓	

### 4.3 Land Unit Two

Flooding is the major biophysical controlling factor in this land unit. Any land use activity that involves structural development (e.g. **housing, light industry**, or structures necessary for **active recreation**) is unsuitable. Flooding renders **agriculture** an unsuitable land use activity in this area.

Conservation is an unsuitable land use activity in this area because of the extensive biological degradation that has already occurred. It would require considerable expenditure to improve the area to the point where conservation was viable. Therefore, based on these financial constraints, this land use activity is unsuitable in this land unit.

Two developmental factors will have a strong influence on the eventual land use choice in this area. If the proposal to widen the Liesbeeck Parkway see fruition it will rule out any other land use in this particular area. The proposed Malta-Berkley Road link, if it ever occurs, will also rule out the possibility of other land uses occurring (e.g. more recreation facilities).

**Passive recreation** is a suitable land use activity in Land Unit Two throughout the year. While flooding restricts recreational activities for part of the year there are several possibilities to improve and upgrade the existing facilities. This should be done in such a way that a greater number of people benefit from these activities in the summer months. Many I&APs felt that this area could be utilised in a manner that benefitted the public.

Land Unit Two is currently owned by SATS. The manner in which this particular piece of land is disposed of will have a direct bearing on the choice of land use activity. This is an important issue that will need to be addressed when a decision is made regarding the appropriate land use for Land Unit Two.

#### 4.3.1 Key decision-making framework for land use suitability in Land Unit Two

Land Use	Suitable	Unsuitable	Reason
Open Space	✓		- this option is a suitable land use activity but the utility value of the land unit is low because most of the Varsvlei area is overrun by dense alien tree thickets.
Conservation		✓	- conservation is unsuitable in this land unit because of the extensive biological degradation that has already occurred. The financial costs of restoring this landscape for conservation are high enough to make this land use activity financially unfeasible.
Passive Recreation	✓		- while flooding imposes limitations on recreational activities in the winter months, there are several opportunities to expand and upgrade current facilities to cater for summer recreation.
Active Recreation		✓	
Housing		✓	- areas that are prone to flooding in this land unit are unsuitable for agriculture, and structural development (including housing, light industry and structures envisaged for active recreation).
Light Industry		✓	
Agriculture		✓	

## 4.4 Land Unit Three

Land Unit Three is occupied exclusively by the South African Astronomical Observatory (SAAO). A number of I&APs felt that the SAAO was an inappropriate land use for this area. However, it is extremely unlikely that this facility will move its operations elsewhere. Therefore, one of the major controlling factors on other land use activities occurring on this land unit is the current land use. The main biophysical factor that limits land use activities is flooding. Certain areas in this land unit are prone to 1:5, 1:20 and 1:50 year floods.

Land use activities such as **open space, conservation and agriculture** are unsuitable in this land unit in light of the current land use. In addition, conservation is inappropriate because of the total dominance of alien vegetation in this land unit. Structural development (e.g. **housing**) is a suitable land use activity in this land unit as long as it conforms with the needs of the Observatory. For example, **light industry** is inappropriate because only buildings that house observatory facilities are suitable in this area. Structural development is unsuitable in areas that are prone to flooding in this land unit.

There are several opportunities to enhance the recreational and educational status of the SAAO. While no formal proposals have been put forward the SAAO represents an opportunity to educate the public about the activities involved in astronomical research.

### 4.4.1 Key decision-making framework for land use suitability in Land Unit Three

Land Use	Suitable	Unsuitable	Reason
Open Space		✓	- open space, conservation, light industry and agriculture are unsuitable in light of the current land use in this land unit. - in addition, conservation is unsuitable because of the predominance of alien vegetation in this area.
Conservation		✓	
Agriculture		✓	
Light Industry		✓	
Passive Recreation	✓		- there is the potential to introduce recreational and educational facilities in the Observatory which will provide the opportunities to educate the public about astronomical research.
Active Recreation	✓		
Housing	✓		- this land unit is suitable for structural development as long as it conforms with the needs of the Observatory. - areas that are prone to flooding in this land unit structural development is unsuitable.

## 4.5 Land Unit Four

The main controlling factor on land use activities in Land Unit Four is current land use. This land unit is the most built up area in the study site and consequently, the opportunities for land use activities such as **open space** and **conservation** are very limited. The only exception is the Pallotti field, which represents an opportunity to combine open space, conservation and recreation in this area.

Several opportunities to improve the recreational facilities in this land unit are available. For example, the two big hospitals in the area (Valkenberg and Alexandra Care) already have a limited number of sporting facilities. These could be upgraded and extended to enable participation by a larger number of people from surrounding communities.

Agriculture is viable on the greywacke soils in this land unit. Restriction on the suitability of this land use activity are the current land uses that are already in place (e.g. housing) where this soil type occurs.

Several sites of historical and archaeological significance are found in Land Unit Four. The national monuments in this area are protected by law and this imposes administrative limitations on the types of land uses that may be suitable in and around these areas.

Land Unit Four presents the best opportunity in the Confluence Area to intensify residential and urban development in existing built up areas. **Housing** is a suitable land use activity in Land Unit Four. There are many opportunities to densify and expand existing housing "estates" (e.g. Maitland Garden Village), and initiate new developments in areas that have low structural densities. **Light industry** is another suitable land use activity in particular sections of this land unit. The optimal placement of this activities will be close to transport lines and existing infrastructure (see Map 9). It is important that new developments take account of the current land uses in this proposed areas so that a clash of interests does not occur. In addition, it is vital that all new developments are subject to feasibility studies of Environmental Impact Assessments that follow the IEM procedure, and include public participation in the decision-making process.

### 4.5.1 Economic development

The location of the Confluence Area in relation to the high concentration of employment and business activities in the surrounding areas makes it an ideal site for economic activity. This includes commercial, manufacturing and light industrial activity. Many advantages that accrue as a result of economies of agglomeration are relevant to the Confluence Area. Establishing businesses will derive benefit from the existing infrastructures, security, service linkages, market linkages and the labour force in the area.

The suitability of the Confluence Area for concentrated economic activity must be weighed against the biophysical, social and developmental limitations already discussed in this chapter. For example, in areas that are prone to flooding economic activity that involves the construction of buildings is an unsuitable land use activity. As with all other developments more detailed feasibility studies will need to be initiated to investigate the suitability of economic development in the Confluence Area.

#### 4.5.2 Key decision-making framework for land use suitability in Land Unit Four

Land Use	Suitable	Unsuitable	Reason
Open Space	✓ *		- the opportunities for open space, conservation and agriculture are very limited as a result of the current land uses in this land unit. - an exception is the Pallotti field, where there is an opportunity to combine open space, conservation and recreation in the creation of a nature park. * while these land uses are specified as suitable the opportunities to implement them are very limited.
Conservation	✓ *		
Agriculture	✓ *		
Passive Recreation	✓		- there are several opportunities to upgrade and extend current facilities within the two hospital campuses, and introduce new facilities (e.g. the Valkenberg Homestead complex) in this land unit.
Active Recreation	✓		
Housing	✓		- this land unit has the greatest potential for residential densification and urban development in the Confluence Area. Several sites are suitable for limited light industrial activity because of their proximity to existing transport links and infrastructure (e.g. the Alexandra and Voortrekker activity corridors).
Light Industry	✓		
Economic development	✓		- this land unit is suitable for economic development because of the lack of biophysical controlling factors and the fact that it is already relatively developed.

**LAND USE SUITABILITY MAPS**

## **Land Suitability Maps**

**Scale of Maps 1:7000 (i.e. 1cm = 70m)**



Suitable

Unsuitable

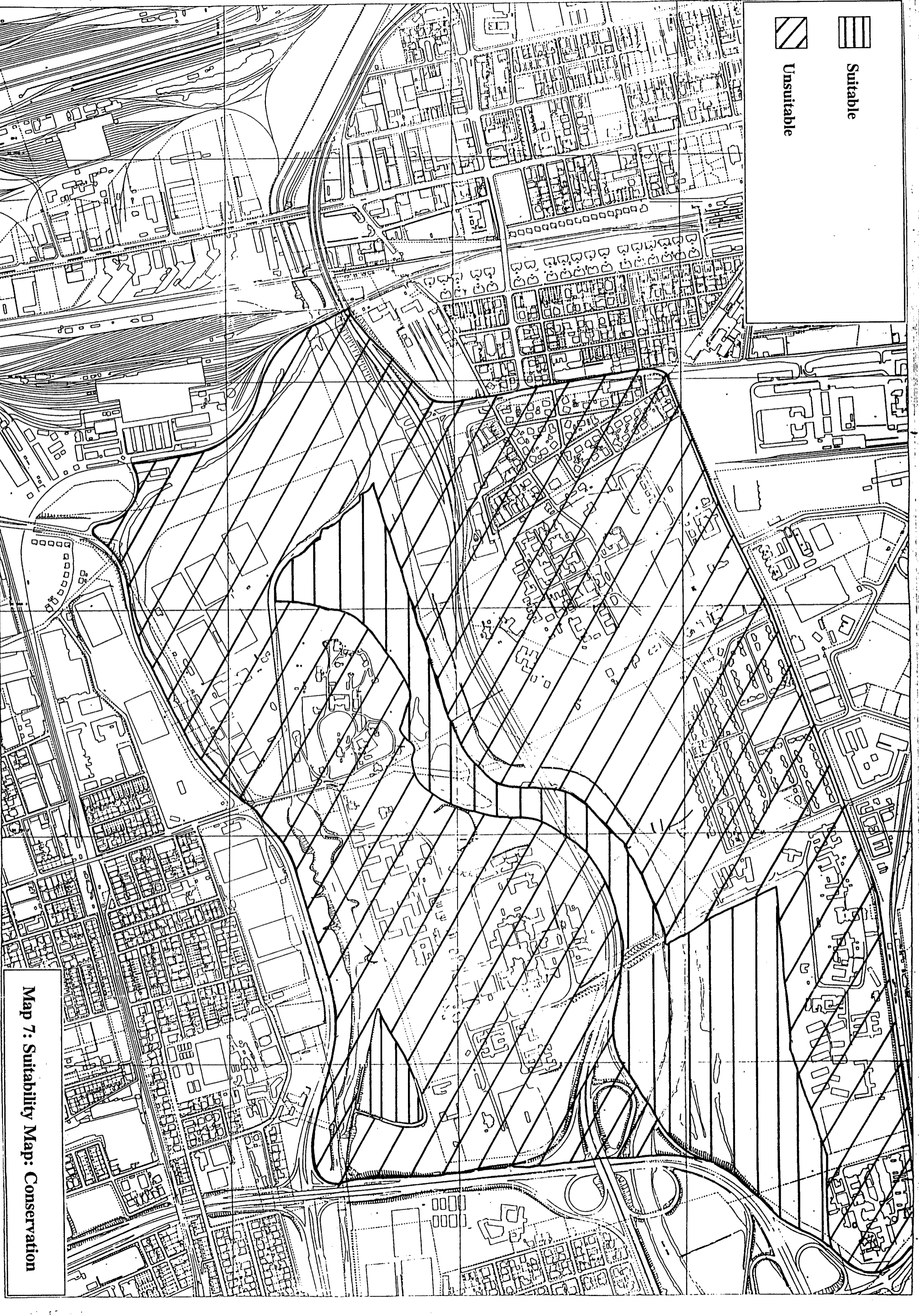
Map 6: Suitability Map: Open space



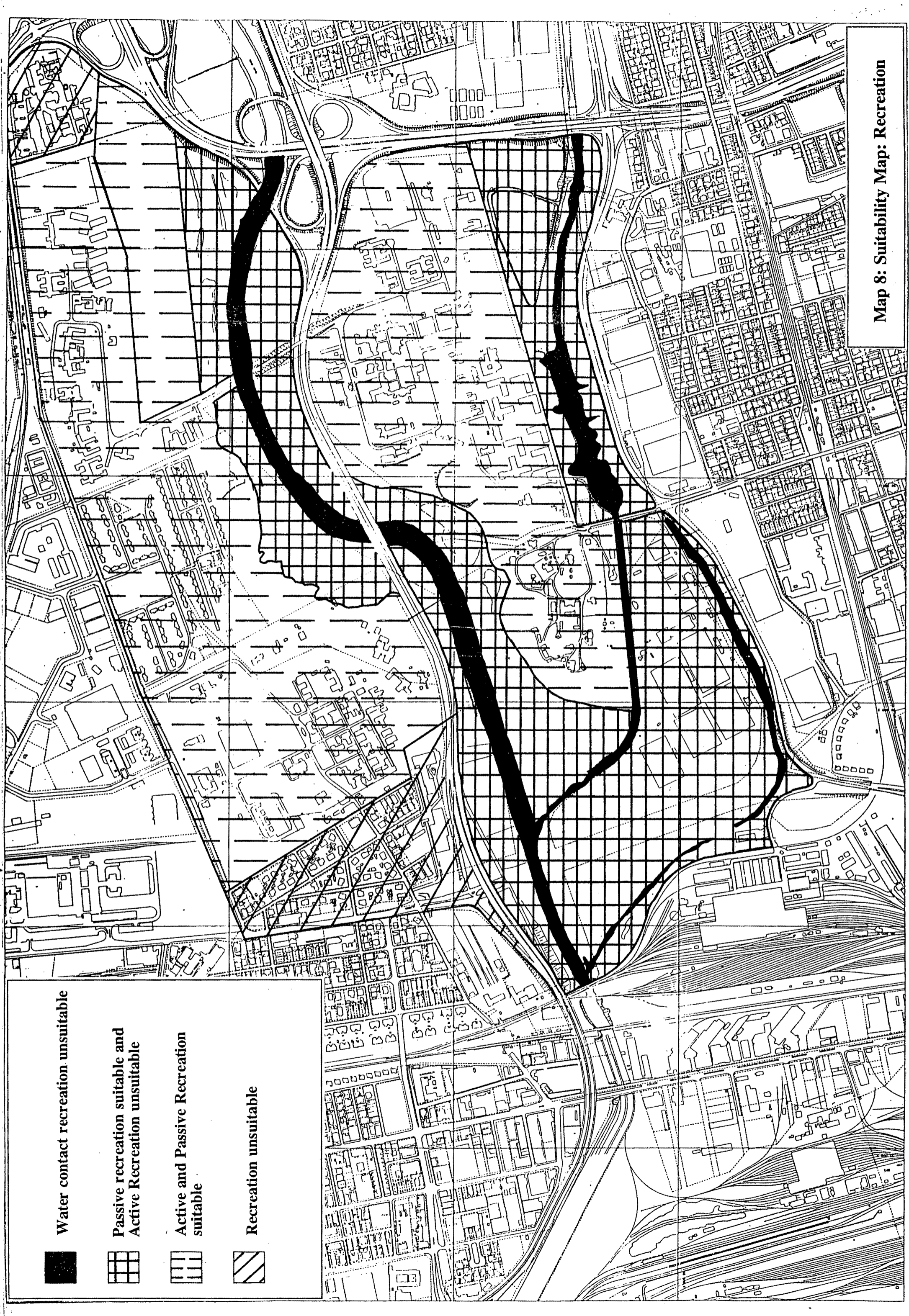
Unsuitable



Suitable



Map 7: Suitability Map: Conservation



Water contact recreation unsuitable

Passive recreation suitable and  
Active Recreation unsuitable

Active and Passive Recreation  
suitable

Recreation unsuitable

Map 8: Suitability Map: Recreation



All areas unsuitable for all forms of structural development

Areas suitable for structural developing (housing, buildings) excluding light industry

Areas of potential suitability for light industry

Map 9: Suitability Map: Housing and Light Industry

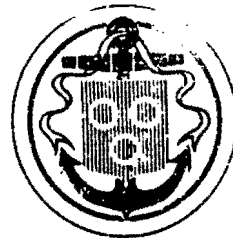


Unsuitable



Suitable

Map 10: Suitability Map: Agriculture



CITY OF CAPE TOWN  
CITY PLANNER'S DEPARTMENT  
STAD KAAPSTAD  
DEPARTEMENT VAN DIE  
STADSBEPLANNER

## MEMORANDUM

Ref/Verw: TP 503/FC

Ask for/Vra vir: Mrs F Currie

Tel: 400-2888

Date/Datum: 1994 -01- 28

To/Aan: The City Administrator  
Attention: Mr Eckermans

**PROPOSED INCORPORATION OF THE PALLOTTI WETLANDS INTO  
THE RAAPENBERG BIRD SANCTUARY NATURE RESERVE (RBSNR)**

I refer to your memorandum reference CS.35/1/2/4 dated 1993-12-17.

The Pallotti wetlands fall within the Greater Culemborg - Black River (C-BR) study area. A report by the City Engineer's Department recommending the possible inclusion of the wetlands was held back in early 1993 pending the outcome of the C-BR project. UCT  
Monte

Significant progress has been made on the C-BR project during the past year which is reflected in the completion of a number of component studies. One of these studies was undertaken by the University of Cape Town's Percy FitzPatrick Institute of African Ornithology (PFIAO). A draft of the Institute's report titled "The biological value of the lower reaches of the Black River and adjacent wetlands and consequent management imperatives" has been received and the final report is expected in the first week of February. I am now in a position to advise further on the proposal to incorporate the Pallotti wetlands into the RBSNR.

None of the C-BR studies received to date have indicated anything other than support for the idea of conserving the Pallotti wetlands. The draft UCT consultants report confirms that the Pallotti wetlands are as important as the Raapenberg wetlands for avifauna and should be conserved.

The only issues which still require clarification are the following:

- the precise definition of the eastern boundary of the proposed nature reserve, which should be determined in consultation with the PFIAO wetlands consultant within the following month; and *Open field not studied and*
- the access requirements for essential service vehicles, for example maintenance and fire fighting vehicles. *near Valherberg St. with dry land.*

It is therefore recommended that:

- the City Engineer should proceed with the proposed incorporation of the Pallotti wetlands into the RBSNR upon receipt of specifications regarding the alignment of the new eastern nature reserve boundary

**Appendix 2:** The proposed incorporation of the Pallotti field into the Raapenberg Bird Sanctuary Nature Reserve (RBSNR) complex.

There is a possibility of combining the open space, conservation and recreation options in if the Pallotti field is incorporated in to the RBSNR complex. However, incorporation of this field is subject to approval by the CCC.

## APPENDICES

### Appendix 1: Engineering solutions to overcome flooding problems in the Confluence Area:

- a. Filling the area with material. The current 'height' of the Varsvlei area is approximately 2.5 metres a.s.l.. In order to overcome the flooding problem, the area would need to be filled beyond the 1:50 floodline (5,6 metre contour). This involves raising the level of a piece of ground 13 ha in extent by 3,1 metres. This is bound to be very expensive. This ground would also require compaction to ensure its suitability for construction;
- b. Structures could be built on stilts. The additional cost of such measures may create considerable expenditure (Bergman, *pers. comm.*);
- c. Construction of subterranean drains. In areas with high water tables, water is pumped out during construction. Subterranean cut-off drains are constructed around the foundations that prevent water inundating the foundations. A pump and sump is installed at the bottom of the drain to pump out water accumulating in the drain. The feasibility of this design is dependent on the amount of water that is to be pumped out. If a pump is needed for 24 hours a day over several months of the year, the costs of running such a pump would be very high and could limit the suitability of that land use. There is no doubt that any problem can be overcome, it is just a matter of cost. In Land Unit Two, the water table is very high, and seasonal rainfall causes inundation of the fields for most of the winter months (Tilanus, *pers. comm.*). Therefore, an engineering solution is bound to be expensive. Flooding is only the primary biophysical controlling factor if certain assumptions are made; that the cost of overcoming flooding problems places severe financial constrictions on structural development that cause it to be economically unfeasible in this area.

## APPENDICES

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#### Personal Communications

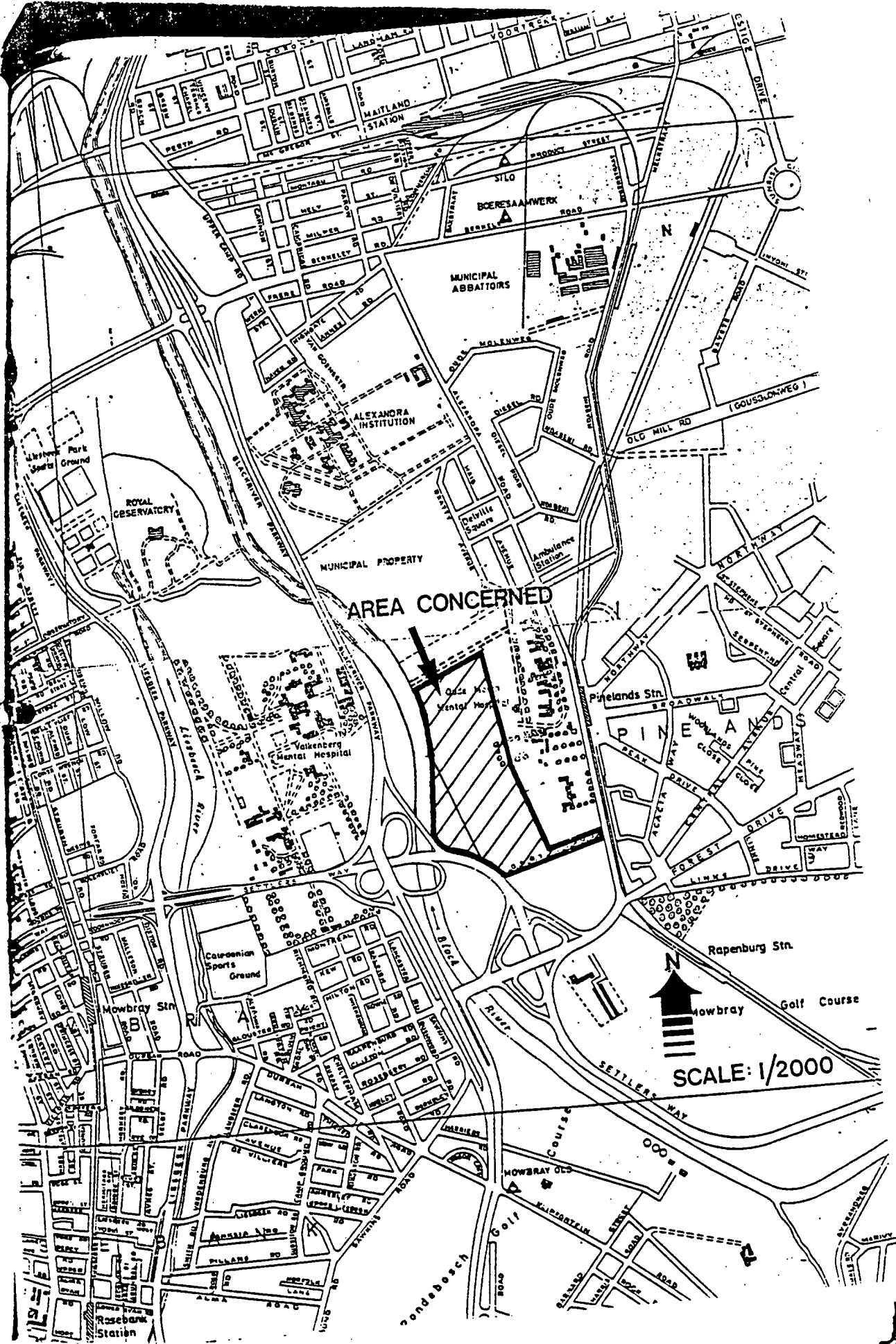
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## REFERENCES



AREA CONCERNED



SCALE: 1/2000



to be provided by my Director of Planning by the end of February;  
and

- discussions should be held with the relevant Branches of the City Engineer's Department to determine the access requirements for essential service vehicles into the area.

Signed

  
CITY PLANNER

DEPARTMENTAL COMMENTS

5. The proposal put forward is to rezone the entire area as indicated on the diagram below to Public Open Space. The eastern portion (ABCDE) is to be leased to the private sector for a nature park to serve both educational and conservation purposes. This proposed usage would be in accordance with Council adopted policies as set out in the Open Space and Recreation Plan for Cape Town (Greening the City) report. The remainder of the area (mostly low-lying land) is proposed to be incorporated into the existing Raapenberg Bird Sanctuary which abuts the north-western edge of the area to be rezoned.

