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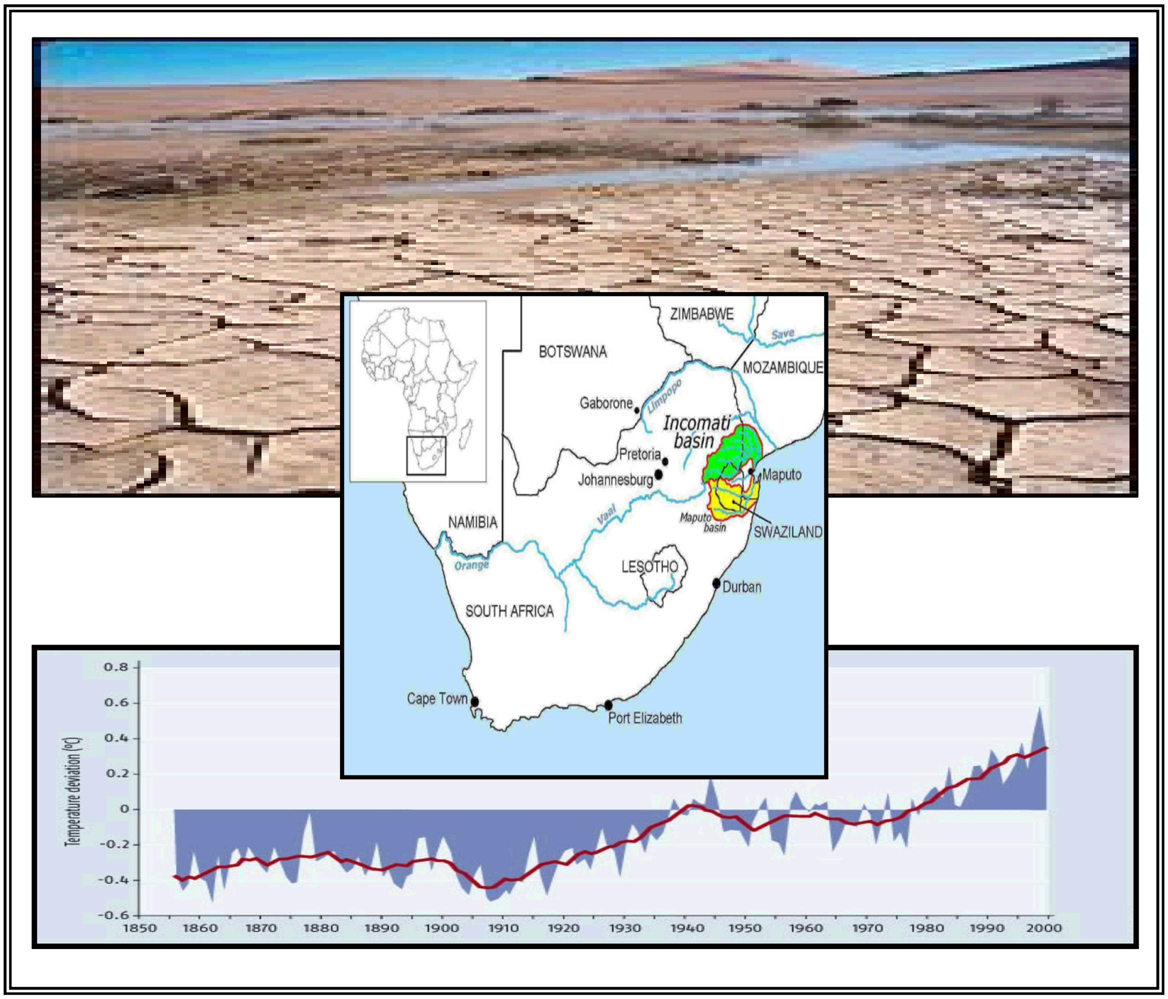

Impact of Climate Change on Water Resources Availability in the Komati River Basin Using WEAP21 Model

Azman Bin Mat Jusoh

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Master of Science Thesis
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ABSTRACT

The subject of changing or fluctuating climate is one of the central issues facing of the atmospheric sciences community. The most profound effect of such climatic changes may be major alterations in regional hydrologic cycles and changes in regional water availability. Within a context of increasing water scarcity, climate change threatens to exacerbate the current supply-demand imbalance. In this study, the impact of climate change on water availability have been modelled and evaluated.

Using the integrated hydrological/water management model, known as WEAP21, this study evaluates the impact of climate change and investigates the sensitivity of water resources to climate change in a part of the Komati river basin. In addition, this study assesses the applicability of WEAP21 model as a hydrological model for climate impact assessment. Using four different climate change scenarios, WEAP21 has been utilised to simulate future water available in the study area for further analysis.

The model shows its capability in producing the streamflow discharge in the calibration and validation process. The performance criteria of R^2, *CE*, *PE* and *VE* computed indicates that the model satisfactorily simulates the streamflow volume in the catchment during the period of 1972 to 1982. In the sensitivity analysis, it was found that the parameter of *LAI* and *Kc* were the most sensitive parameter to the model output. Using an optimum data available, four different climate change scenarios being applied in the model for simulations. Such scenarios have been developed by using hypothetical approach; alteration to the historical precipitation and temperature data available.

The study found that the Komati river basin is very sensitive to climate fluctuations, suggesting that slight changes in the “mean” climate could alter present hydrologic conditions and its water resources. Based on the results obtained, the study area tends to experience a water scarce problem in the period of 2011-2030. This is because with an increase in temperature alone, the study area will face about 10% reduction in water availability.

WEAP21 successfully achieved the aim of this study; to test its capability as a hydrological model for climate impact assessment and to assess the impact of climate change on water availability in the study area. Nevertheless, uncertainty cannot be avoided in this study since the utilisation of the modelling for making the future prediction . However, a key feature of the model is its ability to characterise the complete hydrologic cycle, which allows the planner to track mass balance changes in terms of both the magnitude and nature of the water balance.

Key words: climate change, hydrological model, water availability, water balance, WEAP21 model, Komati catchment

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CE	Nash-Sutcliffe coefficient of efficiency
DWAF	Department of Water Affairs and Forestry
EFR	water for environmental
f_j	quasi-physical tuning parameter
k_c	crop coefficient
k_j	upper storage conductivity
ISP	Internal Strategic Perspective
LAI	leaf area index
N	number of observations
O_i	observed (measured) data points
P_i	modeled (calculate) data points
P	probability in % of the observation of the rank m
P_e	effective rainfall
PET	Penman-Montieth reference crop potential evapotranspiration
Q_{obsi}	measured variable at the i time interval
$\overline{Q_{obsi}}$	mean of the observed discharge
Q_{simi}	simulation discharge at the i time interval
RE	relative error
R^2	coefficient of determination
Sw_j	soil (upper layer) water holding capacity (mm)
T	return period
VE	Percentage error in total runoff volume
WMA	Water management area
$Z_{1,j}$	fraction of the total effective water storage

1 INTRODUCTION

1.1 Background

Global climate change has been an issue of debate over the past decades. One of its most important impacts is what scientists refer to as "an intensification of the hydrological cycle", thereby increasing evapotranspiration rates and altering precipitation patterns. Hydrologic analyses of plausible climate change scenarios indicate that more severe drought will occur in some places and floods in other (Gleick, 1986). This phenomenon directly affects the quantity and quality of the water resources availability which then imposes various impacts on natural ecosystems and human activities. The impact is therefore, a real problem because of the potential to impose additional pressures and affect almost all the sectors of the human endeavour.

At the mesoscale, climate change is likely to affect the local water planning and evaluation especially on the river basins where water resources are stressed under current climate. One of the basins facing this kind of problem is the Komati river basin. Located in the water scarce continent of Africa and shared by Swaziland and South Africa, the Komati river basin faces water deficit problems even in the absence of the climate change. Consequently, the prospect of changing or fluctuating climate will make these problems more complex. Therefore, quantitative estimates of the hydrologic effects of climate change are essential for analysing the potential water resources problems associated with water conflict for planning purposes in the Komati river basin.

To address this need, this study evaluates the impact of climate change on available water resources in one sub-catchment of the Komati river basin using a decision support system known as the Water Evaluation and Planning (WEAP) Model. WEAP is an analytical framework developed for the evaluation of climate change and other drivers that water managers commonly confront (Yates et. al., 2006). Indeed, WEAP21 model is one of the useful tools for the integrated water resources management and it can be used as a database, forecasting and also as a policy analysis tool, depending on the focus of the study. In this regard, the applicability of

WEAP21 in assessing the impact of climate change as well as its main function of the sophisticated water allocation model is tested in this study.

1.2 Problem Definition

It is widely accepted that global warming, due to the enhanced greenhouse effect imposes an increasing threat on water resources. According to Ringius et. al. (1996) although climate change is expected to affect many sectors of the natural and man-made sectors of environment, water is considered to be the most critical factor associated with climate impacts. The similar idea is also highlighted by Houghton (1997) who stated that the most important impact of global warming is on water supplies which are in any case becoming increasingly critical in many places.

In the continent of Africa, the observational records show that the climate has been warming through the 20th century at the rate of about 0.05°C per decade (IPCC, 2001). While the exact nature of the changes in temperature or precipitation, and extreme events are not known, there is general agreement that extreme events will get worse, and trends in most variables will change in response to warming. By 2025, it is assumed that 22 countries will experience a water-stress situation due to rapid population growth, expanding urbanisation, increased economic development and climate change. (Figure 1.1).

In contrast to the assessment of global or large scale variations of the climate driving forces for global hydrology, the impact of climate change on the regional hydrology is still unknown for most regions of world (Kim et. al., 2006). Although climate change is a global phenomenon, the trends and impact may be different on a local scale. Therefore, in order to focus on the assessment of relationships between climate change, water availability and water demand-supply management on a catchment scale, the study has selected one of the water-scarce areas in Africa as a study area. In this regard, two research questions were defined.

i. How sensitive is the study area to climatic change with regard to its water available?
ii. What is the impact to the water quantity in the study area? Will it decrease or increase?

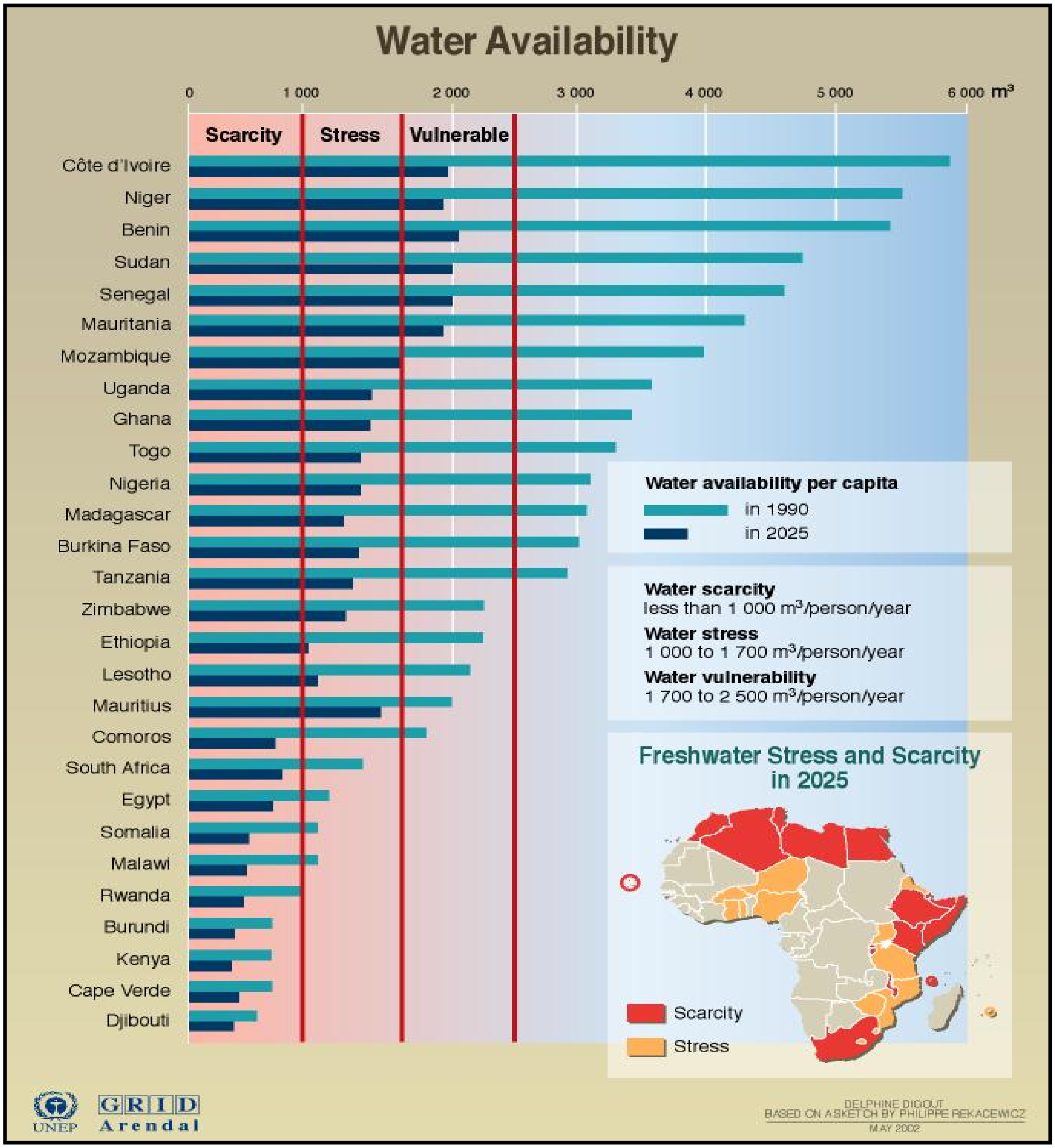

Fig. 1-1: Water availability in Africa under stress due to increasing population pressure and climate change (source: IPCC, 2001)

1.3 Objectives of the study

The main objective of the study is to assess the applicability of WEAP21 as a water balance model for climate impact assessment. More specifically the objectives comprise of:

i. To evaluate the impact of climate change to the water availability in the study area.

ii. To develop a water resources model for the Komati catchment using WEAP21 model.

ii. To assess the sensitivity of the study area to precipitation and temperature change.

iii. To produce a simulation of the projected water availability and to compare the water availability with and without the effect of climate change in the study area

1.4 Limitation of the Study

The study focuses on the assessment of the WEAP21 model and how the Komati catchment could respond to major stresses of climate change in terms of the water availability at the catchment scale. Aiming at this objective, this study does not take into account the other non-climatic impact such as demographic trends, socio-economic and technological development. Moreover, it is beyond the scope of this study to identify the problem of flooding if it may be happened under future climate scenarios perturbed. The study also does not take into account the effect of climate change on the water quality.

1.5 Study Approach

The framework of the study is presented in Figure 1.2.

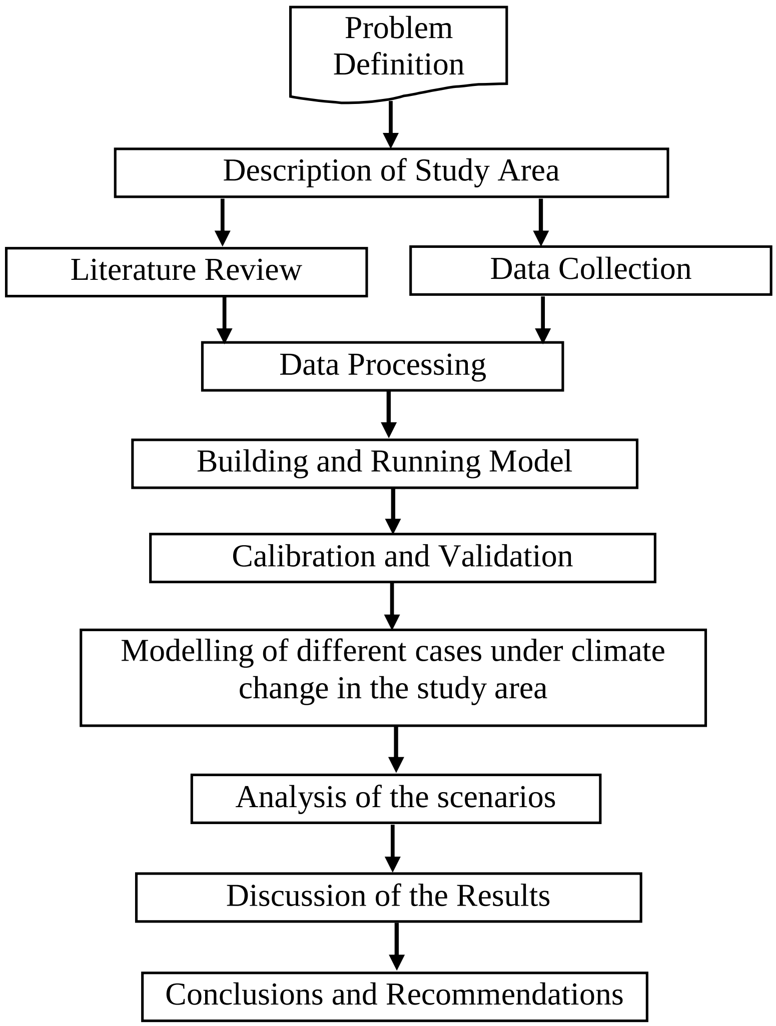

Fig. 1-2: Framework of the study

1.6 Structure of the Report

This thesis is structured into six chapters. A brief summary of each chapter is given below:

Chapter 1: Introduction

Provides a general introduction and address the problems definition of the study. The chapter presents the objectives to be achieved as well as the approach used to evaluate the impact of climate impact on water availability.

Chapter 2: Literature Review

Discusses theories about the causes of climate change and describes its potential impacts to water resources. The using of climate models, hydrological models, and climate change scenarios in order to evaluate the impacts of climate change is presented in this chapter.

Chapter 3: Description of the Study Area

Present an overview of the physical characteristics of the study area. The description of the main features, climate, hydrology and water resources are given briefly in Chapter 3, as a background to evaluate climate model results.

Chapter 4: Methods and Materials

The approach used for climate change studies using WEAP21 model is summarised in this chapter. This chapter also sets out the input data that required to run the WEAP21 model.

Chapter 5 Water Evaluation and Planning (WEAP21) Model

Present a description of the WEAP21 model, which focuses on its applicability as a model for climate impact assessment on a river basin.

Chapter 6 Calibration and Validation

Provides a procedure adopted in this study to adjust parameters values to achieve an optimal fit of model output. Then, the effect on parameter perturbations on model output is presented as well as the validation undertaken in this study.

Chapter 7 Analysis of the Results.

Provide results of the modelling WEAP21. Analysis and discussion of the results which emphasise on the water availability in the study area due to climate change then presented in this chapter.

Chapter 8 Conclusions and Recommendations.

Present principal conclusions which could be drawn from this research. Based on the whole of the study, a set of recommendations also presented in this chapter for further research and development.

2 LITERATURE REVIEW

2.1 Climate Change

The climate changes as a result of variations to components of the climatic systems. Processes in the atmosphere interact strongly with those on land, on and in the oceans, as well as with the cryosphere (those parts of the earth covered with ice) and biosphere. In this respect, the increases of atmospheric concentrations of trace gases such as carbon dioxide, methane, nitrous oxide, tropospheric ozone, the CFCs and others due to human activities enhance the earth's natural greenhouse effect and lead to global warming. As the temperature of the atmosphere rise in response to global warming, the saturation deficit increases, and therefore the warmer atmosphere can contain more moisture. As a consequence, the main greenhouse gases and water vapour will increase, and will result in a positive feedback in global warming.

The above global warming phenomenon has warmed the earth by about 0.7^{o} C during the 20^{th} century (IPCC, 2001; NEAA, 2005). This has not been a gradual process but has occurred mainly in the periods 1920-1945 and 1980-2000, with the years 1995, 1997, 1998, 2001, 2002, 2003, being the warmest since 1860 (NEAA, 2005) as shown in Figure 2.1. Moreover, for the range of scenarios developed in the IPCC Special Report on the Emission Scenarios (SRES), the globally averaged surface air temperature is projected by models to warm 1.4 to 5.8^{o} C by 2100 relative to 1990. Basic to this situation is a recognition that the atmospheric changes are due to both natural fluctuations in climate and anthropogenic activities from the human impact. Furthermore, it is highly likely that GHG emissions will increase over the coming decades.

The IPCC (2001) report, point out that, based on global model simulations and for a wide range of scenarios, global average water vapour concentrations and precipitation are projected to increase during the 21^{st} century. By the second half of the 21^{st} century, it is likely that precipitation will have increased over northern mid to high latitudes and Antarctica in winter. At low latitudes there are both regional increases and decreases over land areas. Larger year-to-year variations in precipitation are very likely over most areas where an increase in mean precipitations is projected.

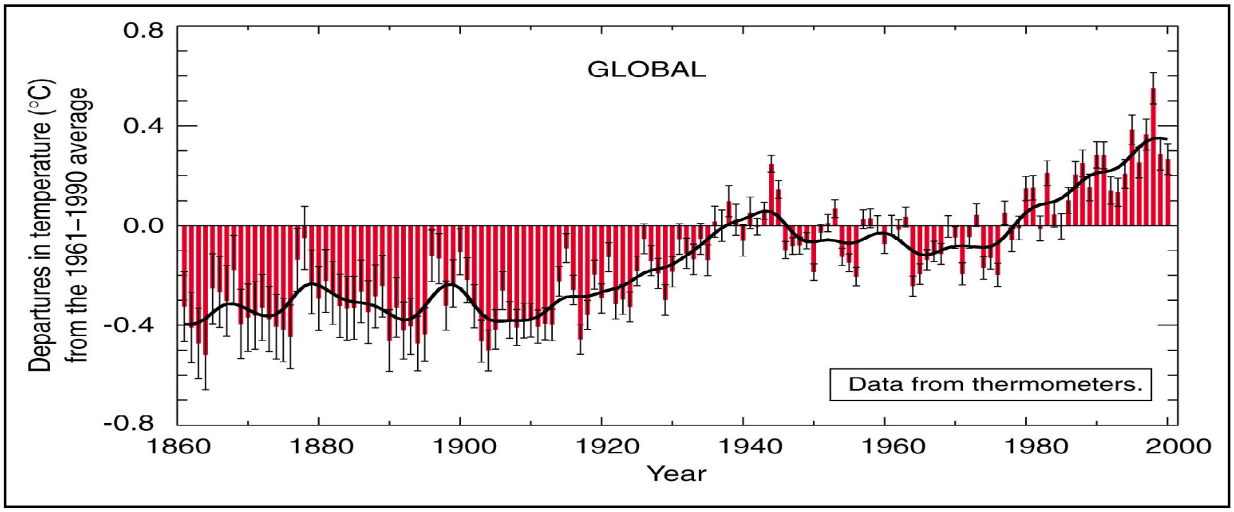

Fig. 2-1: Variations of the Earth's surface temperature for the past 140 years
(Source: IPCC, 2001)

2.2 Projected Climate Change

The Intergovernmental Panel on Climate Change has developed 40 scenarios of future emissions to serve as a primary basis of assessing future climate change and possible strategies. The starting point for each projection of future emissions was a 'storyline', describing the way world population, economies and political structure may evolve over the next few decades (Arnell, 2003). The storylines were divided into four families and led, ultimately to the construction of six "marker scenarios", referred as A1T, A1F1, A1B, A2, B1 and B2 (Giorgi, 2005). The four families can be characterised briefly as follows:

A1: Very rapid economic growth, global population that peaks in mid-century and declines thereafter, and rapid introduction of new and more efficient technologies. Three variants within this family make different assumptions about sources of energy for this rapid growth; fossil intensive (A1F1), non-fossil fuels (A1T) or a balance across all sources (A1B).

A2: High population growth and regionally oriented and per capita economic development. Heterogeneous and market led world. The underlying theme is self-reliance preservation of local identities. Technological change is more fragmented and slower than other storylines.

B1: Same population growth as A1, but development takes a much more environmentally-sustainable pathway with global-scale cooperation and regulation. Clean and efficient technologies are introduced. The emphasis is on global solutions to achieving economic, social and environmental sustainability.

B2: Population increases at lower rate than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in A1 and B1. The scenario is oriented towards environmental protection and social equity, and focuses on locally and regional levels.

Figure 2.2 shows the carbon emissions associated with each emissions scenario, together with the change in global temperature under each scenario.

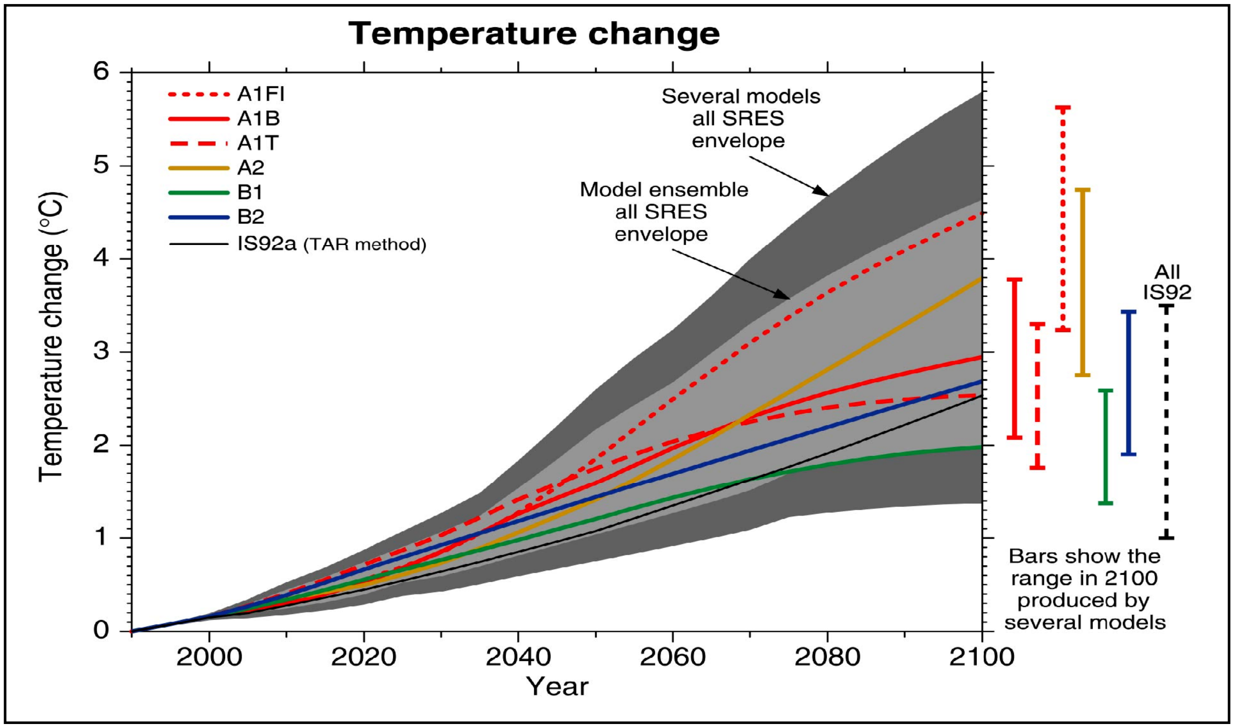

Fig. 2-2: Projected global temperature change (Source: IPCC, 2001)

2.3 Climate Change Impact Analysis

The behaviour of the climate system, its components and their interactions, can be studied and simulated using tools known as climate models. These models are designed to explore the effect of changes in factors such as greenhouse gases, small aerosol particles from human-made and volcanic sources, and solar output (DETR, 1997). Each component or coupled combination of components of the climate system can be represented by models of varying complexity. The most sophisticated process based models that simulate the climate system is the General Circulation Models (GCMs) (Leavesley, 1994; Sharif et. al., 2006).

General circulation models are numerical models based on the fundamental mathematical equations, which able to simulate many features of the climate. By simulating plausible climate scenarios, these models help identify climate outcomes consistent with physical laws and understood changes taking place in atmospheric composition. (Williams et. al., 1998). State-of-the-art GCMs are coupled atmosphere-ocean models, i.e. a model simulating surface and deep ocean circulations is 'coupled' to an atmospheric GCM.

Unfortunately, although the models have been shown unambiguous evolution in many years during the past three decades, there are many arguments of critism with regard to their dominance in the exercise to derive climate change scenarios (Varis et. al., 2004). Indeed the numerical climate projections based on AOGCMs are still very uncertain at the regional scale (Douville, 2005). For instance, due to relatively coarse spatial resolution (order of few hundred km), AOGCM models are often not suitable for simulating detailed regional climate patterns. As a result, a number of "regionalisation techniques" have been developed in the last decade or so to enhance the regional information obtained by AOGCMs and to provide fine spatial and temporal scale climate details (Giorgi, 2005; IPCC, 2001).

2.4 Climate Change Impact on Hydrology and Water Resources

Changes in climate due to an increasing concentration of greenhouse gases have obvious effect on the hydrological cycle. In a warmer climate, more moisture will be hold by warm air in the atmosphere, resulting greater volumes of water evaporates from plants, soils and water bodies. With more moisture in the atmosphere, rainfall and snowfall events tend to be more intense, according to the principle of the hydrological cycle, 'what goes up must come down'. Notably, change in climate induces a change in the hydrological cycle, which in turn induces a change in climate, and so on.

Climate change will have an effect on water resources in many regions. It could further decrease the streamflow and groundwater recharge in many water-scarce areas in the world particularly in arid and semi-arid countries. Streamflow during seasonal low flow periods would decrease in many areas due to greater evaporation. Decreased river flows and higher temperatures, then, would degrade water quality of the rivers. Flood magnitude and frequency could increase in many regions as a consequence of increased precipitation events. Changing climate will cause sea level rise, resulting saline water intrusion into ground water aquifers near the coasts and will decrease the available groundwater resources. Clearly then, impacts on water availability are among the most direct results of climate change (Gleick, 1986; Bobba et. al, 1999; Bronstert et. al., 2005).

Nowadays, the problem of access to adequate and safe water supply is far from being solved at the global scale. Renewable water resources are increasingly recognised as essential to the sustainability of human societies, but approximately 1.7 billion people, roughly one-quarter of the world's population, currently live in countries experiencing water stress (IPCC, 2001). Climate change may worsen these patterns, with some parts of the world receiving more precipitation, and other less. Because of evapotranspiration, temperature increases will raise the water demand of ecosystems, and climate change will also impact the availability and quality of freshwater resources. Therefore, whether beneficial or detrimental, climate change will affect the global freshwater which in turn, will affect many areas of life, including human welfare, domestic and international policies, trading patterns, and resources use.

2.5 Evaluating Regional Hydrologic and Water Resources Impacts of Climatic Changes.

The modelling of water resources systems with respect to climate variations requires certain types of simulation models, often called causal and physically based, simulating hydrological processes within the basin. Therefore, if realistic estimates of actual changes in water availability are to be calculated, regional hydrologic evaluations need to incorporate the complexities of snowfall and snowmelt, topography, soil characteristics, natural and artificial storage, hydrologic variability, and monthly or seasonal variations. Moreover, they need to incorporate information on future climatic changes to the extent that such information is available (Gleick, 1986). The models that are use to evaluate the impact of climate change on hydrology and water resources usually operate in simulation mode.

Numerous modelling approaches have been developed and previous models have been modified to assess the impacts of climate change on water resources. It should be noted however, that each model and approach presents advantages and disadvantages. The selection of models as well as modelling approaches is normally a function of problem objectives, data constraints, and the spatial and temporal scales of application. Therefore, before choosing techniques for assessing the regional hydrologic effects of climatic changes, criteria for using regional models must be set forth (Gleick, 1986).

Considering all the above issues, this study utilises the integrated hydrology / water allocation model, WEAP21 to evaluate the impact of the climate change on water resources availability. This model has been chosen because of its uniquely suited to introducing climate change assessment into water management decision-making process and an understanding of trade-off. Many studies using this model to assess the potential impacts of climate change associated to local water resources, for instance:

- To assess the potential impacts of climate change on its ability to achieve proposed new instream flow requirement in the South Fork of the American River.

- To identify and evaluate the likely impacts of climate change and other stressors on the provision of aquatic ecosystem services.

- SEI-Boston worked with a team to model the links between climate change scenarios, hydrological responses, and agricultural productivity. WEAP was used to study existing and future water availability for agriculture in multiple river basins throughout the world.

2.6 Methodology to Evaluate Regional Hydrologic Impact

The basic method for estimating the impacts of climate change on hydrological behaviour has the following stages:

(1) Determine the parameters of a hydrological model in the study catchment using current climatic inputs and observed stream flows for model validation.

(2) Perturb the historical time series of climatic data according to some climate change scenarios

(3) Simulate the hydrological characteristics of the catchment under perturbed climate using the calibrated hydrological procedure.

(4) Compare the model simulations of the current and possible future hydrological characteristics.

2.7 Generating Climate Change Scenarios

In order to assess the impacts of climate change and to develop efficient climate adaptation strategies, a means of generating future climate scenarios is required. An introduction to different methods which are used to develop climate scenarios as an input to hydrological models are presented in Section 2.7.1, 2.7.2 and 2.7.3.

2.7.1 GCM Based Scenarios

GCM-based scenarios are the most credible and frequently used of developing climate scenarios Ideally, the climate simulations from GCMs could be used directly to drive hydrologic models, which in turn could be used to evaluate the hydrologic and water resources effects of climate change. However, the main problem in this method is the scale mismatch between GCM resolution (data generally provided on a monthly time step at a spatial resolution of several thousands of square kilometres) and catchment hydrological models, which require data on daily scales at resolution of a few square kilometres (IPCC, 2001). Moreover, different GCMs are still giving different values of climate variables changes and so do not provide a single reliable estimate that could be advanced as deterministic forecast for hydrological planning (Xu, 2000)

2.7.2 Analogue Scenarios

Analogue scenarios are constructed by identifying recorded climate regimes which may resemble the future climate in a given region. It involves the use of past warm climate (temporal analogue scenario), or the use of current warm climate in another location as a scenario of future climate in the study area (spatial analogue scenario).

2.7.3 Hypothetical Scenarios

In the hypothetical scenario, simple alteration to existing conditions is applied to generate future climates scenarios. Such scenarios specify average annual changes in temperature and precipitation by simple adjustment, typically, $\Delta T = +1, +2$ and $+4\ ^{0}C$ and $\Delta P = 0, \pm 10\%, \pm 20\%$. The advantage of the hypothetical scenario approach is its simplicity in representing a wide range of alternative scenarios.

2.8 Methods for Generating Climate Scenarios Adopted in the Study

As mentioned in section 2.7.1., the preferred method in projecting future scenarios are usually those derived from GCMs albeit their limitations of grid-point predictions. Nevertheless, use of hypothetical scenario is another option used by researchers in climatic impact studies (Islam et. al., 2005). Many published works were done in this way (e.g. Gleick, 1987; McCabe and Wolock, 1991; Skiles and Hanson, 1994; Yates, 1996; Boorman and Sefton, 1997; Bobba, Jeffries and Singh, 1999; Hailemariam, 1999; Xu, 1999, 2000; Islam, Aramaki and Hanaki, 2005). From this perspective and aiming to the main objective of the study to assess the applicability of WEAP21 as a DSS for climate impact assessment on a river basin, the hypothetical scenario was chosen to generate scenarios because of its simplicity.

3 DESCRIPTION OF THE STUDY AREA

3.1 Physical Features of the Komati River Basin

The Komati catchment is one of major catchment in Incomati Basin (Figure 3.1). It is one of the international catchments in Africa which is shared by Swaziland and South Africa. The Komati river, which is also shared by the same countries originates from this catchment. The Komati catchment has a total catchment area of about 11,200 Mm^2, which comprises the Komati river and its tributary the Lomati river. About 2,560 Mm^2 of the catchment falls in the northern part of Swaziland and the remainder is in South Africa. The Komati river originates just upstream of Nooitgedacht Dam near the town of Carolina in Mpulanga, South Africa. It flows and passes through Northern Swaziland before flowing back to South Africa and joining with Crocodile River. The river then flows into Mozambique at Ressano Garcia. The total length of the river from its source to the confluence with the Crocodile River is approximately 450 km (Nkomo et. al., 2004). Several smaller rivers contribute to the Komati and Lomati in the lower reaches of the river.

3.2 Description of the Vygeboom Sub-catchment

There are six sub-catchments in the Komati river basin, namely Vygeboom, Upper Komati, Lower Komati, Swaziland, Upper Lomati and Lower Lomati. To assess the applicability of the WEAP21 model, only one of these sub-catchmanets was selected for further analysis i.e Vygeboom sub-catchment. The Vygeboom sub-catchment is one of major sub-catchment and is the most upstream part of the Komati catchment. It has a total catchment area of about 3,156 km^2. For the purposes of water resources management, this sub-catchment is formally divided into eight small catchments (known as quaternary catchments) that have similar mean runoff. The quaternary catchments which lie in the Vygeboom sub-catchment are numbered as X11A, X11B, X11C, X11D, X11E, X11F, X11G and X11H (DWAF Report, 2003). The Vygeboom sub-catchment with its quaternary catchments is shown in Figure 3.2.

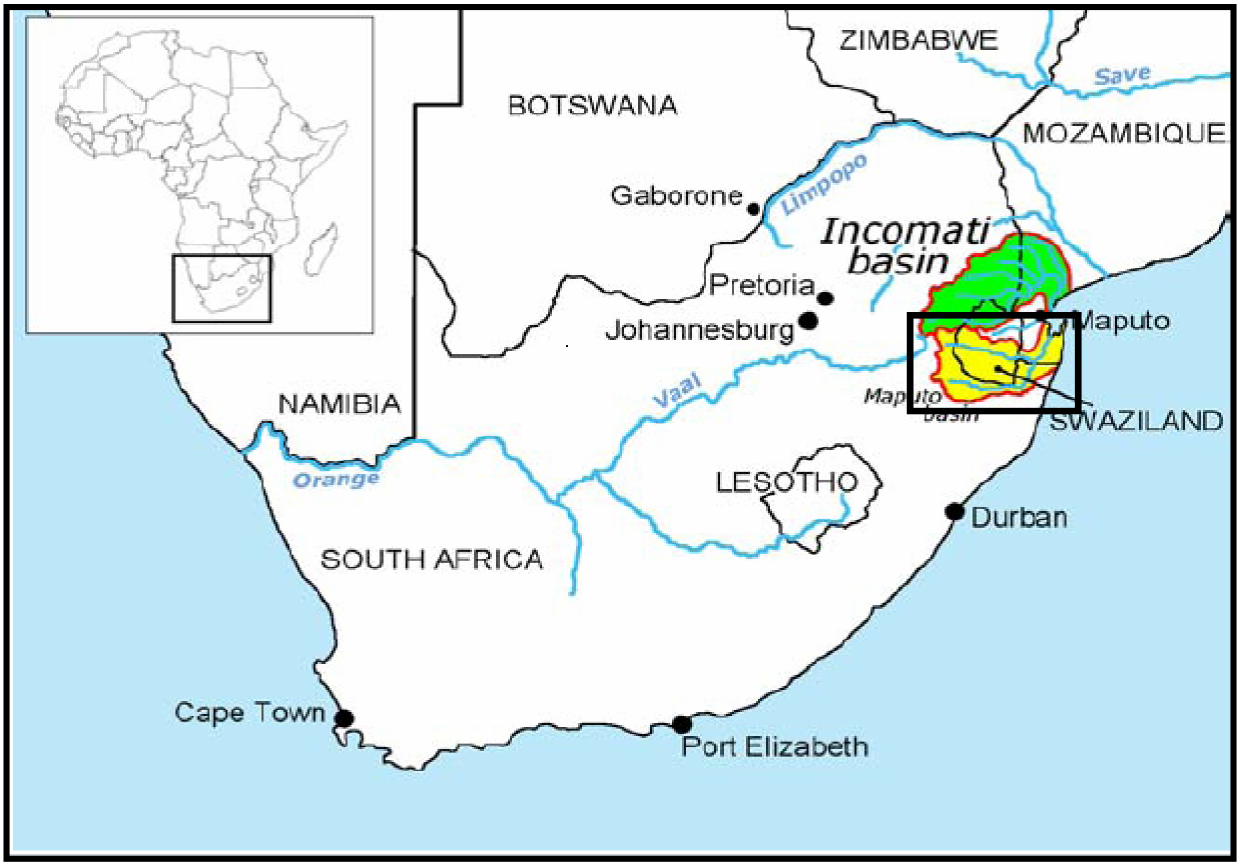

Fig. 3-1: Location of the Komati basin (Source: www.mxa.co.za)

3.3 Climate

The catchment experiences a subtropical type of climate. It is therefore, characterised by wet humid summers and with cool dry winters. The mean annual temperature in the study area is approximately 17 ^{O}C. Maximum temperatures are expected in January and minimum temperatures usually occur in June. Rainfall is seasonal with most rain in the summer months of October to March and it generally increases from east to west. The catchment has a mean annual rainfall of 800 mm/a. The peak rainfall months are December and January. The rainfall regimes that bring rainfall to the catchment are convectional and tropical storms during summer and frontal showers during winter. Temperatures are influenced by variations in elevation, terrain, and ocean currents. The potential evaporation decreases from east to west due to lower temperatures in mountainous western part of the catchment (Nkomo et. al., 2004).

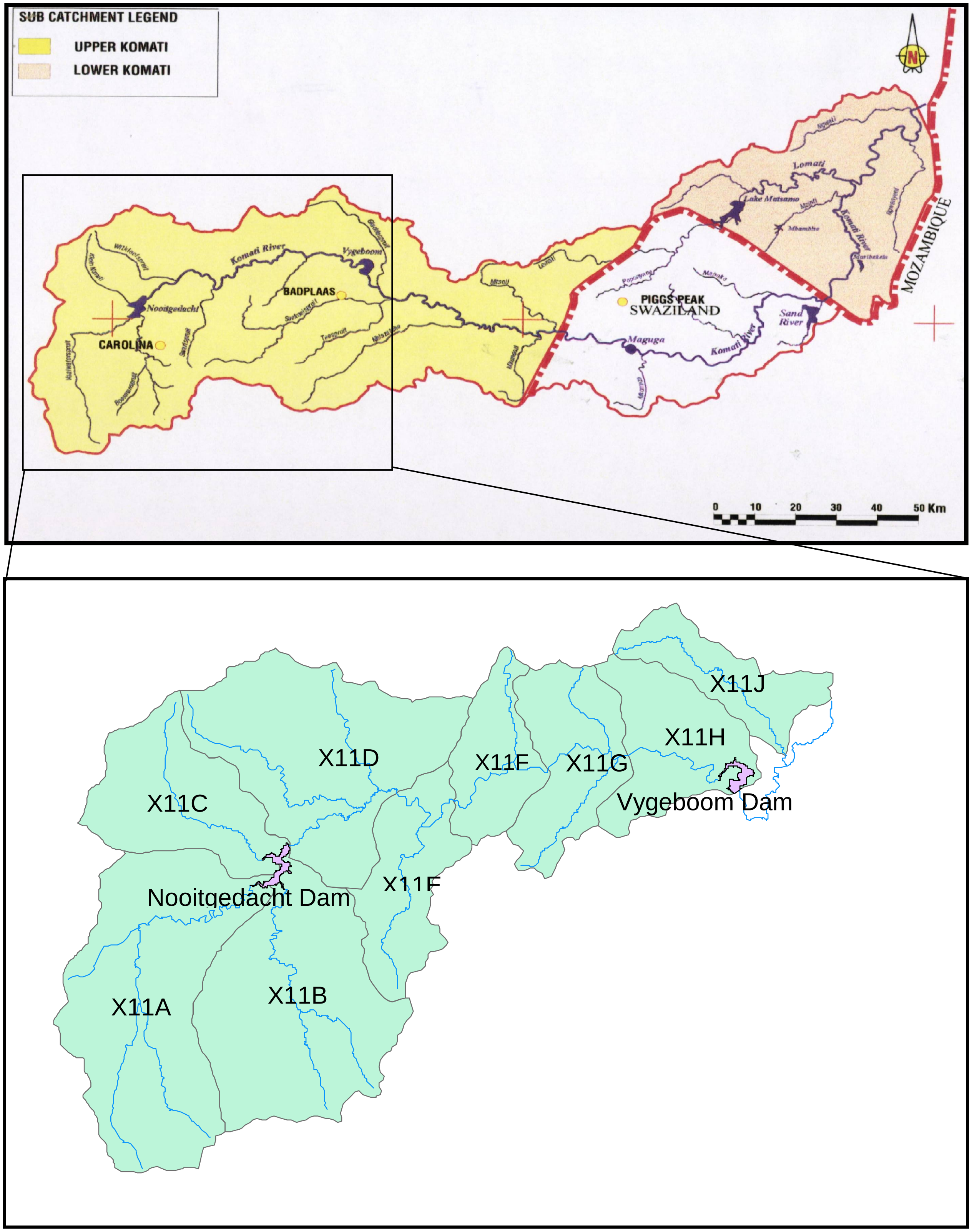

Fig. 3-2: The Komati catchment and the Vygeboom sub-catchment with its quaternary catchment

3.4 Geology

The Komati catchment consists of two broad lithostratographic units. These units are (WMA, 2003):

- Compact openaceous and argillaceous strata
  Deep residual sandstone soils are common, with isolated cases of collapsible fabric. The residual mudrock soils are medium to highly expansive. Numerous coal seams occur within the sedimentary rocks of the Karoo sequence. Coal mining activity exists in the Transvaal plateau and the Lowveld region.

- Compact sedimentary strata
  There are several different formations, consisting of a variety of sedimentary rock types, including quartzite, shale, conglomerate, siltstone, breccia and diamictite. The residual soils are in general very shallow. Significant mineral deposits include gold, arsenic, copper and sulphur.

3.5 Soils

Large parts of the Komati catchment are covered by moderately deep sandy loam, with undulating relief. In the western part of the catchment, there are also occurrences of moderately deep clayey loam, with undulating relief.

3.6 Land Use

The total physical area of the Vygeboom sub-catchment amounts to 3156 km^2. The different land uses in the Vygeboom sub-catchment have been grouped into the following (www.dwaf.gov.za/iwqs/gis_apps/drain2/lc/sec_lc.html):

- Alien vegetation: 27.44 km^2 (0.87% of the total sub-catchment area)
- Thicket and bushland: 70.22 km^2 (2.23% of the total sub-catchment area)
- Unimproved grassland: 2,359.00 km^2 (74.75% of the total sub-catchment area)
- Exotic forest: 121.25 km^2 (3.84% of the total sub-catchment area)
- Waterbodies: 27.67 km^2 (0.88% of the total sub-catchment area)

- Wetlands: 5.42 km^2 (0.17% of the total sub-catchment area)
- Temporary crops, commercial and irrigated: 31.51 km^2 (1.0% of the total sub-catchment area)
- Temporary crops, commercial, dryland: 503.66 km^2 (15.96% of the total sub-catchment area)
- Urban, residential: 6.71 km^2 (0.27% of the total sub-catchment area)
- Urban, industries: 0.16 km^2 (0.01% of the total sub-catchment area)
- Barerock: 0.13 km^2 (0.004% of the total sub-catchment area)
- Mines and quarry: 3.26 km^2 (0.1% of the total sub-catchment area)

Figure 3.3 shows parts of land use in the Komati river basin.

3.7 Demography

In 1995, the population in the Vygeboom sub-catchment is 31,439 people, and consists of an urban population of 21,250 people and a rural population of 10,189 people.

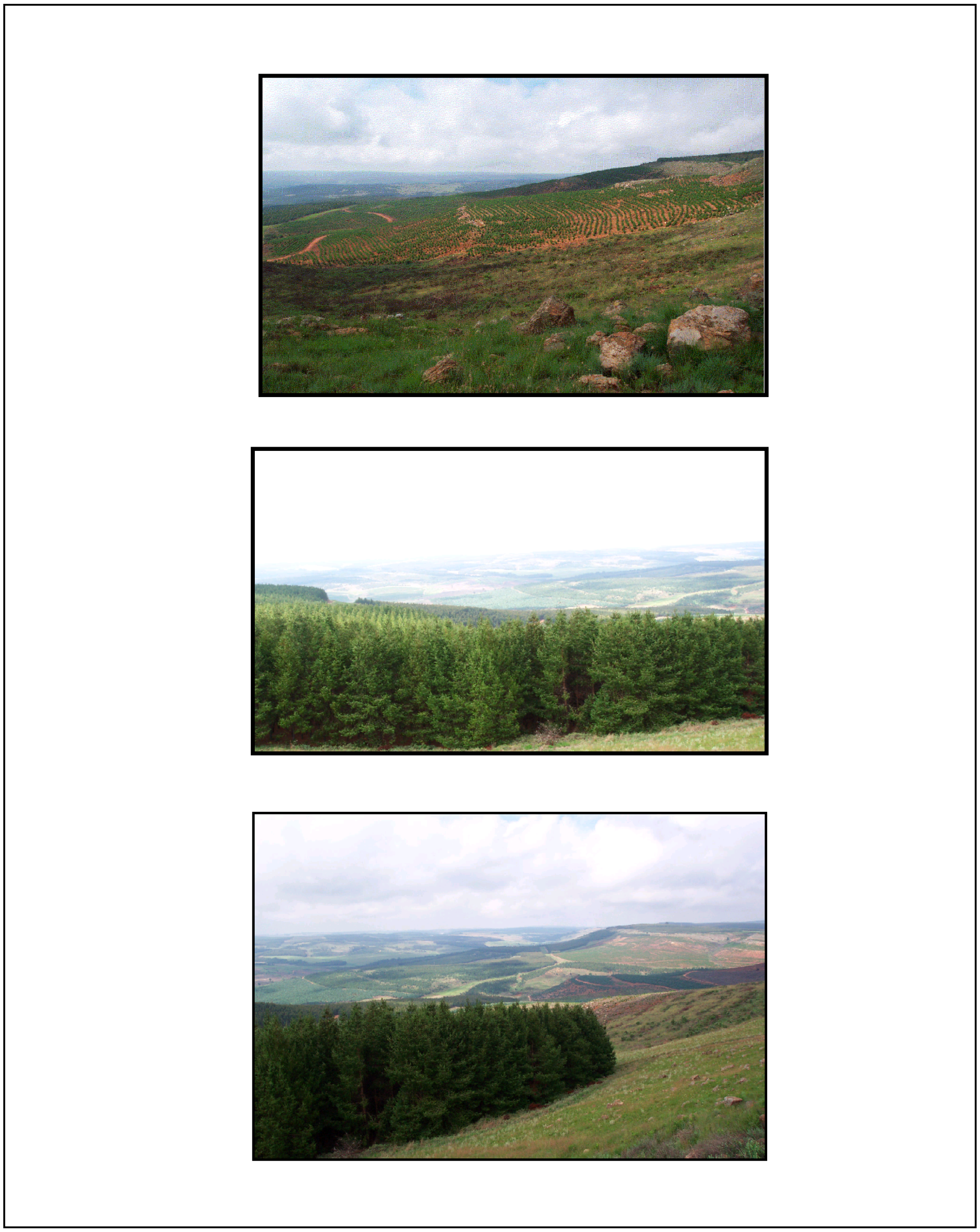

Fig. 3-3: Parts of land use in the study area

4 METHODS AND MATERIALS

4.1 Methods

The general methodology adopted in this study can be described in steps as follows:

4.1.1 Data gathering and Data Processing

Data gathering and processing is the most important step for the modelling. In this study, the hydrological and meteorological data were obtained from Bioresources Engineering and Environmental Hydrology (BEEH), University of Kwazulu Natal, South Africa and the rest (streamflow, land use, water use, etc) has been gathered from the website of the Department of Water Affairs and Forestry (DWAF), South Africa A careful work in ensuring that the best possible data set is used will generally speed up the calibration process. In the data processing stage, it has been noticed that there are some missing data on the streamflow data. Therefore, only a period of 1972 to 1992 of the streamflow data has been chosen for the calibration and validation purposes.

4.1.2 Development of an appropriate WEAP21 Model.

In order to analyse the hydrological process within the study area, it is first need to be represented in the WEAP21 model. Therefore, the Vygeboom sub-catchment with all natural hydrology of the watershed details as well as the infrastructure of the water supply system have been applied in the WEAP model for further analysis. The schematic of the Vygeboom sub-catchment as represented in the WEAP21 model is shown in Figure 4.1.

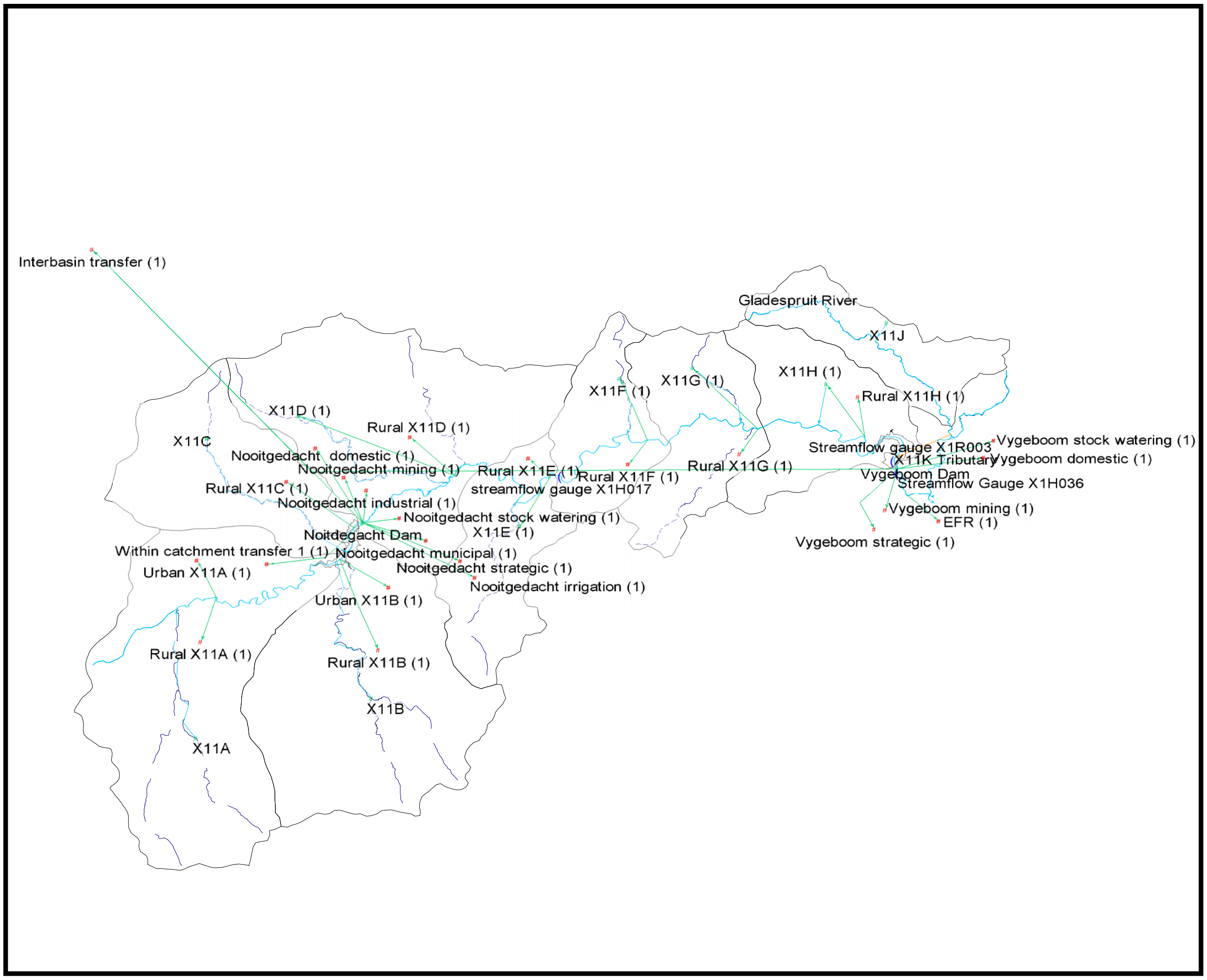

Fig. 4-1: Schematisation of the study area in WEAP21 model

4.1.3 Calibration and Validation of the WEAP21 Model

Model calibration is a procedure to adjust parameter values to achieve an optimal fit of the model output to the corresponding measurement. Calibration procedures in hydrological modelling usually aim to fit simulated data to observed data from gauging stations. The calibration procedure aims at minimizing the difference between simulated and observed stream flows. However, variations between the model and observed data are always expected.

Model calibration then followed by model validation in order to assess the performance of the model. An obvious validation is first made by comparing graphically the simulated values with the observed values. However, this enables only an assessment of the overall adequacy of the model to the observation (streamflow).

There are a large number of objective functions that can be used to estimate the goodness-of-fit of the simulation. Choosing one of these functions for calibration or validation is not easy, as the function chosen depends on the application of the model. In this study, the objective functions used for calibration were coefficient of determination *(R^2)*, Nash-Sutcliffe coefficient of efficiency (*CE*), percentage error in total runoff volume *(VE)* and percentage error in peak discharge *(PE).* A brief summary of each objective function used is presented in the following:

- Coefficient of determination:

$$R^2 = \left(\frac{\sum_{i=1}^{n} \left(Q_{obs,i} - \overline{Q_{obs}}\right)\left(Q_{sim,i} - \overline{Q_{sim}}\right)}{\sqrt{\sum_{i=1}^{n} \left(Q_{obs,i} - \overline{Q_{obs}}\right)^2} \sqrt{\sum_{i=1}^{n} \left(Q_{sim,i} - \overline{Q_{sim}}\right)^2}} \right)^2 \qquad \text{Eq. 1}$$

Where,

$Q_{obs,i}$	=	measured discharge at the i^{th} time interval
Q_{obs}	=	mean of the measured discharge
$Q_{sim,i}$	=	simulated discharge at the i^{th} interval
Q_{sim}	=	mean of the simulated discharge
n	=	number of observations

The range of R^2 lies between 0 and 1 for perfect fit. The largest disadvantage of the coefficient of determination is that when a model which systematically over- or under-predicts all the time it will still result in a good R^2 values close to 1.0, even if all the predictions were wrong.

- The Nash-Sutcliffe coefficient of efficiency:

$$CE = 1 - \frac{\sum_{i=1}^{n} \left(Q_{obsi} - Q_{simi}\right)^2}{\sum_{i=1}^{n} \left(Q_{obsi} - \overline{Q_{obsi}}\right)^2} \qquad \text{Eq. 2}$$

Where:

CE	=	Nash-Sutcliffe coefficient of efficiency
Q_{obsi}	=	The observed discharge at the time step i
$\overline{Q_{obsi}}$	=	The mean of the observed discharge
Q_{simi}	=	the simulation discharge at the time step i
N	=	number of observations

The Nash-Sutcliffe coefficient of efficiency indicates how well the plot of observed versus simulated value fits the 1:1 line and is commonly used in hydrologic model evaluations. If the measured variable is estimated most accurately by the model, then $CE = 1$; If the CE is negative, the quality of the model results is smaller than the average value of the measured variables.

- Percentage error in total runoff volume*:*

$$VE = \frac{\sum_{i=1}^{n}\left(Q_{sim,i} - Q_{obs,i}\right)}{\sum_{i=1}^{n} Q_{obs,i}} * 100\% \qquad \text{Eq. 3}$$

Where:

VE	=	percentage error in total runoff volume
$Q_{sim,i}$	=	the simulated discharge at the time step i
$Q_{obs,i}$	=	the observed discharge at the time step i

For a perfect model, *VE* equals to 0. The smaller the VE, the better the performance of the model.

- Percentage error in peak discharge:

$$PE = \frac{\sum_{i=1}^{m}\left(Q_{sim,p,i} - Q_{obs,p,i}\right)}{\sum_{i=1}^{m} Q_{obs,p,i}} * 100\% \qquad \text{Eq. 4}$$

Time difference between observed and simulated peaks *(PT)*

$$PT = T_{sim,p} - T_{obs,p}$$

where,

$Q_{sim,p,i}$	=	the simulated peak flows
$Q_{obs,p,i}$	=	the observed peak flows
m	=	the number of peak flows
$T_{sim,p}$	=	time the simulated peak occur
$T_{obs,p}$	=	time the observed peak occur

PE provides an indication of the relative absolute accuracy of models in predicting peak flows and ranges from -∞ to +∞ (negative values indicate a general underestimation of peak flows while positive values indicate a general overestimation of peak flows). The *PT* is a measure of the timing difference between the observed and simulated peak flows. It is generally used in conjunction with the *PE* criterion. Given the observed and simulated peak flow where the *PE* is small and the *PT* is large, one can conclude that both peak flows share a similar volume but their timing is not as close. Thus a good agreement in timing and volume requires *PE* and *PT* to be small.

4.1.4 Adopting some expected future climatic changes

For southern Africa, high-resolution GCMs predict a +2 ^{O} C (Mitchell et. al., 1991). In this regards, hypothetical increases in temperature of +2 ^{O} C combined with a change of plus and minus 10% in precipitation have been applied to the 1972 to 1992 historical data to develop climate change scenarios for further analysis. Combinations of temperature and precipitation changes provides four different scenarios as summarised in Table 4.1 which have been used for further analysis with regards to the water availability in the basin.

4.1.5 Model application for the projected climatic scenarios selected

Once the model is simulating the streamflow (calibration) satisfactorily, four developed climate change scenarios for the study area are then being applied to the WEAP21 model for simulation. Then, the climatically affected runoff, evapotranspiration, water demand, water supplied series would be obtained as output of the WEAP21 model.

Table 4-1: Hypothetical climate change scenarios

Scenario	ΔT (^{0}C)	ΔP (%)
Base Case	0	0
Scenario 1	+2	0
Scenario 2	+2	+ 10%
Scenario 3	+2	- 10 %

4.1.6 Quantifying water availability due to the changing climate

The final stage is to quantify the water availability in all scenarios from the simulation of the model. The water availability within the sub-catchment will be evaluated based on the following output of the WEAP21 model:

Difference in storage of the Nooitdegacht dam + Difference in storage of the Vygeboom dam + Outflow to downstream from the Vygeboom dam + Supply delivered form both dams.

The water availability in each scenarios then being analysed in order to evaluate the sensitivity of the study area to climate change.

4.2 Data Requirement

The information required to carry out the analysis in this study are: hydro meteorological, water use in all sectors, land cover etc. Hydro meteorological information that has been collected included: average monthly rainfall, temperature, humidity and streamflow.

4.2.1 Rainfall

One of the basic inputs in the process of assessing impacts of climate change on water resources is historical rainfall data within the specified catchment (Matondo et. al., 2004). The monthly rainfall data for all quaternary catchments were obtained from the BEEH. Although the historical precipitation data from 1950 to 1999 available, the historical precipitation data from 1972 to 1978 was used for calibration due to the streamflow data during this period available.

Then, the monthly time series data from 1972 to 1992 were used to generate the variation in monthly total rainfall due to climate change during the period of analysis, between 2010 and 2030. The rainfall pattern over each quaternary catchment is shown in Figure 4.2. The precipitation over quaternary catchment is ranging between 0 and 373.9 mm. In total, quaternary catchment X11G received the most precipitation (10,854 mm) while quaternary catchment X11B received the least precipitation (7,657 mm) during this period. The avearage precipitation received by each quaternary catchment is ranging between 62.25 mm (X11B) and 88.25 mm (X11G). Detail of the precipitation data is shown in the Appendix A.

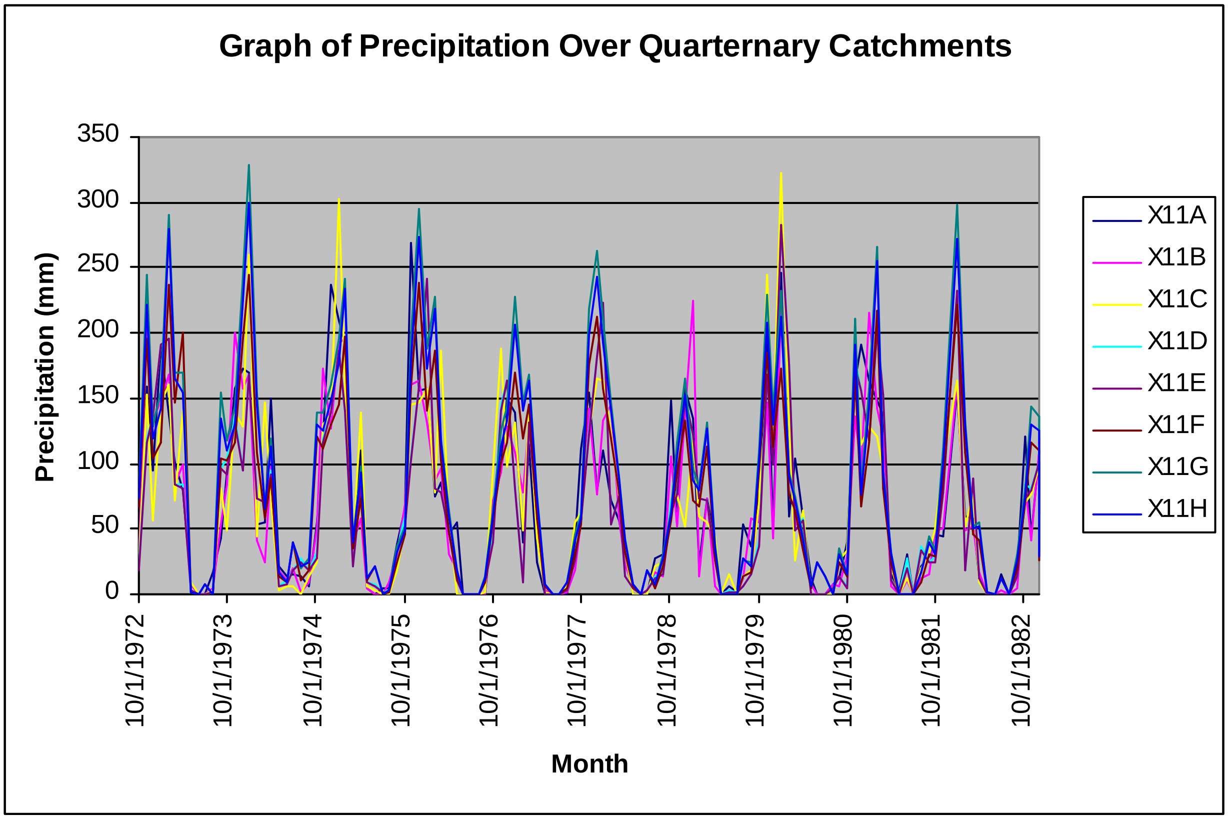

Fig. 4-2: Precipitation pattern over each quaternary catchment

4.2.2 Temperature

Temperature data is mandatory in evaluating the impact of climate change using WEAP21 model. The temperature data was obtained from BEEH as well. Similar to the case for precipitation data, the period 1972 to 1978 has been used for calibration and the period of 1972 to 1992 has been used to generate the temperature pattern for the period of 2010 to 2030 in order to assess its impact on water available. Such data are shown in the Appendix A

4.2.3 Streamflow

The observed streamflow data were obtained from DWAF, which has two measuring stations, X1H017 and X1R003. Station X1H017 is located just downstream of the X11E quaternary catchment (halfway the Vygeboom sub-catchment) and station X1R003 is located just downstream of the Vygeboom reservoir. The locations of both stations are shown in Figure 4.3

The common periods available from these stations were between 1972 and 1982. The streamflow data from station X1H017 are less reliable because it has been noticed that a ‘strange’ streamflow data reading for the month of December 1976 and January 1977. Such reading were about 51-56 Mm^3/month higher than what was recorded at station X1R003. Its normal readings were most of the time smaller than what was recorded at station X1R003. In this case, the streamflow data from station X1R003 was most reliable and will be used for the streamflow anlysis under different climate scenarios.

Figure 4.4 shows the observed streamflow at station X1H017 and X1R003 for the period of 1972-1982. At station X1H017, the maximum monthly streamflow is around 81Mm^3/month which was recorded in the month of December 1976 while the minimum monthly streamflow is around 0.5 Mm^3/month and occurred in the period of June to December 1982. In average, the streamflow at this station is equal to 10.3 Mm^3/month throughout 10 years period (1972-1982)

At station X1R003, the maximum and minimum monthly streamflow were 155 Mm^3/month and 0 Mm^3/month respectively. The maximum monthly streamflow was recorded in the month of February 1974 while the minimum streamflow was recorded in between the period of May to November 1979, September-October 1980, and June-December 1982. The average streamflow for the period of 1972-1982 at this station is 27.0 Mm^3/month.

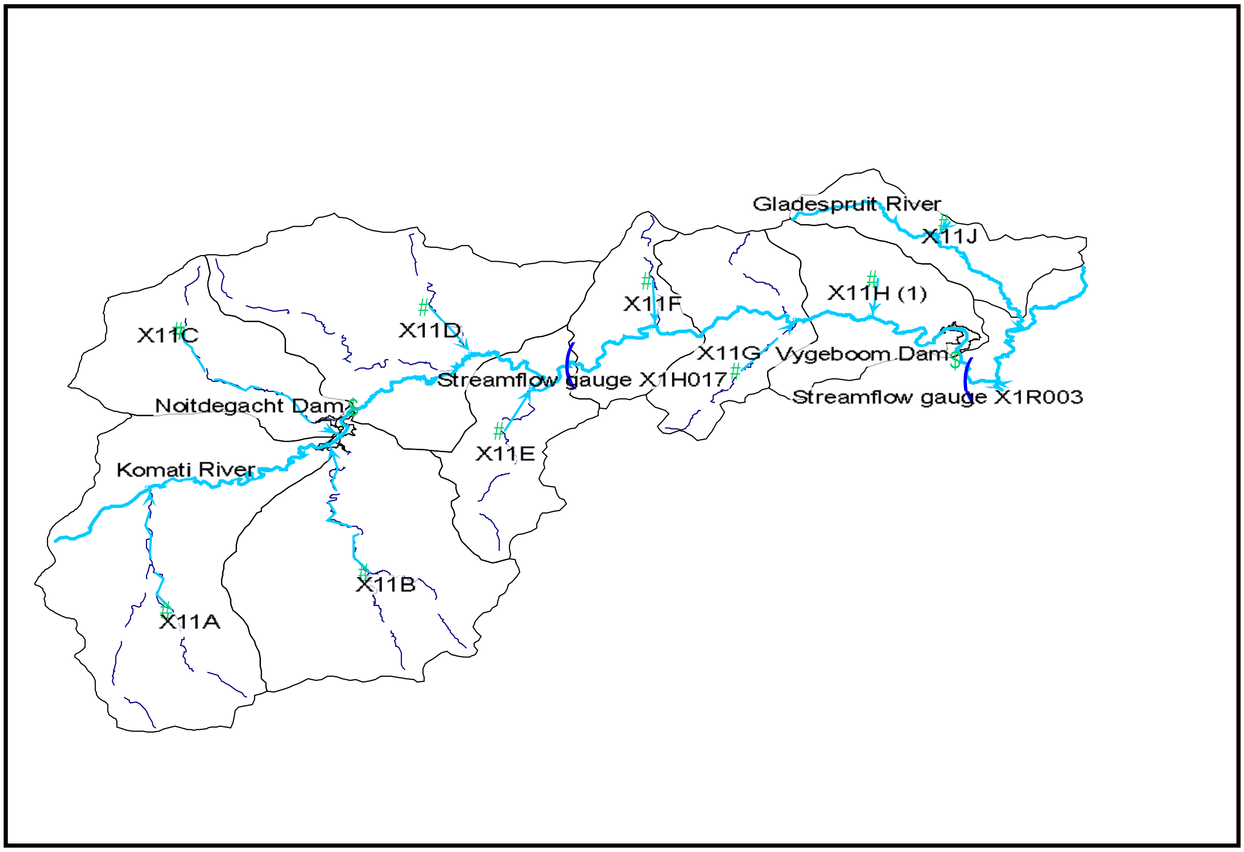

Fig. 4-3: Location of the X1H017 and X1R003 streamflow gauge stations

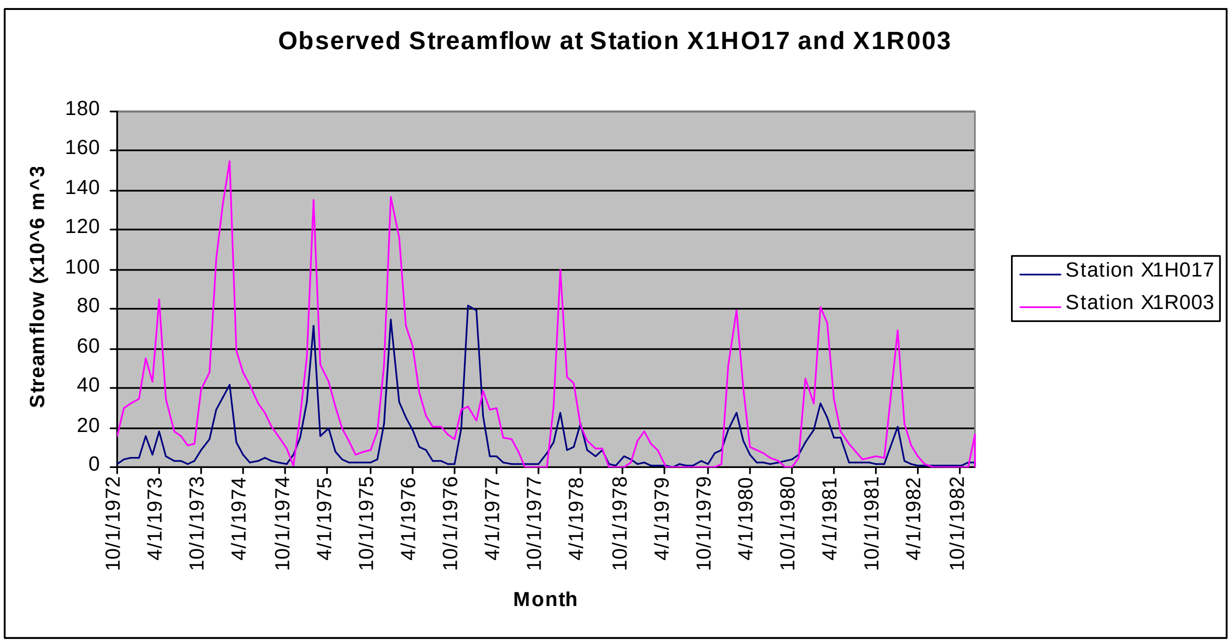

Fig. 4-4: Graph of the observed streamflow at station X1H017 and X1R003 from Oct. 1972 to Sept. 1992

4.3 Water Using Activities

4.3.1 Rural and Urban Water Use

The unit water used in this study is 250 l/c/d for urban population and 55 l/c/d for rural population. Table 4.2 shows the population distribution in each quaternary catchment with its estimation of water consumption.

Table 4-2: Water consumption for rural and urban population

Quaternary Catchment	Urban		Rural	
	Population	Water Used (Mm^3/annum)	Population	Water Used (Mm^3/annum)
X11A	11,950	1.1	2,013	0.04
X11B	9,300	0.8	2,485	0.04
X11C	0	0	1,333	0.03
X11D	0	0	1,959	0.04
X11E	0	0	486	0.01
X11F	0	0	310	0.01
X11G	0	0	476	0.01
X11H	0	0	1,127	0.02

4.3.2 Irrigation

The total irrigated area for each quaternary catchment is shown in Table 4.3.

Table 4-3: Total irrigated area for each quaternary catchment

Quaternary Catchment	Total Water used by Irrigators (Mm^3/annum)
X11D	3.93
X11E	1.60
X11F	1.48
X11G	1.45
X11H	191

4.3.3 Water Transfers

Large amounts of water are transferred from the Komati Catchment to the Olifants catchment for use in several thermal power stations in this area. The transfer to the Olifants catchment is given as 85 Mm^3/annum in the WMA report while current transfers have increased to the 1:200 year yield of this system, which is 97 Mm^3/annum (ISP, 2004). Other large water transfers include irrigation transfers from the Komati River Catchment to the adjacent Mbuluzi River Catchment (46.5 Mm^3/annum), as well as several smaller irrigation transfers throughout the area (unfortunately, such data is not available due to only those transfers over quaternary catchment are taken into account in the WMA).

4.3.4 Existing Water Related Infrastructure

Two significant dams, the Nooitgedacht and Vygeboom dams, are situated in this sub-catchment. These dams make up the majority of the available yield in the upper part of the Komati catchment. The total storage capacity of the Nooitgedacht dam is about 78.8 million m^3 while the Vygeboom dam has a total storage capacity of about 79.2 million m^3. The reservoir operations used in this study are shown in Table 4.4. These two dams are important for several activities in the Komati river basin. Table 4.5 shows the uses with their amount allocated.

Table 4-4: Operation of the Nooitgedacht and Vygeboom dams

Physical and operation of the dams	Nooitgedacht dam	Vygeboom dam
Storage capacity	78.8 Mm^3	79.2 Mm^3
Intial storage	39.4 Mm^3	39.6 Mm^3
Top of conservation	70.9 Mm^3	71.3 Mm^3
Top of buffer	31.5 Mm^3	31.7 Mm^3
Top of inactive	3.9 Mm^3	4.0 Mm^3

Table 4-5: Water uses for the Nooitgedacht and Vygeboom dams

	Amount Allocated (m^3)	
	Nooitgedacht	Vygeboom
Inter basin transfer	52,000,000	45,000,000
Domestic	15,500	19,6005
Mining	5,500,000	5,000,000
Industrial	157,000	-
Stock Watering	50,000	21,500
Municipal	637,000	
Strategic	45,000,000	17,500,000
Irrigation	1,500,000	-

5 WATER EVALUATION AND PLANNING VERSION 21 (WEAP21) MODEL

5.1 Description of the WEAP21 Model

The Water Evaluation and Planning (WEAP) model has a long history of development and use in the water planning arena (Yates et. al., 2005). It was developed by the Stockholm Environment Institute (SEI). WEAP is an integrated hydrology / water resource system, mainly destined for policy makers, having to deal with the complex dynamics of water system. The system is GIS-based, and operates on the basic principle of water balance accounting. Depending on the objectives of the user, WEAP can either be used as a database, as a forecasting tool or as a policy analysis tool. It can be applied at a local level up to very complex river basin system.

Operating on the basic principle of water balance accounting, WEAP21 can account for hydrologic processes within a watershed system and that can capture the propagating and non-linear effects of water withdrawals for different uses (Yates et. al., 2005). The latest version of the model, WEAP21 incorporates a range of physical hydrology process in a watershed with the management of demands and installed infrastructure in a seamless and coherent manner. Therefore, it allows for climate change and other changing anthropogenic stressors, such as land use variations, changes in water demand, alternative operating rules etc. This innovation provides WEAP21 as a robust analysis of future climate scenarios as they assert themselves onto the natural watershed, leading to associated hydrologic responses, all in the context of potential adaptation at a decisions level relevant to local water managers (Yates et. al., 2005).

Furthermore, WEAP21 introduces major advances including a modern graphic user (GUI), a robust solution algorithm to solve the allocation problem, and the integration of hydrologic sub-modulus that include a conceptual rainfall, an alluvial groundwater model, and a stream water quality model. The simulation time step can be as short as one day, to weekly, to monthly, or even seasonally with time horizon from as short as a single year to more than 100 years.

WEAP applications generally involve the following steps (Sieber et. al, 2005):

- Study definition: The time frame, spatial boundaries, system components, and configuration of the problem are established.
- Current accounts: A snapshot of actual water demand, pollution loads, resources and supplies for the system are developed. This can be viewed as a calibration step in the development of an application.
- Scenarios: A set of alternative assumptions about future impacts of policies, costs, and climate, for example, on water demand, supply, hydrology, and pollution can be explored. (Possible scenario opportunities are presented in the next section.)
- Evaluation: The scenarios are evaluated with regard to water sufficiency, costs and benefits, compatibility with environmental targets, and sensitivity to uncertainty in key variables.

The model was run on a monthly time step and tracked the relative storage, z_j and z_2, based on water balance dynamics that include infiltration, ecapotarnspirations, surface runoff, interflow, percolation and baseflow (Yates et. al., 2005). If the time series of temperature is les than 0^oC it is assumed that precipitation falls as snow. Precipitation in fluid form is first by canopy evaporation. Water reaching the ground or set free by snowmelt partially flows off as a surface runoff. The remaining water infiltrates the soil which can be divided into several layers. Downward flow, or percolation, occurs if field capacity of a soil layer is exceeded and if the layer below is not saturated. If the temperature in a particular layer is below the freezing point no redistribution allowed from that layer. Lateral subsurface flow (interflow) in the soil profile is calculated simultaneously with redistribution. Furthermore,, soil moisture is diminished by evaporation from the soil surface and transpiration of plants. Percolation from the bottom of the soil profile recharges the shallow aquifer. The shallow aquifer is a linear reservoir which releases water into surface water bodies (baseflow)and by seepage to the deep aquifer.

Figure 5.1 shows the components of this conceptual model, showing a schematic of the two-layer soil moisture store with the different hydrologic inputs and outputs for a given land cover or crop type. A watershed is first divided into sub-catchments and then further divided into N fractional areas, where a water balance is computed for each fractional area, j of N. Climate is assumed uniform over each fractional area where a continuous mass balance equation is written as:

$$Sw_j \frac{dz_{1,j}}{dt} = P_e(t) - PET(t)\, k_{c,j}(t)\left(\frac{5z_{1,j} - 2z_{1,j}^2}{3}\right) - P_e(t)\, z_{1,j}^{\frac{LAI_j}{2}} - f_j k_j z_{1,j}^2 - (1 - f_j) k_j z_{1,j}^2 \qquad \text{Eq. 5}$$

where:

Sw_j = soil (upper layer) water holding capacity (mm)

P_e = effective rainfall (mm)

PET = Penman-Montieth reference crop potential evapotranspiration (mm/day)

k_c = crop coefficient

LAI = Leaf area index

$Z_{1,j}$ = fraction of the total effective water storage and varies from 0 and 1 where 0 represents the permanent wilting point and 1 field capacity

f_j = quasi-physical tuning parameter related to soil, land cover and topography that fractionally partitions water either horizontally, f_j or vertically (1- f_j)

k_j = upper storage conductivity (mm/time)

WEAP21 includes a simple temperature-index snowmelt model which computes an effective precipitation, P_e. The model estimates snow water equivalent and snowmelt from an accumulated snowpack in the sub-catchment, where m_c is the melt coefficient given as

$$m = \left\{ \begin{array}{lll} 0 & \text{if} & T_i < T_s \\ 1 & \text{if} & T_i < T_l \\ (T_i - T_s)/(T_l - T_s) & \text{if} & T_s \le T_i \le T_l \end{array} \right\} \qquad \text{Eq. 6}$$

with T_i the observed temperature for period i, and T_l and T_s are melting and freezing temperature thresholds, with the melt rate is given as:

$$m_i = \min(Ac_i\, m_c, Em) \quad \text{Eq. 7}$$

Snow accumulation, Ac_i is a function of m_c and the observed total precipitation, P_i

$$Ac_i = Ac_{i-1} + (1 - m_c)\, P_i - m_{i-1} \quad \text{Eq. 8}$$

Where Em is the available melt energy converted to an equivalent water depth/time. The effective precipitation, is P_e is then computed as

$$P_e = P_i m_c + m_r \quad \text{Eq. 9}$$

The surface and interflow runoff contributions from the upper store, Ro from each sub-catchment at time t is

$$Ro\,(t) = \sum_{j=1}^{N} A_j [P_e(t)\, z_{1,j}^{\frac{LAI_2}{2}} + f_j k_j z_{1,j}^2] \quad \text{Eq. 10}$$

Where A_j is the contributing area of each land cover class, j. Interflow is simply

$$I_f(t) = \sum_{j=1}^{N} A_j (f_j k_j z_{1,j}^2) \quad \text{Eq. 11}$$

For sub-basins without a modeled aquifer, a mass balance for the second store is given as

$$Dw \frac{dz_{2,j}}{dt} = (1 - f_j) k_j z_{1,j}^2 - k_2 z_{2,j}^2 \quad \text{Eq. 12}$$

Where the inflow to this deep storage is the deep percolation from the upper storage given in equation 1, and k_2 is the conductivity rate of the lower storage(mm/time) which is given as single value for the catchment, and D_w is the deep water storage capacity (mm). Baseflow is simply

$$B_f(t) = \sum_{j=1}^{N} A_j (k_2 z_{2,j}^2) \qquad \text{Eq. 13}$$

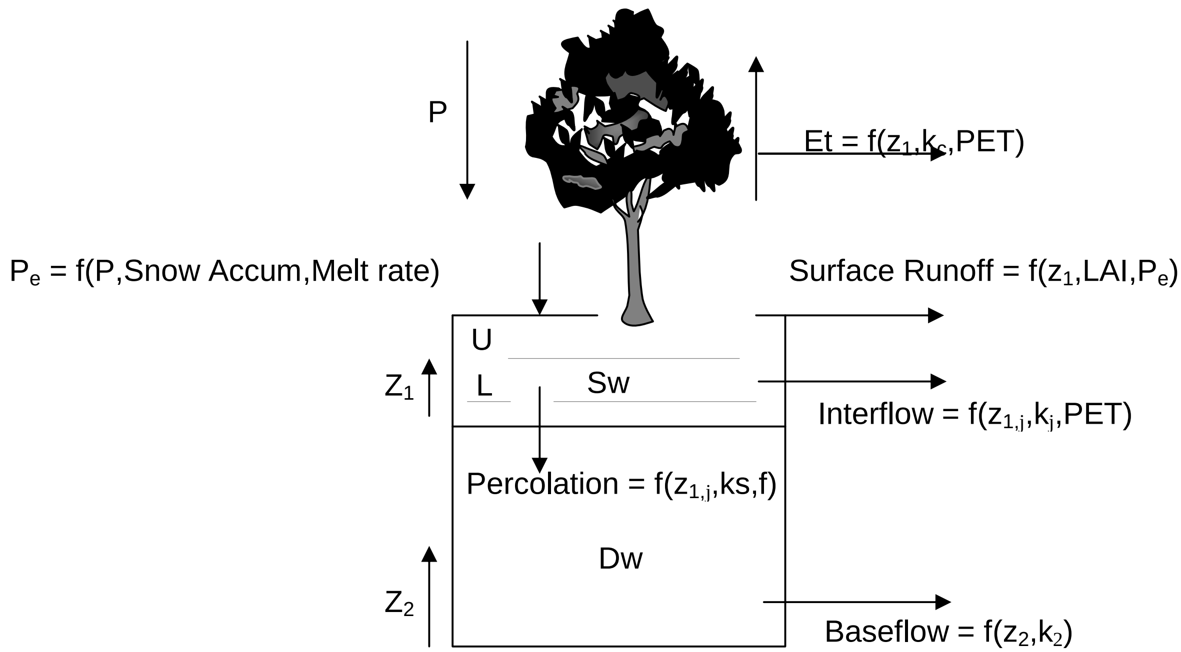

Fig. 5-1: Schematic of two-layer soil moisture store in WEAP21

6 CALIBRATION AND VALIDATION

In this study, using the historical data from 1972 to 1982, the hydrological process that occur in the sub-catchment were modelled and compared to observed streamflow from the two gauging stations in the catchment. In this process, the first six years (1972-1978) of the climatological record were used for calibration, and the remaining four years (1978-1982) were for validation. However, the initial estimation of the model paramater needs to be done before it will be adjusted in the calibration process.

6.1 Initial Parameter Estimation

The parameter estimation began by approximating the values of upper store holding capacity (*Sw)* and leaf area index (*LAI)* based on estimates referenced sources (Yates et. al., 2005). The value of crop coefficient (*Kc)* also has been estimated based on them the FAO reference sources. The lower storage zone, *Dw* were arbitrary set at 1000 mm.

Then, initial conductivity estimates for each quaternary catchment were made by separating the resulting monthly runoff hydrograph into baseflow and interflow components, and then computing an average monthly equivalent water depth. For the study area, the average monthly streamflow volume for the period 1972 to 1982 is given in Figure 6.1, where the average baseflow was estimated as 3×10^6 m^3.

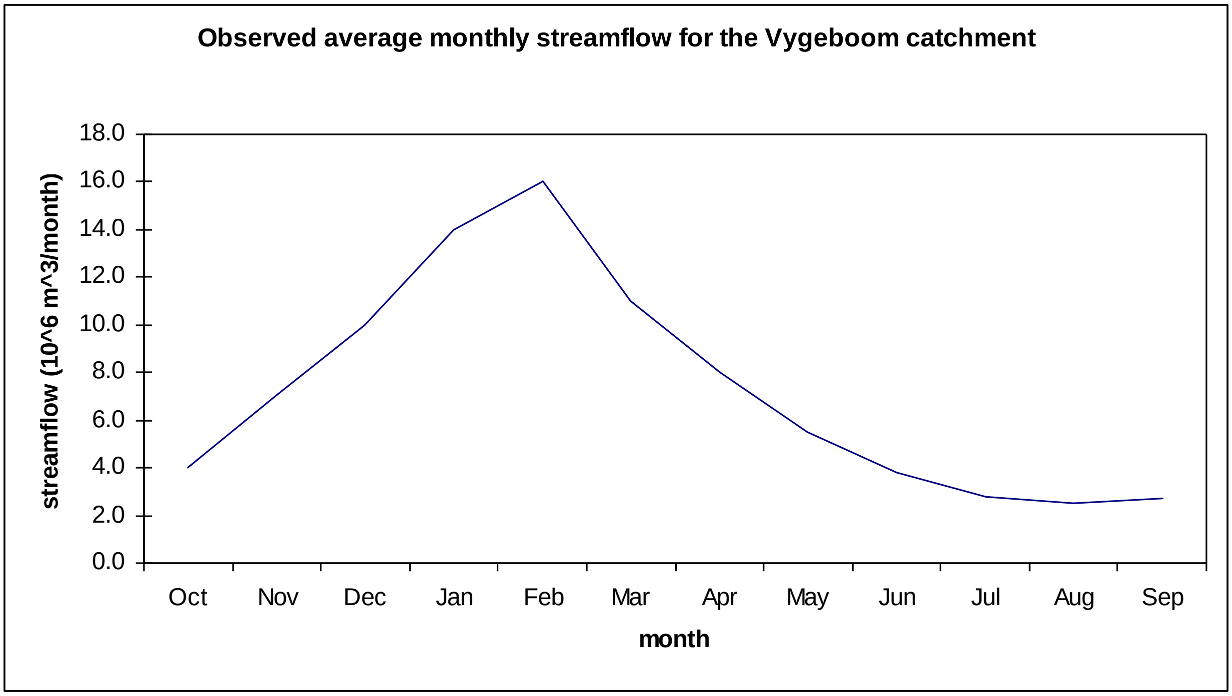

Fig. 6-1: Observed average monthly streanflow for the Vygeboom sub-catchment from 1972-1982

To make a first estimate of the lower store conductivity, k_2, the estimate baseflow volume was divided by each quaternary catchments area. The calculation of the equivalent water depth for each QC is shown in Table 6.1.

Table 6-1: Calculation of equivalent water depth in each quaternary catchment to estimate k_2,

Quaternary Catchment	Area(km^2)	Estimated Baseflow Contribution	Equivalent Water Depth (mm)
X11A	672	20%	$(3 \times 10^6\ m^3 \times 0.2)/ 672 = 0.89$ mm
X11B	598	15%	$(3 \times 10^6\ m^3 \times 0.15)/ 598 = 0.75$ mm
X11C	321	10%	$(3 \times 10^6\ m^3 \times 0.1)/ 321 = 0.93$ mm
X11D	590	15%	$(3 \times 10^6\ m^3 \times 0.15)/ 590 = 0.76$ mm
X11E	241	10%	$(3 \times 10^6\ m^3 \times 0.1)/ 241 = 1.24$ mm
X11F	182	5%	$(3 \times 10^6\ m^3 \times 0.05)/ 182 = 0.82$ mm
X11G	265	10%	$(3 \times 10^6\ m^3 \times 0.1)/ 265 = 1.13$ mm
X11H	286	10%	$(3 \times 10^6\ m^3 \times 0.1)/ 286 = 1.05$ mm
X11J	189	5%	$(3 \times 10^6\ m^3 \times 0.05)/ 189 = 0.79$ mm

From equation 13 and assuming the average relative storage is 20% for every QC, then a first estimate of the lower store conductivity for each QC are as follows:

X11A; $k_2 = 0.89/0.2^2 = 22.3$ mm
X11B; $k_2 = 0.75/0.2^2 = 18.8$ mm
X11C; $k_2 = 0.93/0.2^2 = 23.3$ mm
X11D; $k_2 = 0.76/0.2^2 = 19.0$ mm
X11E; $k_2 = 1.24/0.2^2 = 31.0$ mm
X11F; $k_2 = 0.82/0.2^2 = 20.5$ mm
X11G; $k_2 = 1.13/0.2^2 = 28.35$ mm
X11H; $k_2 = 1.05/0.2^2 = 26.3$ mm
X11J; $k_2 = 0.79/0.2^2 = 19.8$ mm

A similar procedure was followed for estimating initial values of the upper store conductivity (k_j). The average monthly interflow was estimated as the difference between the observed, average monthly baseflow and the monthly average peak discharge. The average peak discharge was approximately 15 x 10^6 m^3, which is 12 x 10^6 m^3 in excess of the 3 x 10^6 m^3 baseflow. Then, the equivalent runoff depth for each QC was calculated as shown in Table 6.2.

Table 6-2: Calculation of equivalent water depth in each quaternary catchment to estimate k_j

Quaternary Catchment	Area(km^2)	Estimated Interflow Contribution	Equivalent Water Depth (mm)
X11A	672	20%	(12x 10^6 m^3 x 0.2)/ 672 = 3.57 mm
X11B	598	15%	(12 x 10^6 m^3 x 0.15)/ 598 = 3.01 mm
X11C	321	10%	(12 x 10^6 m^3 x 0.1)/ 321 = 3.74 mm
X11D	590	15%	(12 x 10^6 m^3 x 0.15)/ 590 = 3.05 mm
X11E	241	10%	(12 x 10^6 m^3 x 0.1)/ 241 = 4.98 mm
X11F	182	5%	(12 x 10^6 m^3 x 0.05)/ 182 = 3.30 mm
X11G	265	10%	(12 x 10^6 m^3 x 0.1)/ 265 = 4.53 mm
X11H	286	10%	(12 x 10^6 m^3 x 0.1)/ 286 = 4.20 mm
X11J	189	5%	(12 x 10^6 m^3 x 0.05)/ 189 = 4.00 mm

Assuming the average relative storage is 30% for every QC, then a first estimate of the upper store conductivity for each QC are as follows:

X11A; $k_j = 3.57/0.3^2 = 39.67$ mm/month
X11B; $k_j = 3.01/0.3^2 = 33.44$ mm/month
X11C; $k_j = 3.74/0.3^2 = 41.56$ mm/month
X11D; $k_j = 3.05/0.3^2 = 33.89$ mm/month

X11E; $k_j = 4.98/0.3^2 = 55.33$mm/month X11F; $k_j = 3.3/0.3^2 = 36.67$ mm/month

X11G; $k_j = 4.53/0.3^2 = 50.33$ mm/month X11H; $k_j = 4.2/0.3^2 = 46.67$ mm/month

X11J; $k_j = 4.0/0.3^2 = 44.44$ mm/month

The initial values of f_j were 0.15 for all sub-fractions, j which assumes that 15 percent of the monthly discharge is interflow that contributes directly to streamflow, while the remaining 85 percent recharge the second store. Table 6.3 shows a list of the different uncalibrated parameters used in the model before an attempt to adjust these values to achieve an optimal fit of model output started.

6.2 First Model Run

The streamflow in the Komati river has been simulated over the period between 1972 and 1978. Figure 6.3 shows a scatter plot of monthly modelled versus observed streamflow volumes at station X1R003 based on the un-calibrated parameter values given in Table 6.3. The first attempt shows that the simulated streamflow was under-predicted. Peak and base flow were most of the time under-predicted. Over prediction of the parameter of *LAI* and *Kc* (These two parameters were the most sensitive parameters to the model; see section 6.3) which leads to less streamflow and groudwater recharge maybe the main reason of the peak and low flow were under-predicted. The comparison between modelled and observed streamflow at this station is shown in Figure 6.2. The performance criteria computed at this station were R^2 = 0.41, *CE* = 0.57, *VE* = -29.91 and *PE* = -22.48.

The discharge also has been simulated at station X1H007 based on the un-calibrated values. However the model shows different performance at this station when there was a considerable gap between the modelled and observed discharge for the period of November 1976 to March 1977. It is important to note that there were ‘strange’ streamflow data have been recorded at station X1H017 as mentioned in section section 4.2.3. Therefore this ‘strange’ data has influenced the performance of the model at this station. The performance criteria computed were R^2 = 0.30, *CE* = 0.24, *VE* = -7.11 and *PE* = -32.25. A comparison between modelled and observed streamflow and a scatter plot of monthly modelled versus observed streamflow volumes at this station are shown in Figure 6.4 and Figure 6.5 respectively.

Table 6-3: Uncalibrated parameter values used for modelling of the streamflow volume

	LAI	*Kc*	*Sw* (mm)	Initial Z_1 (mm)
Alien vegetation	8	1	1500	15
Bushland	4	0.6	900	12.5
Grassland	6	1	900	12.5
Exotic forest	9	1	1500	15
Waterbodies	0.1	1	1000	20
Wetlands	2.5	1.2	1500	22.5
Barerock	2.5	0.5	700	7.5
Cultivated_irrigated	6	0.8	1000	10
Cultivated_dryland	6	0.8	1000	10
Urban_residential	2.5	1	600	15
Urban_industries	3	2.5	600	12.5
Mines and quarry	2	1.2	400	10

	F (0-1)	k_j (mm/month)	k_2 (mm/month)	*Dw* (mm)	Z_2 (%)
X11A	0.15	39.67	22	1000	15
X11B	0.15	33.44	18	1000	15
X11C	0.15	41.56	23	1000	15
X11D	0.15	33.89	19	1000	15
X11E	0.15	55.33	31	1000	15
X11F	0.15	36.67	21	1000	15
X11G	0.15	50.33	29	1000	15
X11H	0.15	46.67	27	1000	15
X11J	0.15	44.44	20	1000	15

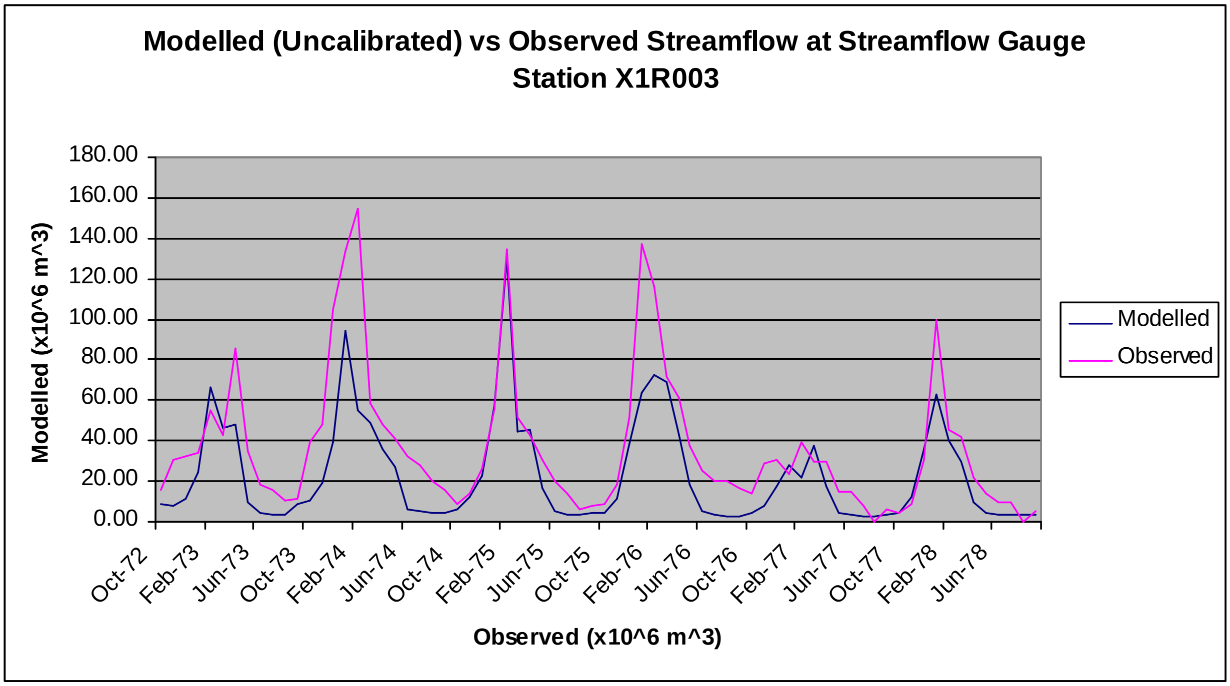

Fig. 6-2: Graph of the monthly modelled versus observed streamflow volumes using un-calibrated parameter values at station X1R003

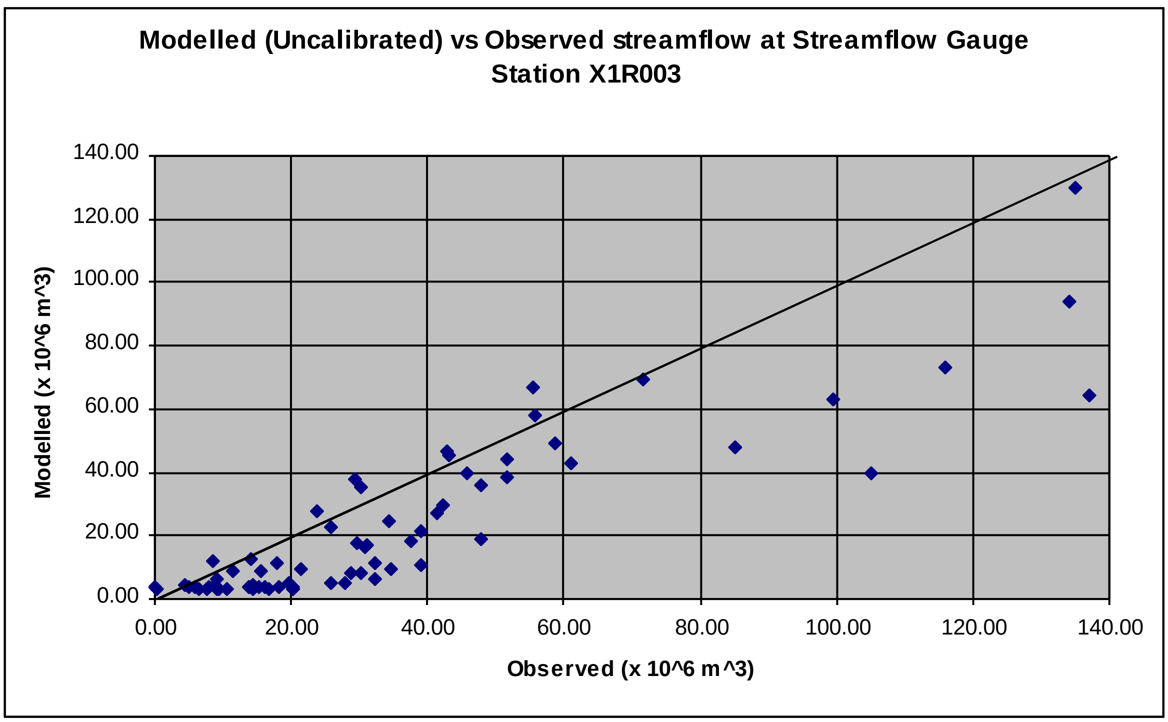

Fig. 6-3: Scatter plot of monthly modelled versus observed streamflow volumes using un-calibrated parameter values at station X1R003

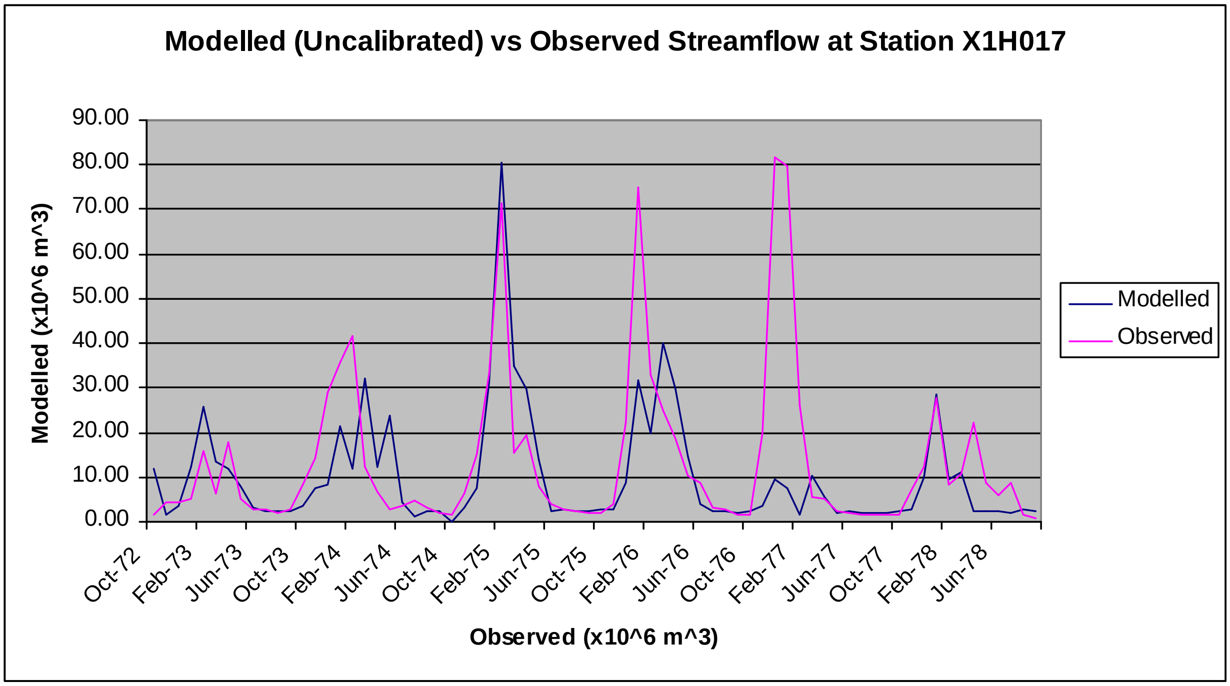

Fig. 6-4: Graph of the monthly modelled versus observed streamflow volumes using un-calibrated parameter values at station X1H017

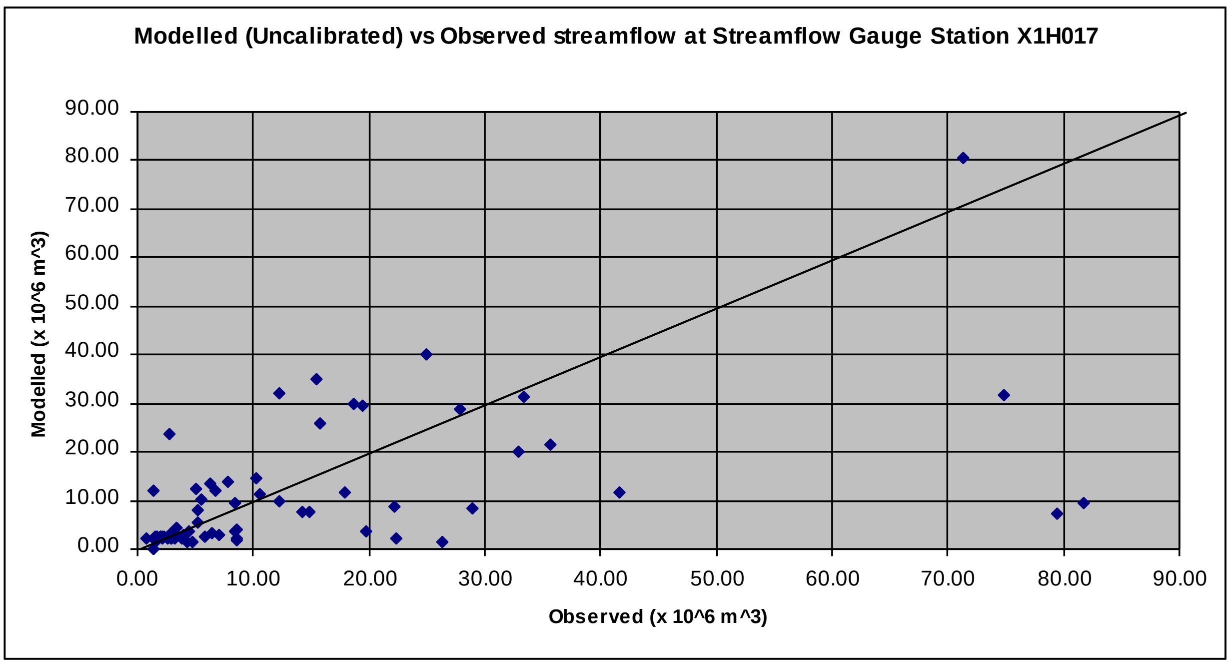

Fig. 6-5: Scatter plot of monthly modelled versus observed streamflow volumes using un-calibrated parameter values at station X1H017

6.3 Parameter Calibration

Model calibration was done manually by visual check of the modelled versus observed streamflow graph, before seeking to find optimal values of the R^2, *CE*, *VE* and *PE*. In this procedure, all uncalibrated parameters have been adjusted via trial and error in order to find optimal model parameters that minimised the sum of the monthly errors between the simulated and observed streamflow. The parameter values adopted after final calibration are shown in Table 6.4.

Table 6-4 : The calibrated parameter values adopted for modelling of the streamflow volume

	LAI	*Kc*	*Sw* (mm)	Initial Z_1 (mm)
Alien vegetation	8	1	1000	25
Bushland	5	0.8	1000	20
Grassland	5	0.9	1200	25
Exotic forest	8	1	2000	30
Waterbodies	0.6	1	300	10
Wetlands	6.5	1.2	800	20
Barerock	0.9	0.2	300	10
Cultivated_irrigated	6	0.9	1500	15
Cultivated_dryland	6	0.9	1500	10
Urban_residential	4	1	600	20
Urban_industries	1	1.2	500	20
Mines and quarry	0.9	1.2	300	15

	F (0-1)	k_j (mm/month)	k_2 (mm/month)	*Dw* (mm)	Z_2 (%)
X11A	0.3	19	22	500	15
X11B	0.3	16.5	18	500	15
X11C	0.3	20.5	23	500	15
X11D	0.3	16.5	19	500	15
X11E	0.3	27	31	500	15
X11F	0.3	18	21	500	20
X11G	0.3	25	29	500	20
X11H	0.3	23	27	500	20
X11J	0.3	21	20	500	20

Figure 6.6 shows the comparison of the modelled and observed streamflow at station X1R003. The model still tends to underpredicted the discharge. The simulated discharge only fits the observed discharge between the periods of December 1974 to March 1975.very well The peak is always under-estimated except in the month of February 1975. The extreme low flows as well, is most of the time under-estimated particularly those below about 40Mm^3 as shown in Figure 6.7. With regards to the model performance criterion, the best computed values of R^2, *CE*, *VE* and *PE* were 0.77, 0.67, -23.59 and -11.52 respectively.

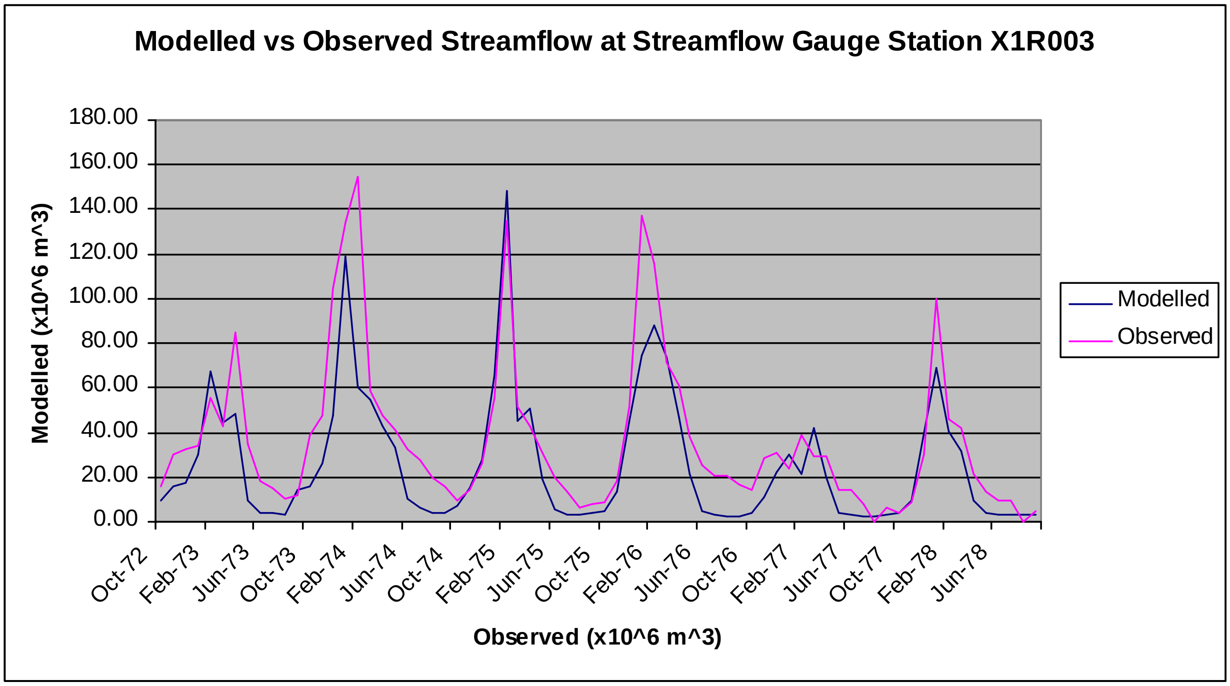

Fig. 6-6: Graph of the monthly modelled versus observed streamflow volumes using calibrated parameter values at station X1R003

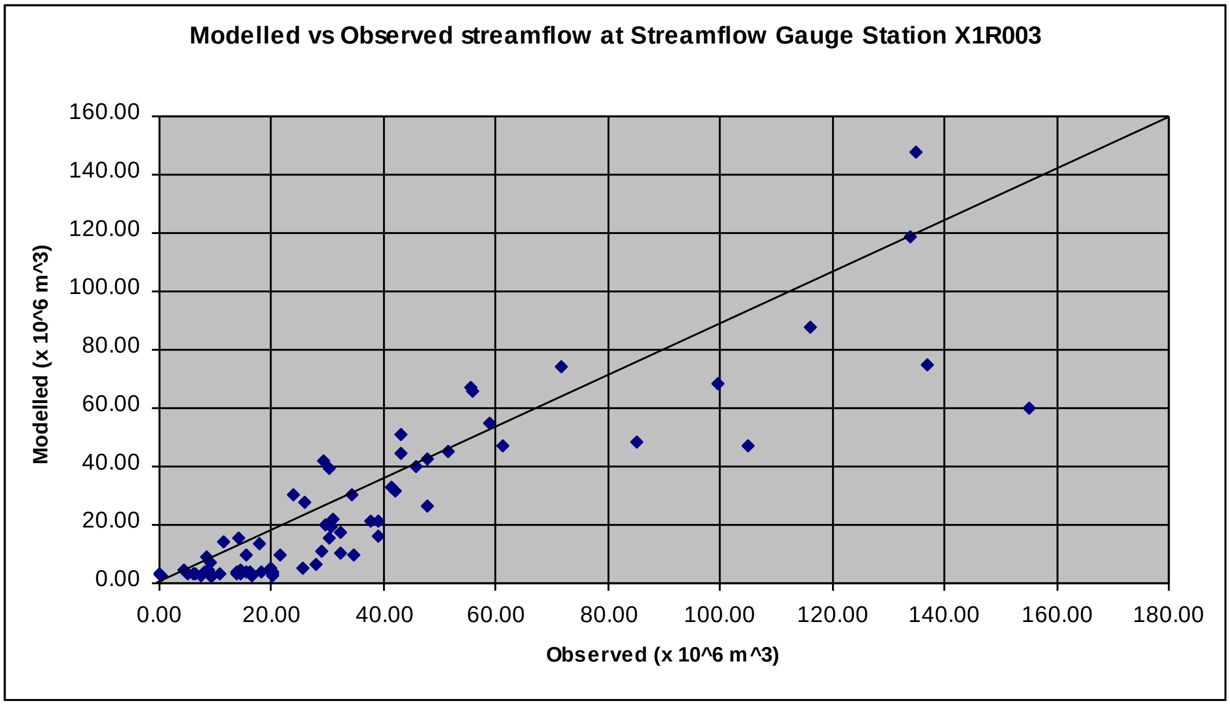

Fig. 6-7: Scatter plot of monthly modelled versus observed streamflow volumes using calibrated parameter values at station X1R003

At station X1H017, however, the model produced a considerable difference pattern which, sometimes it overestimates and sometimes underestimates the discharge. The comparison between modelled and observed streamflow and a scatter plot of monthly modelled versus observed streamflow volumes at station X1H017 are shown in Figure 6.8 and Figure 6.9 respectively. The model simulates inconsistent peak and base flow throughout the period of the study. Most of the time, the peak was over-estimated except in the month of February 1976 and January 1977. However, the peak discharge is greatly under-estimated in the month of November 1976 to March 1977. However, as mentioned in section 4.2.3 the observed data in this particular period were not reliable. It is interesting to note that base flow was satisfactorily modelled at this station. Such discharge well fit the observed baseflow over a whole of the calibration period. The modelling performance at this station based on the performance criteria computed were R^2 = 0.67, CE = 0.14, VE = 4.88 and PE = 16.85.

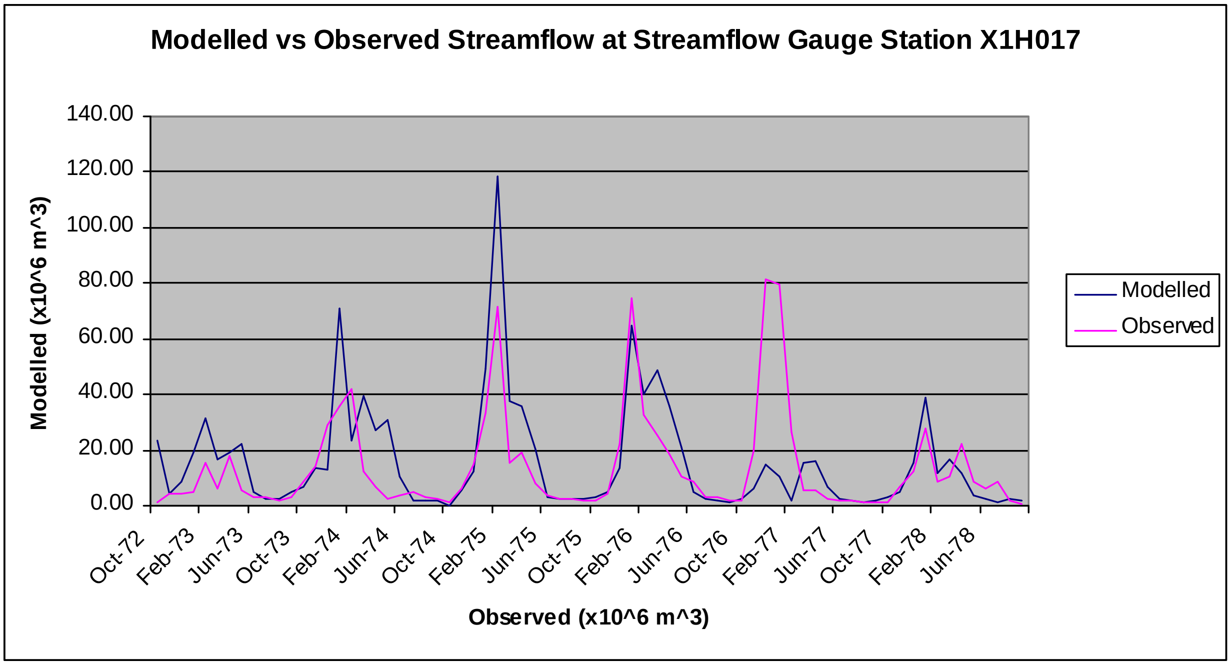

Fig. 6-8: Graph of the monthly modelled versus observed streamflow volumes using calibrated parameter values at station X1H017

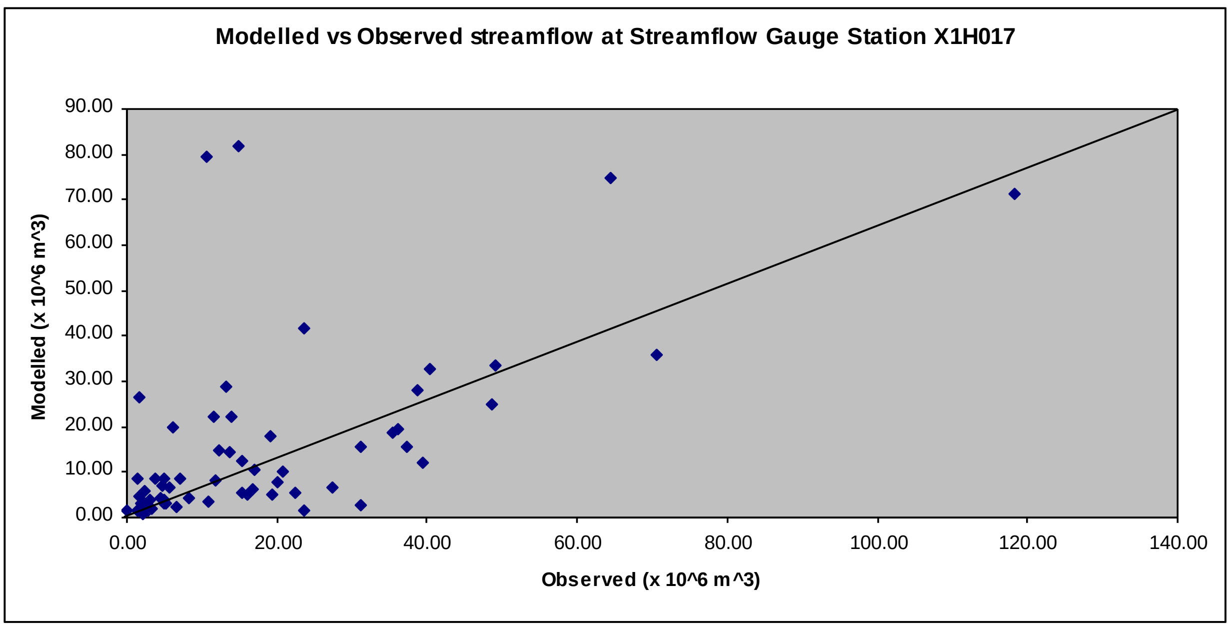

Fig. 6-9: Scatter plot of monthly modelled versus observed streamflow volumes using calibrated parameter values at station X1H017

There were still some differences between modelled and observed streamflow even after final calibration has been done. The inaccuracy of the streamflow, land use, and water uses may be the main cause of the difference found. This is because such data were obtained from DWAF website and no clarification on their accuracy was made. In this case, the difference found can be caused by:

- The steamflow data measured at both stations may not represent the actual natural flow in the study area. This is because both streamflow stations are located downstream of the dams; station X1H017 is located at downstream of the Nooitgedacht dam (while station X1R003 is located just downstream of the Vygeboom dam. Therefore, the reservoir operation will influence the discharge measured at both stations. Unfortunately, such data was not available to estimate the actual natural streamflow.
- An oudated land use data: Based on the sensitivity analysis, parameter for the land use (*LAI* and *Kc*) are the most sensitive to the model output. Therefore, the study area may be dominant with plants with lower *LAI* and *Kc* (ex. grass) instead of forest which has higher *LAI* and *Kc*.
- The return flow data especially from irrigation activities was not available and has been excluded in this study. This flow can have a significant effect to the streamflow measured at both stations. Therefore, the simulated streamflow data would be underestimeted without this data.
- Afforestation is one of the activity in the Vygeboom sub-catchment which causes the reduction in runoff (WMA, 2003). However, this study does not taking into account this activity due to no data on the area involves.
- It is suspected that this study underestimetes the water users as well as the amount used. This is because the resource information (WMA report) did not taking into account some of the activities within the sub-catchment for instance smaller irrigation transfer.

6.4 Model Sensitivity Analysis

In order to assess the sensitivity of the model to the different parameters used for calibration, a sensitivity analysis was undertaken. Sensitivity of the model to parameters was assessed by using the relative change in runoff volume *(ΔVE)* and relative change in Nash-Sutcliffe efficiency *(ΔCE)* as indices. In this procedure, starting with the manual calibration, each parameter has been varied by +50% and -50% while the other parameters were maintained unchanged. Using the the relative change in runoff volume *(ΔVE)* and relative change in Nash-Sutcliffe efficiency *(ΔCE)* as indices, the effect of each parameter change on the runoff-producing events during the period from 1972 to 1978 has been analysed. The larger the *(ΔVE)* and *(ΔCE)*, the more sensitive the model to the parameter under study.

The results of the sensitivity analysis at station X1R003 is presented in Table 6.5. It indicates that the WEAP21 model is very sensitive to the parameter of *Kc* and *LAI*. The most sensitive parameter is the *Kc* when a change of its amount by 50% and -50% causes an increment of 97.71% and a reduction of 259.21 in simulated streamflow volume respectively. Criteria of the *CE* is also most sensitive to the parameter of *Kc* when 50% and -50% change of its amount causes *CE* reduced to the amount of 85.74% and 414.05% respectively. Based on Table 6.5, the second sensitive parameter is *LAI* when *VE* changes in the range of -259 to 97.71 and the *CE* changes in the range of -142.08 to -53.96. Generally, all parameters have a more effect on the volume of the simulated streamflow production compared to the *CE*. Therefore, the model is appropriate for this study to evaluate the water available within the study area.

Table 6-5: Summary of the model sensitivity results

Parameter	Parameter Change (%)	*(ΔCE)* (%)	*(ΔVE)* (%)
LAI	-50 +50	-142.08 -53.96	-259.21 97.71
Kc	-50 +50	-414.05 -85.74	-394.18 122.88
Sw	-50 +50	-12.62 -2.83	-11.89 12.53
Dw	-50 +50	-0.21 0.11	5.16 4.03
Kj	-50	-0.39	5.85

	+50	0.40	2.91
K_2	-50 +50	-1.73 1.08	9.31 1.47
Initial Z_1	-50 +50	-4.96 2.98	16.22 -11.43
Initial Z_2	-50 +50	-2.31 2.54	10.88 -3.31
F	-50 +50	-0.57 0.57	5.67 3.16

6.5 Validation

The data set from 1978 to 1982 has been used for the model validation. Figure 6.10 and 6.11 show the comparison between the modelled and observed discharge at station X1R003 and X1H017. Both stations produces a better simulated discharge compared to the output in the calbration period. Although there are some differences on the peak flow, the baseflow is well computed at both station. The criteria for performance assessment computed at station X1R003 and X1H017 in the model validation are as follows:

Station XR003: R^2 = 0.85, *CE* = 0.84, *VE* = -0.25 and *PE* = 6.51

Station X1H017: R^2 = 0.69, *CE* = 0.50, *VE* = 3.49 and *PE* = 31.45.

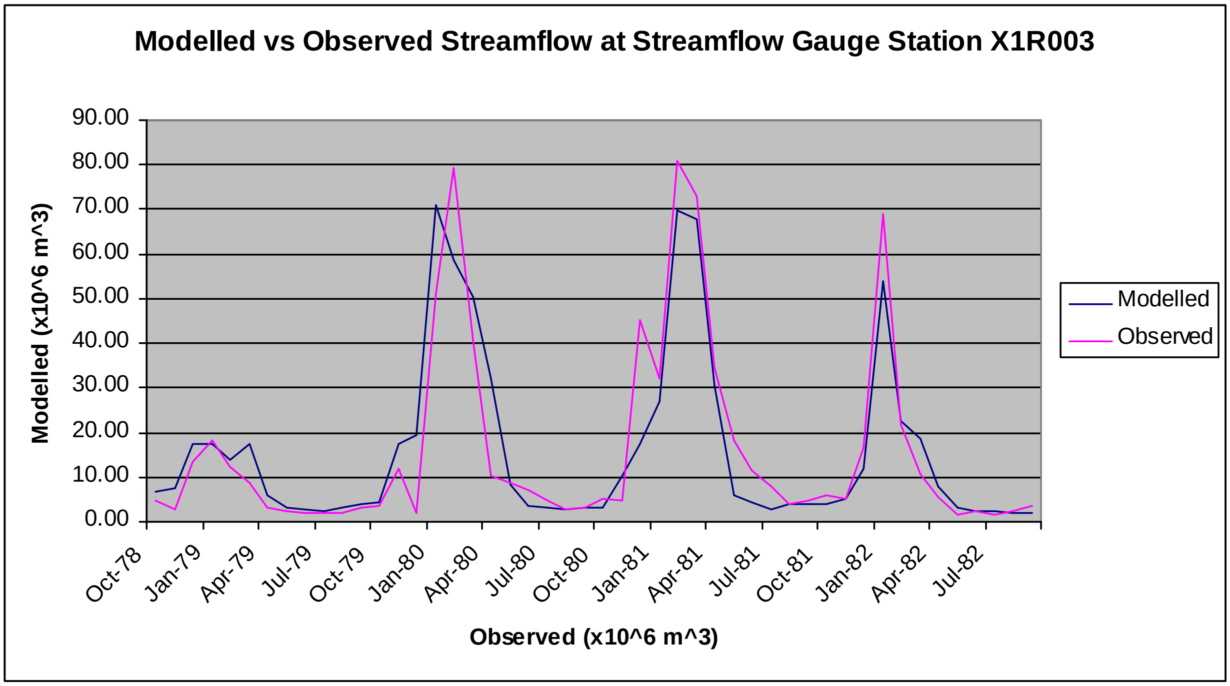

Fig. 6-10: Graph of the monthly modelled versus observed streamflow volumes using calibrated parameter values at station X1R003

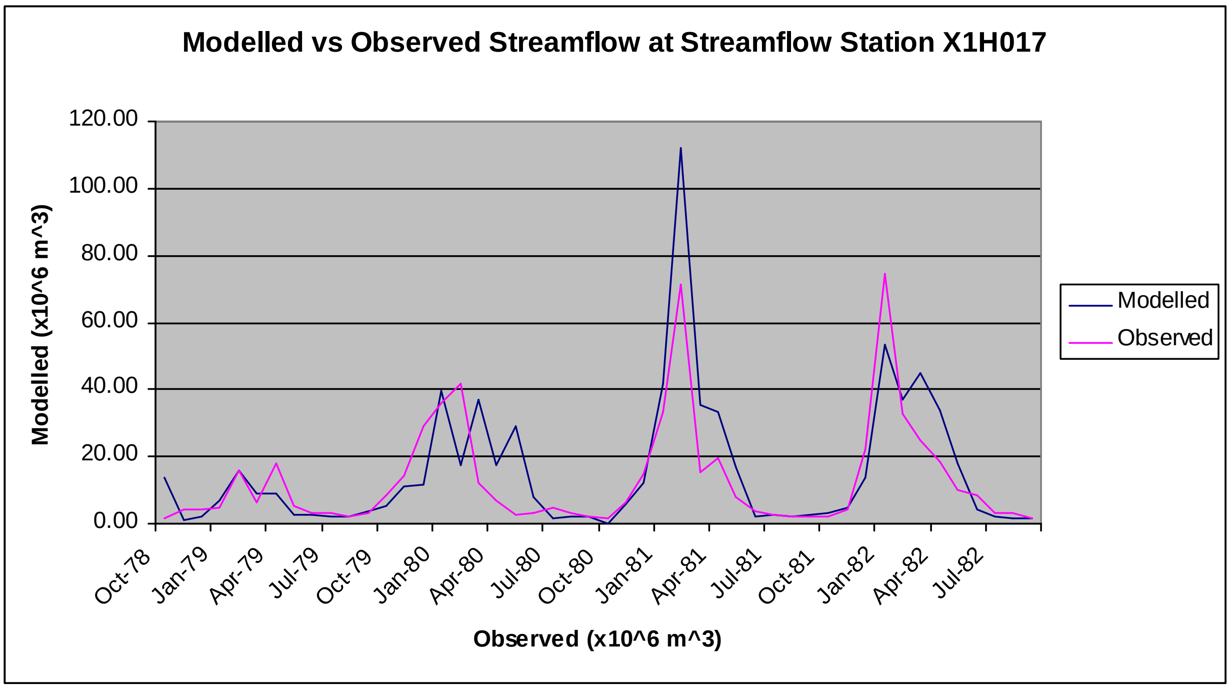

Fig. 6-11: Graph of the monthly modelled versus observed streamflow volumes using calibrated parameter values at station X1H017

6.6 Applicable of the WEPA21 Model

Table 6.6 summarised the performance criteria of the WEAP21 model based on the calibration and validation at station X1H017 and X1R003. The accuracy of the simulation is satisfactorily considering that the model calibrated and validated with a limited data. The model performance for validation shows improvement particularly at station X1R003. Based on this simulation results, it can be stated that WEAP21 model can reproduce the discharge reasonably well and successfully simulates the hydrologic response at regional scale. Model results support Yates D, 2006 that an innovation of the WEAP21 model is that it facilitates the dynamic integration of both the natural hydrology of the watershed and the infrastructure of the water supply system. This allows a robust analysis of future climate change scenarios as they assert themselves onto the natural watershed.

Table 6-6: Summary of the performance criteria of the WEAP21 model

Performance criteria	Calibration		Validation	
	Station X1H017	Station X1R003	Station X1H017	Station X1R003
R^2	0.67	0.77	0.69	0.85
CE	0.14	0.67	0.50	0.84
VE	4.88	-23.59	3.49	-0.25
PE	16.85	-11.52	31.45	6.51

7 ANALYSIS OF RESULTS

The results of water availability could be indirectly obtained from the model output. In order to quantify how much the water availability within the study area between 2011 and 2030, the calculation of such amount involves (from the model output):

- The difference in storage of the Nooitgedacht dam between the month of October 2011 and September 2030; and
- The difference in storage of the Vygeboom dam between the month of October 2011 and September 2030; and
- Monthly outflow from the Vygeboom dam to downstream; and
- Supply delivered form both dams to their users

It is expected that four different amount of water availability would be obtained from the simulation due to different prescribed climate scenarios (Table 7.1).

Table 7-1: Effect of different climate scenarios to water availability

Amount of Water Changes			
Base Case	Scenario 1 +2^{o}C	Scenario 2 +2^{o}C , +10%P	Scenario 3 +2^{o}C , -10%P
reference	Increase / decrease?	Increase / decrease?	Increase / decrease?

7.1 Impact on Water Availability

Water availability is directly affected by temperature and precipitation changes in the study area. Figure 7.1 depicts the projected water availability under all scenarios due to climate change.

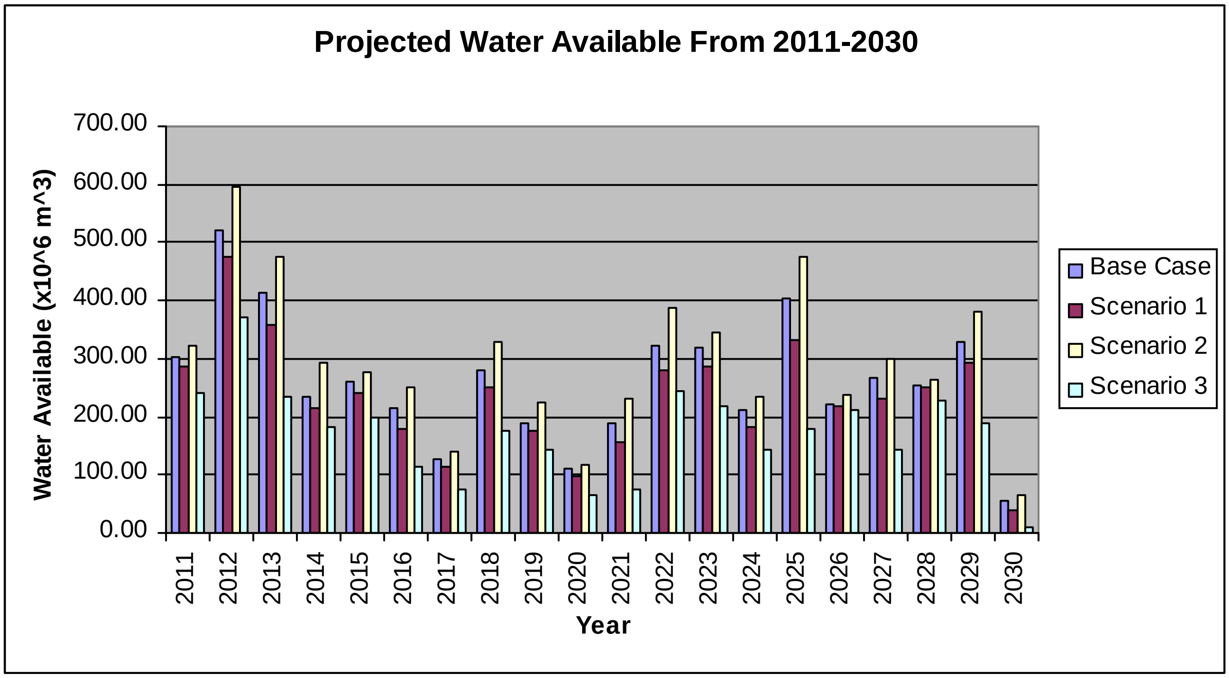

Fig. 7-1: Projected water available from 2011-2030 within the study area

On an annual basis, a temperature increase of 2^{o}C (scenario 1), leads to a small decreases in the water availability. In total, the water availability would be reduced by 10.6% (1,510 Mm^3) over the period of study, from 2011 to 2030. Table 7.2 shows the change in the amount of water available in all scenarios due to climate change.

Table 7-2: Changes in water availability due to climate change over the period of 2011-2030

	Base Case	Scenario 1 +2^{o}C	Scenario 2 +2^{o}C , +10%P	Scenario 3 +2^{o}C , -10%P
Water Availability	5,241Mm^3	4,683 Mm^3	5,842 Mm^3	3,448 Mm^3
Different	-	-557.4 Mm^3 -10.6%	+700.7 Mm^3 +13.4%	-1,792.4 Mm^3 -34.20%

In scenario 2, a 2^{o}C temperature increase with a 10% increase in precipitation would bring a small increase in water availability. This indicates that increasing the mean air temperature in the study area has been sufficient to cause an increase in evapotranspiration, but this increase has generally been lower than the increase in precipitation. As a result, the total water availability would be increased by 13.4% (700.7 Mm^3).

The worst case scenario for water availability is scenario 3, when a combination of temperature increases coupled with a 10% decreased in precipitation, would lead to a 34.2% (1,792.4 Mm^3) reduction in the water availability.

The change in water availability in the study area is directly influenced by an increase of water demand, due to alteration of various components of the hydrological cycle such as the streamflow, evapotranspiration, and soil moisture.

7.1.1 Impact on Crop Water Demand

It was found that the total crop water demand increased by 23.1% (202.3 Mm^3) in scenario 1, 6.1% (6.11 Mm^3) in scenario 2, and 51.41% (51.4 Mm^3) in scenario 3. Table 7.3 shows the total water demand for irrigation activities due to climate change. Obviously, the reduction of water availability has a linear relationship with the crop water demand (irrigation). The increase in temperature in all scenarios accelerates evaporation demand, which is fulfilled to some extent by depletion of the soil moisture storage. Therefore, the source of water for such activity (Komati river and both dams) would be reduced which then, reduced the water availability within the study area.

Table 7-3: Changes in crop water demand due to climate change over the period of 2011-2030

	Base Case	Scenario 1 +2^{o}C	Scenario 2 +2^{o}C , +10%P	Scenario 3 +2^{o}C , -10%P
Crop Water Demand	876Mm^3	1,078 Mm^3	929 Mm^3	1,326 Mm^3
Different	-	+202 Mm^3 +23.1%	+53 Mm^3 +6.1%	450 Mm^3 +51.4%

7.1.2 Impact on Streamflow

Figure 7.2 shows the projected annual streamflow due to climate change at the entrance of the Vygeboom reservoir from 2011 to 2030. Similarly to the case of the effect on water availability, the streamflow would be small decreased in scenario 1, small increases in scenario 2 and a considerable decreased in scenario 3. This is because the streamflow volume is a dependent component for the water availability. The changes in streamflow does not similar to the changes in water availability due to other components influences the latter such as storage of the reservoir, water supplied to the users and so on. The total streamflow changes over the period of 2011 to 2030 are shown in Table 7.4. It would be higher about 20.3% in scenario 2 than the base case. In scenario 1 and 3, it would be reduced by 15% and 45% respectively.

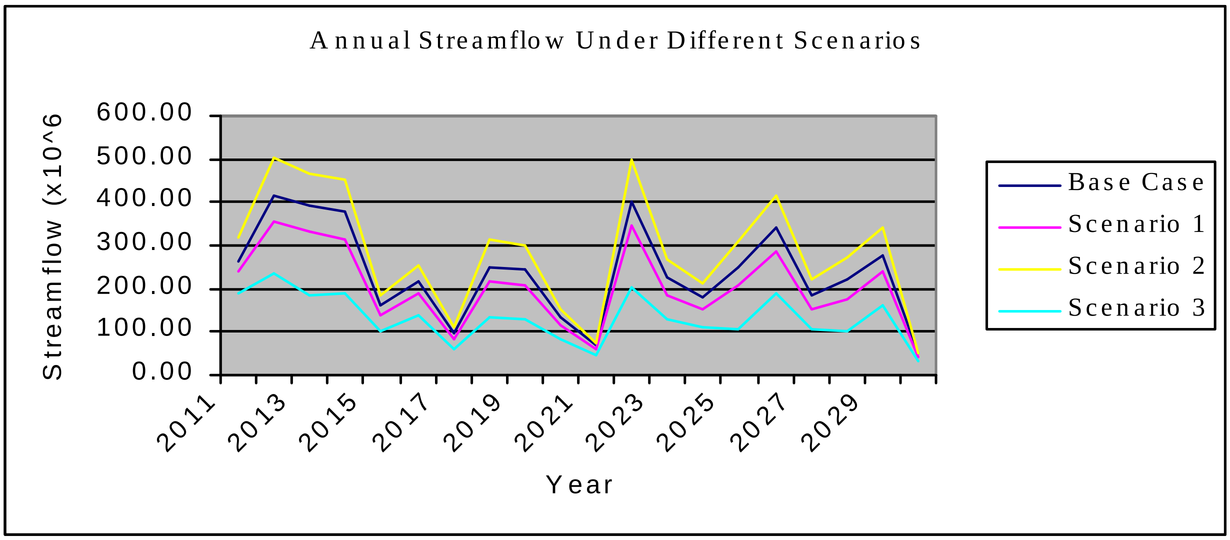

Fig. 7-2: Projected of the annual streamflow due to climate change from 2011-2030

Table 7-4: Changes in streamflow due to climate change over the period of 2011-2030

	Base Case	Scenario 1 $+2^oC$	Scenario 2 $+2^oC$, +10%P	Scenario 3 $+2^oC$, -10%P
Streamflow	4,752 Mm^3	4,039 Mm^3	5,715 Mm^3	2,635 Mm^3
Different	-	-713 Mm^3 -15.0%	+963 Mm^3 +20.3%	-2,117 Mm^3 -44.6%

7.1.3 Impact on Evapotranspiration

Figure 7.3 shows the projected of the annual potential evapotranspiration due to climate change from 2011-2030. Potential evapotranspiration is one of the factors which lead to the reduction of water availability. In this study it was found that the potential evapotranspiration have a similar amount of increment in all three scenarios of about 8.6 Mm^3 or 9.32%. Table 7.5 shows the changes in potential evapotranspiration due to climate change over the period of 2011-2030. This implies that WEAP calculates the potential evapotranspiration based on temperature data. The increases in evapotranspiration, in part explain why water availability within the study area decreases especially in relation to the reservoirs, since there is a direct loss.

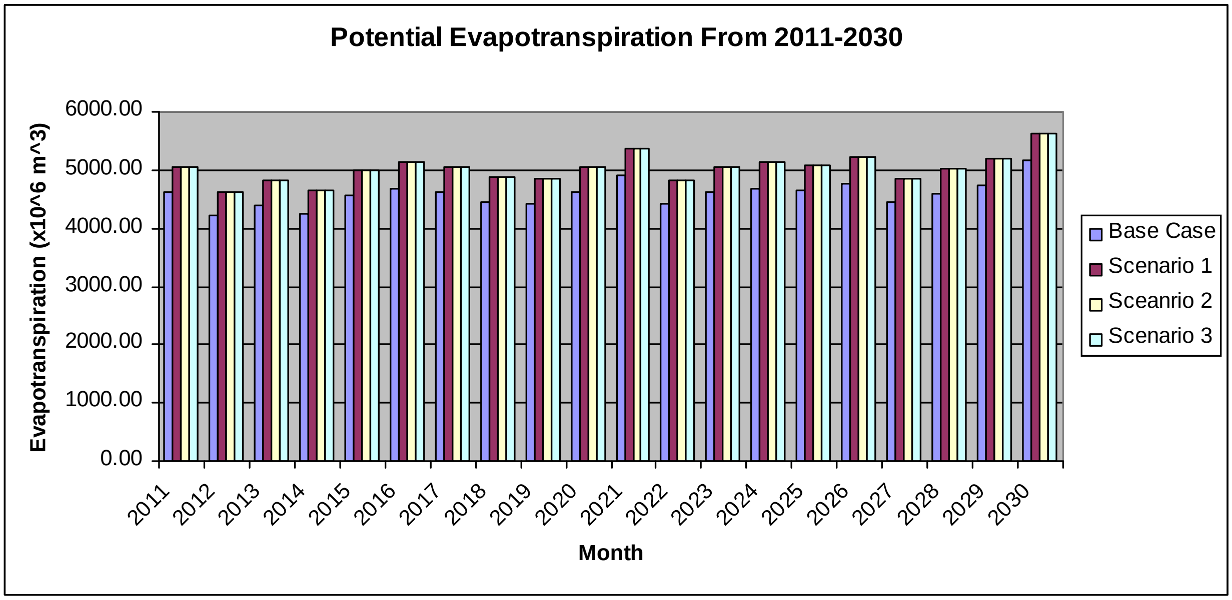

Fig. 7-3: Projected of the annual potential evapotranspiration due to climate change from 2011-2030

Table 7-5: Changes in potential evapotranspiration due to climate change over the period of 2011-2030

	Base Case	Scenario 1 +2°C	Scenario 2 +2°C , +10%P	Scenario 3 +2°C , -10%P
Potential Evapotranspiration	91,892 Mm^3	100,453 Mm^3	100,453 Mm^3	100,453 Mm^3
Different	-	+8561 Mm^3 +9.3%	+8561 Mm^3 +9.3%	+8561 Mm^3 +9.3%

7.1.4 Impact on Storage of the Reservoirs

The storage of the Nooitdegacht and Vygeboom reservoir fluctuates between its top of inactive and top of conservation in order to fulfil the demand from multiple users within the sub-catchment. Figure 7.4 and 7.5 show the monthly storage volumes of the Nooitgedacht and Vygeboom reservoir form 2011to 2030. The Nooitgedacht dam has the least storage volume under scenario 3 when most of the time it fluctuates between 5 Mm^3 to 15 Mm^3. On the other hand, there is not much different in terms of the storage volume at the Vygeboom reservoir under all scenarios. The storage volumes of both dams almost full in the month of January (wet season) but almost empty after supplied water to users from June to October (dry season).

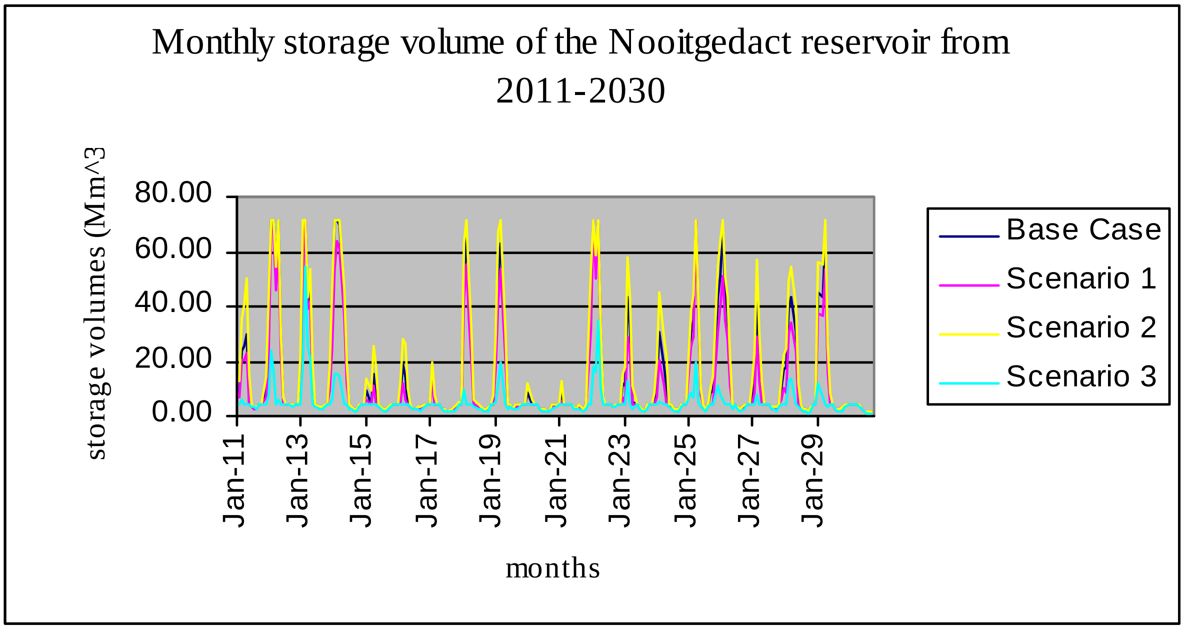

Fig. 7-4: Storage volume of the Nooitgedacht dam from 2011 to 2030

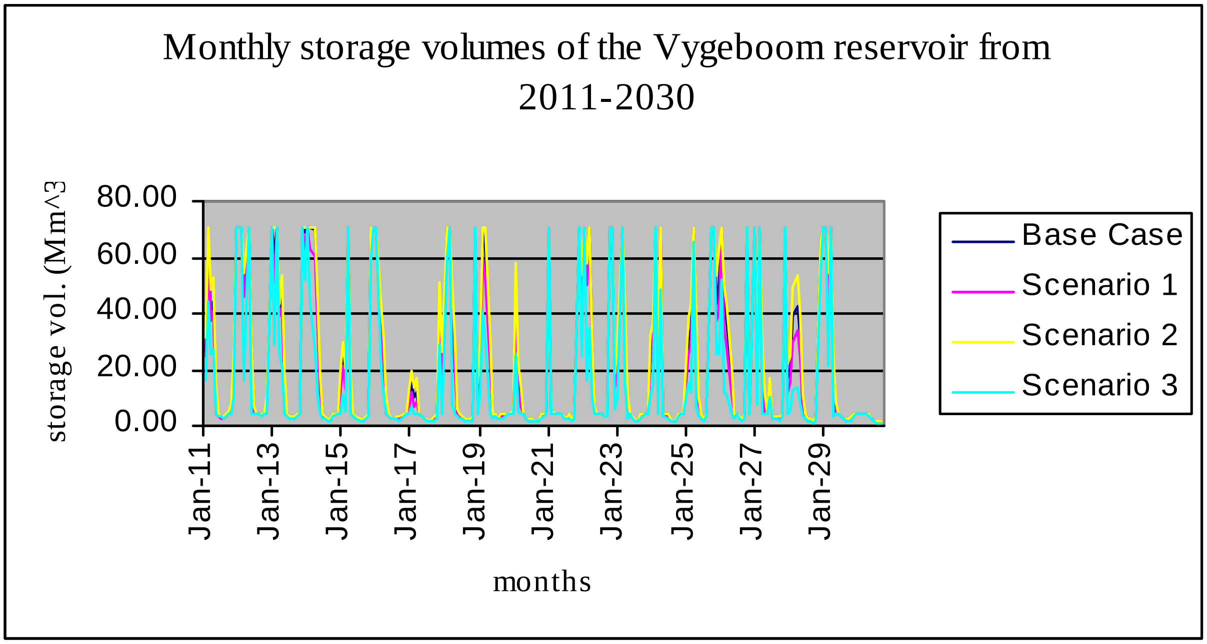

Fig. 7-5: Storage volume of the Vygeboom dam from 2011 to 2030

7.1.5 Impact on Unmet Demand

The study found that the unmet demand tends to increase due to climate scenarios in the Vygeboom sub-catchment. Table 7.6 shows the total unmet demand amount over the period of study, 2011 to 2030. Although scenario 2 shows reduction in such matter, its amount is only 0.02% compared to a big increase in scenario 1 and scenario 3.

Table 7-6: Unmet demand under different scenarios due to climate change

	Base Case	Scenario 1 +2^{o}C	Scenario 2 +2^{o}C , +10%P	Scenario 3 +2^{o}C , -10%P
Unmet Demand	3,533 Mm^3	3,952 Mm^3	3,446 Mm^3	4,905 Mm^3
Different	-	+419 Mm^3 +11.9%	-87 Mm^3 -0.02%	+1,372 Mm^3 +38.8%

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

In this study, the WEAP21 model was applied to evaluate the impact of climate change to water availability under different climate scenarios. The precipitation and temperature data for the period between 1972 and 1992 have been altered to develop four different climate changes scenarios for the model input. For the calibration and validation process, the historical available data between 1972 and 1982 has been used in the model.

The calibration and validation results show that the WEAP21 model can reproduce the discharge reasonably well. The performance criteria in the calibration at station X1H017 were R^2 = 0.67, *CE* = 0.14, *VE* = 4.88, and *PE* = 16.85 while at station X1R003 were R^2 = 0.77, *CE* = 0.67, *VE* = -23.59, and *PE* = -11.52. The performance criteria shows an improvement in the validation when such computed values were R^2 = 0.69, *CE* = 0.50, *VE* = 3.49, and *PE* = 31.45 (at station X1H017) and R^2 = 0.85, *CE* = 0.84, *VE* = -0.25, and *PE* = 6.51 (at station X1R003). Based on the simulation results obtained in the calibration and validation, it can be stated that WEAP21 successfully simulates the hydrologic response at regional scale.

Using the capability of the WEAP21 model for assessing the impact of climate change on water availability, four different climate change scenarios have been simulated for further analysis. The model produced some outputs which then being analysed in order to quantify the water availability in the study area.

This study found that the Komati river basin is very sensitive to climatic change in terms of temperature and precipitation changes. Table 8.1 summarised the impact of temperature and precipitation changes on water availability and its components in the study area. Based on the model output of the unmet demand and considering that this study did not take into account the other pressure such as, population growth, economic development an so on, it is expected that the Komati river basin would face a considerable water supply-demand deficit in the future if no appropriate step is taken. The climate change will seriously affects the water demand for irrigation. This situation would give a significant effect to such activity as well as to other users because they are sharing their right for water. The reduction in streamflow may lead to environmental degradation, soil erosion, ecosystem problem and so on. These entire situation will enhance the current water crisis in this region.

Table 8-1: Summarised of the impact of climate change with associate to water resources

	Scenario 1 (%)	Scenario 2 (%)	Scenario 3 (%)
Water available	-10.6	+13.4	-34.2
Water Demand for Irrigation	+23.1	+6.1	+51.4
Streamflow	-15.0	+20.3	-44.6
Potential Evapotranspiration	+9.3	+9.3	+9.3
Unmet Demand	+11.9	+0.02	+38.8

This study shows the capability of the WEAP21 model for assessing the impact of climate change on water availability at a local scale. From time series applied, WEAP can generate hydrologic responses that are the characteristic of a catchment under consideration

Results of climate change assessment are highly dependent on the input data. Specifically *Kc* and *LAI* since these are the most sensitive parameter. The other important data includes the reservoir operation, water users/demand and their location, and water abstraction.

However, it is necessary to make clear at this juncture that the climate change scenarios used in this study should not necessarily be seen as the future climate in the region, but they are primarily designed to show the sensitivity to change within a reasonable interval.

8.2 Recommendations

Several recommendations can be derived from the results obtained and its analysis. They can be summarised as the following:

- Without GCM model to predict the magnitude and distribution of temperature and precipitation changes, this study unable to predict whether there will be a shift in the seasonal distribution of annual rainfall. Therefore, seasonal wise, this study could not investigate the implication with associate to water available in the study area. In this regards, future climate change studies should also concentrate on probable shifts in seasons and the consequent impact particularly on agriculture. In this case, the combination of GCM model and WEAP model is highly recommended for precise evaluation of climatic change and its impact within the study area.

- Further development of the model for a whole Komati catchment is recommended for in order to investigate the hydrologic response and its consequences on hydrological boundries for the sake of the integrated river basin management in this catchment.

- A complete study should also take into consideration integrating other factors such as anticipated developments in agriculture and industry and population growth in the basin, to produce realistic water resources/availability scenarios.

- WEAP21 is an integrated hydrological / water resources planning model for climate assessment as well as for water planning tool. It is recommended that WEAP's dual function being tested in future studies; to evaluate the impact of climate change, and then to explore and suggest some response in order to mitigate the adverse impacts.

- Clearly major adaptation will be needed in response to increasing water scarcity. Adaptation may require changes in cropping patterns, with a switch to new crops or varieties more tolerant to water scarcity in this study area.

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Appendix A

- Monthly precipitation data over quaternary catchments from October 1972 to September 1982
- Mean monthly temperature data over quaternary catchments from October 1972 to September 1982

Months	Precipitation (mm)								
	Quaternary Catchments								
	X11A	X11B	X11C	X11D	X11E	X11F	X11G	X11H	X11J
Oct-72	29.6	25.5	23.9	20.79	18.18	67.9	78.2	72.7	55.8
Nov-72	159.5	209	152.9	119.43	116.1	196.3	243.8	221.1	190.7
Dec-72	94.4	132.6	57	136.35	136.35	103.8	128.5	118.8	66.5
Jan-73	189.6	148.7	146.5	191.25	191.25	115.7	155.2	141.7	113
Feb-73	138.1	168.4	160.9	195.03	195.03	236.9	290.3	279.6	118.7
Mar-73	101.3	83.5	71.4	83.79	83.79	146.8	170.1	165.1	104.9
Apr-73	79.8	99.9	140.1	83.97	81.63	200.7	168.9	154	121.1
May-73	7.1	8.4	9.1	3.51	3.51	1.5	1.9	1.9	4.3
Jun-73	0	0	0	0	0	0	0	0	0.2
Jul-73	0	0	0	0	0	7.4	7.4	7.4	0.8
Aug-73	17.5	4.9	3.4	2.16	1.98	0	0	0	0.8
Sep-73	42.8	53.2	81.7	95.76	95.76	104	154.8	135	114.3
Oct-73	92.9	84.8	49	104.58	92.25	102.7	118.2	110	82.8
Nov-73	157.8	200.7	138.8	135.63	132.03	115.9	143.7	130.6	112.4
Dec-73	172.7	158.1	128.9	94.23	94.23	195.4	242.4	224.2	158.3
Jan-74	168.9	167.9	260.3	168.03	168.03	245	329	300	129.5
Feb-74	53.8	40.7	44.7	73.53	73.53	108.2	155.1	145.7	373.9
Mar-74	54.6	24.7	146.1	70.2	70.2	58.3	67.6	65.5	15.6
Apr-74	150.1	97.4	73.1	95.04	92.16	89.2	119.8	113.2	123.1
May-74	22	18.5	2.6	5.67	5.67	13.6	16.9	16.9	19.4
Jun-74	13	10.8	6.4	11.07	7.92	9.1	9.1	9.1	5.7
Jul-74	14.9	19.4	6.5	18.81	18.81	40.3	40.3	40.3	32.3
Aug-74	13.6	2	0	26.82	24.03	11.3	20.2	20.9	5.5
Sep-74	5.6	8.8	13.9	18	18	18.5	27.5	24	15.9
Oct-74	55.2	50.5	24	31.68	27.9	120.9	139.1	129.3	46.1
Nov-74	118.3	173.3	130.2	119.52	116.1	111.7	138.7	125.7	112.5
Dec-74	236.4	127.1	136.8	139.32	139.32	129.7	160.9	148.9	158
Jan-75	209.8	192.3	302	187.02	187.02	145.1	194.9	177.7	136.2
Feb-75	193.3	195.4	163.1	140.04	140.04	197.4	242.1	233.1	152
Mar-75	39	39.6	37.6	20.97	20.97	35.3	40.8	39.8	94.9
Apr-75	110	58	138.9	84.6	82.17	73.4	98.2	93	71.2
May-75	5.2	4.5	6.5	9.72	9.72	10	12.3	12.3	7.8
Jun-75	0	0	2.9	7.65	5.49	20.8	20.8	20.8	3.4
Jul-75	4.5	0	0	1.98	1.98	0	0	0	4.7
Aug-75	4.5	8.8	0	2.61	2.25	1.4	2.6	2.8	0.7
Sep-75	37.5	30.7	19.1	33.48	33.48	24.8	37	32.1	15.9
Oct-75	65.7	68.4	50.3	59.04	52.38	45.4	52.2	48.5	33.1
Nov-75	269.5	161	145.7	105.75	102.87	158.8	197.6	179.1	172.9
Dec-75	156.2	164.2	146.6	158.58	158.58	238.1	295.3	273.3	120.6
Jan-76	158	131.2	157.2	240.84	240.84	140.4	188.5	172	191.5
Feb-76	74.9	86.5	78.3	80.91	80.91	185.7	227.9	219	351.9
Mar-76	86.1	96.8	186.4	78.3	78.3	102.4	118.7	115.4	171.8
Apr-76	46.5	30	56.6	49.23	47.79	47.4	63.7	60	54.4
May-76	54.8	18.5	0	10.17	10.17	14.5	17.9	17.9	15.5
Jun-76	0	0	0	0	0	0	0	0	0
Jul-76	0	0	0	0	0	0	0	0	0

Months	Precipitation (mm)								
	Quaternary Catchments								
	X11A	X11B	X11C	X11D	X11E	X11F	X11G	X11H	X11J
Aug-76	0	0	0	0	0	0	0	0	0.6
Sep-76	0	0	2	8.46	8.46	9.5	14.1	12.3	4.5
Oct-76	61.7	71.8	94.8	45.09	39.87	56.1	64.3	59.9	53.2
Nov-76	97.9	93.4	188	144.81	140.94	100.5	124.8	113.2	134.1
Dec-76	149.9	128.1	97.7	163.8	163.8	116.2	144	133.4	102.9
Jan-77	139.6	108.2	132	81.72	81.72	168.9	227	207	107.9
Feb-77	40.2	77.6	49.3	9.72	9.72	119.7	146.6	141.3	68.7
Mar-77	114.3	131.8	140.9	130.68	130.68	145.5	168.7	164	139.6
Apr-77	23.8	54.5	43.1	62.73	60.75	57.5	77.1	72.8	92.3
May-77	0	3.2	1.3	0	0	6.2	7.6	7.6	2.3
Jun-77	0	0	0	0.72	0.54	0	0	0	0.1
Jul-77	0	0	0	0	0	0	0	0	0
Aug-77	0	1.3	6.5	3.15	2.79	4.9	8.8	9.1	7.6
Sep-77	39	18	55.3	26.37	26.37	31.3	46.6	40.6	42.1
Oct-77	111.8	57.1	62	63.72	56.34	53.6	61.7	57.4	47.6
Nov-77	154.9	142.2	125.3	125.73	122.31	175.9	218.6	198.2	133.1
Dec-77	78.9	76.9	164.7	182.61	182.61	212.7	263.2	243.5	178.1
Jan-78	110.1	133.5	164.3	222.84	222.84	157.4	211.5	192.6	215.9
Feb-78	71.8	145.5	124.1	53.64	53.64	119.1	146	140.5	186.8
Mar-78	57.1	58.5	74.8	75.6	75.6	78.2	90.3	88.1	88.4
Apr-78	31.8	23.4	32.5	14.49	14.04	32.4	43.3	40.9	17.1
May-78	0	6.5	0	4.41	4.41	5.8	7.1	7.1	6.5
Jun-78	0.4	0	0	0	0	0	0	0	0.1
Jul-78	0	3.2	0	2.61	2.61	19.1	19.1	19.1	14.3
Aug-78	27.9	16.8	20.8	14.31	12.78	4.3	7.6	7.9	4.5
Sep-78	29.9	13.2	24.4	14.85	14.85	20.7	30.8	26.9	28.9
Oct-78	148.8	105.4	68.9	71.46	63.27	56.4	64.9	60.4	64
Nov-78	53.1	51.5	75.7	78.84	76.68	93.6	116.3	105.3	122.8
Dec-78	156.9	136.9	51.3	150.3	150.3	133.5	165.5	153.1	130.3
Jan-79	134.4	224.4	117	122.76	122.76	71.5	96.3	87.6	68.6
Feb-79	23.2	14	59.8	73.89	73.89	66.9	82	78.9	119.7
Mar-79	73.3	72.7	54.6	71.19	71.19	113.1	131.3	127.3	89.5
Apr-79	40.1	6.6	43.6	27.45	26.64	28.2	37.8	35.7	59.1
May-79	0	0	0	0	0	0	0	0	2.1
Jun-79	5.8	3.2	15.6	2.79	1.98	0	0	0	2.3
Jul-79	1.6	0	0	2.07	2.07	0	0	0	3.4
Aug-79	53.7	11.5	14.2	6.48	5.76	14.5	25.8	26.9	21.6
Sep-79	36.9	58.4	18.6	15.21	15.21	17	25.2	22	29.3
Oct-79	79.9	55.4	70.2	41.22	36.27	95.3	109.6	101.9	84.9
Nov-79	197.7	146.9	244.3	173.43	168.75	184.2	228.9	207.6	181.9
Dec-79	48.3	42.1	123.1	99.99	99.99	113	140.1	129.6	81.7
Jan-80	245.7	218	322.3	282.6	282.6	173.1	232.1	212	217.3
Feb-80	59.8	101.3	131.8	175.05	175.05	76.5	93.8	90.2	240.7
Mar-80	103.9	56.5	26	48.6	48.6	64.4	74.8	72.4	48.6
Apr-80	57.9	42.2	64.2	58.68	56.88	32.9	44.1	41.6	39.9

Months	Precipitation (mm)								
	Quaternary Catchments								
	X11A	X11B	X11C	X11D	X11E	X11F	X11G	X11H	X11J
May-80	11.7	7.1	0	0	0	5.2	6.5	6.5	7.4
Jun-80	0	0	0	0	0	24.7	24.7	24.7	0
Jul-80	0	0	0	0	0	13	13	13	0
Aug-80	7.8	7.7	0	5.22	4.68	0	0	0	5.3
Sep-80	12.5	5.5	26.1	13.41	13.41	24	35.7	31.1	21.1
Oct-80	40.5	29.8	33.9	5.94	5.22	13.8	15.9	14.8	29.6
Nov-80	162.8	135.5	180.5	178.83	173.88	170.3	211.2	191.7	214.3
Dec-80	190.4	95.7	115.2	155.7	155.7	66.5	82.5	76.2	110.4
Jan-81	163	215.6	127.8	118.08	118.08	116.9	157.1	143.3	137.7
Feb-81	149	142	121.5	202.23	202.23	216.8	265.9	255.7	177.3
Mar-81	137.2	120.3	94.2	153.36	153.36	81.2	94.1	91.3	144.4
Apr-81	15.2	6.1	21.8	11.34	11.07	24.4	32.8	30.9	27.7
May-81	3.2	0	0	0.72	0.72	0	0	0	9.8
Jun-81	30.5	10.5	12.3	27.63	19.62	0	0	0	11
Jul-81	0	0	0	0	0	0	0	0	0
Aug-81	21.4	11.8	20.1	36.81	32.94	9.4	16.8	17.5	7.6
Sep-81	29.4	15.6	31.3	24.3	24.3	30.2	45	39.2	49.6
Oct-81	45.8	49	49.7	28.35	25.02	29.3	33.6	31.2	41.5
Nov-81	44.5	49.9	101.2	80.46	78.3	89.3	110.9	100.6	159.6
Dec-82	109.1	110.1	97.3	101.07	101.07	109.4	135.7	125.4	136.6
Jan-82	155.2	160.3	164.3	231.57	231.57	221.4	297.7	271.4	192.6
Feb-82	59.8	48.2	52.7	18.54	18.54	108	132.4	127.7	52.7
Mar-82	57.4	51.9	76.6	89.01	89.01	45.2	52.5	51	62.7
Apr-82	12.2	17.4	8.8	12.78	12.42	41.4	55.6	52.6	35.4
May-82	1.2	0	0	0	0	1.2	1.6	1.6	1.9
Jun-82	0	0	0	0	0	0	0	0	0.1
Jul-82	15.6	2.3	0	0	0	11.7	11.7	11.7	8.9
Aug-82	0	0	0	0	0	0	0	0	0.1
Sep-82	18.8	4.2	19.8	14.31	14.31	20.5	30.6	26.6	3.3
Oct-82	120.8	83.5	69.8	83.52	73.71	69.7	80.3	74.4	43.6
Nov-82	43.6	41.3	76.2	81	78.75	115.4	143.1	129.7	80.1
Dec-82	111.5	119.6	113.9	61.74	61.74	26	32.2	29.8	93.2

Months	Temperature (^{O}C)								
	Quaternary Catchments								
	X11A	X11B	X11C	X11D	X11E	X11F	X11G	X11H	X11J
Oct-72	17.2	17.2	17.3	17.4	17.1	17.2	17.2	17.8	17.2
Nov-72	16.5	16.4	16.5	16.6	16.4	16.6	16.9	17.8	17.3
Dec-72	20.3	20.2	20.2	20.2	20.1	20.4	20.9	22.2	21.6
Jan-73	20.2	20.1	20.2	20.3	20	20.4	20.8	22	21.2
Feb-73	18.2	18.1	18.1	18.2	18	18.4	19	20.4	19.9
Mar-73	19.7	19.7	19.6	19.7	19.5	19.9	20.3	21.3	20.6
Apr-73	13.6	13.5	13.5	13.5	13.4	13.9	14.4	16.5	16.2
May-73	11.7	11.9	11.8	11.9	11.8	12.2	12.7	14.9	14.5
Jun-73	9.5	10	9.6	9.7	9.6	10.3	10.9	12.8	12.4
Jul-73	9.2	9.7	9.6	9.6	9.6	10.1	10.6	12.7	12.4
Aug-73	10.8	11.1	10.9	11	10.9	11.4	11.9	13.8	13.5
Sep-73	15.2	15.5	15.3	15.3	15.2	15.7	16.1	17.5	16.7
Oct-73	15.9	15.8	16	16	15.9	16.2	16.6	17.9	17.3
Nov-73	16.3	16.2	16.3	16.4	16.2	16.6	17.2	18.5	17.9
Dec-73	17.4	17.2	17.3	17.4	17.1	17.5	17.9	19.2	18.6
Jan-74	18.6	18.5	18.7	18.8	18.6	18.9	19.6	21.3	20.9
Feb-74	18.6	18.5	18.5	18.6	18.4	18.8	19.3	20.6	20.1
Mar-74	17.7	17.6	17.7	17.7	17.6	18.1	18.6	20.2	19.6
Apr-74	13.7	13.6	13.6	13.7	13.5	14	14.5	16.2	15.7
May-74	10.8	10.9	10.9	10.9	10.9	11.5	12.2	14.7	14.4
Jun-74	9.2	9.7	9.4	9.4	9.4	10.1	11	13.2	12.8
Jul-74	8.9	9.4	9.1	9.2	9.2	9.8	10.4	12.6	12.4
Aug-74	10.8	11.1	10.9	10.9	11	11.4	12	14	13.9
Sep-74	14.1	14.4	14	14.1	14	14.4	15	16.3	15.7
Oct-74	17.4	17.3	17.3	17.4	17.3	17.6	18	19.2	18.6
Nov-74	17.2	17.2	17.2	17.2	17.1	17.4	17.9	19.3	18.8
Dec-74	18	17.8	17.9	18	17.8	18.2	18.7	20.2	19.7
Jan-75	18	17.9	18	18.1	17.9	18.3	18.9	20.5	20.1
Feb-75	17.7	17.7	17.7	17.8	17.6	18	18.7	20.1	19.6
Mar-75	16.4	16.4	16.3	16.3	16.2	16.7	17.2	18.7	18.2
Apr-75	14.1	14.2	14.1	14.2	14.1	14.5	15.2	17.3	17.1
May-75	12.5	12.7	12.5	12.5	12.5	12.9	13.4	15.5	15.2
Jun-75	9.5	10.2	9.7	9.8	9.8	10.4	11.1	13	12.6
Jul-75	9	9.4	9.3	9.3	9.3	9.9	10.5	12.8	12.7
Aug-75	11.3	11.6	11.3	11.4	11.4	11.9	12.5	14.3	14
Sep-75	16	16.1	15.9	15.9	15.7	16.2	16.4	17.6	16.7
Oct-75	15.5	15.3	15.4	15.5	15.3	15.7	16.1	17.3	16.7
Nov-75	17.2	17.2	17.3	17.4	17.1	17.6	18.1	19.4	18.7
Dec-75	17.6	17.4	17.4	17.5	17.3	17.8	18.3	19.6	19
Jan-76	17.4	17.3	17.4	17.5	17.3	17.7	18.3	20	19.6
Feb-76	18	18	18	18.1	17.8	18.3	19	20.4	19.8
Mar-76	17.5	17.5	17.4	17.4	17.3	17.8	18.3	19.8	19.3
Apr-76	14.2	14.3	14.3	14.4	14.3	14.8	15.4	17.3	16.9
May-76	10.3	10.3	10.2	10.2	10.2	10.8	11.4	13.7	13.4

Months	Temperature (^{O}C)								
	Quaternary Catchments								
	X11A	X11B	X11C	X11D	X11E	X11F	X11G	X11H	X11J
Jun-76	9.1	9.6	9.2	9.3	9.3	10	10.8	12.9	12.6
Jul-76	9.1	9.7	9.4	9.5	9.4	10	10.5	12.6	12.4
Aug-76	10.9	11.3	11	11	11	11.4	11.7	13.4	13.1
Sep-76	16.1	16.5	16.1	16.2	16.1	16.4	16.6	17.9	17
Oct-76	15.6	15.6	15.6	15.7	15.5	16	16.4	17.8	17.2
Nov-76	17.4	17.4	17.5	17.6	17.4	17.9	18.5	19.8	19.1
Dec-76	18.8	18.8	18.8	18.9	18.7	19.1	19.7	21.2	20.6
Jan-77	19.4	19.2	19.4	19.5	19.3	19.8	20.4	22.2	21.8
Feb-77	19	18.9	18.9	19	18.7	19.1	19.6	21	20.4
Mar-77	16.6	16.5	16.5	16.6	16.4	16.9	17.5	18.8	18.2
Apr-77	15.8	15.8	15.7	15.8	15.7	16.1	16.6	18.5	18.1
May-77	11.6	12	11.7	11.8	11.8	12.3	12.9	15.3	15.1
Jun-77	10	10.9	10.4	10.4	10.5	11.1	11.9	14.1	13.9
Jul-77	9.2	9.6	9.4	9.4	9.4	10	10.6	12.7	12.2
Aug-77	11.5	11.7	11.5	11.6	11.5	12	12.5	14.4	14.1
Sep-77	15.2	15.5	15.3	15.3	15.3	15.8	16.3	17.8	17.2
Oct-77	17.7	17.6	17.7	17.8	17.7	18	18.4	19.6	18.9
Nov-77	18.2	18.1	18	18.1	17.9	18.3	18.7	19.9	19.2
Dec-77	19.1	19.2	19.2	19.3	19.1	19.5	20	21.2	20.7
Jan-78	18.1	18	18.3	18.4	18.1	18.5	19	20.4	19.7
Feb-78	18.7	18.6	18.6	18.7	18.6	18.9	19.5	20.8	20.3
Mar-78	18	18.1	17.9	18	17.8	18.3	18.8	20.2	19.6
Apr-78	14.2	14.4	14.4	14.5	14.4	14.9	15.4	17.2	16.6
May-78	12	12.4	12.2	12.3	12.2	12.7	13.4	15.6	15.3
Jun-78	8.4	9.3	8.9	9	8.9	9.6	10.2	12	11.5
Jul-78	9.5	9.8	9.7	9.7	9.7	10.4	10.8	13	12.6
Aug-78	14.9	15.2	15	15	14.9	15.4	15.6	17.1	16.6
Sep-78	15	15.5	15.3	15.3	15.1	15.6	16.1	17.5	16.7
Oct-78	15.9	15.8	15.9	16	15.8	16.4	16.8	18.1	17.2
Nov-78	17.7	17.5	17.4	17.5	17.4	17.8	18.4	19.7	19.1
Dec-78	17.8	17.7	17.7	17.8	17.6	18	18.5	20.1	19.6
Jan-79	18.3	18.1	18.2	18.3	18.2	18.6	19.3	20.9	20.5
Feb-79	19.8	19.8	19.7	19.8	19.5	20	20.6	22	21.4
Mar-79	17.9	18	18	18.1	17.9	18.3	18.8	20.1	19.5
Apr-79	16.2	16.2	16.2	16.3	16.2	16.7	17.1	18.8	18.2
May-79	12.4	12.8	12.7	12.8	12.7	13.1	13.7	15.6	15.3
Jun-79	9.5	10	9.8	9.8	9.8	10.3	10.9	12.7	12.3
Jul-79	8.2	8.4	8.3	8.4	8.4	8.8	9.5	11.8	11.8
Aug-79	12.5	12.6	12.5	12.5	12.4	12.9	13.2	14.8	14.3
Sep-79	15	15.2	15	15.1	15	15.4	16	17.1	16.3
Oct-79	17.5	17.4	17.4	17.5	17.3	17.7	18	19.2	18.6
Nov-79	17.1	17	17	17.1	17	17.5	18.1	19.5	18.8
Dec-79	18.1	18	18	18.1	17.9	18.2	18.6	19.9	19.3
Jan-80	18.2	18.1	18.3	18.4	18.2	18.5	18.9	20.3	19.8
Feb-80	18.3	18.3	18.4	18.5	18.2	18.7	19.4	21	20.5

	Temperature (°C)								
Months	Quaternary Catchments								
	X11A	X11B	X11C	X11D	X11E	X11F	X11G	X11H	X11J
Mar-80	17.5	17.6	17.5	17.6	17.5	18	18.5	19.9	19.3
Apr-80	14.5	14.7	14.7	14.8	14.7	15.4	16	18.1	17.5
May-80	12	12.5	12.4	12.5	12.3	12.6	13	15.3	15.2
Jun-80	9.3	10.1	9.9	10	9.8	10.2	10.5	12	11.7
Jul-80	8.6	9.3	9.4	9.4	9.3	9.6	9.7	11.6	11.3
Aug-80	11	11.3	11.2	11.3	11.2	11.7	12.1	13.9	13.6
Sep-80	14	14.2	14.1	14.1	14	14.6	15.2	16.6	15.7
Oct-80	17.4	17.2	17.2	17.3	17.1	17.3	17.5	18.6	18.1
Nov-80	17.6	17.5	17.5	17.6	17.4	17.8	18.3	19.4	18.7
Dec-80	18.8	18.9	18.8	18.9	18.7	19	19.4	20.5	19.9
Jan-81	19.8	19.8	19.9	19.9	19.8	20.2	20.8	22.3	21.6
Feb-81	18.2	18.2	18.1	18.2	18	18.3	18.8	20.1	19.6
Mar-81	17	17.2	17	17.1	17	17.6	18.2	20	19.2
Apr-81	14.9	15.2	15.1	15.2	15	15.3	15.6	17.2	16.8
May-81	11.2	11.4	11.5	11.5	11.4	11.9	12.2	14.1	13.7
Jun-81	8.9	9.7	9.4	9.5	9.3	9.9	10.4	12.2	11.9
Jul-81	9.9	10.3	10.1	10.2	10.1	10.7	11.1	13.3	13
Aug-81	10.6	10.8	10.7	10.8	10.6	11.1	11.4	13	12.6
Sep-81	13.4	13.6	13.5	13.6	13.5	14.1	14.7	16.2	15.4
Oct-81	13.1	13	13.1	13.2	13	13.4	14	15.5	14.9
Nov-81	18.6	18.5	18.5	18.6	18.4	18.7	19.3	20.7	20.2
Dec-82	18.2	18.2	18.2	18.3	18.1	18.2	18.3	19.3	18.7
Jan-82	19.5	19.3	19.3	19.4	19.2	19.6	20.1	21.2	20.4
Feb-82	18.7	18.7	18.6	18.7	18.5	19.1	19.8	21.4	20.8
Mar-82	17.9	17.9	17.8	17.9	17.8	18.3	18.9	20.4	19.8
Apr-82	14.3	14.5	14.7	14.8	14.6	15.1	15.5	17.1	16.6
May-82	12.3	12.6	12.5	12.5	12.4	12.9	13.4	15.6	15.4
Jun-82	9.4	10.3	9.8	9.9	9.8	10.3	10.8	12.5	12.3
Jul-82	9.5	10	9.9	9.9	9.9	10.4	10.9	12.9	12.5
Aug-82	11.9	12	11.8	11.9	11.9	12.6	13.3	15.4	15
Sep-82	15.7	15.9	15.7	15.7	15.6	16	16.4	17.5	16.6
Oct-82	16.2	16	16	16.1	16	16.4	16.9	18.3	17.7
Nov-82	17.3	17.1	17.3	17.3	17.2	17.5	17.9	18.9	18.2
Dec-82	20.1	19.9	19.8	19.9	19.8	20.2	20.7	22	21.4

Appendix B

- Monthly precipitation data over quaternary catchments under different scenarios from October 2010 to September 2030
- Mean monthly temperature data over quaternary catchments under different scenarios from October 2010 to September 2030

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11A				X11B			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Oct-2010	29.6	29.6	32.56	26.64	25.5	25.5	28.05	22.95
Nov-2010	159.5	159.5	175.45	143.55	209	209	229.9	188.1
Dec-2010	94.4	94.4	103.84	84.96	132.6	132.6	145.86	119.34
Jan-2011	189.6	189.6	208.56	170.64	148.7	148.7	163.57	133.83
Feb-2011	138.1	138.1	151.91	124.29	168.4	168.4	185.24	151.56
Mar-2011	101.3	101.3	111.43	91.17	83.5	83.5	91.85	75.15
Apr-2011	79.8	79.8	87.78	71.82	99.9	99.9	109.89	89.91
May-2011	7.1	7.1	7.81	6.39	8.4	8.4	9.24	7.56
Jun-2011	0	0	0	0	0	0	0	0
July-2011	0	0	0	0	0	0	0	0
Aug-2011	17.5	17.5	19.25	15.75	4.9	4.9	5.39	4.41
Sep-2011	42.8	42.8	47.08	38.52	53.2	53.2	58.52	47.88
Oct-2011	92.9	92.9	102.19	83.61	84.8	84.8	93.28	76.32
Nov-2011	157.8	157.8	173.58	142.02	200.7	200.7	220.77	180.63
Dec-2011	172.7	172.7	189.97	155.43	158.1	158.1	173.91	142.29
Jan-2012	168.9	168.9	185.79	152.01	167.9	167.9	184.69	151.11
Feb-2012	53.8	53.8	59.18	48.42	40.7	40.7	44.77	36.63
Mar-2012	54.6	54.6	60.06	49.14	24.7	24.7	27.17	22.23
Apr-2012	150.1	150.1	165.11	135.09	97.4	97.4	107.14	87.66
May-2012	22	22	24.2	19.8	18.5	18.5	20.35	16.65
Jun-2012	13	13	14.3	11.7	10.8	10.8	11.88	9.72
July-2012	14.9	14.9	16.39	13.41	19.4	19.4	21.34	17.46
Aug-2012	13.6	13.6	14.96	12.24	2	2	2.2	1.8
Sep-2012	5.6	5.6	6.16	5.04	8.8	8.8	9.68	7.92
Oct-2012	55.2	55.2	60.72	49.68	50.5	50.5	55.55	45.45
Nov-2012	118.3	118.3	130.13	106.47	173.3	173.3	190.63	155.97
Dec-2012	236.4	236.4	260.04	212.76	127.1	127.1	139.81	114.39
Jan-2013	209.8	209.8	230.78	188.82	192.3	192.3	211.53	173.07
Feb-2013	193.3	193.3	212.63	173.97	195.4	195.4	214.94	175.86
Mar-2013	39	39	42.9	35.1	39.6	39.6	43.56	35.64
Apr-2013	110	110	121	99	58	58	63.8	52.2
May-2013	5.2	5.2	5.72	4.68	4.5	4.5	4.95	4.05
Jun-2013	0	0	0	0	0	0	0	0
July-2013	4.5	4.5	4.95	4.05	0	0	0	0
Aug-2013	4.5	4.5	4.95	4.05	8.8	8.8	9.68	7.92
Sep-2013	37.5	37.5	41.25	33.75	30.7	30.7	33.77	27.63
Oct-2013	65.7	65.7	72.27	59.13	68.4	68.4	75.24	61.56
Nov-2013	269.5	269.5	296.45	242.55	161	161	177.1	144.9
Dec-2013	156.2	156.2	171.82	140.58	164.2	164.2	180.62	147.78
Jan-2014	158	158	173.8	142.2	131.2	131.2	144.32	118.08
Feb-2014	74.9	74.9	82.39	67.41	86.5	86.5	95.15	77.85
Mar-2014	86.1	86.1	94.71	77.49	96.8	96.8	106.48	87.12
Apr-2014	46.5	46.5	51.15	41.85	30	30	33	27
May-2014	54.8	54.8	60.28	49.32	18.5	18.5	20.35	16.65
Jun-2014	0	0	0	0	0	0	0	0

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11A				X11B			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
July-2014	0	0	0	0	0	0	0	0
Aug-2014	0	0	0	0	0	0	0	0
Sep-2014	0	0	0	0	0	0	0	0
Oct-2014	61.7	61.7	67.87	55.53	71.8	71.8	78.98	64.62
Nov-2014	97.9	97.9	107.69	88.11	93.4	93.4	102.74	84.06
Dec-2014	149.9	149.9	164.89	134.91	128.1	128.1	140.91	115.29
Jan-2015	139.6	139.6	153.56	125.64	108.2	108.2	119.02	97.38
Feb-2015	40.2	40.2	44.22	36.18	77.6	77.6	85.36	69.84
Mar-2015	114.3	114.3	125.73	102.87	131.8	131.8	144.98	118.62
Apr-2015	23.8	23.8	26.18	21.42	54.5	54.5	59.95	49.05
May-2015	0	0	0	0	3.2	3.2	3.52	2.88
Jun-2015	0	0	0	0	0	0	0	0
July-2015	0	0	0	0	0	0	0	0
Aug-2015	0	0	0	0	1.3	1.3	1.43	1.17
Sep-2015	39	39	42.9	35.1	18	18	19.8	16.2
Oct-2015	111.8	111.8	122.98	100.62	57.1	57.1	62.81	51.39
Nov-2015	154.9	154.9	170.39	139.41	142.2	142.2	156.42	127.98
Dec-2015	78.9	78.9	86.79	71.01	76.9	76.9	84.59	69.21
Jan-2016	110.1	110.1	121.11	99.09	133.5	133.5	146.85	120.15
Feb-2016	71.8	71.8	78.98	64.62	145.5	145.5	160.05	130.95
Mar-2016	57.1	57.1	62.81	51.39	58.5	58.5	64.35	52.65
Apr-2016	31.8	31.8	34.98	28.62	23.4	23.4	25.74	21.06
May-2016	0	0	0	0	6.5	6.5	7.15	5.85
Jun-2016	0.4	0.4	0.44	0.36	0	0	0	0
July-2016	0	0	0	0	3.2	3.2	3.52	2.88
Aug-2016	27.9	27.9	30.69	25.11	16.8	16.8	18.48	15.12
Sep-2016	29.9	29.9	32.89	26.91	13.2	13.2	14.52	11.88
Oct-2016	148.8	148.8	163.68	133.92	105.4	105.4	115.94	94.86
Nov-2016	53.1	53.1	58.41	47.79	51.5	51.5	56.65	46.35
Dec-2016	156.9	156.9	172.59	141.21	136.9	136.9	150.59	123.21
Jan-2017	134.4	134.4	147.84	120.96	224.4	224.4	246.84	201.96
Feb-2017	23.2	23.2	25.52	20.88	14	14	15.4	12.6
Mar-2017	73.3	73.3	80.63	65.97	72.7	72.7	79.97	65.43
Apr-2017	40.1	40.1	44.11	36.09	6.6	6.6	7.26	5.94
May-2017	0	0	0	0	0	0	0	0
Jun-2017	5.8	5.8	6.38	5.22	3.2	3.2	3.52	2.88
July-2017	1.6	1.6	1.76	1.44	0	0	0	0
Aug-2017	53.7	53.7	59.07	48.33	11.5	11.5	12.65	10.35
Sep-2017	36.9	36.9	40.59	33.21	58.4	58.4	64.24	52.56
Oct-2017	79.9	79.9	87.89	71.91	55.4	55.4	60.94	49.86
Nov-2017	197.7	197.7	217.47	177.93	146.9	146.9	161.59	132.21
Dec-2017	48.3	48.3	53.13	43.47	42.1	42.1	46.31	37.89
Jan-2018	245.7	245.7	270.27	221.13	218	218	239.8	196.2
Feb-2018	59.8	59.8	65.78	53.82	101.3	101.3	111.43	91.17

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11A				X11B			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Mar-2018	103.9	103.9	114.29	93.51	56.5	56.5	62.15	50.85
Apr-2018	57.9	57.9	63.69	52.11	42.2	42.2	46.42	37.98
May-2018	11.7	11.7	12.87	10.53	7.1	7.1	7.81	6.39
Jun-2018	0	0	0	0	0	0	0	0
July-2018	0	0	0	0	0	0	0	0
Aug-2018	7.8	7.8	8.58	7.02	7.7	7.7	8.47	6.93
Sep-2018	12.5	12.5	13.75	11.25	5.5	5.5	6.05	4.95
Oct-2018	40.5	40.5	44.55	36.45	29.8	29.8	32.78	26.82
Nov-2018	162.8	162.8	179.08	146.52	135.5	135.5	149.05	121.95
Dec-2018	190.4	190.4	209.44	171.36	95.7	95.7	105.27	86.13
Jan-2019	163	163	179.3	146.7	215.6	215.6	237.16	194.04
Feb-2019	149	149	163.9	134.1	142	142	156.2	127.8
Mar-2019	137.2	137.2	150.92	123.48	120.3	120.3	132.33	108.27
Apr-2019	15.2	15.2	16.72	13.68	6.1	6.1	6.71	5.49
May-2019	3.2	3.2	3.52	2.88	0	0	0	0
Jun-2019	30.5	30.5	33.55	27.45	10.5	10.5	11.55	9.45
July-2019	0	0	0	0	0	0	0	0
Aug-2019	21.4	21.4	23.54	19.26	11.8	11.8	12.98	10.62
Sep-2019	29.4	29.4	32.34	26.46	15.6	15.6	17.16	14.04
Oct-2019	45.8	45.8	50.38	41.22	49	49	53.9	44.1
Nov-2019	44.5	44.5	48.95	40.05	49.9	49.9	54.89	44.91
Dec-2019	109.1	109.1	120.01	98.19	110.1	110.1	121.11	99.09
Jan-2020	155.2	155.2	170.72	139.68	160.3	160.3	176.33	144.27
Feb-2020	59.8	59.8	65.78	53.82	48.2	48.2	53.02	43.38
Mar-2020	57.4	57.4	63.14	51.66	51.9	51.9	57.09	46.71
Apr-2020	12.2	12.2	13.42	10.98	17.4	17.4	19.14	15.66
May-2020	1.2	1.2	1.32	1.08	0	0	0	0
Jun-2020	0	0	0	0	0	0	0	0
July-2020	15.6	15.6	17.16	14.04	2.3	2.3	2.53	2.07
Aug-2020	0	0	0	0	0	0	0	0
Sep-2020	18.8	18.8	20.68	16.92	4.2	4.2	4.62	3.78
Oct-2020	120.8	120.8	132.88	108.72	83.5	83.5	91.85	75.15
Nov-2020	43.6	43.6	47.96	39.24	41.3	41.3	45.43	37.17
Dec-2020	111.5	111.5	122.65	100.35	119.6	119.6	131.56	107.64
Jan-2021	212.7	212.7	233.97	191.43	149.4	149.4	164.34	134.46
Feb-2021	30.9	30.9	33.99	27.81	24.1	24.1	26.51	21.69
Mar-2021	67.5	67.5	74.25	60.75	78.2	78.2	86.02	70.38
Apr-2021	49.5	49.5	54.45	44.55	32.7	32.7	35.97	29.43
May-2021	17.5	17.5	19.25	15.75	26.8	26.8	29.48	24.12
Jun-2021	13	13	14.3	11.7	4.5	4.5	4.95	4.05
July-2021	15.6	15.6	17.16	14.04	7.5	7.5	8.25	6.75
Aug-2021	49.4	49.4	54.34	44.46	23.6	23.6	25.96	21.24
Sep-2021	0	0	0	0	1.4	1.4	1.54	1.26
Oct-2021	107	107	117.7	96.3	64.8	64.8	71.28	58.32
Nov-2021	323.7	323.7	356.07	291.33	263	263	289.3	236.7

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11A				X11B			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Dec-2021	125.8	125.8	138.38	113.22	150.2	150.2	165.22	135.18
Jan-2022	183.7	183.7	202.07	165.33	163.3	163.3	179.63	146.97
Feb-2022	86.3	86.3	94.93	77.67	63.5	63.5	69.85	57.15
Mar-2022	205.2	205.2	225.72	184.68	151.1	151.1	166.21	135.99
Apr-2022	17	17	18.7	15.3	14.3	14.3	15.73	12.87
May-2022	10.4	10.4	11.44	9.36	0	0	0	0
Jun-2022	21.4	21.4	23.54	19.26	16.8	16.8	18.48	15.12
July-2022	37	37	40.7	33.3	39.6	39.6	43.56	35.64
Aug-2022	15.6	15.6	17.16	14.04	8.4	8.4	9.24	7.56
Sep-2022	25.6	25.6	28.16	23.04	16	16	17.6	14.4
Oct-2022	140.5	140.5	154.55	126.45	143	143	157.3	128.7
Nov-2022	61.4	61.4	67.54	55.26	76.7	76.7	84.37	69.03
Dec-2022	190.9	190.9	209.99	171.81	120.8	120.8	132.88	108.72
Jan-2023	94.2	94.2	103.62	84.78	93.6	93.6	102.96	84.24
Feb-2023	174.7	174.7	192.17	157.23	170.3	170.3	187.33	153.27
Mar-2023	54.5	54.5	59.95	49.05	54.1	54.1	59.51	48.69
Apr-2023	0	0	0	0	0	0	0	0
May-2023	15	15	16.5	13.5	27.2	27.2	29.92	24.48
Jun-2023	3.2	3.2	3.52	2.88	4.9	4.9	5.39	4.41
July-2023	0	0	0	0	13.6	13.6	14.96	12.24
Aug-2023	0.6	0.6	0.66	0.54	1.4	1.4	1.54	1.26
Sep-2023	80	80	88	72	119.7	119.7	131.67	107.73
Oct-2023	108.6	108.6	119.46	97.74	102.5	102.5	112.75	92.25
Nov-2023	42.3	42.3	46.53	38.07	93.3	93.3	102.63	83.97
Dec-2023	215	215	236.5	193.5	93.4	93.4	102.74	84.06
Jan-2024	140.1	140.1	154.11	126.09	98.9	98.9	108.79	89.01
Feb-2024	137.5	137.5	151.25	123.75	131.5	131.5	144.65	118.35
Mar-2024	44.8	44.8	49.28	40.32	34.2	34.2	37.62	30.78
Apr-2024	48.7	48.7	53.57	43.83	60.9	60.9	66.99	54.81
May-2024	0	0	0	0	9.4	9.4	10.34	8.46
Jun-2024	11.7	11.7	12.87	10.53	13.3	13.3	14.63	11.97
July-2024	0	0	0	0	0	0	0	0
Aug-2024	1.3	1.3	1.43	1.17	1.5	1.5	1.65	1.35
Sep-2024	18.1	18.1	19.91	16.29	15.4	15.4	16.94	13.86
Oct-2024	154	154	169.4	138.6	76.4	76.4	84.04	68.76
Nov-2024	99.7	99.7	109.67	89.73	71.4	71.4	78.54	64.26
Dec-2024	140.3	140.3	154.33	126.27	99.8	99.8	109.78	89.82
Jan-2025	245.5	245.5	270.05	220.95	180.5	180.5	198.55	162.45
Feb-2025	110.5	110.5	121.55	99.45	95.5	95.5	105.05	85.95
Mar-2025	170.3	170.3	187.33	153.27	207.8	207.8	228.58	187.02
Apr-2025	35.9	35.9	39.49	32.31	21.6	21.6	23.76	19.44
May-2025	2.6	2.6	2.86	2.34	0	0	0	0
Jun-2025	2.6	2.6	2.86	2.34	2.1	2.1	2.31	1.89
July-2025	0	0	0	0	0	0	0	0

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11A				X11B			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Aug-2025	75.3	75.3	82.83	67.77	43.4	43.4	47.74	39.06
Sep-2025	213.1	213.1	234.41	191.79	115.5	115.5	127.05	103.95
Oct-2025	134.8	134.8	148.28	121.32	71.7	71.7	78.87	64.53
Nov-2025	191.9	191.9	211.09	172.71	198	198	217.8	178.2
Dec-2025	85.6	85.6	94.16	77.04	128.3	128.3	141.13	115.47
Jan-2026	87.1	87.1	95.81	78.39	123.3	123.3	135.63	110.97
Feb-2026	65.6	65.6	72.16	59.04	48.2	48.2	53.02	43.38
Mar-2026	77.2	77.2	84.92	69.48	39.5	39.5	43.45	35.55
Apr-2026	29.3	29.3	32.23	26.37	22.9	22.9	25.19	20.61
May-2026	0	0	0	0	0	0	0	0
Jun-2026	40.2	40.2	44.22	36.18	7.4	7.4	8.14	6.66
July-2026	14.9	14.9	16.39	13.41	0	0	0	0
Aug-2026	3.2	3.2	3.52	2.88	2.5	2.5	2.75	2.25
Sep-2026	59.5	59.5	65.45	53.55	4	4	4.4	3.6
Oct-2026	144.5	144.5	158.95	130.05	119	119	130.9	107.1
Nov-2026	84.6	84.6	93.06	76.14	63	63	69.3	56.7
Dec-2026	161.2	161.2	177.32	145.08	157.7	157.7	173.47	141.93
Jan-2027	131.2	131.2	144.32	118.08	110.7	110.7	121.77	99.63
Feb-2027	150.8	150.8	165.88	135.72	111.6	111.6	122.76	100.44
Mar-2027	16.2	16.2	17.82	14.58	41.3	41.3	45.43	37.17
Apr-2027	22.6	22.6	24.86	20.34	12.6	12.6	13.86	11.34
May-2027	42.8	42.8	47.08	38.52	17.6	17.6	19.36	15.84
Jun-2027	91.6	91.6	100.76	82.44	3.7	3.7	4.07	3.33
July-2027	0	0	0	0	0	0	0	0
Aug-2027	16.9	16.9	18.59	15.21	7.8	7.8	8.58	7.02
Sep-2027	21.2	21.2	23.32	19.08	10.4	10.4	11.44	9.36
Oct-2027	63.2	63.2	69.52	56.88	57.5	57.5	63.25	51.75
Nov-2027	254.6	254.6	280.06	229.14	198.8	198.8	218.68	178.92
Dec-2027	141.3	141.3	155.43	127.17	94.8	94.8	104.28	85.32
Jan-2028	91.6	91.6	100.76	82.44	30	30	33	27
Feb-2028	216.6	216.6	238.26	194.94	98.5	98.5	108.35	88.65
Mar-2028	144.9	144.9	159.39	130.41	95.9	95.9	105.49	86.31
Apr-2028	62.8	62.8	69.08	56.52	48.9	48.9	53.79	44.01
May-2028	7.8	7.8	8.58	7.02	5.2	5.2	5.72	4.68
Jun-2028	0	0	0	0	0	0	0	0
July-2028	0	0	0	0	1.3	1.3	1.43	1.17
Aug-2028	0	0	0	0	3.1	3.1	3.41	2.79
Sep-2028	7	7	7.7	6.3	2.4	2.4	2.64	2.16
Oct-2028	76.4	76.4	84.04	68.76	66.3	66.3	72.93	59.67
Nov-2028	176.3	176.3	193.93	158.67	121.2	121.2	133.32	109.08
Dec-2028	105.9	105.9	116.49	95.31	151.9	151.9	167.09	136.71
Jan-2029	253.5	253.5	278.85	228.15	190.4	190.4	209.44	171.36
Feb-2029	89.8	89.8	98.78	80.82	53.8	53.8	59.18	48.42
Mar-2029	18.2	18.2	20.02	16.38	180.6	180.6	198.66	162.54
Apr-2029	0	0	0	0	0	0	0	0

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11A				X11B			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
May-2029	11.7	11.7	12.87	10.53	58.5	58.5	64.35	52.65
Jun-2029	46.8	46.8	51.48	42.12	31.6	31.6	34.76	28.44
July-2029	0	0	0	0	0	0	0	0
Aug-2029	1.3	1.3	1.43	1.17	0	0	0	0
Sep-2029	1.2	1.2	1.32	1.08	56.8	56.8	62.48	51.12
Oct-2029	32.3	32.3	35.53	29.07	48.1	48.1	52.91	43.29
Nov-2029	62.9	62.9	69.19	56.61	88.6	88.6	97.46	79.74
Dec-2029	62.4	62.4	68.64	56.16	61.8	61.8	67.98	55.62
Jan-2030	67.4	67.4	74.14	60.66	54.3	54.3	59.73	48.87
Feb-2030	82.5	82.5	90.75	74.25	150	150	165	135
Mar-2030	40.9	40.9	44.99	36.81	25.1	25.1	27.61	22.59
Apr-2030	41.4	41.4	45.54	37.26	14.8	14.8	16.28	13.32
May-2030	0	0	0	0	0	0	0	0
Jun-2030	0	0	0	0	0	0	0	0
July-2030	0.9	0.9	0.99	0.81	0	0	0	0
Aug-2030	36.4	36.4	40.04	32.76	10.8	10.8	11.88	9.72
Sep-2030	5	5	5.5	4.5	3.7	3.7	4.07	3.33
Oct-2030	60.1	60.1	66.11	54.09	32.8	32.8	36.08	29.52
Nov-2030	38.1	38.1	41.91	34.29	39.4	39.4	43.34	35.46
Dec-2030	254.8	254.8	280.28	229.32	171.6	171.6	188.76	154.44

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11C				X11D			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Oct-2010	23.9	23.9	26.29	21.51	20.79	20.79	22.869	18.711
Nov-2010	152.9	152.9	168.19	137.61	119.43	119.43	131.373	107.487
Dec-2010	57	57	62.7	51.3	136.35	136.35	149.985	122.715
Jan-2011	146.5	146.5	161.15	131.85	191.25	191.25	210.375	172.125
Feb-2011	160.9	160.9	176.99	144.81	195.03	195.03	214.533	175.527
Mar-2011	71.4	71.4	78.54	64.26	83.79	83.79	92.169	75.411
Apr-2011	140.1	140.1	154.11	126.09	83.97	83.97	92.367	75.573
May-2011	9.1	9.1	10.01	8.19	3.51	3.51	3.861	3.159
Jun-2011	0	0	0	0	0	0	0	0
July-2011	0	0	0	0	0	0	0	0
Aug-2011	3.4	3.4	3.74	3.06	2.16	2.16	2.376	1.944
Sep-2011	81.7	81.7	89.87	73.53	95.76	95.76	105.336	86.184
Oct-2011	49	49	53.9	44.1	104.58	104.58	115.038	94.122
Nov-2011	138.8	138.8	152.68	124.92	135.63	135.63	149.193	122.067
Dec-2011	128.9	128.9	141.79	116.01	94.23	94.23	103.653	84.807
Jan-2012	260.3	260.3	286.33	234.27	168.03	168.03	184.833	151.227
Feb-2012	44.7	44.7	49.17	40.23	73.53	73.53	80.883	66.177
Mar-2012	146.1	146.1	160.71	131.49	70.2	70.2	77.22	63.18

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11C				X11D			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Apr-2012	73.1	73.1	80.41	65.79	95.04	95.04	104.544	85.536
May-2012	2.6	2.6	2.86	2.34	5.67	5.67	6.237	5.103
Jun-2012	6.4	6.4	7.04	5.76	11.07	11.07	12.177	9.963
July-2012	6.5	6.5	7.15	5.85	18.81	18.81	20.691	16.929
Aug-2012	0	0	0	0	26.82	26.82	29.502	24.138
Sep-2012	13.9	13.9	15.29	12.51	18	18	19.8	16.2
Oct-2012	24	24	26.4	21.6	31.68	31.68	34.848	28.512
Nov-2012	130.2	130.2	143.22	117.18	119.52	119.52	131.472	107.568
Dec-2012	136.8	136.8	150.48	123.12	139.32	139.32	153.252	125.388
Jan-2013	302	302	332.2	271.8	187.02	187.02	205.722	168.318
Feb-2013	163.1	163.1	179.41	146.79	140.04	140.04	154.044	126.036
Mar-2013	37.6	37.6	41.36	33.84	20.97	20.97	23.067	18.873
Apr-2013	138.9	138.9	152.79	125.01	84.6	84.6	93.06	76.14
May-2013	6.5	6.5	7.15	5.85	9.72	9.72	10.692	8.748
Jun-2013	2.9	2.9	3.19	2.61	7.65	7.65	8.415	6.885
July-2013	0	0	0	0	1.98	1.98	2.178	1.782
Aug-2013	0	0	0	0	2.61	2.61	2.871	2.349
Sep-2013	19.1	19.1	21.01	17.19	33.48	33.48	36.828	30.132
Oct-2013	50.3	50.3	55.33	45.27	59.04	59.04	64.944	53.136
Nov-2013	145.7	145.7	160.27	131.13	105.75	105.75	116.325	95.175
Dec-2013	146.6	146.6	161.26	131.94	158.58	158.58	174.438	142.722
Jan-2014	157.2	157.2	172.92	141.48	240.84	240.84	264.924	216.756
Feb-2014	78.3	78.3	86.13	70.47	80.91	80.91	89.001	72.819
Mar-2014	186.4	186.4	205.04	167.76	78.3	78.3	86.13	70.47
Apr-2014	56.6	56.6	62.26	50.94	49.23	49.23	54.153	44.307
May-2014	0	0	0	0	10.17	10.17	11.187	9.153
Jun-2014	0	0	0	0	0	0	0	0
July-2014	0	0	0	0	0	0	0	0
Aug-2014	0	0	0	0	0	0	0	0
Sep-2014	2	2	2.2	1.8	8.46	8.46	9.306	7.614
Oct-2014	94.8	94.8	104.28	85.32	45.09	45.09	49.599	40.581
Nov-2014	188	188	206.8	169.2	144.81	144.81	159.291	130.329
Dec-2014	97.7	97.7	107.47	87.93	163.8	163.8	180.18	147.42
Jan-2015	132	132	145.2	118.8	81.72	81.72	89.892	73.548
Feb-2015	49.3	49.3	54.23	44.37	9.72	9.72	10.692	8.748
Mar-2015	140.9	140.9	154.99	126.81	130.68	130.68	143.748	117.612
Apr-2015	43.1	43.1	47.41	38.79	62.73	62.73	69.003	56.457
May-2015	1.3	1.3	1.43	1.17	0	0	0	0
Jun-2015	0	0	0	0	0.72	0.72	0.792	0.648
July-2015	0	0	0	0	0	0	0	0
Aug-2015	6.5	6.5	7.15	5.85	3.15	3.15	3.465	2.835
Sep-2015	55.3	55.3	60.83	49.77	26.37	26.37	29.007	23.733
Oct-2015	62	62	68.2	55.8	63.72	63.72	70.092	57.348
Nov-2015	125.3	125.3	137.83	112.77	125.73	125.73	138.303	113.157
Dec-2015	164.7	164.7	181.17	148.23	182.61	182.61	200.871	164.349

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11C				X11D			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Jan-2016	164.3	164.3	180.73	147.87	222.84	222.84	245.124	200.556
Feb-2016	124.1	124.1	136.51	111.69	53.64	53.64	59.004	48.276
Mar-2016	74.8	74.8	82.28	67.32	75.6	75.6	83.16	68.04
Apr-2016	32.5	32.5	35.75	29.25	14.49	14.49	15.939	13.041
May-2016	0	0	0	0	4.41	4.41	4.851	3.969
Jun-2016	0	0	0	0	0	0	0	0
July-2016	0	0	0	0	2.61	2.61	2.871	2.349
Aug-2016	20.8	20.8	22.88	18.72	14.31	14.31	15.741	12.879
Sep-2016	24.4	24.4	26.84	21.96	14.85	14.85	16.335	13.365
Oct-2016	68.9	68.9	75.79	62.01	71.46	71.46	78.606	64.314
Nov-2016	75.7	75.7	83.27	68.13	78.84	78.84	86.724	70.956
Dec-2016	51.3	51.3	56.43	46.17	150.3	150.3	165.33	135.27
Jan-2017	117	117	128.7	105.3	122.76	122.76	135.036	110.484
Feb-2017	59.8	59.8	65.78	53.82	73.89	73.89	81.279	66.501
Mar-2017	54.6	54.6	60.06	49.14	71.19	71.19	78.309	64.071
Apr-2017	43.6	43.6	47.96	39.24	27.45	27.45	30.195	24.705
May-2017	0	0	0	0	0	0	0	0
Jun-2017	15.6	15.6	17.16	14.04	2.79	2.79	3.069	2.511
July-2017	0	0	0	0	2.07	2.07	2.277	1.863
Aug-2017	14.2	14.2	15.62	12.78	6.48	6.48	7.128	5.832
Sep-2017	18.6	18.6	20.46	16.74	15.21	15.21	16.731	13.689
Oct-2017	70.2	70.2	77.22	63.18	41.22	41.22	45.342	37.098
Nov-2017	244.3	244.3	268.73	219.87	173.43	173.43	190.773	156.087
Dec-2017	123.1	123.1	135.41	110.79	99.99	99.99	109.989	89.991
Jan-2018	322.3	322.3	354.53	290.07	282.6	282.6	310.86	254.34
Feb-2018	131.8	131.8	144.98	118.62	175.05	175.05	192.555	157.545
Mar-2018	26	26	28.6	23.4	48.6	48.6	53.46	43.74
Apr-2018	64.2	64.2	70.62	57.78	58.68	58.68	64.548	52.812
May-2018	0	0	0	0	0	0	0	0
Jun-2018	0	0	0	0	0	0	0	0
July-2018	0	0	0	0	0	0	0	0
Aug-2018	0	0	0	0	5.22	5.22	5.742	4.698
Sep-2018	26.1	26.1	28.71	23.49	13.41	13.41	14.751	12.069
Oct-2018	33.9	33.9	37.29	30.51	5.94	5.94	6.534	5.346
Nov-2018	180.5	180.5	198.55	162.45	178.83	178.83	196.713	160.947
Dec-2018	115.2	115.2	126.72	103.68	155.7	155.7	171.27	140.13
Jan-2019	127.8	127.8	140.58	115.02	118.08	118.08	129.888	106.272
Feb-2019	121.5	121.5	133.65	109.35	202.23	202.23	222.453	182.007
Mar-2019	94.2	94.2	103.62	84.78	153.36	153.36	168.696	138.024
Apr-2019	21.8	21.8	23.98	19.62	11.34	11.34	12.474	10.206
May-2019	0	0	0	0	0.72	0.72	0.792	0.648
Jun-2019	12.3	12.3	13.53	11.07	27.63	27.63	30.393	24.867
July-2019	0	0	0	0	0	0	0	0
Aug-2019	20.1	20.1	22.11	18.09	36.81	36.81	40.491	33.129

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11C				X11D			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Sep-2019	31.3	31.3	34.43	28.17	24.3	24.3	26.73	21.87
Oct-2019	49.7	49.7	54.67	44.73	28.35	28.35	31.185	25.515
Nov-2019	101.2	101.2	111.32	91.08	80.46	80.46	88.506	72.414
Dec-2019	97.3	97.3	107.03	87.57	101.07	101.07	111.177	90.963
Jan-2020	164.3	164.3	180.73	147.87	231.57	231.57	254.727	208.413
Feb-2020	52.7	52.7	57.97	47.43	18.54	18.54	20.394	16.686
Mar-2020	76.6	76.6	84.26	68.94	89.01	89.01	97.911	80.109
Apr-2020	8.8	8.8	9.68	7.92	12.78	12.78	14.058	11.502
May-2020	0	0	0	0	0	0	0	0
Jun-2020	0	0	0	0	0	0	0	0
July-2020	0	0	0	0	0	0	0	0
Aug-2020	0	0	0	0	0	0	0	0
Sep-2020	19.8	19.8	21.78	17.82	14.31	14.31	15.741	12.879
Oct-2020	69.8	69.8	76.78	62.82	83.52	83.52	91.872	75.168
Nov-2020	76.2	76.2	83.82	68.58	81	81	89.1	72.9
Dec-2020	113.9	113.9	125.29	102.51	61.74	61.74	67.914	55.566
Jan-2021	183.1	183.1	201.41	164.79	106.11	106.11	116.721	95.499
Feb-2021	59.6	59.6	65.56	53.64	59.67	59.67	65.637	53.703
Mar-2021	100.4	100.4	110.44	90.36	52.11	52.11	57.321	46.899
Apr-2021	36.3	36.3	39.93	32.67	42.48	42.48	46.728	38.232
May-2021	13	13	14.3	11.7	59.4	59.4	65.34	53.46
Jun-2021	11	11	12.1	9.9	12.96	12.96	14.256	11.664
July-2021	16.2	16.2	17.82	14.58	8.91	8.91	9.801	8.019
Aug-2021	37.4	37.4	41.14	33.66	36.36	36.36	39.996	32.724
Sep-2021	0	0	0	0	1.71	1.71	1.881	1.539
Oct-2021	96.6	96.6	106.26	86.94	108.45	108.45	119.295	97.605
Nov-2021	218.9	218.9	240.79	197.01	236.34	236.34	259.974	212.706
Dec-2021	177.7	177.7	195.47	159.93	215.46	215.46	237.006	193.914
Jan-2022	202.7	202.7	222.97	182.43	178.29	178.29	196.119	160.461
Feb-2022	28	28	30.8	25.2	76.59	76.59	84.249	68.931
Mar-2022	100.6	100.6	110.66	90.54	84.15	84.15	92.565	75.735
Apr-2022	14.2	14.2	15.62	12.78	18.09	18.09	19.899	16.281
May-2022	0	0	0	0	0	0	0	0
Jun-2022	16.2	16.2	17.82	14.58	24.84	24.84	27.324	22.356
July-2022	22.1	22.1	24.31	19.89	36.45	36.45	40.095	32.805
Aug-2022	3.9	3.9	4.29	3.51	10.53	10.53	11.583	9.477
Sep-2022	30.2	30.2	33.22	27.18	27	27	29.7	24.3
Oct-2022	104.5	104.5	114.95	94.05	126	126	138.6	113.4
Nov-2022	58.8	58.8	64.68	52.92	126.72	126.72	139.392	114.048
Dec-2022	124.5	124.5	136.95	112.05	109.35	109.35	120.285	98.415
Jan-2023	37.6	37.6	41.36	33.84	112.59	112.59	123.849	101.331
Feb-2023	167.2	167.2	183.92	150.48	167.22	167.22	183.942	150.498
Mar-2023	30.3	30.3	33.33	27.27	77.67	77.67	85.437	69.903
Apr-2023	0	0	0	0	0	0	0	0
May-2023	28.3	28.3	31.13	25.47	51.84	51.84	57.024	46.656

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11C				X11D			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Jun-2023	3.2	3.2	3.52	2.88	2.79	2.79	3.069	2.511
July-2023	4.5	4.5	4.95	4.05	0	0	0	0
Aug-2023	5.8	5.8	6.38	5.22	0	0	0	0
Sep-2023	26.1	26.1	28.71	23.49	57.33	57.33	63.063	51.597
Oct-2023	52.7	52.7	57.97	47.43	47.52	47.52	52.272	42.768
Nov-2023	102.4	102.4	112.64	92.16	35.73	35.73	39.303	32.157
Dec-2023	156.4	156.4	172.04	140.76	160.74	160.74	176.814	144.666
Jan-2024	116.8	116.8	128.48	105.12	189.18	189.18	208.098	170.262
Feb-2024	108.4	108.4	119.24	97.56	214.38	214.38	235.818	192.942
Mar-2024	65.5	65.5	72.05	58.95	46.62	46.62	51.282	41.958
Apr-2024	29.5	29.5	32.45	26.55	62.19	62.19	68.409	55.971
May-2024	0	0	0	0	1.17	1.17	1.287	1.053
Jun-2024	20.8	20.8	22.88	18.72	15.57	15.57	17.127	14.013
July-2024	0	0	0	0	0	0	0	0
Aug-2024	0	0	0	0	0.27	0.27	0.297	0.243
Sep-2024	14.5	14.5	15.95	13.05	15.39	15.39	16.929	13.851
Oct-2024	112.8	112.8	124.08	101.52	87.3	87.3	96.03	78.57
Nov-2024	117.7	117.7	129.47	105.93	87.03	87.03	95.733	78.327
Dec-2024	172.4	172.4	189.64	155.16	66.6	66.6	73.26	59.94
Jan-2025	186.4	186.4	205.04	167.76	236.79	236.79	260.469	213.111
Feb-2025	140.9	140.9	154.99	126.81	103.41	103.41	113.751	93.069
Mar-2025	294.3	294.3	323.73	264.87	193.41	193.41	212.751	174.069
Apr-2025	59.6	59.6	65.56	53.64	39.87	39.87	43.857	35.883
May-2025	0	0	0	0	0	0	0	0
Jun-2025	0	0	0	0	10.17	10.17	11.187	9.153
July-2025	0	0	0	0	0	0	0	0
Aug-2025	47.4	47.4	52.14	42.66	51.3	51.3	56.43	46.17
Sep-2025	149.7	149.7	164.67	134.73	193.5	193.5	212.85	174.15
Oct-2025	73.1	73.1	80.41	65.79	102.96	102.96	113.256	92.664
Nov-2025	201.4	201.4	221.54	181.26	190.35	190.35	209.385	171.315
Dec-2025	130	130	143	117	133.74	133.74	147.114	120.366
Jan-2026	103.3	103.3	113.63	92.97	231.75	231.75	254.925	208.575
Feb-2026	29.7	29.7	32.67	26.73	41.22	41.22	45.342	37.098
Mar-2026	137.7	137.7	151.47	123.93	82.26	82.26	90.486	74.034
Apr-2026	8.8	8.8	9.68	7.92	30.42	30.42	33.462	27.378
May-2026	0	0	0	0	0.9	0.9	0.99	0.81
Jun-2026	20.8	20.8	22.88	18.72	20.7	20.7	22.77	18.63
July-2026	0	0	0	0	4.23	4.23	4.653	3.807
Aug-2026	0	0	0	0	0.36	0.36	0.396	0.324
Sep-2026	41.8	41.8	45.98	37.62	35.91	35.91	39.501	32.319
Oct-2026	117.6	117.6	129.36	105.84	138.78	138.78	152.658	124.902
Nov-2026	53.9	53.9	59.29	48.51	34.02	34.02	37.422	30.618
Dec-2026	159.3	159.3	175.23	143.37	113.04	113.04	124.344	101.736
Jan-2027	104	104	114.4	93.6	94.41	94.41	103.851	84.969

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11C				X11D			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Feb-2027	161.5	161.5	177.65	145.35	154.98	154.98	170.478	139.482
Mar-2027	49.3	49.3	54.23	44.37	14.76	14.76	16.236	13.284
Apr-2027	41.8	41.8	45.98	37.62	29.88	29.88	32.868	26.892
May-2027	16.2	16.2	17.82	14.58	13.59	13.59	14.949	12.231
Jun-2027	55.9	55.9	61.49	50.31	49.77	49.77	54.747	44.793
July-2027	5.8	5.8	6.38	5.22	0	0	0	0
Aug-2027	27.3	27.3	30.03	24.57	9.81	9.81	10.791	8.829
Sep-2027	17.4	17.4	19.14	15.66	13.14	13.14	14.454	11.826
Oct-2027	43.9	43.9	48.29	39.51	77.94	77.94	85.734	70.146
Nov-2027	193.6	193.6	212.96	174.24	210.42	210.42	231.462	189.378
Dec-2027	156.6	156.6	172.26	140.94	88.11	88.11	96.921	79.299
Jan-2028	115.6	115.6	127.16	104.04	111.15	111.15	122.265	100.035
Feb-2028	179.2	179.2	197.12	161.28	128.97	128.97	141.867	116.073
Mar-2028	116.2	116.2	127.82	104.58	89.64	89.64	98.604	80.676
Apr-2028	95.7	95.7	105.27	86.13	80.64	80.64	88.704	72.576
May-2028	31.2	31.2	34.32	28.08	8.82	8.82	9.702	7.938
Jun-2028	0	0	0	0	0	0	0	0
July-2028	0	0	0	0	0.54	0.54	0.594	0.486
Aug-2028	0	0	0	0	6.93	6.93	7.623	6.237
Sep-2028	5.8	5.8	6.38	5.22	3.96	3.96	4.356	3.564
Oct-2028	46.3	46.3	50.93	41.67	30.51	30.51	33.561	27.459
Nov-2028	122.7	122.7	134.97	110.43	105.66	105.66	116.226	95.094
Dec-2028	123.4	123.4	135.74	111.06	163.62	163.62	179.982	147.258
Jan-2029	291	291	320.1	261.9	156.42	156.42	172.062	140.778
Feb-2029	70.7	70.7	77.77	63.63	108.99	108.99	119.889	98.091
Mar-2029	216.2	216.2	237.82	194.58	216.36	216.36	237.996	194.724
Apr-2029	0	0	0	0	6.3	6.3	6.93	5.67
May-2029	4.4	4.4	4.84	3.96	17.91	17.91	19.701	16.119
Jun-2029	28.6	28.6	31.46	25.74	24.93	24.93	27.423	22.437
July-2029	0	0	0	0	0.72	0.72	0.792	0.648
Aug-2029	0	0	0	0	0	0	0	0
Sep-2029	13.3	13.3	14.63	11.97	13.41	13.41	14.751	12.069
Oct-2029	73.7	73.7	81.07	66.33	33.12	33.12	36.432	29.808
Nov-2029	39.7	39.7	43.67	35.73	100.98	100.98	111.078	90.882
Dec-2029	134.5	134.5	147.95	121.05	112.86	112.86	124.146	101.574
Jan-2030	89.6	89.6	98.56	80.64	55.17	55.17	60.687	49.653
Feb-2030	85.8	85.8	94.38	77.22	41.94	41.94	46.134	37.746
Mar-2030	79.9	79.9	87.89	71.91	40.5	40.5	44.55	36.45
Apr-2030	63	63	69.3	56.7	51.84	51.84	57.024	46.656
May-2030	0	0	0	0	0	0	0	0
Jun-2030	0	0	0	0	0	0	0	0
July-2030	0	0	0	0	0	0	0	0
Aug-2030	39	39	42.9	35.1	24.84	24.84	27.324	22.356
Sep-2030	48.7	48.7	53.57	43.83	50.67	50.67	55.737	45.603
Oct-2030	67.8	67.8	74.58	61.02	34.83	34.83	38.313	31.347

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11C				X11D			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Nov-2030	96.7	96.7	106.37	87.03	37.44	37.44	41.184	33.696
Dec-2030	175.4	175.4	192.94	157.86	209.79	209.79	230.769	188.811

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11E				X11F			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Oct-2010	18.18	18.18	20.00	16.362	67.9	67.9	74.69	61.11
Nov-2010	116.1	116.1	127.71	104.49	196.3	196.3	215.93	176.67
Dec-2010	136.35	136.35	149.99	122.715	103.8	103.8	114.18	93.42
Jan-2011	191.25	191.25	210.38	172.125	115.7	115.7	127.27	104.13
Feb-2011	195.03	195.03	214.53	175.527	236.9	236.9	260.59	213.21
Mar-2011	83.79	83.79	92.17	75.411	146.8	146.8	161.48	132.12
Apr-2011	81.63	81.63	89.79	73.467	200.7	200.7	220.77	180.63
May-2011	3.51	3.51	3.86	3.159	1.5	1.5	1.65	1.35
Jun-2011	0	0	0.00	0	0	0	0	0
July-2011	0	0	0.00	0	7.4	7.4	8.14	6.66
Aug-2011	1.98	1.98	2.18	1.782	0	0	0	0
Sep-2011	95.76	95.76	105.34	86.184	104	104	114.4	93.6
Oct-2011	92.25	92.25	101.48	83.025	102.7	102.7	112.97	92.43
Nov-2011	132.03	132.03	145.23	118.827	115.9	115.9	127.49	104.31
Dec-2011	94.23	94.23	103.65	84.807	195.4	195.4	214.94	175.86
Jan-2012	168.03	168.03	184.83	151.227	245	245	269.5	220.5
Feb-2012	73.53	73.53	80.88	66.177	108.2	108.2	119.02	97.38
Mar-2012	70.2	70.2	77.22	63.18	58.3	58.3	64.13	52.47
Apr-2012	92.16	92.16	101.38	82.944	89.2	89.2	98.12	80.28
May-2012	5.67	5.67	6.24	5.103	13.6	13.6	14.96	12.24
Jun-2012	7.92	7.92	8.71	7.128	9.1	9.1	10.01	8.19
July-2012	18.81	18.81	20.69	16.929	40.3	40.3	44.33	36.27
Aug-2012	24.03	24.03	26.43	21.627	11.3	11.3	12.43	10.17
Sep-2012	18	18	19.80	16.2	18.5	18.5	20.35	16.65
Oct-2012	27.9	27.9	30.69	25.11	120.9	120.9	132.99	108.81
Nov-2012	116.1	116.1	127.71	104.49	111.7	111.7	122.87	100.53
Dec-2012	139.32	139.32	153.25	125.388	129.7	129.7	142.67	116.73
Jan-2013	187.02	187.02	205.72	168.318	145.1	145.1	159.61	130.59
Feb-2013	140.04	140.04	154.04	126.036	197.4	197.4	217.14	177.66
Mar-2013	20.97	20.97	23.07	18.873	35.3	35.3	38.83	31.77
Apr-2013	82.17	82.17	90.39	73.953	73.4	73.4	80.74	66.06
May-2013	9.72	9.72	10.69	8.748	10	10	11	9
Jun-2013	5.49	5.49	6.04	4.941	20.8	20.8	22.88	18.72
July-2013	1.98	1.98	2.18	1.782	0	0	0	0
Aug-2013	2.25	2.25	2.48	2.025	1.4	1.4	1.54	1.26
Sep-2013	33.48	33.48	36.83	30.132	24.8	24.8	27.28	22.32
Oct-2013	52.38	52.38	57.62	47.142	45.4	45.4	49.94	40.86
Nov-2013	102.87	102.87	113.16	92.583	158.8	158.8	174.68	142.92
Dec-2013	158.58	158.58	174.44	142.722	238.1	238.1	261.91	214.29
Jan-2014	240.84	240.84	264.92	216.756	140.4	140.4	154.44	126.36
Feb-2014	80.91	80.91	89.00	72.819	185.7	185.7	204.27	167.13
Mar-2014	78.3	78.3	86.13	70.47	102.4	102.4	112.64	92.16
Apr-2014	47.79	47.79	52.57	43.011	47.4	47.4	52.14	42.66

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11E				X11F			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
May-2014	10.17	10.17	11.19	9.153	14.5	14.5	15.95	13.05
Jun-2014	0	0	0.00	0	0	0	0	0
July-2014	0	0	0.00	0	0	0	0	0
Aug-2014	0	0	0.00	0	0	0	0	0
Sep-2014	8.46	8.46	9.31	7.614	9.5	9.5	10.45	8.55
Oct-2014	39.87	39.87	43.86	35.883	56.1	56.1	61.71	50.49
Nov-2014	140.94	140.94	155.03	126.846	100.5	100.5	110.55	90.45
Dec-2014	163.8	163.8	180.18	147.42	116.2	116.2	127.82	104.58
Jan-2015	81.72	81.72	89.89	73.548	168.9	168.9	185.79	152.01
Feb-2015	9.72	9.72	10.69	8.748	119.7	119.7	131.67	107.73
Mar-2015	130.68	130.68	143.75	117.612	145.5	145.5	160.05	130.95
Apr-2015	60.75	60.75	66.83	54.675	57.5	57.5	63.25	51.75
May-2015	0	0	0.00	0	6.2	6.2	6.82	5.58
Jun-2015	0.54	0.54	0.59	0.486	0	0	0	0
July-2015	0	0	0.00	0	0	0	0	0
Aug-2015	2.79	2.79	3.07	2.511	4.9	4.9	5.39	4.41
Sep-2015	26.37	26.37	29.01	23.733	31.3	31.3	34.43	28.17
Oct-2015	56.34	56.34	61.97	50.706	53.6	53.6	58.96	48.24
Nov-2015	122.31	122.31	134.54	110.079	175.9	175.9	193.49	158.31
Dec-2015	182.61	182.61	200.87	164.349	212.7	212.7	233.97	191.43
Jan-2016	222.84	222.84	245.12	200.556	157.4	157.4	173.14	141.66
Feb-2016	53.64	53.64	59.00	48.276	119.1	119.1	131.01	107.19
Mar-2016	75.6	75.6	83.16	68.04	78.2	78.2	86.02	70.38
Apr-2016	14.04	14.04	15.44	12.636	32.4	32.4	35.64	29.16
May-2016	4.41	4.41	4.85	3.969	5.8	5.8	6.38	5.22
Jun-2016	0	0	0.00	0	0	0	0	0
July-2016	2.61	2.61	2.87	2.349	19.1	19.1	21.01	17.19
Aug-2016	12.78	12.78	14.06	11.502	4.3	4.3	4.73	3.87
Sep-2016	14.85	14.85	16.34	13.365	20.7	20.7	22.77	18.63
Oct-2016	63.27	63.27	69.60	56.943	56.4	56.4	62.04	50.76
Nov-2016	76.68	76.68	84.35	69.012	93.6	93.6	102.96	84.24
Dec-2016	150.3	150.3	165.33	135.27	133.5	133.5	146.85	120.15
Jan-2017	122.76	122.76	135.04	110.484	71.5	71.5	78.65	64.35
Feb-2017	73.89	73.89	81.28	66.501	66.9	66.9	73.59	60.21
Mar-2017	71.19	71.19	78.31	64.071	113.1	113.1	124.41	101.79
Apr-2017	26.64	26.64	29.30	23.976	28.2	28.2	31.02	25.38
May-2017	0	0	0.00	0	0	0	0	0
Jun-2017	1.98	1.98	2.18	1.782	0	0	0	0
July-2017	2.07	2.07	2.28	1.863	0	0	0	0
Aug-2017	5.76	5.76	6.34	5.184	14.5	14.5	15.95	13.05
Sep-2017	15.21	15.21	16.73	13.689	17	17	18.7	15.3
Oct-2017	36.27	36.27	39.90	32.643	95.3	95.3	104.83	85.77
Nov-2017	168.75	168.75	185.63	151.875	184.2	184.2	202.62	165.78
Dec-2017	99.99	99.99	109.99	89.991	113	113	124.3	101.7

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11E				X11F			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Jan-2018	282.6	282.6	310.86	254.34	173.1	173.1	190.41	155.79
Feb-2018	175.05	175.05	192.56	157.545	76.5	76.5	84.15	68.85
Mar-2018	48.6	48.6	53.46	43.74	64.4	64.4	70.84	57.96
Apr-2018	56.88	56.88	62.57	51.192	32.9	32.9	36.19	29.61
May-2018	0	0	0.00	0	5.2	5.2	5.72	4.68
Jun-2018	0	0	0.00	0	24.7	24.7	27.17	22.23
July-2018	0	0	0.00	0	13	13	14.3	11.7
Aug-2018	4.68	4.68	5.15	4.212	0	0	0	0
Sep-2018	13.41	13.41	14.75	12.069	24	24	26.4	21.6
Oct-2018	5.22	5.22	5.74	4.698	13.8	13.8	15.18	12.42
Nov-2018	173.88	173.88	191.27	156.492	170.3	170.3	187.33	153.27
Dec-2018	155.7	155.7	171.27	140.13	66.5	66.5	73.15	59.85
Jan-2019	118.08	118.08	129.89	106.272	116.9	116.9	128.59	105.21
Feb-2019	202.23	202.23	222.45	182.007	216.8	216.8	238.48	195.12
Mar-2019	153.36	153.36	168.70	138.024	81.2	81.2	89.32	73.08
Apr-2019	11.07	11.07	12.18	9.963	24.4	24.4	26.84	21.96
May-2019	0.72	0.72	0.79	0.648	0	0	0	0
Jun-2019	19.62	19.62	21.58	17.658	0	0	0	0
July-2019	0	0	0.00	0	0	0	0	0
Aug-2019	32.94	32.94	36.23	29.646	9.4	9.4	10.34	8.46
Sep-2019	24.3	24.3	26.73	21.87	30.2	30.2	33.22	27.18
Oct-2019	25.02	25.02	27.52	22.518	29.3	29.3	32.23	26.37
Nov-2019	78.3	78.3	86.13	70.47	89.3	89.3	98.23	80.37
Dec-2019	101.07	101.07	111.18	90.963	109.4	109.4	120.34	98.46
Jan-2020	231.57	231.57	254.73	208.413	221.4	221.4	243.54	199.26
Feb-2020	18.54	18.54	20.39	16.686	108	108	118.8	97.2
Mar-2020	89.01	89.01	97.91	80.109	45.2	45.2	49.72	40.68
Apr-2020	12.42	12.42	13.66	11.178	41.4	41.4	45.54	37.26
May-2020	0	0	0.00	0	1.2	1.2	1.32	1.08
Jun-2020	0	0	0.00	0	0	0	0	0
July-2020	0	0	0.00	0	11.7	11.7	12.87	10.53
Aug-2020	0	0	0.00	0	0	0	0	0
Sep-2020	14.31	14.31	15.74	12.879	20.5	20.5	22.55	18.45
Oct-2020	73.71	73.71	81.08	66.339	69.7	69.7	76.67	62.73
Nov-2020	78.75	78.75	86.63	70.875	115.4	115.4	126.94	103.86
Dec-2020	61.74	61.74	67.91	55.566	26	26	28.6	23.4
Jan-2021	106.11	106.11	116.72	95.499	159.4	159.4	175.34	143.46
Feb-2021	59.67	59.67	65.64	53.703	57.2	57.2	62.92	51.48
Mar-2021	52.11	52.11	57.32	46.899	86.1	86.1	94.71	77.49
Apr-2021	41.22	41.22	45.34	37.098	37.6	37.6	41.36	33.84
May-2021	59.4	59.4	65.34	53.46	30.3	30.3	33.33	27.27
Jun-2021	9.18	9.18	10.10	8.262	9.1	9.1	10.01	8.19
July-2021	8.91	8.91	9.80	8.019	3.9	3.9	4.29	3.51
Aug-2021	32.67	32.67	35.94	29.403	37.4	37.4	41.14	33.66
Sep-2021	1.71	1.71	1.88	1.539	22.7	22.7	24.97	20.43

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11E				X11F			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Oct-2021	95.76	95.76	105.34	86.184	48.5	48.5	53.35	43.65
Nov-2021	229.5	229.5	252.45	206.55	209.9	209.9	230.89	188.91
Dec-2021	215.46	215.46	237.01	193.914	134	134	147.4	120.6
Jan-2022	178.29	178.29	196.12	160.461	235.7	235.7	259.27	212.13
Feb-2022	76.59	76.59	84.25	68.931	34.9	34.9	38.39	31.41
Mar-2022	84.15	84.15	92.57	75.735	143.8	143.8	158.18	129.42
Apr-2022	17.55	17.55	19.31	15.795	20.7	20.7	22.77	18.63
May-2022	0	0	0.00	0	14.1	14.1	15.51	12.69
Jun-2022	17.64	17.64	19.40	15.876	26.6	26.6	29.26	23.94
July-2022	36.45	36.45	40.10	32.805	79.5	79.5	87.45	71.55
Aug-2022	9.36	9.36	10.30	8.424	0	0	0	0
Sep-2022	27	27	29.70	24.3	47.2	47.2	51.92	42.48
Oct-2022	111.24	111.24	122.36	100.116	150.9	150.9	165.99	135.81
Nov-2022	123.12	123.12	135.43	110.808	104	104	114.4	93.6
Dec-2022	109.35	109.35	120.29	98.415	72.6	72.6	79.86	65.34
Jan-2023	112.59	112.59	123.85	101.331	100.7	100.7	110.77	90.63
Feb-2023	167.22	167.22	183.94	150.498	242.6	242.6	266.86	218.34
Mar-2023	77.67	77.67	85.44	69.903	68.9	68.9	75.79	62.01
Apr-2023	0	0	0.00	0	0	0	0	0
May-2023	51.84	51.84	57.02	46.656	0	0	0	0
Jun-2023	1.98	1.98	2.18	1.782	0	0	0	0
July-2023	0	0	0.00	0	0	0	0	0
Aug-2023	0	0	0.00	0	4.3	4.3	4.73	3.87
Sep-2023	57.33	57.33	63.06	51.597	18.1	18.1	19.91	16.29
Oct-2023	41.94	41.94	46.13	37.746	91.2	91.2	100.32	82.08
Nov-2023	34.56	34.56	38.02	31.104	85.6	85.6	94.16	77.04
Dec-2023	160.74	160.74	176.81	144.666	253.3	253.3	278.63	227.97
Jan-2024	189.18	189.18	208.10	170.262	89.2	89.2	98.12	80.28
Feb-2024	214.38	214.38	235.82	192.942	68.3	68.3	75.13	61.47
Mar-2024	46.62	46.62	51.28	41.958	50	50	55	45
Apr-2024	60.21	60.21	66.23	54.189	28.2	28.2	31.02	25.38
May-2024	1.17	1.17	1.29	1.053	8.4	8.4	9.24	7.56
Jun-2024	11.07	11.07	12.18	9.963	16.2	16.2	17.82	14.58
July-2024	0	0	0.00	0	0	0	0	0
Aug-2024	0.18	0.18	0.20	0.162	3.5	3.5	3.85	3.15
Sep-2024	15.39	15.39	16.93	13.851	16.8	16.8	18.48	15.12
Oct-2024	77.22	77.22	84.94	69.498	111.7	111.7	122.87	100.53
Nov-2024	84.78	84.78	93.26	76.302	67.4	67.4	74.14	60.66
Dec-2024	66.6	66.6	73.26	59.94	98.9	98.9	108.79	89.01
Jan-2025	236.79	236.79	260.47	213.111	106.5	106.5	117.15	95.85
Feb-2025	103.41	103.41	113.75	93.069	102.9	102.9	113.19	92.61
Mar-2025	193.41	193.41	212.75	174.069	119.7	119.7	131.67	107.73
Apr-2025	38.7	38.7	42.57	34.83	76.3	76.3	83.93	68.67
May-2025	0	0	0.00	0	3.4	3.4	3.74	3.06

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11E				X11F			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Jun-2025	7.29	7.29	8.02	6.561	5.3	5.3	5.83	4.77
July-2025	0	0	0.00	0	0	0	0	0
Aug-2025	45.81	45.81	50.39	41.229	28.4	28.4	31.24	25.56
Sep-2025	193.5	193.5	212.85	174.15	103.3	103.3	113.63	92.97
Oct-2025	90.9	90.9	99.99	81.81	149.8	149.8	164.78	134.82
Nov-2025	185.31	185.31	203.84	166.779	153.4	153.4	168.74	138.06
Dec-2025	133.74	133.74	147.11	120.366	123.9	123.9	136.29	111.51
Jan-2026	231.75	231.75	254.93	208.575	137.7	137.7	151.47	123.93
Feb-2026	41.22	41.22	45.34	37.098	82.8	82.8	91.08	74.52
Mar-2026	82.26	82.26	90.49	74.034	75.5	75.5	83.05	67.95
Apr-2026	29.61	29.61	32.57	26.649	54.9	54.9	60.39	49.41
May-2026	0.9	0.9	0.99	0.81	0	0	0	0
Jun-2026	14.94	14.94	16.43	13.446	62.4	62.4	68.64	56.16
July-2026	4.23	4.23	4.65	3.807	1.3	1.3	1.43	1.17
Aug-2026	0.27	0.27	0.30	0.243	1.4	1.4	1.54	1.26
Sep-2026	35.91	35.91	39.50	32.319	59.6	59.6	65.56	53.64
Oct-2026	122.58	122.58	134.84	110.322	161.8	161.8	177.98	145.62
Nov-2026	33.03	33.03	36.33	29.727	29.4	29.4	32.34	26.46
Dec-2026	113.04	113.04	124.34	101.736	102.1	102.1	112.31	91.89
Jan-2027	94.41	94.41	103.85	84.969	109.7	109.7	120.67	98.73
Feb-2027	154.98	154.98	170.48	139.482	248.5	248.5	273.35	223.65
Mar-2027	14.76	14.76	16.24	13.284	46.4	46.4	51.04	41.76
Apr-2027	28.89	28.89	31.78	26.001	34.3	34.3	37.73	30.87
May-2027	13.59	13.59	14.95	12.231	22	22	24.2	19.8
Jun-2027	35.64	35.64	39.20	32.076	37	37	40.7	33.3
July-2027	0	0	0.00	0	7.8	7.8	8.58	7.02
Aug-2027	8.73	8.73	9.60	7.857	7.7	7.7	8.47	6.93
Sep-2027	13.14	13.14	14.45	11.826	3.9	3.9	4.29	3.51
Oct-2027	68.76	68.76	75.64	61.884	118.5	118.5	130.35	106.65
Nov-2027	204.39	204.39	224.83	183.951	189.8	189.8	208.78	170.82
Dec-2027	88.11	88.11	96.92	79.299	85.6	85.6	94.16	77.04
Jan-2028	111.15	111.15	122.27	100.035	71.2	71.2	78.32	64.08
Feb-2028	128.97	128.97	141.87	116.073	50.7	50.7	55.77	45.63
Mar-2028	89.64	89.64	98.60	80.676	82.4	82.4	90.64	74.16
Apr-2028	78.21	78.21	86.03	70.389	56.5	56.5	62.15	50.85
May-2028	8.82	8.82	9.70	7.938	13.1	13.1	14.41	11.79
Jun-2028	0	0	0.00	0	0	0	0	0
July-2028	0.54	0.54	0.59	0.486	0	0	0	0
Aug-2028	6.21	6.21	6.83	5.589	0	0	0	0
Sep-2028	3.96	3.96	4.36	3.564	0	0	0	0
Oct-2028	26.91	26.91	29.60	24.219	73.1	73.1	80.41	65.79
Nov-2028	102.87	102.87	113.16	92.583	104.5	104.5	114.95	94.05
Dec-2028	163.62	163.62	179.98	147.258	203	203	223.3	182.7
Jan-2029	156.42	156.42	172.06	140.778	217.5	217.5	239.25	195.75
Feb-2029	108.99	108.99	119.89	98.091	109.2	109.2	120.12	98.28

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11E				X11F			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Mar-2029	216.36	216.36	238.00	194.724	243.3	243.3	267.63	218.97
Apr-2029	6.12	6.12	6.73	5.508	0	0	0	0
May-2029	17.91	17.91	19.70	16.119	27.2	27.2	29.92	24.48
Jun-2029	17.73	17.73	19.50	15.957	23.4	23.4	25.74	21.06
July-2029	0.72	0.72	0.79	0.648	0	0	0	0
Aug-2029	0	0	0.00	0	0	0	0	0
Sep-2029	13.41	13.41	14.75	12.069	0	0	0	0
Oct-2029	29.25	29.25	32.18	26.325	21.4	21.4	23.54	19.26
Nov-2029	97.92	97.92	107.71	88.128	100.7	100.7	110.77	90.63
Dec-2029	112.86	112.86	124.15	101.574	98	98	107.8	88.2
Jan-2030	55.17	55.17	60.69	49.653	70	70	77	63
Feb-2030	41.94	41.94	46.13	37.746	32.9	32.9	36.19	29.61
Mar-2030	40.5	40.5	44.55	36.45	57.2	57.2	62.92	51.48
Apr-2030	50.31	50.31	55.34	45.279	25.4	25.4	27.94	22.86
May-2030	0	0	0.00	0	0	0	0	0
Jun-2030	0	0	0.00	0	0	0	0	0
July-2030	0	0	0.00	0	0	0	0	0
Aug-2030	22.14	22.14	24.35	19.926	5.7	5.7	6.27	5.13
Sep-2030	50.67	50.67	55.74	45.603	0	0	0	0
Oct-2030	30.87	30.87	33.96	27.783	43.9	43.9	48.29	39.51
Nov-2030	36.45	36.45	40.10	32.805	22.8	22.8	25.08	20.52
Dec-2030	209.79	209.79	230.77	188.811	0	0	0	0

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11G				X11H			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Oct-2010	78.2	78.2	86.02	70.38	72.7	72.7	79.97	65.43
Nov-2010	243.8	243.8	268.18	219.42	221.1	221.1	243.21	198.99
Dec-2010	128.5	128.5	141.35	115.65	118.8	118.8	130.68	106.92
Jan-2011	155.2	155.2	170.72	139.68	141.7	141.7	155.87	127.53
Feb-2011	290.3	290.3	319.33	261.27	279.6	279.6	307.56	251.64
Mar-2011	170.1	170.1	187.11	153.09	165.1	165.1	181.61	148.59
Apr-2011	168.9	168.9	185.79	152.01	154	154	169.4	138.6
May-2011	1.9	1.9	2.09	1.71	1.9	1.9	2.09	1.71
Jun-2011	0	0	0	0	0	0	0	0
July-2011	7.4	7.4	8.14	6.66	7.4	7.4	8.14	6.66
Aug-2011	0	0	0	0	0	0	0	0
Sep-2011	154.8	154.8	170.28	139.32	135	135	148.5	121.5
Oct-2011	118.2	118.2	130.02	106.38	110	110	121	99
Nov-2011	143.7	143.7	158.07	129.33	130.6	130.6	143.66	117.54
Dec-2011	242.4	242.4	266.64	218.16	224.2	224.2	246.62	201.78
Jan-2012	329	329	361.9	296.1	300	300	330	270

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11G				X11H			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Feb-2012	155.1	155.1	170.61	139.59	145.7	145.7	160.27	131.13
Mar-2012	67.6	67.6	74.36	60.84	65.5	65.5	72.05	58.95
Apr-2012	119.8	119.8	131.78	107.82	113.2	113.2	124.52	101.88
May-2012	16.9	16.9	18.59	15.21	16.9	16.9	18.59	15.21
Jun-2012	9.1	9.1	10.01	8.19	9.1	9.1	10.01	8.19
July-2012	40.3	40.3	44.33	36.27	40.3	40.3	44.33	36.27
Aug-2012	20.2	20.2	22.22	18.18	20.9	20.9	22.99	18.81
Sep-2012	27.5	27.5	30.25	24.75	24	24	26.4	21.6
Oct-2012	139.1	139.1	153.01	125.19	129.3	129.3	142.23	116.37
Nov-2012	138.7	138.7	152.57	124.83	125.7	125.7	138.27	113.13
Dec-2012	160.9	160.9	176.99	144.81	148.9	148.9	163.79	134.01
Jan-2013	194.9	194.9	214.39	175.41	177.7	177.7	195.47	159.93
Feb-2013	242.1	242.1	266.31	217.89	233.1	233.1	256.41	209.79
Mar-2013	40.8	40.8	44.88	36.72	39.8	39.8	43.78	35.82
Apr-2013	98.2	98.2	108.02	88.38	93	93	102.3	83.7
May-2013	12.3	12.3	13.53	11.07	12.3	12.3	13.53	11.07
Jun-2013	20.8	20.8	22.88	18.72	20.8	20.8	22.88	18.72
July-2013	0	0	0	0	0	0	0	0
Aug-2013	2.6	2.6	2.86	2.34	2.8	2.8	3.08	2.52
Sep-2013	37	37	40.7	33.3	32.1	32.1	35.31	28.89
Oct-2013	52.2	52.2	57.42	46.98	48.5	48.5	53.35	43.65
Nov-2013	197.6	197.6	217.36	177.84	179.1	179.1	197.01	161.19
Dec-2013	295.3	295.3	324.83	265.77	273.3	273.3	300.63	245.97
Jan-2014	188.5	188.5	207.35	169.65	172	172	189.2	154.8
Feb-2014	227.9	227.9	250.69	205.11	219	219	240.9	197.1
Mar-2014	118.7	118.7	130.57	106.83	115.4	115.4	126.94	103.86
Apr-2014	63.7	63.7	70.07	57.33	60	60	66	54
May-2014	17.9	17.9	19.69	16.11	17.9	17.9	19.69	16.11
Jun-2014	0	0	0	0	0	0	0	0
July-2014	0	0	0	0	0	0	0	0
Aug-2014	0	0	0	0	0	0	0	0
Sep-2014	14.1	14.1	15.51	12.69	12.3	12.3	13.53	11.07
Oct-2014	64.3	64.3	70.73	57.87	59.9	59.9	65.89	53.91
Nov-2014	124.8	124.8	137.28	112.32	113.2	113.2	124.52	101.88
Dec-2014	144	144	158.4	129.6	133.4	133.4	146.74	120.06
Jan-2015	227	227	249.7	204.3	207	207	227.7	186.3
Feb-2015	146.6	146.6	161.26	131.94	141.3	141.3	155.43	127.17
Mar-2015	168.7	168.7	185.57	151.83	164	164	180.4	147.6
Apr-2015	77.1	77.1	84.81	69.39	72.8	72.8	80.08	65.52
May-2015	7.6	7.6	8.36	6.84	7.6	7.6	8.36	6.84
Jun-2015	0	0	0	0	0	0	0	0
July-2015	0	0	0	0	0	0	0	0
Aug-2015	8.8	8.8	9.68	7.92	9.1	9.1	10.01	8.19
Sep-2015	46.6	46.6	51.26	41.94	40.6	40.6	44.66	36.54
Oct-2015	61.7	61.7	67.87	55.53	57.4	57.4	63.14	51.66

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11G				X11H			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Nov-2015	218.6	218.6	240.46	196.74	198.2	198.2	218.02	178.38
Dec-2015	263.2	263.2	289.52	236.88	243.5	243.5	267.85	219.15
Jan-2016	211.5	211.5	232.65	190.35	192.6	192.6	211.86	173.34
Feb-2016	146	146	160.6	131.4	140.5	140.5	154.55	126.45
Mar-2016	90.3	90.3	99.33	81.27	88.1	88.1	96.91	79.29
Apr-2016	43.3	43.3	47.63	38.97	40.9	40.9	44.99	36.81
May-2016	7.1	7.1	7.81	6.39	7.1	7.1	7.81	6.39
Jun-2016	0	0	0	0	0	0	0	0
July-2016	19.1	19.1	21.01	17.19	19.1	19.1	21.01	17.19
Aug-2016	7.6	7.6	8.36	6.84	7.9	7.9	8.69	7.11
Sep-2016	30.8	30.8	33.88	27.72	26.9	26.9	29.59	24.21
Oct-2016	64.9	64.9	71.39	58.41	60.4	60.4	66.44	54.36
Nov-2016	116.3	116.3	127.93	104.67	105.3	105.3	115.83	94.77
Dec-2016	165.5	165.5	182.05	148.95	153.1	153.1	168.41	137.79
Jan-2017	96.3	96.3	105.93	86.67	87.6	87.6	96.36	78.84
Feb-2017	82	82	90.2	73.8	78.9	78.9	86.79	71.01
Mar-2017	131.3	131.3	144.43	118.17	127.3	127.3	140.03	114.57
Apr-2017	37.8	37.8	41.58	34.02	35.7	35.7	39.27	32.13
May-2017	0	0	0	0	0	0	0	0
Jun-2017	0	0	0	0	0	0	0	0
July-2017	0	0	0	0	0	0	0	0
Aug-2017	25.8	25.8	28.38	23.22	26.9	26.9	29.59	24.21
Sep-2017	25.2	25.2	27.72	22.68	22	22	24.2	19.8
Oct-2017	109.6	109.6	120.56	98.64	101.9	101.9	112.09	91.71
Nov-2017	228.9	228.9	251.79	206.01	207.6	207.6	228.36	186.84
Dec-2017	140.1	140.1	154.11	126.09	129.6	129.6	142.56	116.64
Jan-2018	232.1	232.1	255.31	208.89	212	212	233.2	190.8
Feb-2018	93.8	93.8	103.18	84.42	90.2	90.2	99.22	81.18
Mar-2018	74.8	74.8	82.28	67.32	72.4	72.4	79.64	65.16
Apr-2018	44.1	44.1	48.51	39.69	41.6	41.6	45.76	37.44
May-2018	6.5	6.5	7.15	5.85	6.5	6.5	7.15	5.85
Jun-2018	24.7	24.7	27.17	22.23	24.7	24.7	27.17	22.23
July-2018	13	13	14.3	11.7	13	13	14.3	11.7
Aug-2018	0	0	0	0	0	0	0	0
Sep-2018	35.7	35.7	39.27	32.13	31.1	31.1	34.21	27.99
Oct-2018	15.9	15.9	17.49	14.31	14.8	14.8	16.28	13.32
Nov-2018	211.2	211.2	232.32	190.08	191.7	191.7	210.87	172.53
Dec-2018	82.5	82.5	90.75	74.25	76.2	76.2	83.82	68.58
Jan-2019	157.1	157.1	172.81	141.39	143.3	143.3	157.63	128.97
Feb-2019	265.9	265.9	292.49	239.31	255.7	255.7	281.27	230.13
Mar-2019	94.1	94.1	103.51	84.69	91.3	91.3	100.43	82.17
Apr-2019	32.8	32.8	36.08	29.52	30.9	30.9	33.99	27.81
May-2019	0	0	0	0	0	0	0	0
Jun-2019	0	0	0	0	0	0	0	0

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11G				X11H			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
July-2019	0	0	0	0	0	0	0	0
Aug-2019	16.8	16.8	18.48	15.12	17.5	17.5	19.25	15.75
Sep-2019	45	45	49.5	40.5	39.2	39.2	43.12	35.28
Oct-2019	33.6	33.6	36.96	30.24	31.2	31.2	34.32	28.08
Nov-2019	110.9	110.9	121.99	99.81	100.6	100.6	110.66	90.54
Dec-2019	135.7	135.7	149.27	122.13	125.4	125.4	137.94	112.86
Jan-2020	297.7	297.7	327.47	267.93	271.4	271.4	298.54	244.26
Feb-2020	132.4	132.4	145.64	119.16	127.7	127.7	140.47	114.93
Mar-2020	52.5	52.5	57.75	47.25	51	51	56.1	45.9
Apr-2020	55.6	55.6	61.16	50.04	52.6	52.6	57.86	47.34
May-2020	1.6	1.6	1.76	1.44	1.6	1.6	1.76	1.44
Jun-2020	0	0	0	0	0	0	0	0
July-2020	11.7	11.7	12.87	10.53	11.7	11.7	12.87	10.53
Aug-2020	0	0	0	0	0	0	0	0
Sep-2020	30.6	30.6	33.66	27.54	26.6	26.6	29.26	23.94
Oct-2020	80.3	80.3	88.33	72.27	74.4	74.4	81.84	66.96
Nov-2020	143.1	143.1	157.41	128.79	129.7	129.7	142.67	116.73
Dec-2020	32.2	32.2	35.42	28.98	29.8	29.8	32.78	26.82
Jan-2021	214.4	214.4	235.84	192.96	195.4	195.4	214.94	175.86
Feb-2021	70.2	70.2	77.22	63.18	67.6	67.6	74.36	60.84
Mar-2021	99.9	99.9	109.89	89.91	97	97	106.7	87.3
Apr-2021	50.4	50.4	55.44	45.36	47.7	47.7	52.47	42.93
May-2021	37.6	37.6	41.36	33.84	37.6	37.6	41.36	33.84
Jun-2021	9.1	9.1	10.01	8.19	9.1	9.1	10.01	8.19
July-2021	3.9	3.9	4.29	3.51	3.9	3.9	4.29	3.51
Aug-2021	66.8	66.8	73.48	60.12	69.4	69.4	76.34	62.46
Sep-2021	33.8	33.8	37.18	30.42	29.4	29.4	32.34	26.46
Oct-2021	55.9	55.9	61.49	50.31	51.9	51.9	57.09	46.71
Nov-2021	260.5	260.5	286.55	234.45	236.7	236.7	260.37	213.03
Dec-2021	166	166	182.6	149.4	153.7	153.7	169.07	138.33
Jan-2022	351.3	351.3	386.43	316.17	311.5	311.5	342.65	280.35
Feb-2022	42.9	42.9	47.19	38.61	41.2	41.2	45.32	37.08
Mar-2022	166.6	166.6	183.26	149.94	161.8	161.8	177.98	145.62
Apr-2022	27.7	27.7	30.47	24.93	26.1	26.1	28.71	23.49
May-2022	17.5	17.5	19.25	15.75	17.5	17.5	19.25	15.75
Jun-2022	26.6	26.6	29.26	23.94	26.6	26.6	29.26	23.94
July-2022	79.5	79.5	87.45	71.55	79.5	79.5	87.45	71.55
Aug-2022	0	0	0	0	0	0	0	0
Sep-2022	70.3	70.3	77.33	63.27	61.4	61.4	67.54	55.26
Oct-2022	174	174	191.4	156.6	161.8	161.8	177.98	145.62
Nov-2022	129.1	129.1	142.01	116.19	117.2	117.2	128.92	105.48
Dec-2022	89.9	89.9	98.89	80.91	83.2	83.2	91.52	74.88
Jan-2023	135.3	135.3	148.83	121.77	123.3	123.3	135.63	110.97
Feb-2023	297.5	297.5	327.25	267.75	286	286	314.6	257.4
Mar-2023	80	80	88	72	77.5	77.5	85.25	69.75

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11G				X11H			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Apr-2023	0	0	0	0	0	0	0	0
May-2023	0	0	0	0	0	0	0	0
Jun-2023	0	0	0	0	0	0	0	0
July-2023	0	0	0	0	0	0	0	0
Aug-2023	7.8	7.8	8.58	7.02	8.1	8.1	8.91	7.29
Sep-2023	26.8	26.8	29.48	24.12	23.4	23.4	25.74	21.06
Oct-2023	104.8	104.8	115.28	94.32	97.4	97.4	107.14	87.66
Nov-2023	106	106	116.6	95.4	96.3	96.3	105.93	86.67
Dec-2023	314.2	314.2	345.62	282.78	290.5	290.5	319.55	261.45
Jan-2024	120	120	132	108	109.5	109.5	120.45	98.55
Feb-2024	83.8	83.8	92.18	75.42	80.7	80.7	88.77	72.63
Mar-2024	57.7	57.7	63.47	51.93	56	56	61.6	50.4
Apr-2024	37.8	37.8	41.58	34.02	35.7	35.7	39.27	32.13
May-2024	10.4	10.4	11.44	9.36	10.4	10.4	11.44	9.36
Jun-2024	16.2	16.2	17.82	14.58	16.2	16.2	17.82	14.58
July-2024	0	0	0	0	0	0	0	0
Aug-2024	6.2	6.2	6.82	5.58	6.5	6.5	7.15	5.85
Sep-2024	25	25	27.5	22.5	21.8	21.8	23.98	19.62
Oct-2024	128.7	128.7	141.57	115.83	119.7	119.7	131.67	107.73
Nov-2024	83.7	83.7	92.07	75.33	76.1	76.1	83.71	68.49
Dec-2024	122.7	122.7	134.97	110.43	113.3	113.3	124.63	101.97
Jan-2025	143.2	143.2	157.52	128.88	130.5	130.5	143.55	117.45
Feb-2025	126.1	126.1	138.71	113.49	121.4	121.4	133.54	109.26
Mar-2025	138.9	138.9	152.79	125.01	134.8	134.8	148.28	121.32
Apr-2025	102.2	102.2	112.42	91.98	96.7	96.7	106.37	87.03
May-2025	4.2	4.2	4.62	3.78	4.2	4.2	4.62	3.78
Jun-2025	5.3	5.3	5.83	4.77	5.3	5.3	5.83	4.77
July-2025	0	0	0	0	0	0	0	0
Aug-2025	50.7	50.7	55.77	45.63	52.6	52.6	57.86	47.34
Sep-2025	153.6	153.6	168.96	138.24	134	134	147.4	120.6
Oct-2025	172.4	172.4	189.64	155.16	160	160	176	144
Nov-2025	190.6	190.6	209.66	171.54	172.7	172.7	189.97	155.43
Dec-2025	153.5	153.5	168.85	138.15	142	142	156.2	127.8
Jan-2026	185	185	203.5	166.5	168.9	168.9	185.79	152.01
Feb-2026	101.3	101.3	111.43	91.17	97.5	97.5	107.25	87.75
Mar-2026	87.7	87.7	96.47	78.93	85	85	93.5	76.5
Apr-2026	73.8	73.8	81.18	66.42	69.6	69.6	76.56	62.64
May-2026	0	0	0	0	0	0	0	0
Jun-2026	62.4	62.4	68.64	56.16	62.4	62.4	68.64	56.16
July-2026	1.3	1.3	1.43	1.17	1.3	1.3	1.43	1.17
Aug-2026	2.5	2.5	2.75	2.25	2.6	2.6	2.86	2.34
Sep-2026	88.8	88.8	97.68	79.92	77.4	77.4	85.14	69.66
Oct-2026	186.1	186.1	204.71	167.49	172.9	172.9	190.19	155.61
Nov-2026	36.6	36.6	40.26	32.94	33.2	33.2	36.52	29.88

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11G				X11H			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Dec-2026	150.5	150.5	165.55	135.45	131.7	131.7	144.87	118.53
Jan-2027	147.5	147.5	162.25	132.75	134.5	134.5	147.95	121.05
Feb-2027	304.6	304.6	335.06	274.14	293.2	293.2	322.52	263.88
Mar-2027	53.9	53.9	59.29	48.51	52.3	52.3	57.53	47.07
Apr-2027	46	46	50.6	41.4	43.5	43.5	47.85	39.15
May-2027	27.3	27.3	30.03	24.57	27.3	27.3	30.03	24.57
Jun-2027	37	37	40.7	33.3	37	37	40.7	33.3
July-2027	7.8	7.8	8.58	7.02	7.8	7.8	8.58	7.02
Aug-2027	13.6	13.6	14.96	12.24	14.1	14.1	15.51	12.69
Sep-2027	5.9	5.9	6.49	5.31	5.1	5.1	5.61	4.59
Oct-2027	136.2	136.2	149.82	122.58	126.7	126.7	139.37	114.03
Nov-2027	235.8	235.8	259.38	212.22	213.8	213.8	235.18	192.42
Dec-2027	105.8	105.8	116.38	95.22	98	98	107.8	88.2
Jan-2028	95.7	95.7	105.27	86.13	87.2	87.2	95.92	78.48
Feb-2028	62.2	62.2	68.42	55.98	59.9	59.9	65.89	53.91
Mar-2028	95.6	95.6	105.16	86.04	92.5	92.5	101.75	83.25
Apr-2028	75.9	75.9	83.49	68.31	71.8	71.8	78.98	64.62
May-2028	16.2	16.2	17.82	14.58	16.2	16.2	17.82	14.58
Jun-2028	0	0	0	0	0	0	0	0
July-2028	0	0	0	0	0	0	0	0
Aug-2028	0	0	0	0	0	0	0	0
Sep-2028	0	0	0	0	0	0	0	0
Oct-2028	84.2	84.2	92.62	75.78	78.2	78.2	86.02	70.38
Nov-2028	129.8	129.8	142.78	116.82	117.5	117.5	129.25	105.75
Dec-2028	251.7	251.7	276.87	226.53	232.7	232.7	255.97	209.43
Jan-2029	292.6	292.6	321.86	263.34	266.7	266.7	293.37	240.03
Feb-2029	133.9	133.9	147.29	120.51	128.8	128.8	141.68	115.92
Mar-2029	282.5	282.5	310.75	254.25	273.9	273.9	301.29	246.51
Apr-2029	0	0	0	0	0	0	0	0
May-2029	33.8	33.8	37.18	30.42	33.8	33.8	37.18	30.42
Jun-2029	23.4	23.4	25.74	21.06	23.4	23.4	25.74	21.06
July-2029	0	0	0	0	0	0	0	0
Aug-2029	0	0	0	0	0	0	0	0
Sep-2029	0	0	0	0	0	0	0	0
Oct-2029	24.8	24.8	27.28	22.32	23	23	25.3	20.7
Nov-2029	125.2	125.2	137.72	112.68	113.5	113.5	124.85	102.15
Dec-2029	121.6	121.6	133.76	109.44	112.2	112.2	123.42	100.98
Jan-2030	93.7	93.7	103.07	84.33	85.6	85.6	94.16	77.04
Feb-2030	40.3	40.3	44.33	36.27	38.7	38.7	42.57	34.83
Mar-2030	66.3	66.3	72.93	59.67	64.2	64.2	70.62	57.78
Apr-2030	34	34	37.4	30.6	32.2	32.2	35.42	28.98
May-2030	0	0	0	0	0	0	0	0
Jun-2030	0	0	0	0	0	0	0	0
July-2030	0	0	0	0	0	0	0	0
Aug-2030	10.2	10.2	11.22	9.18	10.7	10.7	11.77	9.63

	Precipitation (mm)							
	Quaternary Catchments							
Months	X11G				X11H			
	B.Case	Scen. 1	Scen. 2	Scen. 3	B.Case	Scen. 1	Scen. 2	Scen. 3
Sep-2030	0	0	0	0	0	0	0	0
Oct-2030	50.5	50.5	55.55	45.45	46.9	46.9	51.59	42.21
Nov-2030	28.3	28.3	31.13	25.47	25.7	25.7	28.27	23.13
Dec-2030	0	0	0	0	0	0	0	0

	Temperature (^{O}C)							
	Quaternary Catchments							
Months	X11A		X11B		X11C		X11D	
	Base Case	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**
Oct-2010	17.2	19.2	17.2	19.2	17.3	19.3	17.4	19.4
Nov-2010	16.5	18.5	16.4	18.4	16.5	18.5	16.6	18.6
Dec-2010	20.3	22.3	20.2	22.2	20.2	22.2	20.2	22.2
Jan-2011	20.2	22.2	20.1	22.1	20.2	22.2	20.3	22.3
Feb-2011	18.2	20.2	18.1	20.1	18.1	20.1	18.2	20.2
Mar-2011	19.7	21.7	19.7	21.7	19.6	21.6	19.7	21.7
Apr-2011	13.6	15.6	13.5	15.5	13.5	15.5	13.5	15.5
May-2011	11.7	13.7	11.9	13.9	11.8	13.8	11.9	13.9
Jun-2011	9.5	11.5	10	12	9.6	11.6	9.7	11.7
July-2011	9.2	11.2	9.7	11.7	9.6	11.6	9.6	11.6
Aug-2011	10.8	12.8	11.1	13.1	10.9	12.9	11	13
Sep-2011	15.2	17.2	15.5	17.5	15.3	17.3	15.3	17.3
Oct-2011	15.9	17.9	15.8	17.8	16	18	16	18
Nov-2011	16.3	18.3	16.2	18.2	16.3	18.3	16.4	18.4
Dec-2011	17.4	19.4	17.2	19.2	17.3	19.3	17.4	19.4
Jan-2012	18.6	20.6	18.5	20.5	18.7	20.7	18.8	20.8
Feb-2012	18.6	20.6	18.5	20.5	18.5	20.5	18.6	20.6
Mar-2012	17.7	19.7	17.6	19.6	17.7	19.7	17.7	19.7
Apr-2012	13.7	15.7	13.6	15.6	13.6	15.6	13.7	15.7
May-2012	10.8	12.8	10.9	12.9	10.9	12.9	10.9	12.9
Jun-2012	9.2	11.2	9.7	11.7	9.4	11.4	9.4	11.4
July-2012	8.9	10.9	9.4	11.4	9.1	11.1	9.2	11.2
Aug-2012	10.8	12.8	11.1	13.1	10.9	12.9	10.9	12.9
Sep-2012	14.1	16.1	14.4	16.4	14	16	14.1	16.1
Oct-2012	17.4	19.4	17.3	19.3	17.3	19.3	17.4	19.4
Nov-2012	17.2	19.2	17.2	19.2	17.2	19.2	17.2	19.2
Dec-2012	18	20	17.8	19.8	17.9	19.9	18	20
Jan-2013	18	20	17.9	19.9	18	20	18.1	20.1
Feb-2013	17.7	19.7	17.7	19.7	17.7	19.7	17.8	19.8
Mar-2013	16.4	18.4	16.4	18.4	16.3	18.3	16.3	18.3
Apr-2013	14.1	16.1	14.2	16.2	14.1	16.1	14.2	16.2
May-2013	12.5	14.5	12.7	14.7	12.5	14.5	12.5	14.5
Jun-2013	9.5	11.5	10.2	12.2	9.7	11.7	9.8	11.8
July-2013	9	11	9.4	11.4	9.3	11.3	9.3	11.3
Aug-2013	11.3	13.3	11.6	13.6	11.3	13.3	11.4	13.4

	Temperature (^{O}C)							
	Quaternary Catchments							
Months	X11A		X11B		X11C		X11D	
	Base Case	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**
Sep-2013	16	18	16.1	18.1	15.9	17.9	15.9	17.9
Oct-2013	15.5	17.5	15.3	17.3	15.4	17.4	15.5	17.5
Nov-2013	17.2	19.2	17.2	19.2	17.3	19.3	17.4	19.4
Dec-2013	17.6	19.6	17.4	19.4	17.4	19.4	17.5	19.5
Jan-2014	17.4	19.4	17.3	19.3	17.4	19.4	17.5	19.5
Feb-2014	18	20	18	20	18	20	18.1	20.1
Mar-2014	17.5	19.5	17.5	19.5	17.4	19.4	17.4	19.4
Apr-2014	14.2	16.2	14.3	16.3	14.3	16.3	14.4	16.4
May-2014	10.3	12.3	10.3	12.3	10.2	12.2	10.2	12.2
Jun-2014	9.1	11.1	9.6	11.6	9.2	11.2	9.3	11.3
July-2014	9.1	11.1	9.7	11.7	9.4	11.4	9.5	11.5
Aug-2014	10.9	12.9	11.3	13.3	11	13	11	13
Sep-2014	16.1	18.1	16.5	18.5	16.1	18.1	16.2	18.2
Oct-2014	15.6	17.6	15.6	17.6	15.6	17.6	15.7	17.7
Nov-2014	17.4	19.4	17.4	19.4	17.5	19.5	17.6	19.6
Dec-2014	18.8	20.8	18.8	20.8	18.8	20.8	18.9	20.9
Jan-2015	19.4	21.4	19.2	21.2	19.4	21.4	19.5	21.5
Feb-2015	19	21	18.9	20.9	18.9	20.9	19	21
Mar-2015	16.6	18.6	16.5	18.5	16.5	18.5	16.6	18.6
Apr-2015	15.8	17.8	15.8	17.8	15.7	17.7	15.8	17.8
May-2015	11.6	13.6	12	14	11.7	13.7	11.8	13.8
Jun-2015	10	12	10.9	12.9	10.4	12.4	10.4	12.4
July-2015	9.2	11.2	9.6	11.6	9.4	11.4	9.4	11.4
Aug-2015	11.5	13.5	11.7	13.7	11.5	13.5	11.6	13.6
Sep-2015	15.2	17.2	15.5	17.5	15.3	17.3	15.3	17.3
Oct-2015	17.7	19.7	17.6	19.6	17.7	19.7	17.8	19.8
Nov-2015	18.2	20.2	18.1	20.1	18	20	18.1	20.1
Dec-2015	19.1	21.1	19.2	21.2	19.2	21.2	19.3	21.3
Jan-2016	18.1	20.1	18	20	18.3	20.3	18.4	20.4
Feb-2016	18.7	20.7	18.6	20.6	18.6	20.6	18.7	20.7
Mar-2016	18	20	18.1	20.1	17.9	19.9	18	20
Apr-2016	14.2	16.2	14.4	16.4	14.4	16.4	14.5	16.5
May-2016	12	14	12.4	14.4	12.2	14.2	12.3	14.3
Jun-2016	8.4	10.4	9.3	11.3	8.9	10.9	9	11
July-2016	9.5	11.5	9.8	11.8	9.7	11.7	9.7	11.7
Aug-2016	14.9	16.9	15.2	17.2	15	17	15	17
Sep-2016	15	17	15.5	17.5	15.3	17.3	15.3	17.3
Oct-2016	15.9	17.9	15.8	17.8	15.9	17.9	16	18
Nov-2016	17.7	19.7	17.5	19.5	17.4	19.4	17.5	19.5
Dec-2016	17.8	19.8	17.7	19.7	17.7	19.7	17.8	19.8
Jan-2017	18.3	20.3	18.1	20.1	18.2	20.2	18.3	20.3
Feb-2017	19.8	21.8	19.8	21.8	19.7	21.7	19.8	21.8
Mar-2017	17.9	19.9	18	20	18	20	18.1	20.1
Apr-2017	16.2	18.2	16.2	18.2	16.2	18.2	16.3	18.3
May-2017	12.4	14.4	12.8	14.8	12.7	14.7	12.8	14.8
Jun-2017	9.5	11.5	10	12	9.8	11.8	9.8	11.8
July-2017	8.2	10.2	8.4	10.4	8.3	10.3	8.4	10.4
Aug-2017	12.5	14.5	12.6	14.6	12.5	14.5	12.5	14.5
Sep-2017	15	17	15.2	17.2	15	17	15.1	17.1
Oct-2017	17.5	19.5	17.4	19.4	17.4	19.4	17.5	19.5

	Temperature (^{O}C)							
	Quaternary Catchments							
Months	X11A		X11B		X11C		X11D	
	Base Case	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**
Nov-2017	17.1	19.1	17	19	17	19	17.1	19.1
Dec-2017	18.1	20.1	18	20	18	20	18.1	20.1
Jan-2018	18.2	20.2	18.1	20.1	18.3	20.3	18.4	20.4
Feb-2018	18.3	20.3	18.3	20.3	18.4	20.4	18.5	20.5
Mar-2018	17.5	19.5	17.6	19.6	17.5	19.5	17.6	19.6
Apr-2018	14.5	16.5	14.7	16.7	14.7	16.7	14.8	16.8
May-2018	12	14	12.5	14.5	12.4	14.4	12.5	14.5
Jun-2018	9.3	11.3	10.1	12.1	9.9	11.9	10	12
July-2018	8.6	10.6	9.3	11.3	9.4	11.4	9.4	11.4
Aug-2018	11	13	11.3	13.3	11.2	13.2	11.3	13.3
Sep-2018	14	16	14.2	16.2	14.1	16.1	14.1	16.1
Oct-2018	17.4	19.4	17.2	19.2	17.2	19.2	17.3	19.3
Nov-2018	17.6	19.6	17.5	19.5	17.5	19.5	17.6	19.6
Dec-2018	18.8	20.8	18.9	20.9	18.8	20.8	18.9	20.9
Jan-2019	19.8	21.8	19.8	21.8	19.9	21.9	19.9	21.9
Feb-2019	18.2	20.2	18.2	20.2	18.1	20.1	18.2	20.2
Mar-2019	17	19	17.2	19.2	17	19	17.1	19.1
Apr-2019	14.9	16.9	15.2	17.2	15.1	17.1	15.2	17.2
May-2019	11.2	13.2	11.4	13.4	11.5	13.5	11.5	13.5
Jun-2019	8.9	10.9	9.7	11.7	9.4	11.4	9.5	11.5
July-2019	9.9	11.9	10.3	12.3	10.1	12.1	10.2	12.2
Aug-2019	10.6	12.6	10.8	12.8	10.7	12.7	10.8	12.8
Sep-2019	13.4	15.4	13.6	15.6	13.5	15.5	13.6	15.6
Oct-2019	13.1	15.1	13	15	13.1	15.1	13.2	15.2
Nov-2019	18.6	20.6	18.5	20.5	18.5	20.5	18.6	20.6
Dec-2019	18.2	20.2	18.2	20.2	18.2	20.2	18.3	20.3
Jan-2020	19.5	21.5	19.3	21.3	19.3	21.3	19.4	21.4
Feb-2020	18.7	20.7	18.7	20.7	18.6	20.6	18.7	20.7
Mar-2020	17.9	19.9	17.9	19.9	17.8	19.8	17.9	19.9
Apr-2020	14.3	16.3	14.5	16.5	14.7	16.7	14.8	16.8
May-2020	12.3	14.3	12.6	14.6	12.5	14.5	12.5	14.5
Jun-2020	9.4	11.4	10.3	12.3	9.8	11.8	9.9	11.9
July-2020	9.5	11.5	10	12	9.9	11.9	9.9	11.9
Aug-2020	11.9	13.9	12	14	11.8	13.8	11.9	13.9
Sep-2020	15.7	17.7	15.9	17.9	15.7	17.7	15.7	17.7
Oct-2020	16.2	18.2	16	18	16	18	16.1	18.1
Nov-2020	17.3	19.3	17.1	19.1	17.3	19.3	17.3	19.3
Dec-2020	20.1	22.1	19.9	21.9	19.8	21.8	19.9	21.9
Jan-2021	20.9	22.9	20.8	22.8	20.9	22.9	21	23
Feb-2021	20.2	22.2	20.1	22.1	20.1	22.1	20.2	22.2
Mar-2021	18.5	20.5	18.5	20.5	18.4	20.4	18.5	20.5
Apr-2021	17.1	19.1	17.2	19.2	17.1	19.1	17.1	19.1
May-2021	12.7	14.7	13	15	12.8	14.8	12.9	14.9
Jun-2021	10.1	12.1	10.8	12.8	10.4	12.4	10.4	12.4
July-2021	9.9	11.9	10.3	12.3	10.1	12.1	10.2	12.2
Aug-2021	10.3	12.3	10.7	12.7	10.5	12.5	10.6	12.6
Sep-2021	16.4	18.4	16.6	18.6	16.2	18.2	16.3	18.3
Oct-2021	15.6	17.6	15.4	17.4	15.5	17.5	15.6	17.6
Nov-2021	18.4	20.4	18.3	20.3	18.4	20.4	18.4	20.4

	Temperature (^{O}C)							
	Quaternary Catchments							
Months	X11A		X11B		X11C		X11D	
	Base Case	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**
Dec-2021	18.4	20.4	18.4	20.4	18.5	20.5	18.6	20.6
Jan-2022	18.4	20.4	18.2	20.2	18.4	20.4	18.5	20.5
Feb-2022	18.3	20.3	18.3	20.3	18.4	20.4	18.5	20.5
Mar-2022	17.4	19.4	17.2	19.2	17.3	19.3	17.4	19.4
Apr-2022	14.4	16.4	14.6	16.6	14.6	16.6	14.7	16.7
May-2022	12	14	12.5	14.5	12.4	14.4	12.5	14.5
Jun-2022	8.6	10.6	9.3	11.3	8.8	10.8	8.9	10.9
July-2022	9.6	11.6	10.1	12.1	10	12	10.1	12.1
Aug-2022	12.1	14.1	12.5	14.5	12.1	14.1	12.2	14.2
Sep-2022	15.5	17.5	15.9	17.9	15.7	17.7	15.8	17.8
Oct-2022	17.5	19.5	17.3	19.3	17	19	17	19
Nov-2022	16.3	18.3	16	18	15.7	17.7	15.8	17.8
Dec-2022	18.6	20.6	18.5	20.5	18.4	20.4	18.5	20.5
Jan-2023	19.6	21.6	19.5	21.5	19.5	21.5	19.6	21.6
Feb-2023	19.1	21.1	19.1	21.1	19	21	19.1	21.1
Mar-2023	18.1	20.1	18.3	20.3	18.1	20.1	18.2	20.2
Apr-2023	15.1	17.1	15.5	17.5	15.3	17.3	15.3	17.3
May-2023	11.4	13.4	11.9	13.9	11.6	13.6	11.7	13.7
Jun-2023	9.9	11.9	10.8	12.8	10.4	12.4	10.4	12.4
July-2023	9.3	11.3	9.9	11.9	9.7	11.7	9.8	11.8
Aug-2023	12.4	14.4	12.9	14.9	12.6	14.6	12.6	14.6
Sep-2023	15.2	17.2	15.7	17.7	15.4	17.4	15.5	17.5
Oct-2023	16.7	18.7	16.6	18.6	16.6	18.6	16.7	18.7
Nov-2023	17.5	19.5	17.6	19.6	17.7	19.7	17.8	19.8
Dec-2023	18.3	20.3	18.3	20.3	18.5	20.5	18.6	20.6
Jan-2024	18.9	20.9	19	21	19	21	19.1	21.1
Feb-2024	18.1	20.1	18.2	20.2	18.2	20.2	18.3	20.3
Mar-2024	17.8	19.8	18	20	17.8	19.8	17.8	19.8
Apr-2024	15.5	17.5	15.7	17.7	15.5	17.5	15.6	17.6
May-2024	13.1	15.1	13.7	15.7	13.4	15.4	13.4	15.4
Jun-2024	9.5	11.5	10.3	12.3	9.9	11.9	10	12
July-2024	9.6	11.6	10.2	12.2	9.9	11.9	10	12
Aug-2024	12.9	14.9	13.4	15.4	13.2	15.2	13.2	15.2
Sep-2024	14.6	16.6	15.1	17.1	14.8	16.8	14.8	16.8
Oct-2024	15.8	17.8	15.8	17.8	15.9	17.9	15.9	17.9
Nov-2024	17.2	19.2	17.3	19.3	17.2	19.2	17.3	19.3
Dec-2024	18.8	20.8	18.7	20.7	18.9	20.9	19	21
Jan-2025	19.7	21.7	19.7	21.7	19.7	21.7	19.8	21.8
Feb-2025	21.1	23.1	21.2	23.2	21	23	21.1	23.1
Mar-2025	18.4	20.4	18.7	20.7	18.6	20.6	18.6	20.6
Apr-2025	16.8	18.8	17	19	17	19	17.1	19.1
May-2025	13.5	15.5	14	16	13.7	15.7	13.8	15.8
Jun-2025	8.5	10.5	9.3	11.3	9.1	11.1	9.1	11.1
July-2025	8.6	10.6	9.2	11.2	9.1	11.1	9.1	11.1
Aug-2025	11	13	11.2	13.2	11.1	13.1	11.2	13.2
Sep-2025	14	16	14.3	16.3	14.1	16.1	14.2	16.2
Oct-2025	15.3	17.3	15.2	17.2	15.2	17.2	15.3	17.3
Nov-2025	18.6	20.6	18.6	20.6	18.6	20.6	18.7	20.7
Dec-2025	20	22	19.9	21.9	20.1	22.1	20.2	22.2
Jan-2026	20.4	22.4	20.4	22.4	20.4	22.4	20.5	22.5

	Temperature (^{O}C)							
	Quaternary Catchments							
Months	X11A		X11B		X11C		X11D	
	Base Case	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**
Feb-2026	19.9	21.9	20	22	19.9	21.9	20	22
Mar-2026	18.9	20.9	19.1	21.1	19.1	21.1	19.2	21.2
Apr-2026	15.6	17.6	15.7	17.7	15.8	17.8	15.9	17.9
May-2026	12.2	14.2	12.7	14.7	12.7	14.7	12.8	14.8
Jun-2026	9.1	11.1	9.7	11.7	9.6	11.6	9.7	11.7
July-2026	10	12	10.8	12.8	10.7	12.7	10.7	12.7
Aug-2026	12.7	14.7	13.3	15.3	13.2	15.2	13.3	15.3
Sep-2026	14.9	16.9	15.1	17.1	15	17	15.1	17.1
Oct-2026	15.8	17.8	15.8	17.8	15.9	17.9	15.9	17.9
Nov-2026	16.7	18.7	16.6	18.6	16.6	18.6	16.7	18.7
Dec-2026	17.7	19.7	17.5	19.5	17.6	19.6	17.7	19.7
Jan-2027	18.3	20.3	18.2	20.2	18.4	20.4	18.5	20.5
Feb-2027	17.2	19.2	17.1	19.1	17.2	19.2	17.3	19.3
Mar-2027	18.1	20.1	18.1	20.1	18.4	20.4	18.4	20.4
Apr-2027	14.3	16.3	14.5	16.5	14.6	16.6	14.7	16.7
May-2027	13	15	13.3	15.3	13.4	15.4	13.5	15.5
Jun-2027	10.6	12.6	11	13	11.1	13.1	11.1	13.1
July-2027	9.5	11.5	10	12	10	12	10.1	12.1
Aug-2027	13.3	15.3	13.5	15.5	13.7	15.7	13.7	15.7
Sep-2027	14.6	16.6	15	17	14.9	16.9	15	17
Oct-2027	16	18	15.9	17.9	16	18	16	18
Nov-2027	17.3	19.3	17.4	19.4	17.3	19.3	17.3	19.3
Dec-2027	18.4	20.4	18.2	20.2	18.2	20.2	18.3	20.3
Jan-2028	18.9	20.9	18.9	20.9	18.9	20.9	19	21
Feb-2028	18.5	20.5	18.7	20.7	18.8	20.8	18.9	20.9
Mar-2028	18.1	20.1	18.4	20.4	18.2	20.2	18.3	20.3
Apr-2028	15.6	17.6	15.9	17.9	15.9	17.9	16	18
May-2028	11.4	13.4	11.8	13.8	11.9	13.9	12	14
Jun-2028	10.1	12.1	10.8	12.8	10.8	12.8	10.9	12.9
July-2028	10.5	12.5	10.9	12.9	11	13	11.1	13.1
Aug-2028	11.1	13.1	11.5	13.5	11.4	13.4	11.5	13.5
Sep-2028	14.5	16.5	14.9	16.9	14.8	16.8	14.9	16.9
Oct-2028	17.3	19.3	17.3	19.3	17.5	19.5	17.6	19.6
Nov-2028	18.7	20.7	18.7	20.7	18.7	20.7	18.8	20.8
Dec-2028	19.1	21.1	19	21	19.2	21.2	19.4	21.4
Jan-2029	19.6	21.6	19.7	21.7	19.8	21.8	19.9	21.9
Feb-2029	19.2	21.2	19.2	21.2	19.4	21.4	19.5	21.5
Mar-2029	17.6	19.6	17.7	19.7	17.6	19.6	17.7	19.7
Apr-2029	14.4	16.4	14.8	16.8	14.9	16.9	14.9	16.9
May-2029	12.1	14.1	12.7	14.7	12.6	14.6	12.7	14.7
Jun-2029	9.7	11.7	10.3	12.3	10.3	12.3	10.4	12.4
July-2029	9.5	11.5	10	12	10	12	10	12
Aug-2029	12.1	14.1	12.3	14.3	12.3	14.3	12.4	14.4
Sep-2029	15.8	17.8	16	18	16	18	16.1	18.1
Oct-2029	17.5	19.5	17.5	19.5	17.6	19.6	17.7	19.7
Nov-2029	18.4	20.4	18.5	20.5	18.5	20.5	18.6	20.6
Dec-2029	18.3	20.3	18.2	20.2	18.4	20.4	18.5	20.5
Jan-2030	20	22	20	22	20.1	22.1	20.2	22.2
Feb-2030	21.1	23.1	21.1	23.1	21.2	23.2	21.3	23.3

	Temperature (^{O}C)							
	Quaternary Catchments							
Months	X11A		X11B		X11C		X11D	
	Base Case	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**
Mar-2030	18.6	20.6	18.9	20.9	18.8	20.8	18.9	20.9
Apr-2030	17.3	19.3	17.7	19.7	17.7	19.7	17.8	19.8
May-2030	12.4	14.4	12.9	14.9	13	15	13	15
Jun-2030	10.1	12.1	10.8	12.8	10.8	12.8	10.9	12.9
July-2030	9.9	11.9	10.4	12.4	10.5	12.5	10.6	12.6
Aug-2030	10.9	12.9	11.2	13.2	11.2	13.2	11.2	13.2
Sep-2030	17.9	19.9	18.2	20.2	18.1	20.1	18.1	20.1
Oct-2030	18.4	20.4	18.4	20.4	18.4	20.4	18.5	20.5
Nov-2030	18.1	20.1	18.1	20.1	18.1	20.1	18.2	20.2
Dec-2030	19.9	21.9	19.8	21.8	19.9	21.9	19.9	21.9

	Temperature (^{O}C)							
	Quaternary Catchments							
Months	**X11E**		**X11F**		**X11G**		**X11H**	
	Base Case	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**
Oct-2010	17.1	19.1	17.2	19.2	17.2	19.2	17.8	19.8
Nov-2010	16.4	18.4	16.6	18.6	16.9	18.9	17.8	19.8
Dec-2010	20.1	22.1	20.4	22.4	20.9	22.9	22.2	24.2
Jan-2011	20	22	20.4	22.4	20.8	22.8	22	24
Feb-2011	18	20	18.4	20.4	19	21	20.4	22.4
Mar-2011	19.5	21.5	19.9	21.9	20.3	22.3	21.3	23.3
Apr-2011	13.4	15.4	13.9	15.9	14.4	16.4	16.5	18.5
May-2011	11.8	13.8	12.2	14.2	12.7	14.7	14.9	16.9
Jun-2011	9.6	11.6	10.3	12.3	10.9	12.9	12.8	14.8
July-2011	9.6	11.6	10.1	12.1	10.6	12.6	12.7	14.7
Aug-2011	10.9	12.9	11.4	13.4	11.9	13.9	13.8	15.8
Sep-2011	15.2	17.2	15.7	17.7	16.1	18.1	17.5	19.5
Oct-2011	15.9	17.9	16.2	18.2	16.6	18.6	17.9	19.9
Nov-2011	16.2	18.2	16.6	18.6	17.2	19.2	18.5	20.5
Dec-2011	17.1	19.1	17.5	19.5	17.9	19.9	19.2	21.2
Jan-2012	18.6	20.6	18.9	20.9	19.6	21.6	21.3	23.3
Feb-2012	18.4	20.4	18.8	20.8	19.3	21.3	20.6	22.6
Mar-2012	17.6	19.6	18.1	20.1	18.6	20.6	20.2	22.2
Apr-2012	13.5	15.5	14	16	14.5	16.5	16.2	18.2
May-2012	10.9	12.9	11.5	13.5	12.2	14.2	14.7	16.7
Jun-2012	9.4	11.4	10.1	12.1	11	13	13.2	15.2
July-2012	9.2	11.2	9.8	11.8	10.4	12.4	12.6	14.6
Aug-2012	11	13	11.4	13.4	12	14	14	16
Sep-2012	14	16	14.4	16.4	15	17	16.3	18.3
Oct-2012	17.3	19.3	17.6	19.6	18	20	19.2	21.2
Nov-2012	17.1	19.1	17.4	19.4	17.9	19.9	19.3	21.3
Dec-2012	17.8	19.8	18.2	20.2	18.7	20.7	20.2	22.2
Jan-2013	17.9	19.9	18.3	20.3	18.9	20.9	20.5	22.5
Feb-2013	17.6	19.6	18	20	18.7	20.7	20.1	22.1

	Temperature (^{O}C)							
	Quaternary Catchments							
Months	**X11E**		**X11F**		**X11G**		**X11H**	
	Base Case	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**
Mar-2013	16.2	18.2	16.7	18.7	17.2	19.2	18.7	20.7
Apr-2013	14.1	16.1	14.5	16.5	15.2	17.2	17.3	19.3
May-2013	12.5	14.5	12.9	14.9	13.4	15.4	15.5	17.5
Jun-2013	9.8	11.8	10.4	12.4	11.1	13.1	13	15
July-2013	9.3	11.3	9.9	11.9	10.5	12.5	12.8	14.8
Aug-2013	11.4	13.4	11.9	13.9	12.5	14.5	14.3	16.3
Sep-2013	15.7	17.7	16.2	18.2	16.4	18.4	17.6	19.6
Oct-2013	15.3	17.3	15.7	17.7	16.1	18.1	17.3	19.3
Nov-2013	17.1	19.1	17.6	19.6	18.1	20.1	19.4	21.4
Dec-2013	17.3	19.3	17.8	19.8	18.3	20.3	19.6	21.6
Jan-2014	17.3	19.3	17.7	19.7	18.3	20.3	20	22
Feb-2014	17.8	19.8	18.3	20.3	19	21	20.4	22.4
Mar-2014	17.3	19.3	17.8	19.8	18.3	20.3	19.8	21.8
Apr-2014	14.3	16.3	14.8	16.8	15.4	17.4	17.3	19.3
May-2014	10.2	12.2	10.8	12.8	11.4	13.4	13.7	15.7
Jun-2014	9.3	11.3	10	12	10.8	12.8	12.9	14.9
July-2014	9.4	11.4	10	12	10.5	12.5	12.6	14.6
Aug-2014	11	13	11.4	13.4	11.7	13.7	13.4	15.4
Sep-2014	16.1	18.1	16.4	18.4	16.6	18.6	17.9	19.9
Oct-2014	15.5	17.5	16	18	16.4	18.4	17.8	19.8
Nov-2014	17.4	19.4	17.9	19.9	18.5	20.5	19.8	21.8
Dec-2014	18.7	20.7	19.1	21.1	19.7	21.7	21.2	23.2
Mar-2015	16.4	18.4	16.9	18.9	17.5	19.5	18.8	20.8
Apr-2015	15.7	17.7	16.1	18.1	16.6	18.6	18.5	20.5
May-2015	11.8	13.8	12.3	14.3	12.9	14.9	15.3	17.3
Jun-2015	10.5	12.5	11.1	13.1	11.9	13.9	14.1	16.1
July-2015	9.4	11.4	10	12	10.6	12.6	12.7	14.7
Aug-2015	11.5	13.5	12	14	12.5	14.5	14.4	16.4
Sep-2015	15.3	17.3	15.8	17.8	16.3	18.3	17.8	19.8
Oct-2015	17.7	19.7	18	20	18.4	20.4	19.6	21.6
Nov-2015	17.9	19.9	18.3	20.3	18.7	20.7	19.9	21.9
Dec-2015	19.1	21.1	19.5	21.5	20	22	21.2	23.2
Jan-2016	18.1	20.1	18.5	20.5	19	21	20.4	22.4
Feb-2016	18.6	20.6	18.9	20.9	19.5	21.5	20.8	22.8
Mar-2016	17.8	19.8	18.3	20.3	18.8	20.8	20.2	22.2
Apr-2016	14.4	16.4	14.9	16.9	15.4	17.4	17.2	19.2
May-2016	12.2	14.2	12.7	14.7	13.4	15.4	15.6	17.6
Jun-2016	8.9	10.9	9.6	11.6	10.2	12.2	12	14
July-2016	9.7	11.7	10.4	12.4	10.8	12.8	13	15
Aug-2016	14.9	16.9	15.4	17.4	15.6	17.6	17.1	19.1
Sep-2016	15.1	17.1	15.6	17.6	16.1	18.1	17.5	19.5
Oct-2016	15.8	17.8	16.4	18.4	16.8	18.8	18.1	20.1
Nov-2016	17.4	19.4	17.8	19.8	18.4	20.4	19.7	21.7
Dec-2016	17.6	19.6	18	20	18.5	20.5	20.1	22.1
Jan-2017	18.2	20.2	18.6	20.6	19.3	21.3	20.9	22.9
Feb-2017	19.5	21.5	20	22	20.6	22.6	22	24
Mar-2017	17.9	19.9	18.3	20.3	18.8	20.8	20.1	22.1
Apr-2017	16.2	18.2	16.7	18.7	17.1	19.1	18.8	20.8
May-2017	12.7	14.7	13.1	15.1	13.7	15.7	15.6	17.6

	Temperature (^{O}C)							
	Quaternary Catchments							
Months	**X11E**		**X11F**		**X11G**		**X11H**	
	Base Case	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**
Jun-2017	9.8	11.8	10.3	12.3	10.9	12.9	12.7	14.7
July-2017	8.4	10.4	8.8	10.8	9.5	11.5	11.8	13.8
Aug-2017	12.4	14.4	12.9	14.9	13.2	15.2	14.8	16.8
Sep-2017	15	17	15.4	17.4	16	18	17.1	19.1
Oct-2017	17.3	19.3	17.7	19.7	18	20	19.2	21.2
Nov-2017	17	19	17.5	19.5	18.1	20.1	19.5	21.5
Dec-2017	17.9	19.9	18.2	20.2	18.6	20.6	19.9	21.9
Jan-2018	18.2	20.2	18.5	20.5	18.9	20.9	20.3	22.3
Feb-2018	18.2	20.2	18.7	20.7	19.4	21.4	21	23
Mar-2018	17.5	19.5	18	20	18.5	20.5	19.9	21.9
Apr-2018	14.7	16.7	15.4	17.4	16	18	18.1	20.1
May-2018	12.3	14.3	12.6	14.6	13	15	15.3	17.3
Jun-2018	9.8	11.8	10.2	12.2	10.5	12.5	12	14
July-2018	9.3	11.3	9.6	11.6	9.7	11.7	11.6	13.6
Aug-2018	11.2	13.2	11.7	13.7	12.1	14.1	13.9	15.9
Sep-2018	14	16	14.6	16.6	15.2	17.2	16.6	18.6
Oct-2018	17.1	19.1	17.3	19.3	17.5	19.5	18.6	20.6
Nov-2018	17.4	19.4	17.8	19.8	18.3	20.3	19.4	21.4
Dec-2018	18.7	20.7	19	21	19.4	21.4	20.5	22.5
Jan-2019	19.8	21.8	20.2	22.2	20.8	22.8	22.3	24.3
Feb-2019	18	20	18.3	20.3	18.8	20.8	20.1	22.1
Mar-2019	17	19	17.6	19.6	18.2	20.2	20	22
Apr-2019	15	17	15.3	17.3	15.6	17.6	17.2	19.2
May-2019	11.4	13.4	11.9	13.9	12.2	14.2	14.1	16.1
Jun-2019	9.3	11.3	9.9	11.9	10.4	12.4	12.2	14.2
Sep-2019	13.5	15.5	14.1	16.1	14.7	16.7	16.2	18.2
Oct-2019	13	15	13.4	15.4	14	16	15.5	17.5
Nov-2019	18.4	20.4	18.7	20.7	19.3	21.3	20.7	22.7
Dec-2019	18.1	20.1	18.2	20.2	18.3	20.3	19.3	21.3
Jan-2020	19.2	21.2	19.6	21.6	20.1	22.1	21.2	23.2
Feb-2020	18.5	20.5	19.1	21.1	19.8	21.8	21.4	23.4
Mar-2020	17.8	19.8	18.3	20.3	18.9	20.9	20.4	22.4
Apr-2020	14.6	16.6	15.1	17.1	15.5	17.5	17.1	19.1
May-2020	12.4	14.4	12.9	14.9	13.4	15.4	15.6	17.6
Jun-2020	9.8	11.8	10.3	12.3	10.8	12.8	12.5	14.5
July-2020	9.9	11.9	10.4	12.4	10.9	12.9	12.9	14.9
Aug-2020	11.9	13.9	12.6	14.6	13.3	15.3	15.4	17.4
Sep-2020	15.6	17.6	16	18	16.4	18.4	17.5	19.5
Oct-2020	16	18	16.4	18.4	16.9	18.9	18.3	20.3
Nov-2020	17.2	19.2	17.5	19.5	17.9	19.9	18.9	20.9
Dec-2020	19.8	21.8	20.2	22.2	20.7	22.7	22	24
Jan-2021	20.9	22.9	21.2	23.2	21.6	23.6	22.7	24.7
Feb-2021	20	22	20.4	22.4	20.8	22.8	22	24
Mar-2021	18.3	20.3	18.7	20.7	19.1	21.1	20.5	22.5
Apr-2021	17.1	19.1	17.4	19.4	17.6	19.6	19.1	21.1
May-2021	12.8	14.8	13.2	15.2	13.4	15.4	15.3	17.3
Jun-2021	10.3	12.3	10.9	12.9	11.5	13.5	13.4	15.4
July-2021	10.1	12.1	10.8	12.8	11.2	13.2	13.3	15.3
Aug-2021	10.5	12.5	11.1	13.1	11.6	13.6	13.5	15.5
Sep-2021	16.2	18.2	16.6	18.6	16.8	18.8	18.3	20.3

	Temperature (^{O}C)							
	Quaternary Catchments							
Months	**X11E**		**X11F**		X11G		X11H	
	Base Case	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**
Oct-2021	15.4	17.4	15.7	17.7	16	18	17.2	19.2
Nov-2021	18.2	20.2	18.6	20.6	19.1	21.1	20.2	22.2
Dec-2021	18.4	20.4	18.8	20.8	19.3	21.3	20.5	22.5
Jan-2022	18.2	20.2	18.6	20.6	19	21	20.6	22.6
Feb-2022	18.1	20.1	18.4	20.4	18.8	20.8	20.2	22.2
Mar-2022	16.9	18.9	17.4	19.4	17.6	19.6	18.9	20.9
Apr-2022	14.5	16.5	14.9	16.9	15.3	17.3	17.1	19.1
May-2022	12.4	14.4	12.8	14.8	13.2	15.2	15.3	17.3
Jun-2022	8.9	10.9	9.6	11.6	10.3	12.3	12.2	14.2
July-2022	10	12	10.8	12.8	11.3	13.3	13.3	15.3
Aug-2022	12.2	14.2	12.6	14.6	12.8	14.8	14.1	16.1
Sep-2022	15.6	17.6	16.1	18.1	16.5	18.5	17.7	19.7
Oct-2022	17.2	19.2	17.3	19.3	17.7	19.7	18.6	20.6
Nov-2022	15.8	17.8	16.2	18.2	16.5	18.5	17.8	19.8
Dec-2022	18.3	20.3	18.7	20.7	19	21	20.3	22.3
Jan-2023	19.4	21.4	19.8	21.8	20.1	22.1	21.7	23.7
Feb-2023	18.9	20.9	19.3	21.3	19.7	21.7	20.9	22.9
Mar-2023	18.1	20.1	18.5	20.5	19	21	20.2	22.2
Apr-2023	15.4	17.4	15.7	17.7	16.1	18.1	17.6	19.6
May-2023	11.6	13.6	12	14	12.4	14.4	14.3	16.3
Jun-2023	10.4	12.4	11	13	11.6	13.6	13.3	15.3
July-2023	9.7	11.7	10.4	12.4	10.8	12.8	12.8	14.8
Aug-2023	12.6	14.6	13	15	13.4	15.4	15	17
Sep-2023	15.3	17.3	15.6	17.6	16	18	17.2	19.2
Oct-2023	16.6	18.6	17.1	19.1	17.7	19.7	19.2	21.2
Nov-2023	17.6	19.6	18	20	18.5	20.5	19.8	21.8
Feb-2024	18	20	18.4	20.4	18.9	20.9	19.9	21.9
Mar-2024	17.7	19.7	18.2	20.2	18.6	20.6	19.9	21.9
Apr-2024	15.5	17.5	15.9	17.9	16.2	18.2	17.7	19.7
May-2024	13.4	15.4	13.8	15.8	14.2	16.2	15.9	17.9
Jun-2024	9.9	11.9	10.6	12.6	11.2	13.2	12.9	14.9
July-2024	9.9	11.9	10.5	12.5	10.9	12.9	13	15
Aug-2024	13.1	15.1	13.5	15.5	13.9	15.9	15.8	17.8
Sep-2024	14.7	16.7	15.1	17.1	15.5	17.5	16.7	18.7
Oct-2024	15.8	17.8	16.2	18.2	16.6	18.6	18.2	20.2
Nov-2024	17.1	19.1	17.5	19.5	17.9	19.9	18.8	20.8
Dec-2024	18.8	20.8	19.1	21.1	19.4	21.4	20.6	22.6
Jan-2025	19.6	21.6	19.9	21.9	20.2	22.2	21.4	23.4
Feb-2025	20.9	22.9	21.2	23.2	21.5	23.5	22.8	24.8
Mar-2025	18.5	20.5	18.9	20.9	19.3	21.3	20.6	22.6
Apr-2025	16.9	18.9	17.2	19.2	17.5	19.5	19.1	21.1
May-2025	13.7	15.7	14.4	16.4	14.9	16.9	16.8	18.8
Jun-2025	9	11	9.8	11.8	10.5	12.5	12.4	14.4
July-2025	9.1	11.1	9.7	11.7	10.2	12.2	12.6	14.6
Aug-2025	11.1	13.1	11.7	13.7	12.2	14.2	14.1	16.1
Sep-2025	14	16	14.3	16.3	14.6	16.6	15.9	17.9
Oct-2025	15.1	17.1	15.4	17.4	15.7	17.7	16.9	18.9
Nov-2025	18.5	20.5	18.7	20.7	18.9	20.9	19.6	21.6
Dec-2025	20	22	20.3	22.3	20.7	22.7	22	24

	Temperature (^{O}C)							
	Quaternary Catchments							
Months	**X11E**		X11F		X11G		X11H	
	Base Case	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**
Jan-2026	20.3	22.3	20.6	22.6	20.9	22.9	22	24
Feb-2026	19.7	21.7	20	22	20.3	22.3	21.3	23.3
Mar-2026	18.9	20.9	19.3	21.3	19.7	21.7	21	23
Apr-2026	15.7	17.7	16.2	18.2	16.7	18.7	18.3	20.3
May-2026	12.5	14.5	13.1	15.1	13.6	15.6	15.5	17.5
Jun-2026	9.5	11.5	10.1	12.1	10.7	12.7	12.5	14.5
July-2026	10.5	12.5	11	13	11.3	13.3	13.3	15.3
Aug-2026	13.2	15.2	13.6	15.6	14	16	15.8	17.8
Sep-2026	14.8	16.8	15.2	17.2	15.4	17.4	16.8	18.8
Oct-2026	15.7	17.7	16	18	16.3	18.3	17.3	19.3
Nov-2026	16.5	18.5	16.8	18.8	17.1	19.1	18.1	20.1
Dec-2026	17.5	19.5	17.8	19.8	18.2	20.2	19.3	21.3
Jan-2027	18.2	20.2	18.6	20.6	19.1	21.1	20.5	22.5
Feb-2027	17.1	19.1	17.5	19.5	18.2	20.2	19.6	21.6
Mar-2027	18.3	20.3	18.7	20.7	19.3	21.3	20.6	22.6
Apr-2027	14.4	16.4	14.8	16.8	15.1	17.1	16.6	18.6
May-2027	13.3	15.3	13.7	15.7	14.1	16.1	15.9	17.9
Jun-2027	10.9	12.9	11.3	13.3	11.6	13.6	13	15
July-2027	10	12	10.4	12.4	10.9	12.9	12.9	14.9
Aug-2027	13.6	15.6	14	16	14.4	16.4	15.9	17.9
Sep-2027	14.9	16.9	15.3	17.3	15.8	17.8	17.2	19.2
Oct-2027	15.9	17.9	16.4	18.4	16.9	18.9	18.4	20.4
Nov-2027	17.2	19.2	17.5	19.5	17.9	19.9	18.8	20.8
Dec-2027	18.3	20.3	18.6	20.6	19.1	21.1	20.4	22.4
Jan-2028	18.9	20.9	19.2	21.2	19.6	21.6	21.1	23.1
Feb-2028	18.6	20.6	18.9	20.9	19.3	21.3	20.3	22.3
Mar-2028	18.2	20.2	18.5	20.5	18.9	20.9	20.3	22.3
Apr-2028	15.9	17.9	16.2	18.2	16.5	18.5	18.1	20.1
May-2028	11.7	13.7	12.2	14.2	12.7	14.7	14.7	16.7
Aug-2028	11.4	13.4	11.9	13.9	12.4	14.4	14	16
Sep-2028	14.6	16.6	14.9	16.9	15.1	17.1	16.3	18.3
Oct-2028	17.3	19.3	17.6	19.6	17.9	19.9	19	21
Nov-2028	18.5	20.5	18.6	20.6	18.8	20.8	19.5	21.5
Dec-2028	19.1	21.1	19.3	21.3	19.6	21.6	20.7	22.7
Jan-2029	19.6	21.6	19.9	21.9	20.2	22.2	21.6	23.6
Feb-2029	19.2	21.2	19.5	21.5	19.9	21.9	21.4	23.4
Mar-2029	17.5	19.5	17.8	19.8	18.2	20.2	19.5	21.5
Apr-2029	14.7	16.7	15	17	15.4	17.4	17	19
May-2029	12.5	14.5	12.9	14.9	13.3	15.3	15.2	17.2
Jun-2029	10.2	12.2	10.6	12.6	11	13	12.2	14.2
July-2029	9.9	11.9	10.4	12.4	10.9	12.9	13	15
Aug-2029	12.3	14.3	12.7	14.7	13	15	14.6	16.6
Sep-2029	15.9	17.9	16.2	18.2	16.5	18.5	17.9	19.9
Oct-2029	17.5	19.5	17.8	19.8	18.1	20.1	19.2	21.2
Nov-2029	18.4	20.4	18.6	20.6	19	21	20	22
Dec-2029	18.3	20.3	18.5	20.5	18.9	20.9	19.9	21.9
Jan-2030	19.9	21.9	20.2	22.2	20.4	22.4	21.9	23.9
Feb-2030	21.1	23.1	21.4	23.4	21.7	23.7	22.7	24.7
Mar-2030	18.7	20.7	19	21	19.3	21.3	20.4	22.4
Apr-2030	17.6	19.6	18	20	18.3	20.3	19.8	21.8

	Temperature (^{O}C)							
	Quaternary Catchments							
Months	**X11E**		X11F		X11G		X11H	
	Base Case	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**	**Base Case**	**Scen. 1/2/3**
May-2030	12.9	14.9	13.4	15.4	13.9	15.9	15.9	17.9
Jun-2030	10.7	12.7	11.2	13.2	11.7	13.7	13.2	15.2
July-2030	10.4	12.4	11	13	11.4	13.4	13.5	15.5
Aug-2030	11.1	13.1	12	14	12.4	14.4	14.1	16.1
Sep-2030	18	20	18.5	20.5	18.6	20.6	19.7	21.7
Oct-2030	18.4	20.4	18.8	20.8	19	21	19.8	21.8
Nov-2030	18	20	18.5	20.5	19	21	20.4	22.4
Dec-2030	19.8	21.8	20.1	22.1	20.6	22.6	22	24

Appendix C

Model output of the WEAP21model: water demand under different scenarios from October 2011 to September 2030

Base Case: Water Demand (not including loss, reuse and DSM) (Million Cubic Meter)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
EFR	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00
Interbasin transfer	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00
Nooitgedacht mining	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
Nooitgedacht strategic	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00
Vygeboom mining	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Vygeboom strategic	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50
Within catchment transfer 1	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47
X11D	8.02	3.44	10.94	11.05	19.99	15.26	20.80	14.88	7.63	20.73
X11E	3.45	1.50	4.74	4.77	8.61	6.59	8.94	6.40	3.27	8.90
X11F	3.23	1.36	3.17	4.66	6.50	5.29	10.25	6.89	6.53	8.15
X11G	4.24	0.00	3.87	4.05	6.18	6.46	11.40	6.58	8.60	8.89
X11H	4.18	1.99	6.42	6.78	10.51	9.19	14.11	11.29	10.85	13.07
All Others	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73
Sum	315.33	300.49	321.34	323.52	344.00	334.98	357.71	338.25	329.08	351.93

Cont...

2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Sum**
27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	540.00
97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	1,940.00
5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	110.00
88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	1,760.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	100.00
17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	350.00
46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	929.40
23.29	10.46	11.21	14.92	10.24	11.06	14.96	15.75	15.90	32.86	293.42
11.89	4.67	4.84	6.45	4.47	4.74	4.74	6.64	6.79	14.07	126.48
9.58	3.17	5.31	8.58	6.26	4.65	3.43	8.70	6.67	14.80	127.20
10.60	2.20	6.53	8.89	6.01	3.89	4.10	7.20	6.55	17.63	133.87
15.24	6.14	9.13	11.72	9.92	6.46	6.52	11.94	9.21	20.44	195.08
5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	114.62
362.80	318.84	329.21	342.76	329.10	323.00	325.95	342.43	337.32	392.00	6,720.06

Scenario 1: Water Demand (not including loss, reuse and DSM) (Million Cubic Meter)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
EFR	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00
Interbasin transfer	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00
Nooitgedacht mining	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
Nooitgedacht strategic	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00
Vygeboom mining	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Vygeboom strategic	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50
Within catchment transfer 1	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47
X11D	8.05	7.14	15.49	14.69	21.38	20.48	29.55	16.38	11.22	28.39
X11E	3.46	3.11	6.71	6.35	9.20	8.83	12.72	7.05	4.81	12.18
X11F	3.24	1.54	4.92	5.24	8.19	7.15	13.07	9.09	8.59	10.88
X11G	4.26	1.86	4.33	6.51	8.83	8.96	14.19	9.18	9.46	13.60
X11H	4.20	4.10	8.70	9.34	11.70	11.90	17.71	8.77	11.66	14.94
All Others	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73
Sum	315.41	309.95	332.35	334.33	351.50	349.52	379.46	342.67	337.95	372.19

Cont...

2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Sum**
27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	540.00
97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	1940.00
5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	110.00
88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	1760.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	100.00
17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	350.00
46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	929.40
27.50	11.33	14.40	19.88	14.64	12.27	15.44	20.26	20.67	34.43	363.61
11.93	4.95	6.23	8.58	6.39	5.25	6.75	8.72	8.86	14.79	156.86
14.13	5.04	7.33	10.90	9.88	4.76	5.19	6.35	6.59	15.20	157.30
15.36	4.20	7.18	11.76	8.45	6.17	4.55	11.71	9.03	20.65	180.25
18.65	6.72	9.97	14.75	13.08	6.77	8.78	8.73	9.18	20.69	220.33
5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	114.62
379.78	324.44	337.30	358.07	344.64	327.42	332.90	347.97	346.53	397.96	6922.36

Scenario 2: Water Demand (not including loss, reuse and DSM) (Million Cubic Meter)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
EFR	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00
Interbasin transfer	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00
Nooitgedacht mining	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
Nooitgedacht strategic	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00
Vygeboom mining	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Vygeboom strategic	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50
Within catchment transfer 1	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47
X11D	8.03	3.59	11.43	11.55	20.63	15.77	24.69	16.26	11.53	23.91
X11E	3.45	1.56	4.95	4.99	8.89	6.82	10.22	6.89	4.98	10.28
X11F	3.21	1.44	3.32	4.89	6.75	6.87	10.57	7.05	8.14	10.01
X11G	4.21	0.00	4.08	6.10	6.47	6.72	11.74	8.58	8.89	9.20
X11H	4.16	3.80	6.65	8.84	10.96	9.51	16.27	11.37	11.14	13.73
All Others	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73
Sum	315.27	302.59	322.63	328.55	345.90	337.89	365.69	342.36	336.88	359.34

Cont...

2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Sum**
27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	540.00
97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	1940.00
5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	110.00
88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	1760.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	100.00
17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	350.00
46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	929.40
23.05	10.65	11.59	15.38	10.54	11.56	15.35	16.25	16.41	33.41	311.59
10.02	4.66	4.99	6.65	4.60	4.95	6.32	6.89	7.02	14.32	133.47
9.50	3.16	6.87	8.80	6.33	4.80	3.54	8.46	6.67	15.11	135.48
10.72	2.21	6.84	9.20	6.15	4.05	4.29	9.18	6.70	19.27	144.60
15.37	6.25	9.45	12.00	9.90	6.65	6.72	11.63	9.23	20.84	204.47
5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	114.62
360.86	319.12	331.95	344.23	329.73	324.21	328.42	344.62	338.23	395.16	6773.62

Scenario 3: Water Demand (not including loss, reuse and DSM) (Million Cubic Meter)

EFR	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00

Interbasin transfer	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00
Nooitgedacht mining	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50
Nooitgedacht strategic	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00
Vygeboom mining	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Vygeboom strategic	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50
Within catchment transfer 1	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47
X11D	8.07	10.73	15.37	15.53	28.88	25.37	34.99	21.01	15.57	32.90
X11E	3.47	4.65	6.65	6.70	12.42	10.92	12.30	8.66	6.67	14.11
X11F	3.27	3.08	6.67	6.73	10.36	8.67	15.03	8.83	8.97	14.24
X11G	4.30	2.00	6.45	6.95	11.33	9.52	17.48	11.77	11.23	14.32
X11H	4.24	4.41	9.46	11.32	14.57	11.98	18.69	13.51	13.94	19.09
All Others	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73
Sum	315.55	317.08	336.80	339.42	369.76	358.66	390.70	355.98	348.59	386.86

Cont...

2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	**Sum**
27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	540.00
97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	97.00	1940.00
5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	5.50	110.00
88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	88.00	1760.00
5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	100.00
17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	17.50	350.00
46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	46.47	929.40
37.13	14.67	15.28	25.11	22.88	16.32	14.91	20.97	22.21	50.78	448.69
16.08	7.60	6.57	10.83	9.95	7.00	6.51	9.01	9.52	21.76	191.39
14.08	5.27	8.34	13.16	13.90	5.05	6.40	11.48	9.25	22.48	195.27
18.91	6.50	9.53	14.63	13.36	6.27	6.69	12.51	9.65	24.99	218.40
21.36	8.84	11.47	17.72	18.32	7.12	8.80	15.51	12.47	29.88	272.68
5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	114.62
399.76	335.09	343.38	373.65	370.62	333.96	335.51	361.68	355.29	442.08	7170.44

Appendix D

Model output of the WEAP21 model: Potential evapotranspiration under different scenarios from October 2011 to September 2030

ETPotential Cubic Meter

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Base Case	4.62E+09	4.21E+09	4.4E+09	4.24E+09	4.57E+09	4.69E+09	4.62E+09	4.46E+09	4.43E+09	4.62E+09	4.91E+09
Scenario 1	5.05E+09	4.61E+09	4.82E+09	4.65E+09	5E+09	5.13E+09	5.05E+09	4.88E+09	4.85E+09	5.06E+09	5.36E+09
Scenario 2	5.05E+09	4.61E+09	4.82E+09	4.65E+09	5E+09	5.13E+09	5.05E+09	4.88E+09	4.85E+09	5.06E+09	5.36E+09
Scenario 3	5.05E+09	4.61E+09	4.82E+09	4.65E+09	5E+09	5.13E+09	5.05E+09	4.88E+09	4.85E+09	5.06E+09	5.36E+09

Cont...

2022	2023	2024	2025	2026	2027	2028	2029	2030	**Sum**
4.42E+09	4.62E+09	4.69E+09	4.65E+09	4.77E+09	4.45E+09	4.58E+09	4.75E+09	5.16E+09	9.19E+10
4.84E+09	5.05E+09	5.13E+09	5.08E+09	5.22E+09	4.86E+09	5.01E+09	5.19E+09	5.63E+09	1E+11
4.84E+09	5.05E+09	5.13E+09	5.08E+09	5.22E+09	4.86E+09	5.01E+09	5.19E+09	5.63E+09	1E+11
4.84E+09	5.05E+09	5.13E+09	5.08E+09	5.22E+09	4.86E+09	5.01E+09	5.19E+09	5.63E+09	1E+11

Appendix E

Analysis on the water available under different scenarios from October 2011 to September 2030

Analysis on water available under base case: (cubic meter)

	2011	2012	2013	2014	2015	2016	2017
Difference in Storage (Nooidegacht)	23378935.92	-14205615	18932620	-32611221.22	0	0	0
Difference in Storage (Vygeboom)	44751120.7	0	-2385534	-52125064.71	54510599	-60895121	9059898.7
Outflow to Downstream (Vygeboom)	19825663.78	315560509	208003598	131482795.3	62398114	134009566	12154550
Supply Delivered:							
EFR	19825663.78	22710816	19268058	17174722.12	13729226	13582797	12154550
Interbasin transfer	71091582.52	75524043	63129323	61701779.46	47586157	48797454	37157959
Nooitgedacht irrigation	911090.1454	1087759.1	930982.26	954176.2972	695853.08	647256.05	483527.21
Nooitgedacht mining	3340663.866	3988450	3413601.6	3498646.423	2551461.3	2373272.2	1772933.1
Nooitgedacht strategic	53447680.49	63812235	54614709	55976872.09	40819740	37969413	28362566
Urban X11A	662324.5736	790755.54	676785.31	693646.4107	505856.19	470528.18	351504.14
Vygeboom mining	3306221.899	3740833.2	2945302.9	2904109.589	2268986.4	2479452.1	1657534.2
Vygeboom strategic	11571776.65	13092916	10308560	10164383.56	7941452.2	8678082.2	5801369.9
Within catchment transfer 1	28224019.46	33697211	28840290	29559605.07	21555606	20050439	14977369
X11D	6730977.357	77996.564	1255009.5	578552.4365	341990.07	3625912.3	555509.47
X11E	2896294.004	33894.697	546673.7	252514.6857	148119.29	1589945.1	241186.21
X11H	3509724.703	45091.666	91884.684	373628.0388	2053109.9	197233.67	1125264.6
All Others	8266817.629	2387382.6	2132040.4	2581331.693	1794093.4	1738139	2236182.3
Sum	213784837.1	220989384	188153219	186413967.9	141991651	142199924	106877456
Monthly Water Available (Base Case)	301740557.5	522344277	412703903	233160477.2	258900364	215314370	128091905

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2018	2019	2020	2021	2022	2023	2024	2025
534920.78	-534920.8	0	36267677	-28477898	-6041720	-1748058	47477736
-6164328	-8980450	0	38702184	-26415725	10852970	-23139429	47237949
119016801	29259435	12446902	31761923	183532580	146400898	94424649	117590724
15749830	15923533	12446902	9177738	19513428	18085751	12980453	17690314
56582723	57206768	36417482	28254160	65292821	58932467	46633478	63313750
800398.99	827470.26	410516.66	375412.7	973968.41	801129.67	721186.39	966465.94
2934796.3	3034057.6	1505227.8	1376513.2	3571217.5	2937475.4	2644350.1	3543708.4
46953775	48541257	24079280	22018353	57136539	46996666	42306660	56695646
581856.71	601536.4	298428.51	272909.39	708034.45	582387.89	524272.46	702580.47
2479452.1	2479452.1	1687252.2	910882.42	3075859.7	2904109.6	2068493.2	2841215
8678082.2	8678082.2	5905382.5	3188088.5	10765509	10164384	7239726	9944252.3
24794795	25633094	12715502	11627192	30171988	24817444	22340801	29939167
3433691	120603.79	224814.54	1997990.8	662981.13	203335.62	1899570.5	1091767.7
1502145.5	52244.294	97814.66	818458.36	297786.36	87476.089	824615.77	479189.28
104357.84	1957509.3	1107148.7	1011682	389622.47	136532.71	593301.38	1741445.4
1882633.4	3339163.9	1937267.2	2167734.3	2557009.3	1995128.8	2402505	3768394.9
166478536	168394772	98833019	83197114	195116765	168644287	143179412	192717896
279865930	188138837	111279921	189928897	323755722	319856434	212716575	405024305

Contd..

2026	2027	2028	2029	2030	**Sum**	
-43388952	8701043.3	-12789827	0	-1985305		**-6,490,585.66**
19742051	-54254768	54254768	-66980000	-1975278		**-24,204,157.68**
59032508	136232928	48971363	215637683	7255476		**2,084,998,665.74**
19036494	17328486	16081915	17118226	7255476		**316,834,379.49**
62109417	62254192	57527717	59698074	19030874		**1,078,242,222.11**
956091.89	827298.45	889628.95	846286.71	227273.5		**15,333,772.61**
3505670.3	3033427.6	3261972.8	3103051.3	833336.1		**56,223,832.91**
56088530	48531901	52190094	49646626	13329013		**899,517,556.73**
695038.97	601411.5	646723.18	615215.17	165218.3		**11,147,013.78**
2921930	2904109.6	2904109.6	2904109.6	323515.4		**49,706,930.51**
10226755	10164384	10164384	10164384	1132304		**173,974,256.78**
29618568	25628153	27559928	26216804	7038628		**475,006,600.70**
71067.446	1052428.3	612484.3	2222998.2	1458197		**28,217,878.33**
30342.848	1384509.5	255352.87	950312.86	623932.8		**13,112,808.85**
39054.942	0	364907.03	1391796.7	724233.1		**16,957,528.79**
2107218.7	1794110.6	2130638.2	3991695.6	1523156		**52,732,642.65**
187406180	175504411	174589855	178869579	53665157		**3,187,007,424.25**
222791786	266183615	265026159	327527263	56960049		**5,241,311,346.65**
TOTAL WATER AVAILABLE (BASE CASE)						**5,241,311,346.65**

Analysis on water available under scenario 1: (cubic meter)

	2011	2012	2013	2014	2015	2016	2017
Difference in Storage (Nooidegacht)	16156238	-10874830	12698011	-21124124	0	0	0
Difference in Storage (Vygeboom)	46464816	0	-8258878	-51014123	59273002	-64538551	8216976.1
Outflow to Downstream (Vygeboom)	19538016	274248677	173686882	104025318	56376719	118648221	10561442
Supply delivered:							
EFR	19538016	21474833	17500046	16554974	12962996	13446187	10561442
Interbasin transfer	67781903	73194503	60464030	59475278	44050244	44818990	35580120
Nooitgedacht irrigation	882481.08	1051960.1	882785.41	919745.87	587596.15	552906.28	408204.37
Nooitgedacht mining	3235763.9	3857186.9	3236879.9	3372401.5	2154519.2	2027323	1496749.4
Nooitgedacht strategic	51768534	61712025	51787884	53956954	34468691	32434227	23943626
Vygeboom mining	2741862.4	3290970.5	2904109.6	2904109.6	2068493.2	2190713.8	1657534.2
Vygeboom strategic	9596518.5	11518397	10164384	10164384	7239726	7667498.2	5801369.9
Within catchment transfer 1	27337316	32588157	27347534	28492950	18201819	17127483	12643867
X11D	6729571.5	96027.224	876378.71	3582383.6	103880.03	2717368.3	868818.6
X11E	2895390.6	41914.059	381560.62	1565661.9	44868.059	1189636.6	377929.35
X11F	2712403	0	0	175222.18	1237945.8	45162.074	383107.52
X11H	3510682.5	55036.618	809166.17	239077.5	1730021.3	63139.214	521197.48
All Others	6139761.4	3028891.6	2523143.9	2808198.5	1774817.3	1699409.6	1693613.4
Sum	204870204	211909901	178877902	184211341	126625617	125980044	95937579
Monthly Water Available (Base Case)	287029274	475283748	357003917	216098412	242275337	180089714	114715997

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2018	2019	2020	2021	2022	2023	2024	2025
0	0	0	27256577	-24066850	-3189727	0	35843922
-5043204	-5615221	0	33743875	-24372513	8453855.8	-17825218	35662892
99378862	22371771	11569622	28218640	143393315	123585482	71801557	78760955
14900363	15079456	11569622	8019461.4	18603315	16407918	11954403	16776779
53530935	54174341	32250066	20865805	61649796	55655280	42947301	58734107
728115.4	747462.73	335727.83	308886.47	937857.82	722256.91	637508.24	899326.76
2669756.5	2740696.7	1231002	1132583.7	3438812	2648275.3	2337530.2	3297531.5
42713885	43848206	19691669	18116976	55018051	42368717	37397542	52756091
2479452.1	2479452.1	1456887.4	496001.06	2973072	2493150.7	2068493.2	2584256.2
8678082.2	8678082.2	5099106	1736003.7	10405752	8726027.4	7239726	9044896.7
22555844	23154842	10398544	9566998.5	29053282	22373571	19748452	27858813
3245418.9	3204439.2	612122.83	3065731.4	242240.27	3235226.5	1348373.6	1451800.4
1418705.7	1378252.4	265709.87	1330054.2	105819.84	1453229.8	582104.73	637241.82
0	1556257.5	294369.64	588324.74	109065.21	0	582672.48	2270249.6
1190882.4	202407.53	407725.9	777730.65	143662.77	0	781918.76	2872447
2095822.4	2148813.2	1462731.2	1451974	2815372.9	2122935.7	2152294	3368307.1
156207262	159392709	85075284	67456531	185496098	158206588	129778320	182551848
250542920	176149259	96644906	156675623	280450050	287056200	183754659	332819617

Contd..

2026	2027	2028	2029	2030	**Sum**	
-35527676	6339529.9	-6655776	0	-2274069		**-5,418,773.85**
31317108	-59085886	59085886	-66980000	-2262584		**-22,777,767.46**
44224302	118270060	44116105	194751886	5225509		**1,742,753,339.79**
17502334	16735112	15477559	16253414	5225509		**296,543,741.57**
59123931	59300389	55604563	57493529	11217611		**1,007,912,725.01**
900476.07	733387.44	859889.85	774697.36	173542.6		**14,044,814.70**
3301745.6	2689087.3	3152929.5	2840557	636322.9		**51,497,653.90**
52825711	43021732	50445377	45445970	10176802		**823,898,668.38**
2904109.6	2757458.4	2479452.1	2551235.8	0		**45,480,813.78**
10164384	9651104.3	8678082.2	8929325.5	0		**159,182,848.23**
27895577	22718408	26638598	23998571	5374045		**435,074,671.81**
0	3151239.4	207101.85	1767663.3	2247374		**38,753,159.65**
0	1401376.4	91331.098	760597.5	884540.6		**16,805,925.08**
0	0	1272125	624878.95	1318865		**13,170,648.46**
0	463424.02	1662075.7	1071706.4	1744069		**18,246,370.82**
2571473.6	2156155.8	2521543.1	3319948.8	939822.5		**48,795,030.27**
177189742	164778874	169090627	165832095	39938504		**2,969,407,071.66**
217203476	230302578	265636842	293603980	40627361		**4,683,963,870.15**
TOTAL WATER AVAILABLE (SCENARIO 1)						**4,683,963,870.15**

Analysis on water available under scenario 2: (cubic meter)

	2011	2012	2013	2014	2015	2016	2017
Difference in Storage (Nooidegacht)	29863540	-20675057	23498339	-41891237	0	0	0
Difference in Storage (Vygeboom)	39070106	0	0	-51146751	51146751	-57874512	13110911
Outflow to Downstream (Vygeboom)	26645989	393107155	258906741	198002830	70111355	157103727	12371944
Supply delivered:							
EFR	20858677	22704136	19638156	17404677	14904505	14221425	12371944
Interbasin transfer	74936727	75905456	64555151	62527914	52287309	51091784	37960607
Nooitgedacht irrigation	994673.34	1095118	956885.91	966951.58	777811.87	717901.47	549739.86
Nooitgedacht mining	3647135.6	4015432.7	3508581.7	3545489.1	2851976.9	2632305.4	2015712.8
Nooitgedacht strategic	58350505	64243958	56134389	56726355	45628664	42113921	32247716
Vygeboom mining	3315068.5	3751288.1	2952195.7	2904109.6	2313292.2	2479452.1	1681611.8
Vygeboom strategic	11602740	13129508	10332685	10164384	8096522.6	8678082.2	5885641.3
Within catchment transfer 1	30813045	33925190	29642785	29955383	24095046	22239022	17028993
X11D	6805530.4	77118.87	1225398.4	585896.5	323715.11	3629219.6	614395.02
X11E	2929000.6	33516.784	534072.49	255947.21	140304.61	1594431.3	790909.09
X11F	2725744.3	30949.703	58142.039	267776	130217.58	157059.25	809917.54
X11H	3525535.1	175197.34	81981.411	375353.61	2083421.8	207498.32	1105890.4
All Others	6452545.6	3164435.9	2806506.2	3052750.3	2377621.1	2249216.2	1958462.9
Sum	226956927	222251306	192426930	188732987	156010409	152011317	115021541
Monthly Water Available (Scenario 2)	322536561	594683404	474832010	293697829	277268514	251240533	140504395

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2018	2019	2020	2021	2022	2023	2024	2025
3637639.3	-3637639	0	50052410	-38695359	-6384014	-4605191	59229064
-10877206	-10436778	-902414.6	49799620	-34741011	12923661	-26400775	57714421
167930659	63526527	12008523	34820194	262765326	163229310	107584201	159143511
15912064	16235540	12008523	9941432.8	19854416	18089574	14264246	18069759
57165563	58327680	37728769	32042819	66378613	61586107	51245624	64413757
836948.46	850044.54	459302.48	439651.07	984623.22	845655.52	792508.25	996139.17
3068811	3116830	1684109.1	1612053.9	3610285.1	3100736.9	2905863.6	3652510.3
49098758	49866362	26942057	25787004	57761621	49608849	46490876	58437223
2904109.6	2904109.6	1773131.8	1232876.7	3109962.5	2944340	2068493.2	2904109.6
10164384	10164384	6205961.2	4315068.5	10884869	10305190	7239726	10164384
25927492	26332839	14227243	13617296	30502074	26196855	24550352	30858838
249978.42	155795.32	1233019.1	2380448.3	737428.01	208568.48	2123002.7	1176369.9
105193.37	67659.496	537333.69	1034154.9	323855.85	89606.343	921304.55	517083.56
93125.746	1480657.7	555060.09	1061370.1	315859.14	103264.46	482758.81	1270355
218661.77	1906016.5	751471.49	1251641	437530.6	140299.52	657114	2051387.9
2498534.2	2519716.3	1533268.8	2013661	3046945	2586911.7	2734680.4	3482970.7
168243623	173927634	105639249	96729477	197948083	175805957	156476550	197994888
328934715	223379743	116745358	231401700	387277039	345574915	233054785	474081884

Contd..

2026	2027	2028	2029	2030	Sum	
-51935518	10762024	-18423416	0	-1960808		**-11,165,223.53**
7684084.3	-48649631	48649631	-66980000	-1950905		**-29,860,799.46**
91197009	152772191	52779856	263890100	7628676		**2,655,525,823.80**
19448841	18103824	16469567	17529145	7628676		**325,659,125.82**
63899764	65039664	59053863	60799763	22233722		**1,119,180,656.98**
979575.81	878550.79	913229.13	881763.24	255185.6		**16,172,259.29**
3591778	3221352.9	3348506.8	3233131.9	935680.4		**59,298,284.05**
57466254	51538705	53574638	51727916	14966523		**948,712,294.97**
2939136.8	2904109.6	2904109.6	2904109.6	445496		**51,335,112.49**
10286979	10164384	10164384	10164384	1559236		**179,672,893.70**
30346100	27215950	28291062	27315867	7903345		**500,984,776.67**
63812.353	1216591.2	571595.2	2395400.9	1644388		**27,417,671.43**
27254.381	1415236.8	242473.29	1027284.8	704103.3		**13,290,726.40**
25562.968	0	535648.47	961480.89	701676.5		**11,766,626.35**
34479.388	0	728097.42	1481509.6	793021.4		**18,006,108.60**
2835296	2535052.8	2829484.1	3889185.2	1488898		**56,056,142.18**
191944832	184233421	179626658	184310940	61259951		**3,327,552,678.92**
238890407	299118005	262632729	381221040	64976913		**5,942,052,479.73**
TOTAL WATER AVAILABLE (SCENARIO 2)						**5,942,052,479.73**

Analysis on water available under scenario 3: (cubic meter)

	2011	2012	2013	2014	2015	2016	2017
Difference in Storage (Nooidegacht)	3806183.3	-3806183	2147952.7	-2147953	0	0	0
Difference in Storage (Vygeboom)	54541011	0	-18696204	-48283796	66980000	-66980000	0
Outflow to Downstream (Vygeboom)	17528544	212508873	97178436	77198085	41005325	85575449	9242916.9
EFR	17528544	16540526	15315699	14033263	11577241	13389041	9242916.9
Interbasin transfer	57758047	55790694	50282795	50415798	40058563	41364932	23695972
Nooitgedacht mining	2273966.3	2884896.6	2800111.5	2730876.9	1111295.7	967727.46	901827.19
Nooitgedacht strategic	36377554	46153910	44798819	43691089	17776367	15479276	14424871
Vygeboom mining	2598676.2	2664126	2068493.2	2479452.1	1986901.3	2069388.1	948892.43
Vygeboom strategic	9095366.7	9324441.2	7239726	8678082.2	6954154.7	7242858.3	3321123.5
Within catchment transfer 1	19209829	24372411	23656831	23071874	9387133.6	8174112.9	7617315.5
X11D	6617623.2	278099.41	2967759.9	2814063.3	636100.21	1866402.4	482987.94
X11E	2846326.4	120334.81	1297306.7	1224413.8	276359.65	814427.9	1461291.9
X11F	2683999.8	0	169705.5	1193223.5	292364.47	1182432.6	204488.61
X11G	3528928.1	0	0	27028.608	372402.85	0	108960.36
X11H	3476258.2	0	238475.11	2024844.4	410064.97	1997482.2	1906486.9
All Others	2532487.8	3065749.5	2948708.5	2853505.7	1318451.9	1215798.4	1060842.2
Sum	166527606	161195189	153784431	155237514	92157399	95763879	65377977
Monthly Water Available (Scenario 3)	242403345	369897879	234414615	182003851	200142725	114359328	74620894

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2018	2019	2020	2021	2022	2023	2024	2025
0	0	0	0	0	0	0	4090122.9
0	0	0	21136343	-18878904	4797494.8	-7054934	21343329
58098984	13512618	8348773.9	14719057	107361717	89128195	52345075	21577144
13389041	13062607	8348773.9	5673545.2	14739787	13536749	11433363	11954713
45896754	45853135	24135312	12720819	52185236	48632025	39492889	42948412
1575468.9	2034646.2	638883.19	526022.83	2908017.2	1707746.1	1374061.7	2223489.1
25203886	32552145	10217767	8411977.3	46524587	27319478	21980551	35573631
2309213.4	1956953.9	1073572.8	424657.53	2479452.1	2493150.7	1937047.8	2054794.5
8082246.9	6849338.8	3757504.9	1486301.4	8678082.2	8726027.4	6779667.4	7191780.8
13309370	17189752	5395677.7	4442097.5	24568154	14426547	11607230	18785303
2340457.1	2571427.6	1120174.1	2541296	875909.92	2569710.8	504803.43	1404939.2
984530.04	1098080.7	482443.75	1099928.6	454682.64	1125401	217761.95	612813.59
1230638.9	1126872.9	515292.03	1352860.2	0	1389954.5	204870.52	2333932.6
0	1664788.5	47718.055	150412.61	0	0	262316.66	2109725.4
1805593.4	1792931.5	660681.84	841514.11	122203.62	1808740	278351.72	2941950.7
1776586.1	2184851.8	799657.54	612176.14	3040463.2	1908786.6	1554199.8	2343098.4
117903786	129937531	57193459	40283608	156576575	125644316	97627114	132478583
176002770	143450148	65542233	76139009	245059389	219570006	142917255	179489179

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2026	2027	2028	2029	2030	**Sum**	
-4090123	0	0	0	-2834097		**-2,834,097.48**
45636671	-66377566	66377566	-66980000	-2819784		**-15,258,773.28**
32858347	86609122	32894959	143216007	1064022		**1,201,971,652.19**
15715622	16162587	13389041	12517634	1064022		**248,614,715.55**
52219899	48241101	48101370	42162194	3284777		**825,240,725.29**
2183470.9	1539515.3	2146459.4	1687192.9	186432.6		**34,402,107.98**
34931918	24626339	34341132	26991398	2980004		**550,356,697.55**
2643619.8	2240309.1	2479452.1	2068493.2	0		**38,976,646.15**
9252669.1	7841081.8	8678082.2	7239726	0		**136,418,261.51**
18446434	13004386	18134459	14253298	1573645		**290,625,860.63**
50472.013	3591919.3	0	1013697.4	1676340		**35,924,183.01**
21736.701	1584717.2	0	435819.22	717430.4		**16,875,806.86**
0	1174733.5	0	436141.69	730832.1		**16,222,343.38**
0	0	0	762011.37	618278.9		**9,652,571.36**
0	1878009.8	0	826425.56	945472.9		**23,955,486.87**
2405073.9	1794071.8	2311973.7	1826996.5	196641.9		**37,750,121.56**
137870916	123678770	129581969	112221027	13973876		**2,265,015,527.70**
212275811	143910326	228854495	188457034	9384017		**3,448,894,309.13**
TOTAL WATER AVAILABLE (SCENARIO 3)						**3,448,894,309.13**

Total Water Available (Base Case)	5,241,311,346.65
Total Water Available (Scenario 1)	4,683,963,870.15
Total Water Available (Scenario 2)	5,942,052,479.73
Total Water Available (Scenario 3)	3,448,894,309.13

Amount of Water Changes					
Scenario 1 - Base Case		Scenario 2 - Base Case		Scenario 3- Base Case	
Mm^3	%	Mm^3	%	Mm^3	%
-557.35	-10.63	700.74	13.37	-1792.42	-34.20