

Floodline Determination

Olifants Management Model Programme Bulk Raw Water Study Phase

Sub-Phase 2F

Lebalelo Water User Association (LWUA)

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Abbreviations:

Acronym	Description
2D	Two-Dimensional
ARI	Annual Recurrence Interval
DEA	Department of Environmental Affairs
CDNGI	Chief Directorate: National Geo-spatial Information
CN	Curve Number
DEM	Digital Elevation Model
DWS	Department of Water and Sanitation
GIS	Geographic Information System
HEC-HMS	Hydrological Engineering Centre of the U.S. Army Corps of Engineers' Hydrologic Modelling System
HEC-RAS	Hydrological Engineering Centre of the U.S. Army Corps of Engineers' River Analysis System
LiDAR	Light Detection and Ranging
LWUA	Lebalelo Water User Association
masl	Meters Above Sea Level
NWA	National Water Act, 1998 (Act No. 36 of 1998)
OMMP–BRWSP	Olifants Management Model Programme Bulk Raw Water Study Phase
ORWRDP-2	Olifants River Water Resources Development Project – Phase 2
RI	Recurrence Interval
SANLC	South African Land Cover
SCS-SA	Soil Conservation Service method for South Africa
TCTA	Trans-Caledon Tunnel Authority
UHM	Unit Hydrograph Method
WUL	Water Use Licence
WULA	Water Use Licence Application
WTW	Water Treatment Works
ZNJV	Zutari Ndodana Joint Venture

Definitions

Term	Definition
Infiltration	Transfer of water from the surface to the sub surface location, the rate of infiltration depends on soil and land use characteristics
Catchment	Area contributing to run-off at certain point via surface and sub-surface flow.
Flow path	Location where enough water has accumulated in the catchment area to form a concentrated stream
Run-off	Measurement of the amount of water that is produced from a specific catchment area.
Hydrology	Hydrology is the study of precipitation and water, especially its movement, in relation to the land. It represents the amount of water (run-off) that comes from a catchment. It deals with the circulation of water through the hydrological cycle and the quantification of run-off caused by rainfall. In land development, hydrology usually refers to the rate of precipitation, the volume of water, the velocity of surface run-off and the time of arrival at a particular point (the project site)
Hydraulics	Hydraulics is the science of transporting water through pipes and channels (streams, rivers, lakes, etc.). In land development, hydraulic analysis is used after the hydrological reporting process to design stormwater drainage networks or to assess the flow characteristics of natural channels.
Regulated area of Watercourse	With reference to National Water Act (NWA) of 1998, section 21 (c) and (i), this term means: (a) The outer edge of the 1 in 100-year floodline and /or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam. (b) In the absence of a determined 1 in 100-year floodline or riparian area the area within 100 m from the edge of a watercourse where the edge of the watercourse is the first, identifiable annual bank fill flood bench (subject to compliance to section 144 of the Act); or

1 INTRODUCTION

1.1 Background

The Zutari Ndodana Joint Venture (ZNJV) was previously appointed by the Trans-Caledon Tunnel Authority (TCTA), on behalf of the Department of Water and Sanitation (DWS) for the provision of professional services for the Olifants River Water Resources Development Project – Phase 2 (ORWRDP-2).

The ORWRDP-2 has since been reconstituted to become the Olifants Management Model Programme Bulk Raw Water Study Phase (OMMP–BRWSP) in recent years, with the Lebalelo Water User Association (LWUA) acting as the implementing agent. One of the projects within this appointment is Phase 2F, that comprises a 60 km of pipeline intended to convey water to the Olifantspoort Water Treatment Works (WTW), thereby augmenting the water supply to Polokwane and surrounding rural areas.

The pipeline route is situated within the Olifant Water Management Area, within quaternary region B71E (Matadi, Moopetsi, Motse Catchment group), B52E (Monametsi Catchment Group), B52G (Olifants Catchment Group) and B52E (Pelangwe Catchment group). The Catchment and the locality of the scope elements can be seen in Figure 1-1:

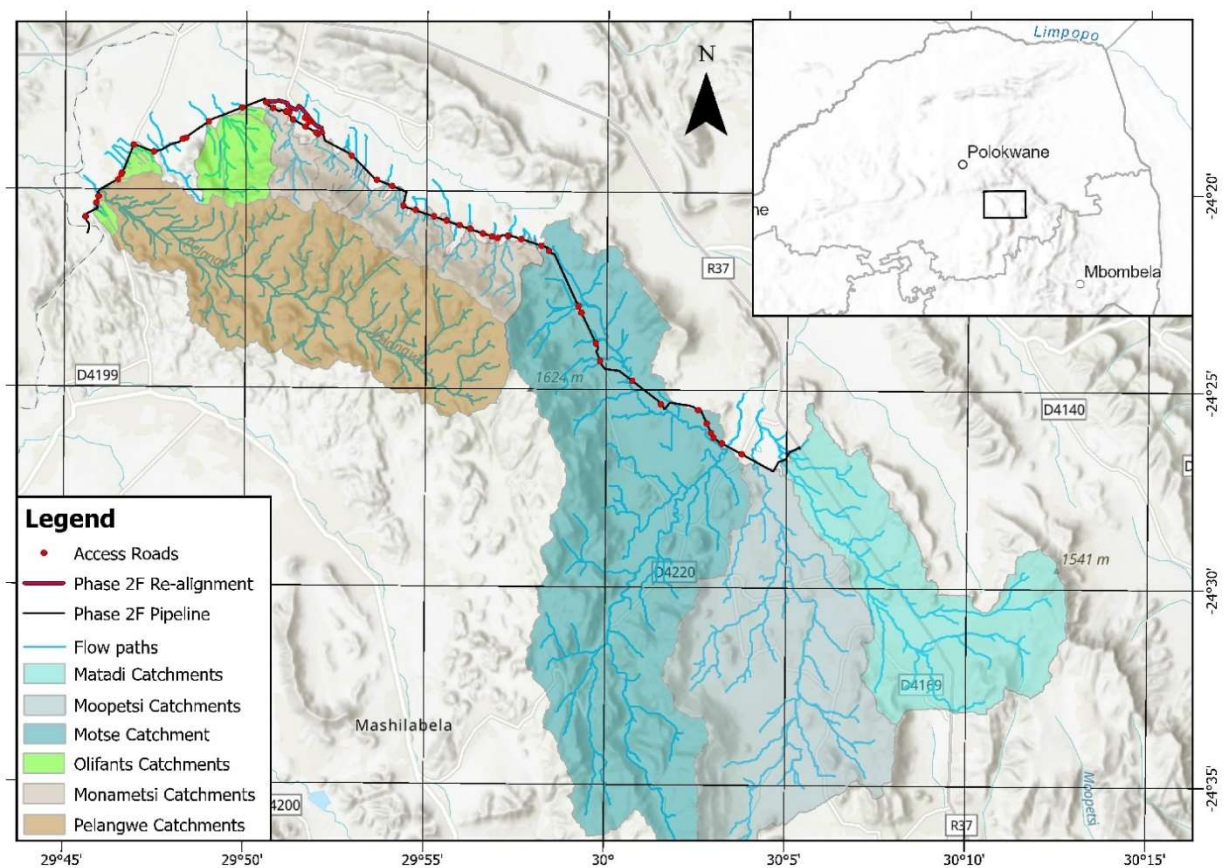


Figure 1-1: Locality Map

The pipeline routes designed for the Olifants River Water Resources Development Project cross various perennial and non-perennial streams. The extent of these crossings requires Water Use Licences (WUL) in accordance with the National Water Act, 1998 (Act No.36 of 1998).

The required floodline studies were completed in 2016 and submitted to the DWS as part of the Water Use Licence Application (WULA). An overview of the information contained in the relevant studies can be found below:

Table 1-1: Existing hydrology and floodline studies

Phase	Date completed	Consultant	Summary of Crossings	Reference Documents
2B	April 2016	Aurecon Ndodana Joint Venture	2 River crossings 11 Dry crossings	112007-2B-00-RP-CC-0001
2B+	December 2016	Aurecon	6 River crossings*	111605 - Design Report: Floodlines for six crossings along the proposed pipeline
2D	June 2016	Aurecon Ndodana Joint Venture	1 River crossing 13 Dry crossings	112007-2D-00-RP-CC-0001 112007-2D-00-RP-CC-0002
2EF	September 2016	Aurecon Ndodana Joint Venture Scour modelling by ASP	8 River Crossings 24 Dry Crossings	112007-EF-00-RP-CC-0001 112007-EF-00-RP-CC-0002

During the discussion regarding the submission of the WUL, it was indicated that specialist studies (including the hydrology and floodline studies) older than 5 years should be reviewed by a specialist to confirm that they are still valid, and that the final submission must include a confirmation of validity from the specialist.

The requirement to review floodlines after 5 years and recalculate floodlines after 10 years (Brooker, et al., 2023) speaks to the fact that a floodlines have an applicable design life that defines the suitability of the floodline to be used for authorization purposes.

The design life and suitability of a floodline is influenced by the following factors:

1. Changes in catchment characteristics (Development, land-use changes etc.)
2. Changes in the nature of the watercourse (Thalweg location, riparian conditions, etc.)
3. Availability of applicable data (Topographical information, rainfall data, etc.)
4. Refinement of analysis tool (Hydraulic and hydrological)

Zutari, as the Professional Services Provider in 2016 was requested to review the reports listed in Table 1-1 and evaluate the applicability of the generated floodlines for re-certification. After reviewing the applicable documentation, Zutari recommended that the historical floodlines be recalculated and submitted in support of the WUL. The findings of the review are documented in a technical memorandum (1002569-00-00-ME-YY-00001).

The purpose of this report is to provide feedback on the updated floodline analysis for the Phase 2F pipeline Olifants River Water Resources Development Project.

1.2 Floodline certification

A certified floodline is required by the National Water Act (NWA) as a basis for new development. The floodline should be certified by professionals and based on the best available information and practise.

This study has been prepared based on the best available information and practise as described in Section 1.3 and are certified by a specialist according to the specialist declaration attached in Appendix E.

1.3 Methodology

The process of determining floodlines can generally be divided into three main stages: Catchment delineation (determining the number of crossings), Hydrology (determining the design flood peak and the flow distribution) and Hydraulics (routing the flow through the terrain and any obstructions to determine the floodlines). The methods, software and data sources used for each of the 3 main components are summarised in Table 1-2 and Table 1-3 below.

Table 1-2: Methodology software and basis

Design Item	Method	Software	Basis for attributes
Catchment delineation	Auto delineation	ArcGIS Pro	Digital Elevation Model (DEM)
Hydrology	Rational Method Alternative 3	Spreadsheet	Rainfall information, DEM, Landcover database, Soil type database
	Soil Conservation Service for South Africa (SCS-SA) Method	Hydrological Engineering Centre of the U.S. Army Corps of Engineers' Hydrologic Modelling System (HEC-HMS), Spreadsheet.	
	Unit Hydrograph Method (UHM)	Spreadsheet	DEM
Hydraulics	Two-dimensional (2D) floodline modelling	United States Army Corps of Engineers Hydrologic Engineering Centre – River Analysis System (HEC-RAS)	DEM, Landcover database, Hydraulic structures

Table 1-3: Base information extent of use and reference

Base info	Extent of information used	Reference
DEM	The extent of the pipeline has been surveyed with Light Detection and Ranging (LiDAR) dated 2016. Beyond site boundaries the DEM information was substituted with information from sourced from Chief Directorate: National Geo-spatial Information (CDNGI).	(Department: Agriculture, Land Reform and Rural Development, 2024)
Pipeline design criteria	Pipeline alignment and applicable attributes based on the OMMP-BRWSP Phase 2D, 2H and 2F Design Report	Report 1002569-00-00-RP-ZZ-00005
Rainfall information	The Design Rainfall Software was exclusively used.	(Smithers & Schulze, 2002)
Landcover database	The landcover database was used as basis and adjusted manually with information from site visits, arial imagery and web imagery.	(Geoterralmage Pty Ltd (GTI) for the Department of Environmental Affairs (DEA), 2016)
Soil type database	The soil type database was used exclusively.	(Schulze, 2012)
Hydraulic structures	Based on site measurements and assumptions were area not accessible.	

2 CATCHMENT DELINEATION

Where flow paths that were determined by flow accumulation crosses the proposed pipeline route and upstream catchment was delineated, using ArcGIS and the DEM. The catchments were grouped into the North and South catchments (based on the direction of the larger drainage basin) and are shown in Figure 2-1:

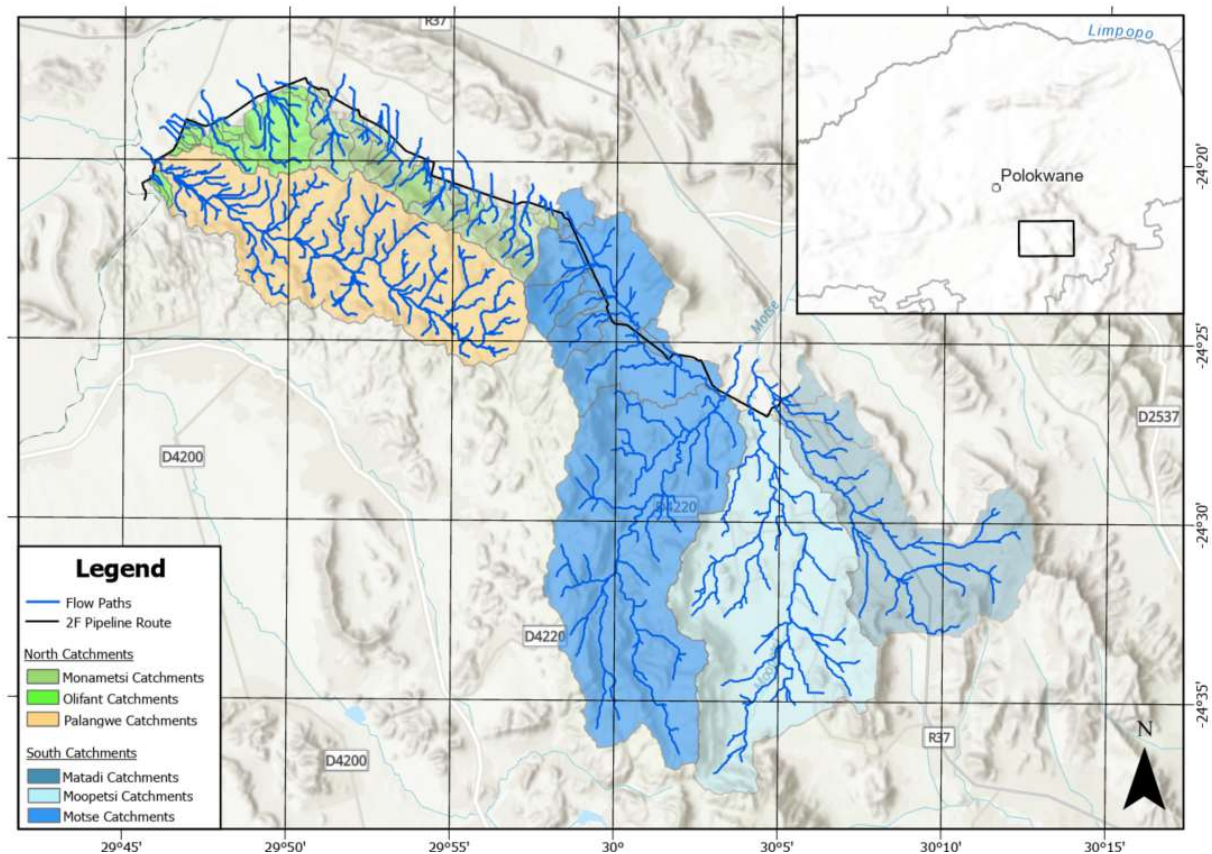


Figure 2-1: Catchment delineation

A total of 57 catchments were delineated for the Phase 2F pipeline, 41 form part of the North catchments and 16 form part of the South catchments. The crossing locations for the Northern and Southern areas can be seen in Figure 2-2 and Figure 2-3 respectively.

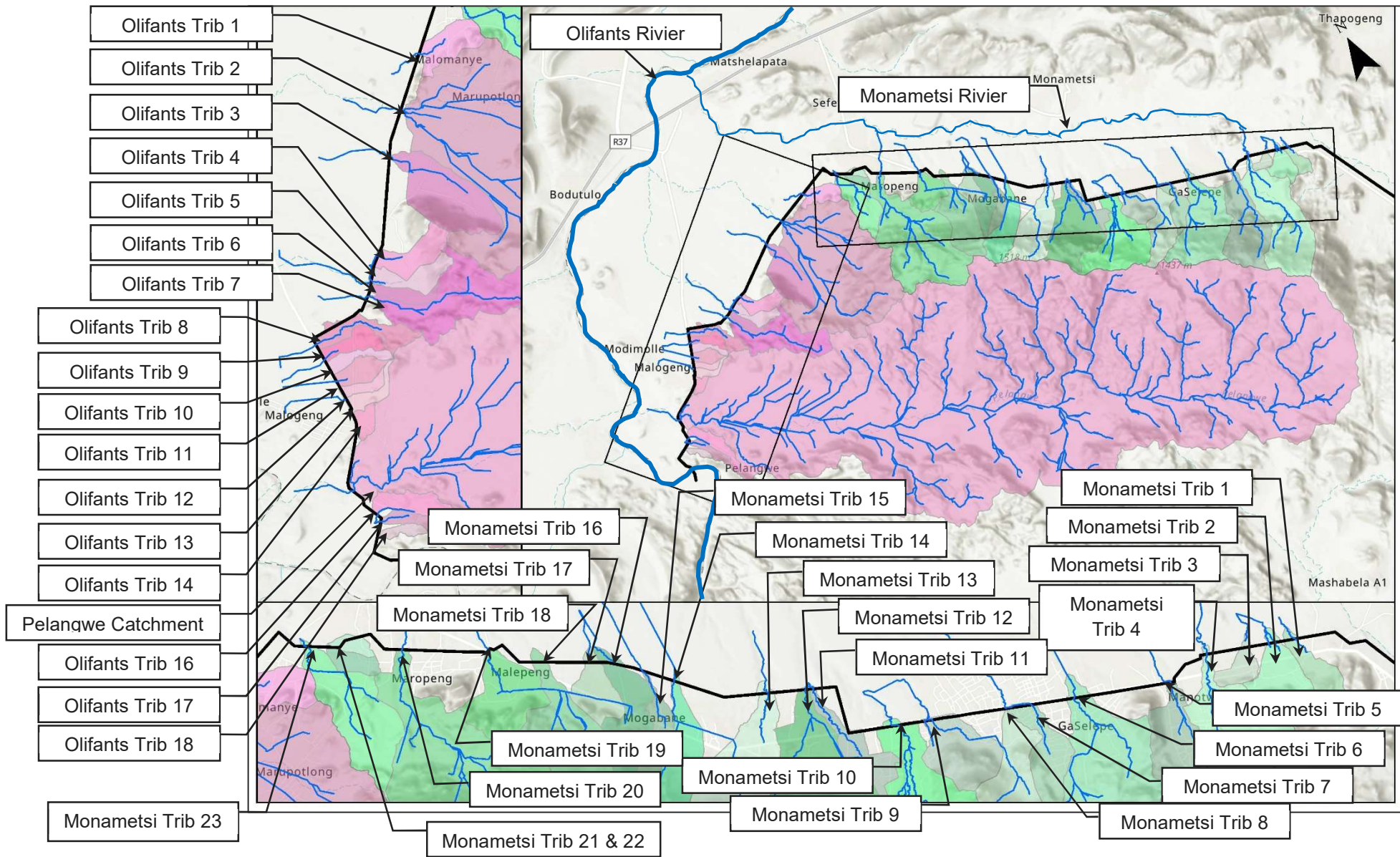


Figure 2-2: Northern Sub-catchments

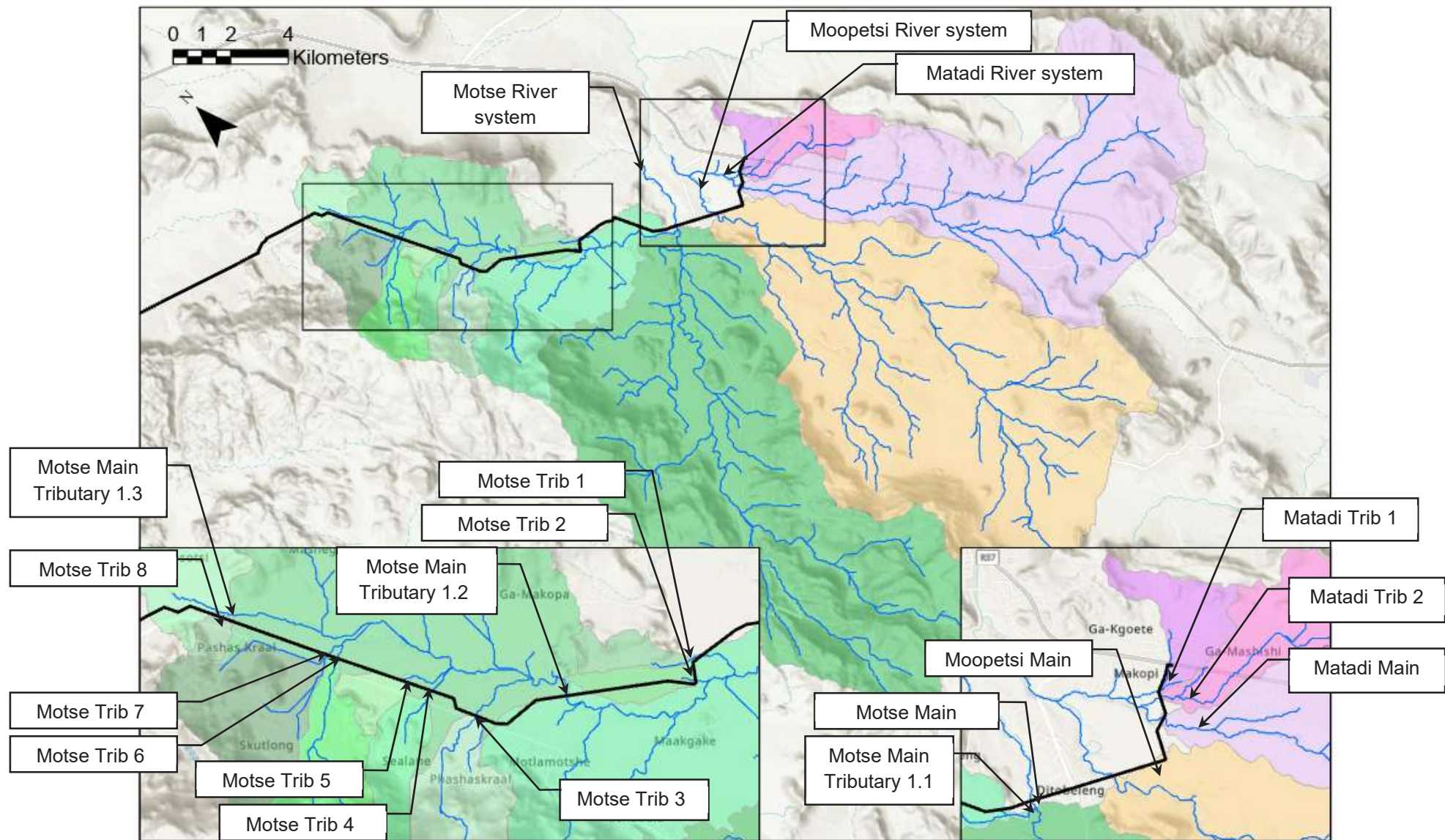


Figure 2-3: Southern Sub-catchments

3 FLOOD HYDROLOGY

As described in Section 1.3, flood hydrology is one of the main components of a floodline analysis. Various flood estimation methods are available, each with their own unique set of inputs and limitations. The main flood estimation methods used for this analysis were:

- ▶ SCS-SA method
- ▶ Rational method alternative 3
- ▶ UHM

Table 3-1 provides a summary of the main inputs as well as applicable catchment size for each flood estimation method according to the SANRAL Drainage Manual (SANRAL, 2013):

Table 3-1: Applicable flood estimation methods

Flood estimation method	Input Information	Maximum Catchment Size (km ²)
Rational method alternative 3	Catchment area, watercourse length, average slope, catchment characteristics, design rainfall depth	<15
SCS-SA method	Design rainfall depth, catchment area, Curve Number, catchment lag	<30
UHM	Design rainfall depth, catchment area, watercourse length, length catchment centroid, mean annual rainfall, veld type and synthetic regional unit hydrograph	15 to 5000

For this analysis, the SCS-SA method was applied to catchments smaller than 30 km², while the UHM method was used for larger catchments. In cases where multiple methods were applicable, one was selected as a comparison tool to validate the results.

3.1 Rainfall Analysis

The rainfall data for the catchment area was extracted using the Design Rainfall Estimation Tool for South Africa (Smithers & Schulze, 2002). The software contains rainfall data for a 1'x1' latitude and longitude grid over South Africa. The information per grid point is calculated from the 6 nearest rainfall stations.

The user specifies the coordinates for the centre of the catchment and the software provides the information for the nearest grid point. Based on the location of the catchments, the six closest rainfall stations are shown in Figure 3-1:

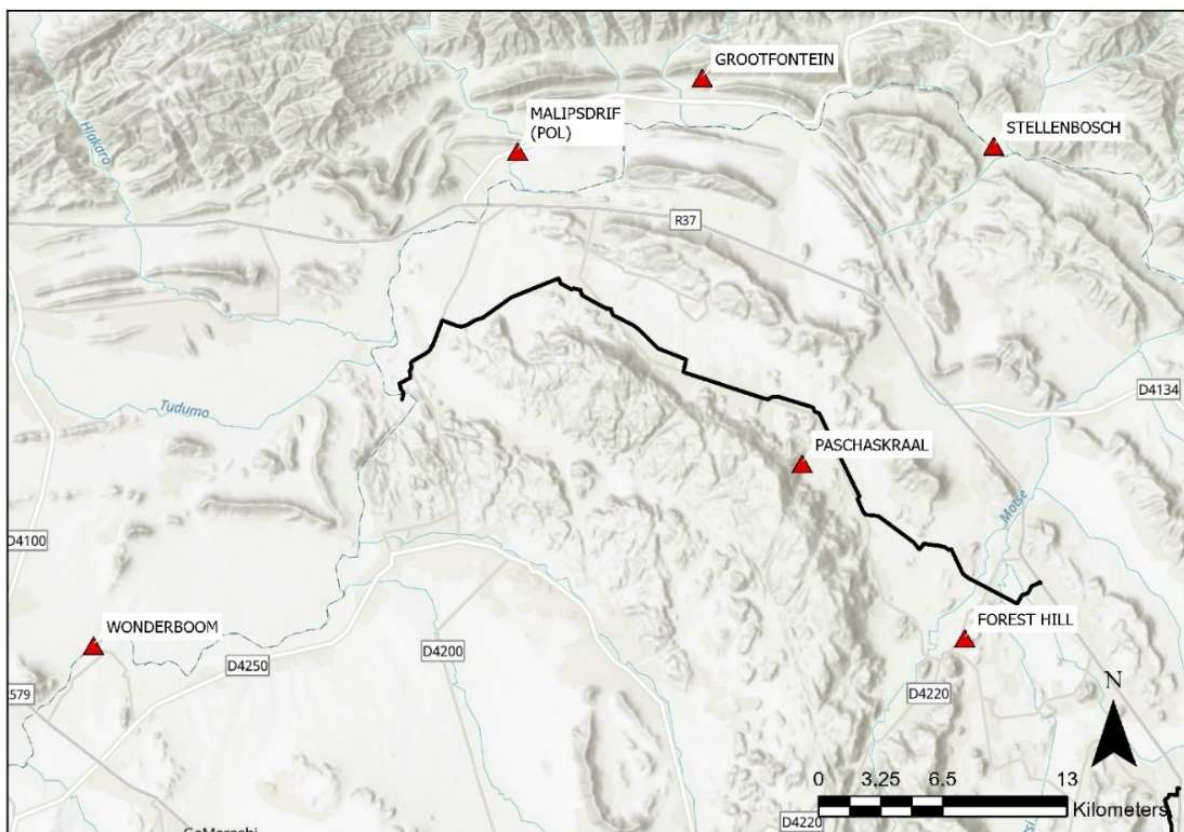


Figure 3-1: Rainfall station close to the site

The gridded rainfall data was developed for both the Northern and Southern catchments and a summary of the information for both areas are shown in Table 3-2 and Table 3-3:

Table 3-2: North Catchments - Point rainfall results

Duration	Rainfall depth per Return Period (years)						
	2	5	10	20	50	100	200
2 hours	40	54	65	76	91	103	116
12 hours	56	77	91	107	128	145	163
24 hours	64	87	104	121	146	165	185
1 day	53	73	87	101	122	138	155

Table 3-3: South Catchments - Point rainfall results

Duration	Rainfall depth per Return Period (years)						
	2	5	10	20	50	100	200
2 hours	39	53	64	74	89	101	114
12 hours	55	75	90	105	127	144	162
24 hours	63	86	103	121	145	165	185
1 day	52	72	86	101	121	137	154

3.2 Catchment characteristics

A total of 57 catchments were analysed to determine the run-off values with sizes ranging between 0.12 km² and 130 km². The characteristics of the individual catchments were taken from the sources discussed in Section 1.3 and are explained in detail in this section.

The topographic characteristics of each catchment, e.g. the distribution of slopes within the catchment, the longest watercourse and the longest watercourse slope were calculated from a combined DEM. The DEM was created by combining the detail Lidar survey of the pipeline reserve and the information available from the CDNGI Geospatial portal (Department: Agriculture, Land Reform and Rural Development, 2024). It should be noted that there are areas where catchments have been identified but the pipeline deviates from the lidar survey and therefor the surface at the crossing consist of opensource information.

The landcover types within the catchment were extracted from the National Landcover Database 2022 (Geoterralmage Pty Ltd (GTI) for the Department of Environmental Affairs (DEA), 2016).

The soil types within the catchment were obtained from the dataset “Hydrological soil groups over South Africa at terrain unit resolution” (Schulze, 2012). For the purpose of the calculation the soil classes are simplified into only A, B, C, D, sub-categories will be grouped together with the area with more stormflow potential (i.e. B/C will be combined with an area with higher stormflow potential (i.e. C).

3.2.1 Rational method alternative 3

The catchment response is accounted for in the Rational method alternative 3 by means of the run-off coefficient (C_1), this is a subjective variable and is determined using strict guidelines and engineering judgement. These coefficients are mainly split into Rural and Urban coefficients with the Rural coefficients further divided into surface slope (C_s), Permeability (C_p) and Vegetation (C_v) coefficients.

The DEM was used to calculate the percentage of the surface within a catchment which falls within the different slope categories required to calculate the surface slope run-off coefficient (C_s).

The landcover data was used to determine the percentages of different vegetation cover (C_v) as well as the composition of urban landscapes within the catchments (C_2).

The soil data was used to determine the percentage of each hydrological soil group within every catchment. The soil groups were then assigned to the permeability categories in the Rational method and then used to determine the permeability run-off coefficient (C_p). The permeability categories and assigned hydrological soil groups are shown below:

Rational permeability categories:

- ▶ Very Permeable
- ▶ Permeable
- ▶ Semi-Permeable
- ▶ Impermeable

Hydrological Soil Group:

SCS type A soil
SCS type B soil
SCS type C soil
SCS type D soil

3.2.2 SCS-SA method

The SCS-SA method utilizes a 24-hour hyetograph which applied to the catchment to determine the run-off. Figure 3-2 below was used to determine type of hyetograph to be used.

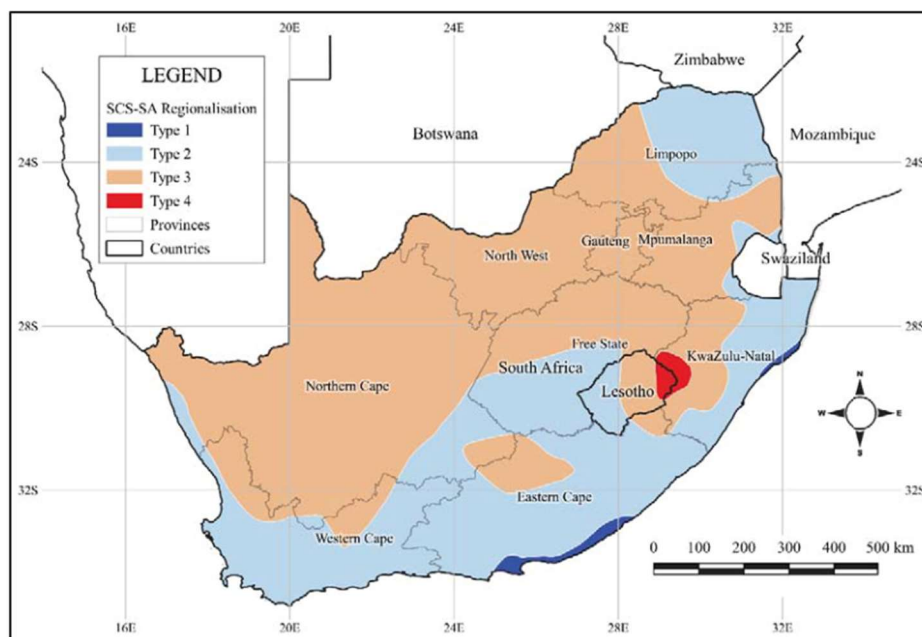


Figure 3-2: SCS-SA – Storm type regions

The Rainfall is simulated by a 24-hour SCS type 2 Hyetograph (as determined using Figure 3-2), using the total 24-hour rainfall depth of 165 mm.

The SCS-SA method relies on a Curve Number (CN) value for the calculations. The CN value is an index that expresses the stormflow reaction of a catchment to a rainfall event. The CN number is calculated taking into account the hydrological properties of the soil and the characteristics of the land cover. The CN number can be further adjusted to the assumed antecedent soil moisture. A higher CN value means that more run-off would be generated by a given rainfall event.

The calculated curve numbers for the Northern and Southern catchments are shown below:

Table 3-4: Northern Catchments – Olifants Curve Numbers

Catchment name	Curve Number
Olifants Tributary 1	83.5
Olifants Tributary 2	83.1
Olifants Tributary 3	85.2
Olifants Tributary 4	77.5
Olifants Tributary 5	82.3
Olifants Tributary 6	86.3
Olifants Tributary 7	81.4
Olifants Tributary 8	80.3
Olifants Tributary 9	80.3
Olifants Tributary 10	84.3
Olifants Tributary 11	83.7
Olifants Tributary 12	82.2
Olifants Tributary 13	84.8
Olifants Tributary 14	84.7
Olifants Tributary 15	82.8
Olifants Tributary 16	81.0
Olifants Tributary 17	80.2
Olifants Tributary 18	65.7

Table 3-5: Northern Catchments – Monametsi Curve Numbers

Catchment name	Curve Number
Monametsi Tributary 1	70.5
Monametsi Tributary 2	79.9
Monametsi Tributary 3	61.8
Monametsi Tributary 4	78.2
Monametsi Tributary 5	83.2
Monametsi Tributary 6	82.4
Monametsi Tributary 7	79.0
Monametsi Tributary 8	82.3
Monametsi Tributary 9	80.5
Monametsi Tributary 10	81.9
Monametsi Tributary 11	78.9
Monametsi Tributary 12	83.4
Monametsi Tributary 13	80.6
Monametsi Tributary 14	80.8
Monametsi Tributary 15	82.3
Monametsi Tributary 16	82.8
Monametsi Tributary 17	81.6
Monametsi Tributary 18	82.0
Monametsi Tributary 19	81.3
Monametsi Tributary 20	81.6
Monametsi Tributary 21	78.7
Monametsi Tributary 22	79.0
Monametsi Tributary 23	84.6

Table 3-6: Southern Catchments – Curve Numbers

Catchment name	Curve Number
Moopesti Main	87.0
Motse Main	84.5
Motse Main Tributary 1.1	85.1
Motse Main Tributary 1.2	86.06
Motse Main Tributary 1.3	84.66
Motse Tributary 1	85.72
Motse Tributary 2	80.08
Motse Tributary 3	85.46
Motse Tributary 4	82.54
Motse Tributary 5	86.30
Motse Tributary 6	89.16
Motse Tributary 7	82.13
Motse Tributary 8	82.76
Matadi Main	83.5
Matadi Tributary 1	82.68
Matadi Tributary 2	88.05

3.2.3 UHM

The unit hydrograph concept helps define the distinct physical characteristics of a catchment in the form of a hydrograph. Its size and duration are influenced by the intensity and length of rainfall. A unit hydrograph represents the run-off response of a specific catchment and is metrically defined as the hydrograph generated by one millimetre of run-off resulting from a uniform rainfall of a specific duration. The duration of the hydrograph corresponds to the rainfall duration, while its volume is directly related to the rainfall intensity.

The specific unit hydrograph to be used is dependent on the veld type of the catchment and using Figure 3-3 below the veld type was assumed to be region 8.

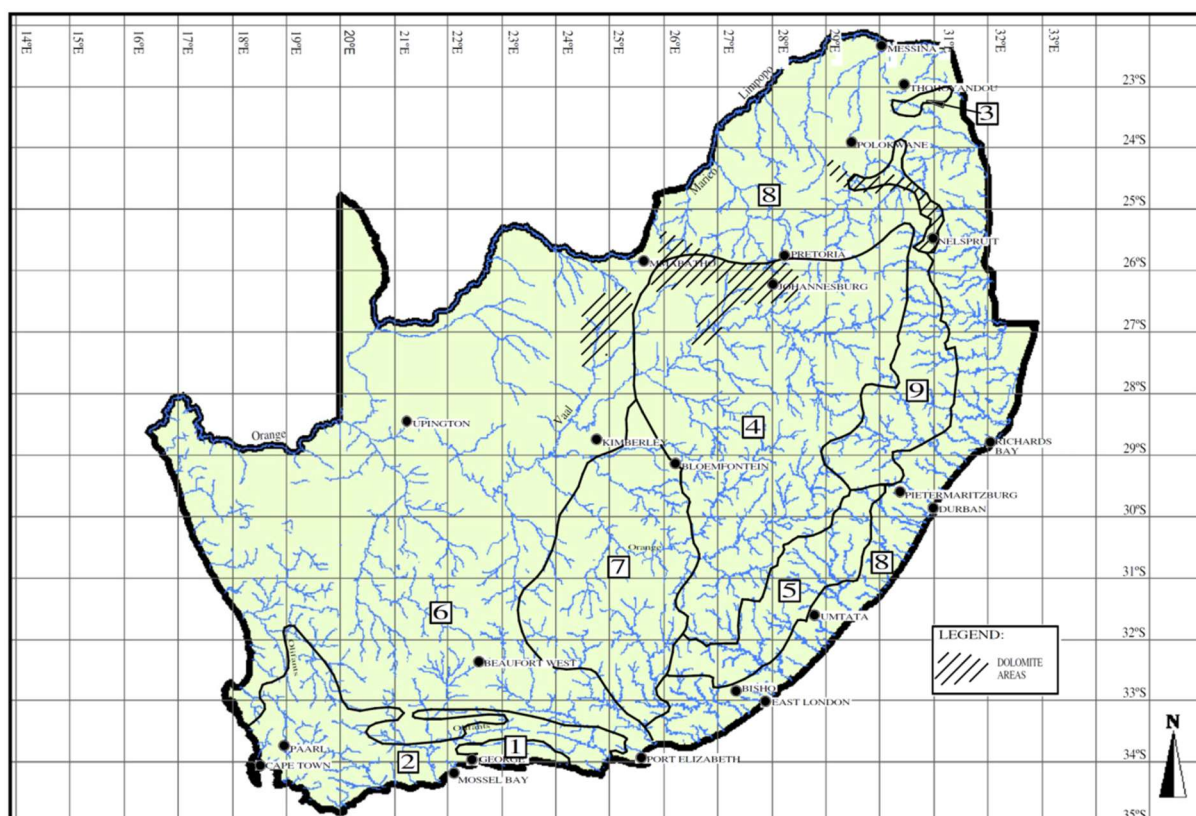


Figure 3-3: Regions with generalised veld types (SANRAL, 2013)

3.3 Design Flood Determination

The SCS-SA method was used within HEC-HMS Version 4.12 to determine the run-off hydrographs for each catchment. Both the UHM and Rational method were calculated using spreadsheets. Where applicable, the SCS-SA results were compared with the UHM and the Rational method. The UHM is only used for catchments larger than 15 km². The results can be seen in Table 3-7 to Table 3-9.

Table 3-7: Northern Catchments – Olifants flood peaks

Catchment name	Area (km ²)	1 in 100-year Peak flow (m ³ /s)		
		SCS-SA	Rational Alt 3	UHM
Olifants Tributary 1	0.60	13	9	-
Olifants Tributary 2	10.61	124	105	-
Olifants Tributary 3	1.66	31	16	-
Olifants Tributary 4	0.60	12	11	-
Olifants Tributary 5	0.49	11	7	-

Catchment name	Area (km ²)	1 in 100-year Peak flow (m ³ /s)		
		SCS-SA	Rational Alt 3	UHM
Olifants Tributary 6	0.27	6	3	-
Olifants Tributary 7	2.38	39	24	-
Olifants Tributary 8	0.58	11	8	-
Olifants Tributary 9	0.34	7	5	-
Olifants Tributary 10	0.22	5	5	-
Olifants Tributary 11	0.33	7	6	-
Olifants Tributary 12	0.17	4	2	-
Olifants Tributary 13	0.23	6	2	-
Olifants Tributary 14	0.17	4	3	-
Pelangwe Catchment	108.64	644	301	214
Olifants Tributary 16	0.62	12	6	-
Olifants Tributary 17	0.33	8	4	-
Olifants Tributary 18	0.15	3	3	-

Table 3-8: Northern Catchments – Monametsi flood peaks

Catchment name	Area (km ²)	1 in 100-year Peak flow (m ³ /s)		
		SCS-SA	Rational Alt 3	UHM
Monametsi Tributary 1	0.34	7	6	-
Monametsi Tributary 2	0.63	14	10	-
Monametsi Tributary 3	0.22	3	3	-
Monametsi Tributary 4	4.31	68	47	-
Monametsi Tributary 5	2.85	56	40	-
Monametsi Tributary 6	3.44	63	43	-
Monametsi Tributary 7	0.65	14	7	-
Monametsi Tributary 8	1.40	31	23	-
Monametsi Tributary 9	0.83	19	13	-
Monametsi Tributary 10	2.90	55	43	-
Monametsi Tributary 11	0.48	8	4	-
Monametsi Tributary 12	2.80	53	39	-
Monametsi Tributary 13	2.03	41	32	-
Monametsi Tributary 14	1.35	30	25	-
Monametsi Tributary 15	0.42	12	7	-
Monametsi Tributary 16	0.88	21	12	-
Monametsi Tributary 17	0.45	11	5	-
Monametsi Tributary 18	1.97	41	35	-
Monametsi Tributary 19	0.91	20	14	-
Monametsi Tributary 20	5.86	93	73	-
Monametsi Tributary 21	0.12	3	2	-
Monametsi Tributary 22	0.19	4	3	-
Monametsi Tributary 23	1.35	27	16	-

Table 3-9: Southern Catchments – Flood Peak

Catchment name	Area (km ²)	1 in 100-year Peak flow (m ³ /s)		
		SCS-SA	Rational Alt 3	UHM
Moopesti Main	123.34	725	270	216
Motse Main	129.18	755	380	328
Motse Main Tributary 1.1	63.32	437	206	147
Motse Main Tributary 1.2	40.78	315	292	203
Motse Main Tributary 1.3	3.20	44	34	-
Motse Tributary 1	1.00	18	12	-
Motse Tributary 2	0.99	13	8	-
Motse Tributary 3	4.96	71	79	-
Motse Tributary 4	2.02	37	30	-
Motse Tributary 5	0.80	16	9	-
Motse Tributary 6	5.60	77	80	-
Motse Tributary 7	5.34	72	83	-
Motse Tributary 8	0.45	10	9	-
Matadi Main	70.88	453	190	139
Matadi Tributary 1	2.31	33	29	-
Matadi Tributary 2	5.83	75	44	-

The design flood estimation was carried out using three methods: the SCS-SA, Rational, and UHM. For smaller catchments, the SCS-SA method was selected, while the UHM was applied to larger catchments. The Rational Method served as a verification tool to ensure the reliability of the results. It was determined that the flood peaks from the SCS-SA method would be used for catchments smaller than 15 km², whereas the UHM was applied to catchments larger than 30 km².

A key advantage of both the SCS-SA and UHM methods is that they generate a hydrograph as part of their outputs, which can be directly used in the hydraulic analysis. In cases where both methods were applicable, the most conservative assumption was adopted to ensure a robust and reliable flood estimation. The calculation sheets for the SCS-SA method, Rational method and the UHM are provided in Appendix A to Appendix C.

4 FLOOD HYDRAULICS

This section describes the configuration and modelling of the flood hydraulics. The flood hydraulics describes the flow of the water through the site taking any hydraulic structures into account.

A 2D hydraulic model was configured for the full site extent. The model also included the numerous culverts and bridges which were measured during the site investigation. HEC-RAS Version 6.6 was used to model the hydraulics for this area.

4.1 Main Site Model Configuration

The following data were used to configure and calibrate the HEC-RAS 2D hydraulic model:

- ▶ The topography, represented by a DEM, was generated from LiDAR data.
- ▶ Hydraulic structures measurements.
- ▶ Flood hydrographs (Section 3).
- ▶ Manning's roughness coefficients determined using recommendations from literature.
- ▶ Aerial photographs

Typically, LiDAR data are processed to remove vegetation and buildings so that a topographical model of the ground is generated. The LiDAR data covers the pipeline route with a buffer zone of approximately 300 m on each side. The DEM based on the Lidar survey can be seen in Figure 4-1.

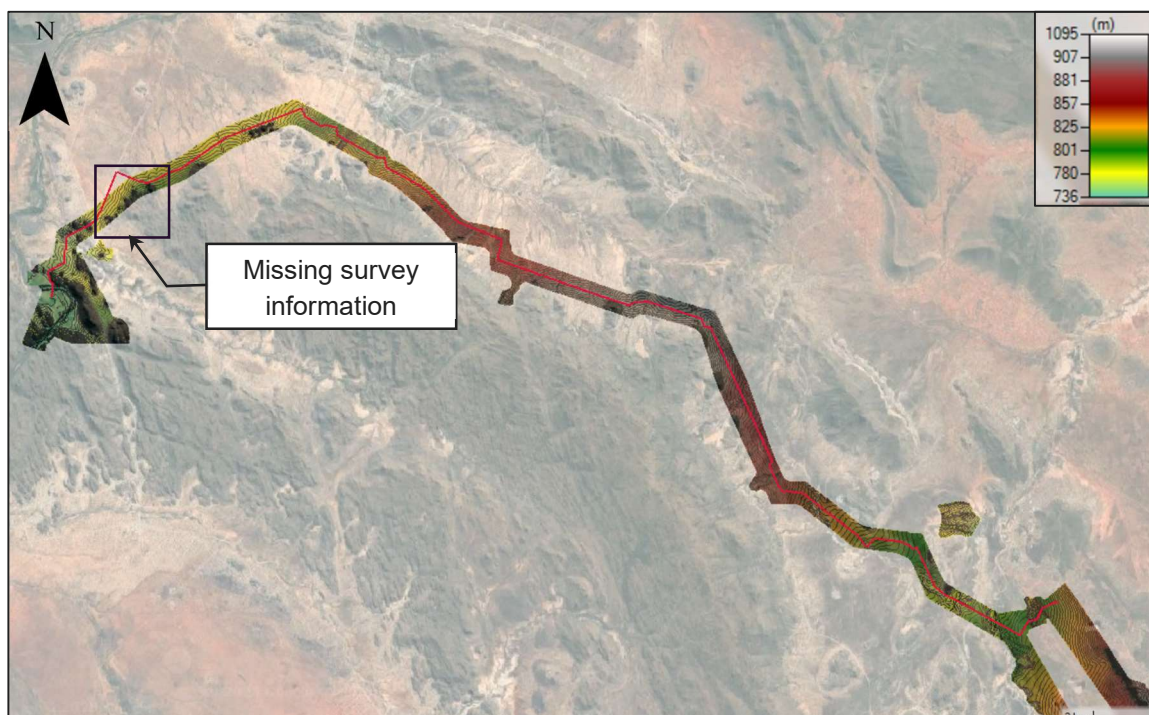


Figure 4-1: LiDAR survey extent

It should be noted that a portion of the pipeline deviates from the LiDAR survey at the chainage 20 400 m. The catchments within this area are listed below (refer to Figure 2-2):

- ▶ Olifants 8
- ▶ Olifants 9
- ▶ Olifants 10
- ▶ Olifants 11
- ▶ Olifants 12

This area was supplemented with opensource information from the CDNGI Geospatial portal and is shown in Figure 4-2.

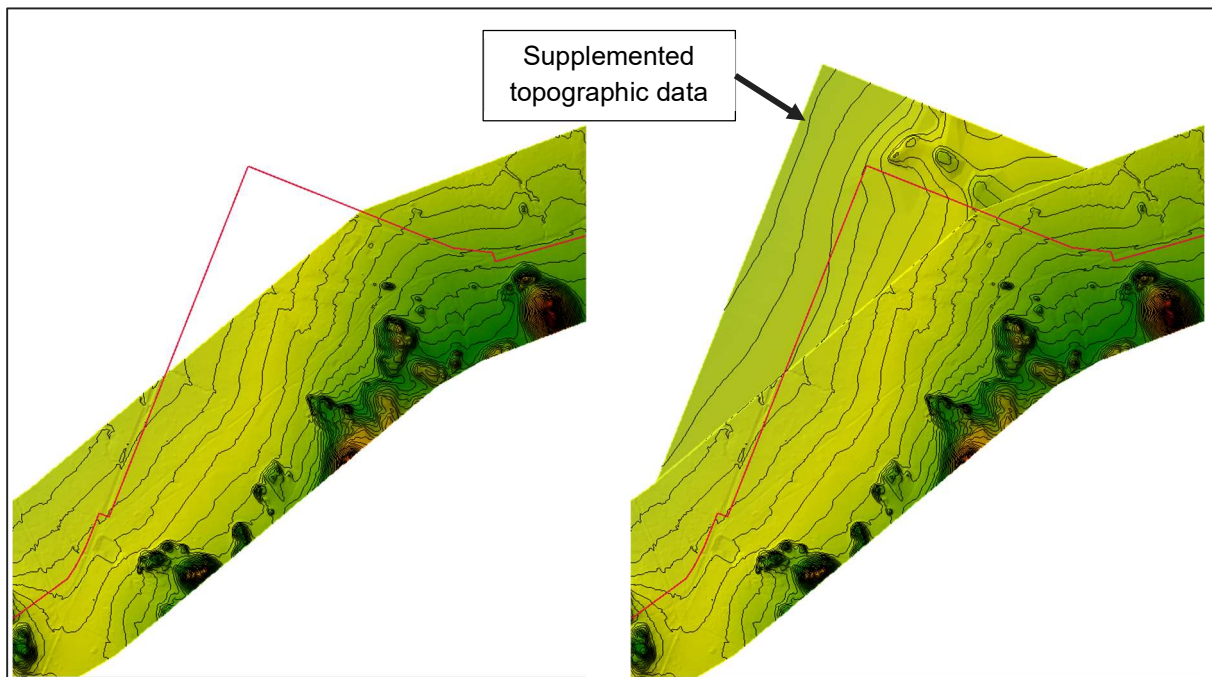


Figure 4-2: Phase 2F supplemented DEM area

The information used to supplement the LiDAR data is of a much lower quality and would not be sufficient for certified floodline analysis. However, due to the small size and low peak flows of the catchments within this area, the risk involved with these catchments have been classified as low and therefore it was decided that these areas have sufficient information to provide indicative floodlines/inundation areas due to the impediment of flow due to an obstruction (road, berm, culvert, etc).

Additionally, due to the age of the LiDAR survey (2016), various upgrades to road D4190 have not been captured, with the available LiDAR information still reflecting the old road alignment and levels. This mainly affects the following catchments (refer to Figure 2-2):

- ▶ Olifants 13
- ▶ Olifants 14
- ▶ Palangwe

For Olifants catchments 13 and 14, the same approach was applied as for catchments 8 to 12. These are classified as minor catchments with small drainage areas and low peak flows; therefore, no additional intervention measures were deemed necessary. Given the relatively low risk of flooding and erosion in these areas, it was considered sufficient to provide indicative floodlines and inundation areas. However, these areas may be re-evaluated if more recent survey data becomes available.

In contrast, due to the size and significance of the Palangwe catchment, on-site measurements and assumptions were incorporated into the model to capture road levels and bridge details.

The 2D model operates with a computational mesh. The mesh was generated at an initial resolution of 20 m and was refined in numerous areas to allow accurate modelling of the hydraulics. Mesh refinement included delineation of breaklines on barriers to flow, such as embankments and levees, and along flowpath centrelines to align the cells with the direction of flow. Some examples of the computational mesh perimeter and breaklines within a typical refinement area can be seen in Figure 4-3.

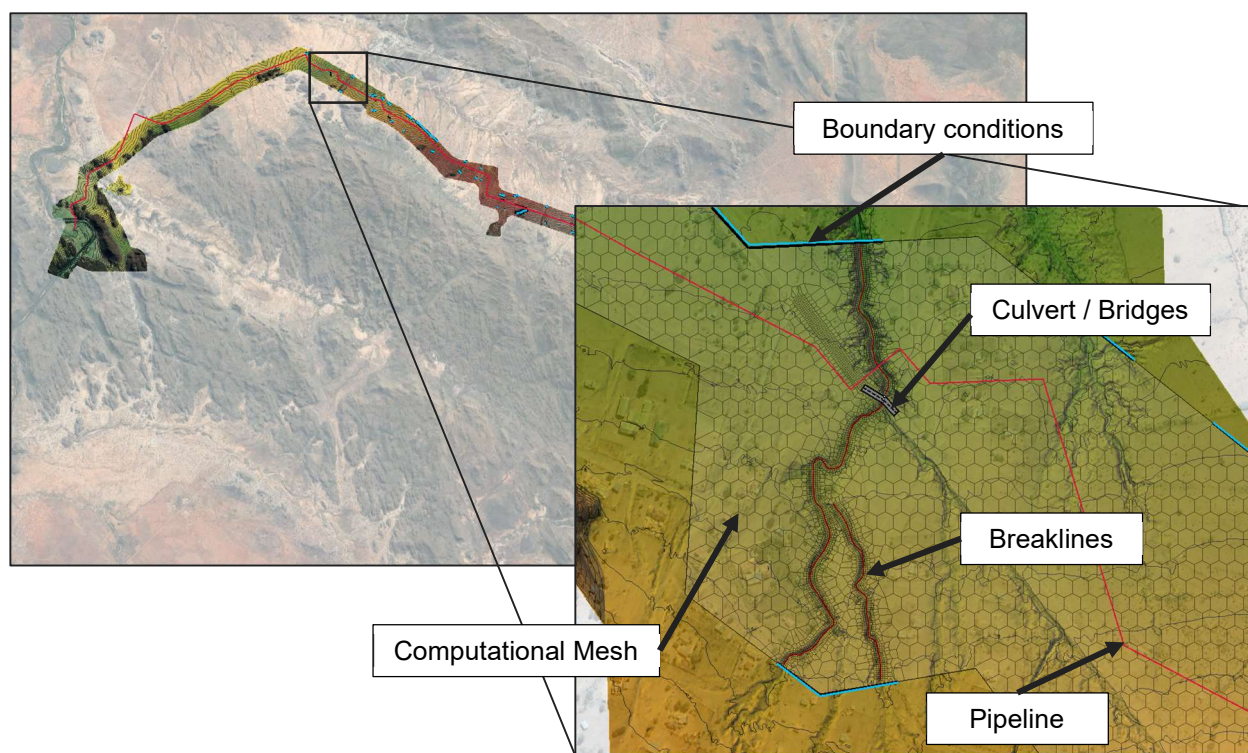


Figure 4-3: Computational mesh example of refinement

Possible hydraulic structures such as culverts and bridges were identified using aerial imagery and the LiDAR data. These structures were included in the model and the dimensions of these structures were based on site measurements.

Hydraulic resistance to flow is represented using Manning's roughness values in HEC-RAS. Since each land cover category tends to be reasonably uniform from a hydraulic resistance perspective, land cover is often used as a proxy for hydraulic resistance.

The South African National Land Cover (SANLC) 2022 database (Geoterralmage Pty Ltd (GTI) for the Department of Environmental Affairs (DEA), 2016) was assessed for applicability but it was found that the scattered trees in the area was often classified individually but the pixel size of the classification is bigger than the tree girth, this would cause very high manning's values scattered along the river area. Due to the inaccuracy of this information, a roughness value representing the combination of grassland and scattered bush ($n = 0.05$) was found to better represent the area and therefore adopted in the model. Furthermore, the low-flow stream width is very narrow and defining this separate from the overbanks would have a major effect on the results.

As most of the watercourses are non-perennial streams, the thalweg of the watercourses could be seen from the aerial imagery. From this, it could be seen that most riverbeds are made up of non-cohesive soils and it was assumed that these areas have low Manning n -values. Typical Manning n -value can be seen in Table 4-1 for reference (Brooker, et al., 2023).

Table 4-1: Manning n value for natural channels

Description	Range of Manning n
Main Channel : Clean and straight	0.025 – 0.033
Main Channel : Clean and winding	0.033 – 0.045
Main Channel : Very Weedy with pools timber and underbrush	0.075 – 0.150
Flood Plains : Grass , short	0.025 – 0.035
Flood Plains : Brush, light with trees in foliage	0.040 – 0.080
Flood Plains : Brush, medium to dense with trees in foliage	0.070 – 0.160
Flood Plains : Heavy stand of trees, little undergrowth, flood stage below branches	0.080 – 0.120

4.2 Flood Hydraulic Results

The results for the 1 in 100-year floodlines for each crossing are provided in Appendix D. It should be noted that only indicative floodlines/inundation areas were provided for Olifants catchments 8 to 14. This is mainly due to a lack of detailed survey information as well as the low risk associated with these catchments (refer to Section 4.1).

For the section of the pipeline affected by flooding, key hydraulic parameters are summarized in Table 4-2 to Table 4-4. These include the maximum inundation depth and the highest recorded velocity along the flooded pipeline section.

Table 4-2: Northern Catchments – Olifants Hydraulic results

Catchment name	Max depth (m)	Max velocity (m/s)
Olifants Tributary 1	0.73	2.35
Olifants Tributary 2	2.34	1.80
Olifants Tributary 3	2.69	1.63
Olifants Tributary 4	0.29	0.92
Olifants Tributary 5	0.32	0.85
Olifants Tributary 6	0.48	1.39
Olifants Tributary 7	0.40	1.65
*Olifants Tributary 8	0.24	0.94
*Olifants Tributary 9	0.13	1.02
*Olifants Tributary 10	0.09	0.66
*Olifants Tributary 11	0.67	2.31
*Olifants Tributary 12	0.15	2.17
*Olifants Tributary 13	0.25	0.96
*Olifants Tributary 14	0.33	0.83
Pelangwe Catchment	1.76	4.99
Olifants Tributary 16	0.81	1.91
Olifants Tributary 17	0.63	1.53
Olifants Tributary 18	0.41	0.87

*Minor Catchments – Indicative floodlines/inundation areas provided

Table 4-3: Northern Catchments – Monametsi Hydraulic results

Catchment name	Max depth (m)	Max velocity (m/s)
Monametsi Tributary 1	0.35	0.94
Monametsi Tributary 2	0.87	2.42
Monametsi Tributary 3	0.41	0.82
Monametsi Tributary 4	1.58	3.96
Monametsi Tributary 5	0.42	2.08
Monametsi Tributary 6	2.16	1.87
Monametsi Tributary 7 & 8	2.76	1.01
Monametsi Tributary 9	0.43	1.09
Monametsi Tributary 10	1.31	1.25
Monametsi Tributary 11	0.70	2.14
Monametsi Tributary 12	1.18	3.67
Monametsi Tributary 13	1.19	3.16

Catchment name	Max depth (m)	Max velocity (m/s)
Monametsi Tributary 14	1.14	3.05
Monametsi Tributary 15	0.21	0.92
Monametsi Tributary 16	1.27	2.19
Monametsi Tributary 17	1.43	2.35
Monametsi Tributary 18	1.14	1.96
Monametsi Tributary 19	1.36	4.44
Monametsi Tributary 20	2.14	3.08
Monametsi Tributary 21	0.55	1.74
Monametsi Tributary 22	0.93	1.28
Monametsi Tributary 23	1.22	2.50

Table 4-4: Southern Catchments – Hydraulic results

Catchment name	Max depth (m)	Max velocity (m/s)
Moopesti Main	3.81	2.93
Motse Main & Motse Main Tributary 1.1	5.39	2.94
Motse Main Tributary 1.2	3.32	2.93
Motse Main Tributary 1.3	*N/A	*N/A
Motse Tributary 1	2.00	1.32
Motse Tributary 2	1.48	2.01
Motse Tributary 3	2.15	2.14
Motse Tributary 4	2.39	2.61
Motse Tributary 5	1.62	1.43
Motse Tributary 6	2.06	2.39
Motse Tributary 7	2.97	2.55
Motse Tributary 8	1.19	0.93
Matadi Main	1.78	4.29
Matadi Tributary 1	1.32	1.59
Matadi Tributary 2	1.66	3.63

*N/A – Tributary does not cross pipeline

4.3 Scour Report Review

The proposed pipeline crosses the Olifants river from chainage 25 800 to 25 900. The location of the crossing is shown in Figure 4-4:

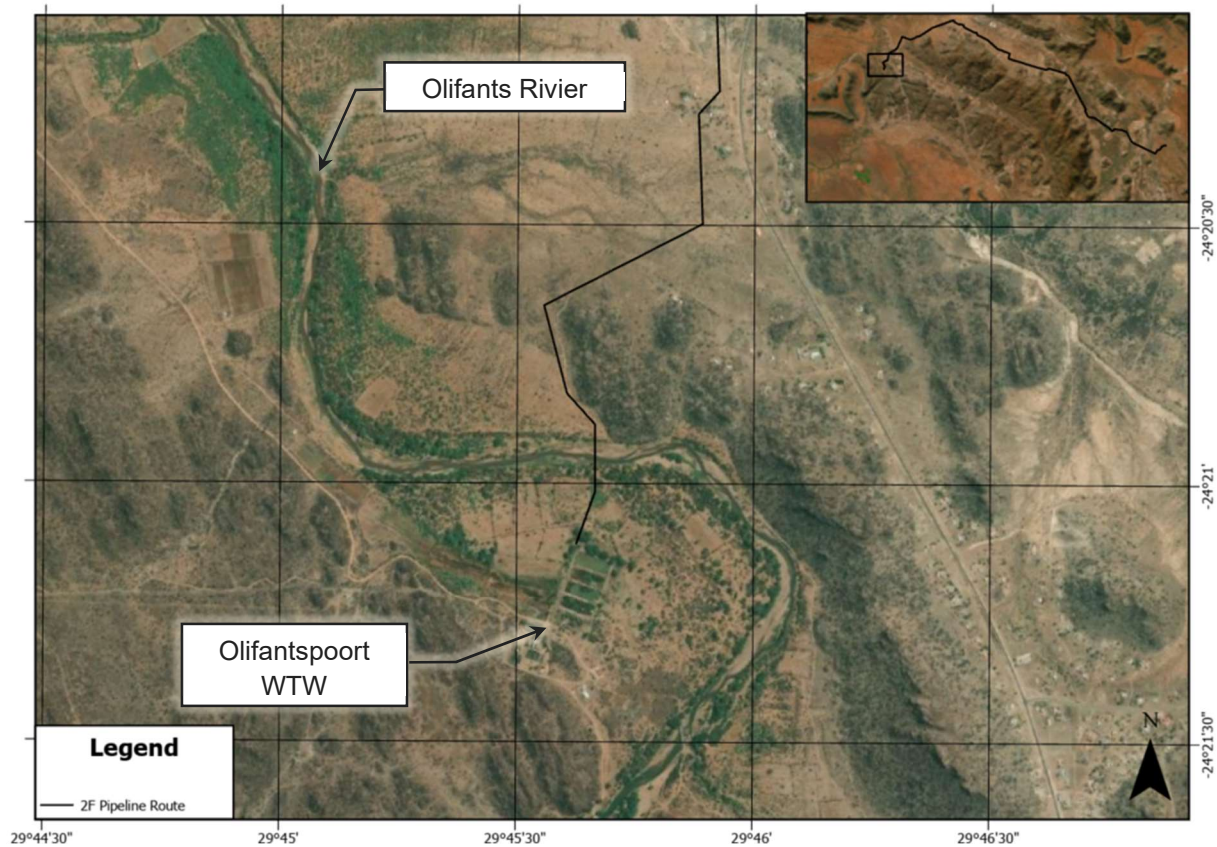


Figure 4-4: Phase 2F Pipeline – Olifants river crossing

ASP Technologies (Pty) Ltd conducted a detailed scour analysis at this location in 2016 by means of hydrodynamic modelling. Zutari (Pty) Ltd was appointed to review the analysis and establish whether the information is still applicable. The report is provided in Appendix F.

A summary of the conclusions and recommendations of the report is provided below:

- ▶ The flood analysis for the pipeline crossing was conducted using a probabilistic approach, primarily based on DWS flow gauging station B5H002, with extended records derived from downstream stations. The dataset included a historical flood event from 1908, and a Log Pearson Type 3 distribution was used to determine Annual Recurrence Interval (ARI) flood peaks. The results were validated against the Regional Maximum Flood methodology, with necessary adjustments for measurement inaccuracies. The 1 in 100-year flood peak was estimated at 6,000 m³/s, with additional consideration given to 10-, 50-, 100-, and 200-year flood events to ensure a robust pipeline design.
- ▶ A two-dimensional hydrodynamic model was developed using LiDAR data (2 m × 2 m grid), incorporating spatially varying hydraulic roughness based on calibration from similar alluvial rivers. The model included sediment grading analysis for riverbed characterization and a uniform flow-based downstream boundary condition.
- ▶ The flood simulations indicated high flow velocities at the pipeline crossing, with scour depths varying by flood magnitude. For 10- and 50-year floods, the deepest scour occurred near the right bank of the main channel, whereas for 100- and 200-year floods, the deepest scour shifted to the left bank. Despite the observed scour, the proposed pipeline crossing site remains viable, as the scoured main channel is relatively narrow compared to other sections of the river. However, significant floodplain scour was also observed on the left bank during larger flood events.

- ▶ To mitigate these risks, it was recommended that the pipeline be buried sufficiently deep beneath the riverbed and floodplain. The top of the concrete casing should be placed at a depth of 13.5 m below the current bed level at the deepest scour location on the right bank. This depth was determined by considering the lowest scoured bed level, subtracting bed dune height, and incorporating an additional 1.5 m safety factor.
- ▶ For structural protection, a concrete casing was proposed for all pipeline sections within the 1 in 100-year floodline, though extending the casing to the 200-year floodline is recommended due to the strategic importance of the pipeline.

After reviewing the flood analysis and pipeline design considerations, it was determined that the information remains sufficient and does not require any updates. The methodologies used for flood peak determination, hydrodynamic modelling, and scour assessment are still applicable, and the proposed mitigation measures for pipeline protection remain appropriate. The depth calculations for the concrete casing, as well as the consideration of flood events up to the 200-year flood, provide an adequate design framework. Therefore, no revisions to the existing analysis or recommendations are necessary at this time.

5 CONCLUSIONS AND RECOMMENDATIONS

This report presents the determination of the 1 in 100-year design flood levels for crossing points along the Phase 2F pipeline of the OMMP–BRWSP. The design floods for the relevant flow paths were estimated using best-practice methodologies to ensure accuracy and reliability.

The floodlines provided in this study can be used to assess flooding risks at the site boundary and assist in identifying suitable locations for future development as well as necessary flood protection measures. However, it is important to note that any changes in land use within the catchment area or modifications to hydraulic structures may impact the floodlines, necessitating periodic reassessment as conditions evolve.

Additionally, pipe crossings of the minor Olifants catchments, that fall outside the LiDAR data coverage (Olifants 8 to 14), the floodlines/inundation levels provided are indicative and may be updated once a detailed survey becomes available. Despite this, Zutari considers the risk of scour and inundation at these crossings to be minimal.

6 REFERENCES

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Appendix A

SCS-SA Calculation Sheets

FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Wian Lombard
Project Title	Olifant	Date: 08/01/2025
River	Olifants Tributary 1	

INPUT DATA:	Catchment characteristics
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Total catchment area	0.60 km ²			
Length of watercourse (L)	1.71 km	Location Lat	24	41
		Long	30	11
<u>Watercourse slope (10/85)</u>	0.02 m/m	<u>Catchment slope:</u>	0.16	Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA:	Landuse and Runoff Curve Number (CN) coefficients
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Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 83.50

Gridded Curve Number: 83.50

CALCULATIONS:	Time of concentration
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Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow:	30%
Channel flow:	70%
	100%

Overland flow (over fairly even and flat ground) where: T_c Time of concentration (overland) 0.78 hours

$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$	r	Roughness coefficient	Medium grass cover 0.4
	L	Hydraulic length of catchment	1.707876 km
	S	Overland slope	0.159722 m/m

$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$	r	Roughness coefficient	Medium grass cover 0.4
	L	Hydraulic length of catchment	1.707876 km
	S	Overland slope	0.159722 m/m

Channel flow

$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S} \right)^{0.385}$	where;	Tc	Time of concentration (channel)	0.42 hours
		L	Hydraulic length of catchment	1.71 km
		S	Average channel slope	0.0239 m/m

$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S} \right)^{0.385}$	where;	Tc	Time of concentration (channel)	0.42 hours
		L	Hydraulic length of catchment	1.71 km
		S	Average channel slope	0.0239 m/m

Total time of concentration	0.53 hours
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CALCULATIONS: Catchment response	
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For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: 0.41 hours

Storm Type:	2	24.42 minutes
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<u>Areal Reduction Factor</u>	100.0%
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Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

Soil retention	normal	50.2 mm	6	25400	354
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$$S = \frac{CN}{CN} - 254$$

Lagtime	40.35 M 4 D 1.1	10.8 (S + 25.4) 0.7
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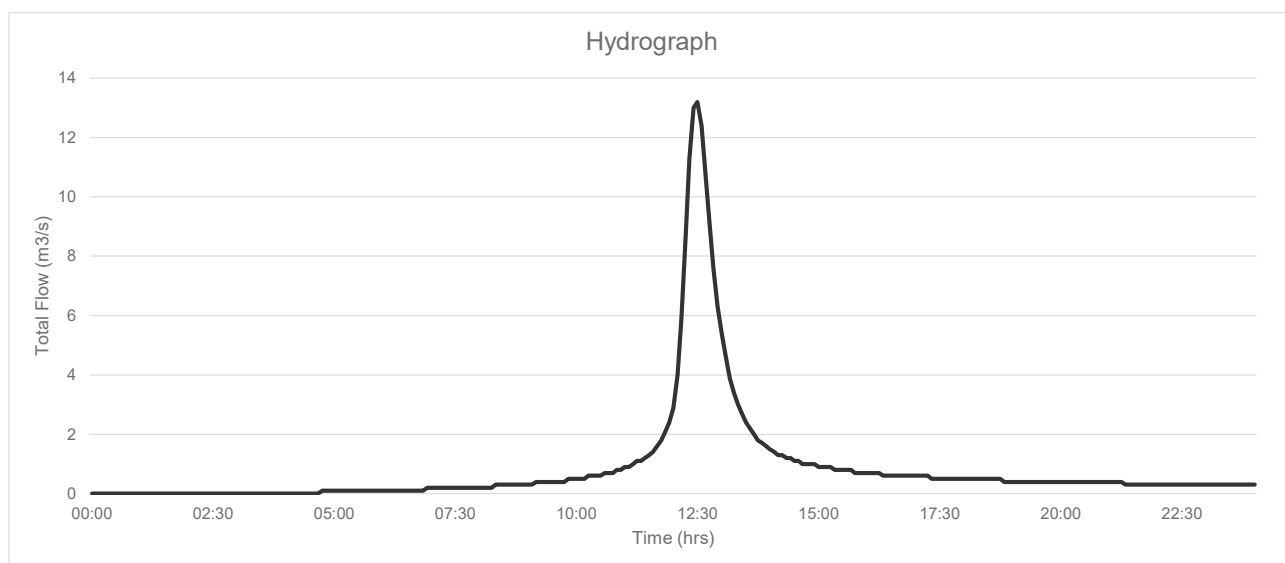
$$\text{SA: } L = \frac{A \cdot \text{MAP}}{41.67 \cdot \gamma^{0.3} /_{20\text{min}}^{0.87}} \quad \text{USA: } L = \frac{t^{0.75} (3 + 25.4)}{7069 \cdot \gamma^{0.5}}$$
$$\text{SA: } L = \frac{A \cdot \text{MAP}}{41.67 \cdot \gamma^{0.3} /_{20\text{min}}^{0.87}} \quad \text{USA: } L = \frac{t^{0.75} (3 + 23.4)}{7069 \cdot \gamma^{0.5}}$$

where; A	0.60 km ²	where; I	1,708 m
MAP	549.9649 mm	S	50.2 mm
y	15.97 %	y	15.97 %
I ₃₀	35.3 mm/hr	L	0.28 hrs
L	0.41 hrs		

where; A	0.60 km ²	where; I	1,708 m
MAP	549.9649 mm	S	50.2 mm
y	15.97 %	y	15.97 %
I ₃₀	35.3 mm/hr	L	0.28 hrs
L	0.41 hrs		

RESULTS:

100 yr Peak Flow **13.20** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Wian Lombard
Project Title	Olifant	Date: 08/01/2025
River	Olifants Tributary 2	

INPUT DATA:	Catchment characteristics
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Total catchment area	10.61 km ²			
Length of watercourse (L)	6.62 km	Location Lat	24	24
		Long	30	44
<u>Watercourse slope (10/85)</u>	0.07 m/m	<u>Catchment slope:</u>	0.18	Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	99.1%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	53	64	63
5yr	20%	73	87	86
10yr	10%	87	104	103
20yr	5%	101	121	120
50yr	2%	122	146	144
100yr	1%	138	165	163
200yr	0.5%	155	185	184

INPUT DATA:	Landuse and Runoff Curve Number (CN) coefficients
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Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 83.13

CALCULATIONS:	Time of concentration
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Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow:	0%
Channel flow:	100%
	100%

<u>Overland flow (over fairly even and flat ground)</u>	where;	T _c	Time of concentration (overland)	1.42 hours
$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$		r	Roughness coefficient	Medium grass cover 0.4
		L	Hydraulic length of catchment	6.621511 km
		S	Overland slope	0.181701 m/m

Channel flow

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

where; T_c Time of concentration (channel) 0.79 hours
 L Hydraulic length of catchment 6.62 km
 S Average channel slope 0.0711 m/m

Total time of concentration	0.79 hours
-----------------------------	------------

CALCULATIONS:	Catchment response
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For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

<u>Catchment type:</u>	Well vegetated	----->	Lag time:	1.08 hours
<u>Storm Type:</u>	2			64.68 minutes
Areal Reduction Factor	99.1%			

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	52.7 mm	2-year 30min rainfall	35.0 mm/hr

<u>Soil retention</u>	normal	51.5 mm	$S = \frac{25400}{CN} - 254$
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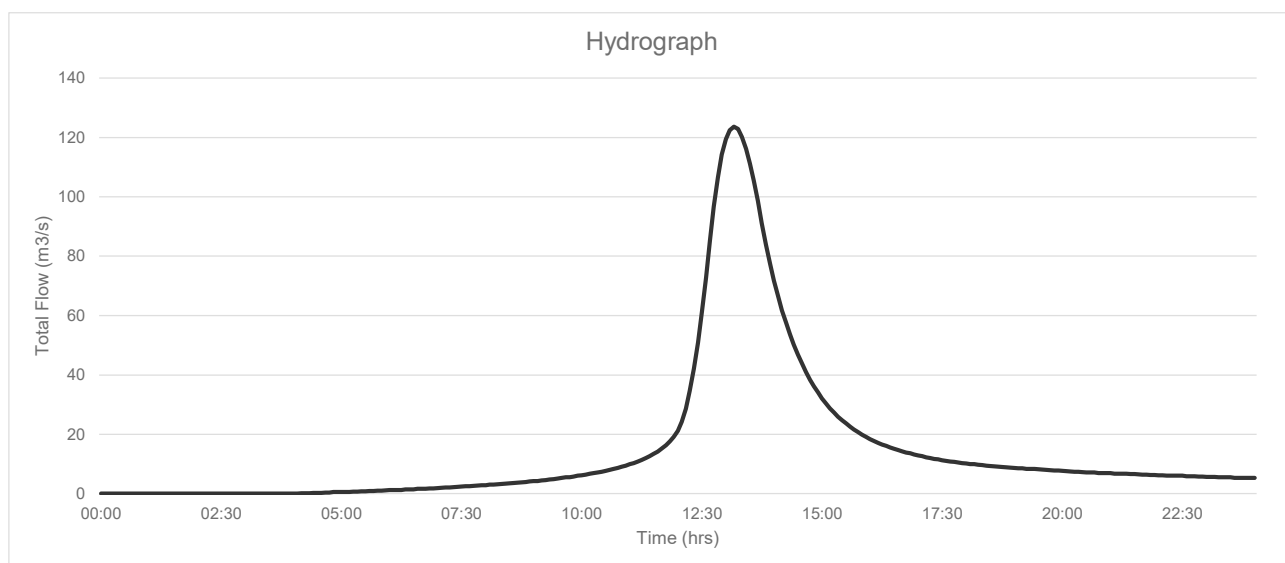
<u>Initial abstraction</u>	normal	5.2 mm	$I_a = 0.1 \cdot S$
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<u>Lagtime</u>	SA:	$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$	USA:	$L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$
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where; A	10.61 km ²	where; l	6,622 m
MAP	549.9649 mm	S	51.5 mm
y	18.17 %	y	18.17 %
I ₃₀	35.0 mm/hr	L	0.79 hrs
L	1.08 hrs		

RESULTS:

100 yr Peak Flow **123.70** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Wian Lombard
Project Title	Olifant	Date: 08/01/2025
River	Olifants Tributary 3	

INPUT DATA:	Catchment characteristics
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Total catchment area	1.66 km ²			
Length of watercourse (L)	3.00 km	Location Lat	24	24
		Long	30	44
<u>Watercourse slope (10/85)</u>	0.02 m/m	<u>Catchment slope:</u>	0.17	Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA:	Landuse and Runoff Curve Number (CN) coefficients
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Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 85.21

CALCULATIONS:	Time of concentration
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Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow:	30%
Channel flow:	70%
	100%

<u>Overland flow (over fairly even and flat ground)</u>	where;	T _c	Time of concentration (overland)	0.99 hours
$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$		r	Roughness coefficient	Medium grass cover 0.4
		L	Hydraulic length of catchment	2.997762 km
		S	Overland slope	0.170414 m/m

[illegible]

$T_c = \left(\frac{0.87 \cdot L^2}{C} \right)^{0.385}$	where;	t_c	Time of concentration (channel)	0.64 hours
		L	Hydraulic length of catchment	3.00 km
		C	Channel roughness coefficient	0.0247 s/m ^{1/3}

τ_c	$(1000 \cdot S_{av})$	S	Average channel slope	0.0247 m/m
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Total time of concentration	0.75 hours
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CALCULATIONS:	Catchment response
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For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

<u>Catchment type:</u>	Well vegetated	----->	Lag time:	0.57 hours
Storm Type:	2			34.19 minutes

Areal Reduction Factor	100.0%
Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation	

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

Soil retention	normal	44.1 mm	$S = \frac{25400}{CN} - 254$
Initial abstraction	normal	4.4 mm	$I = 0.1 \cdot S$

$$t_a = 0.1 \pm 0.05$$

Lagtime SA:
$$l_i = \frac{A^{0.35} MAP^{1.1}}{S}$$
 USA:
$$l_i = \frac{l^{0.8} (S + 25.4)^{0.7}}{S}$$

$$41.67 \cdot y^{0.3} I_{30min}^{0.87} \quad - \quad 7069 \cdot y^{0.5}$$

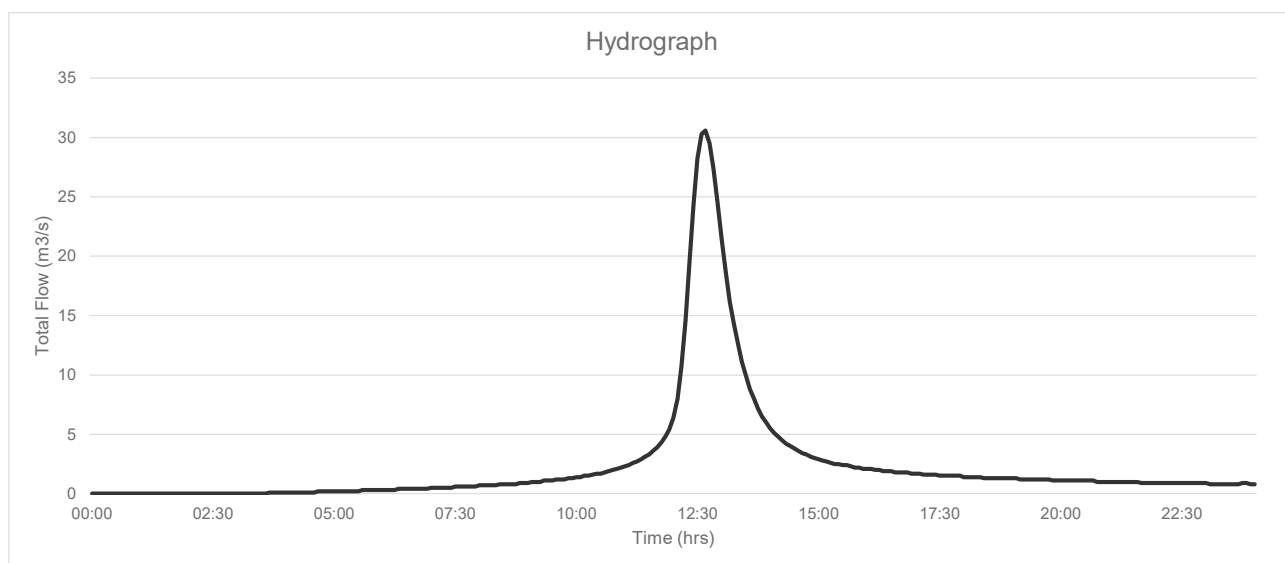
where; A	1.66 km2	where; l	2,998 m
MAP	549.9649 mm	S	44.1 mm

y	17.04 %	y	17.04 %
I ₃₀	35.3 mm/hr	L	0.40 hrs
I	0.57 hrs		

$\frac{1}{2} \times 100 = 50$	$\frac{1}{2} \times 100 = 50$
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RESULTS:

100 yr Peak Flow **30.60** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
Project Title **Olifant**
River **Olifants Tributary 4**

Calculated by: **Wian Lombard**
Date: **08/01/2025**

INPUT DATA: Catchment characteristics

Total catchment area **0.60** km²
Length of watercourse (L) **1.76** km
Watercourse slope (10/85) **0.15** m/m

Location Lat **24** Deg **41** Min **24** Sec
Long **30** **11** **44**
Catchment slope: **0.21** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **549.96** mm ARF = **100.0%**
1-day point design rainfall (mm) **549.96** 1-day areal design rainfall (mm) **549.96**

Recurrence Interval years	AEP (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: **Obtained from Soils Group map**
Gridded Curve Number: **77.47**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: **Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%**

Overland flow: **0%**
Channel flow: **100%**
100%

Overland flow (over fairly even and flat ground) where; Tc Time of concentration (overland) **0.74** hours
r Roughness coefficient Medium grass cover **0.4**
L Hydraulic length of catchment **1.764661** km
S Overland slope **0.214439** m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; Tc Time of concentration (channel) **0.22** hours
L Hydraulic length of catchment **1.76** km
S Average channel slope **0.1461** m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration **0.22** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: **0.37** hours
Storm Type: **2** **22.29** minutes
Areal Reduction Factor **100.0%**

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall **53.2** mm 30min factor **0.664**
Aerial rainfall **53.2** mm 2-year 30min rainfall **35.3** mm/hr

Soil retention normal **73.9** mm $S = \frac{25400}{CN} - 254$

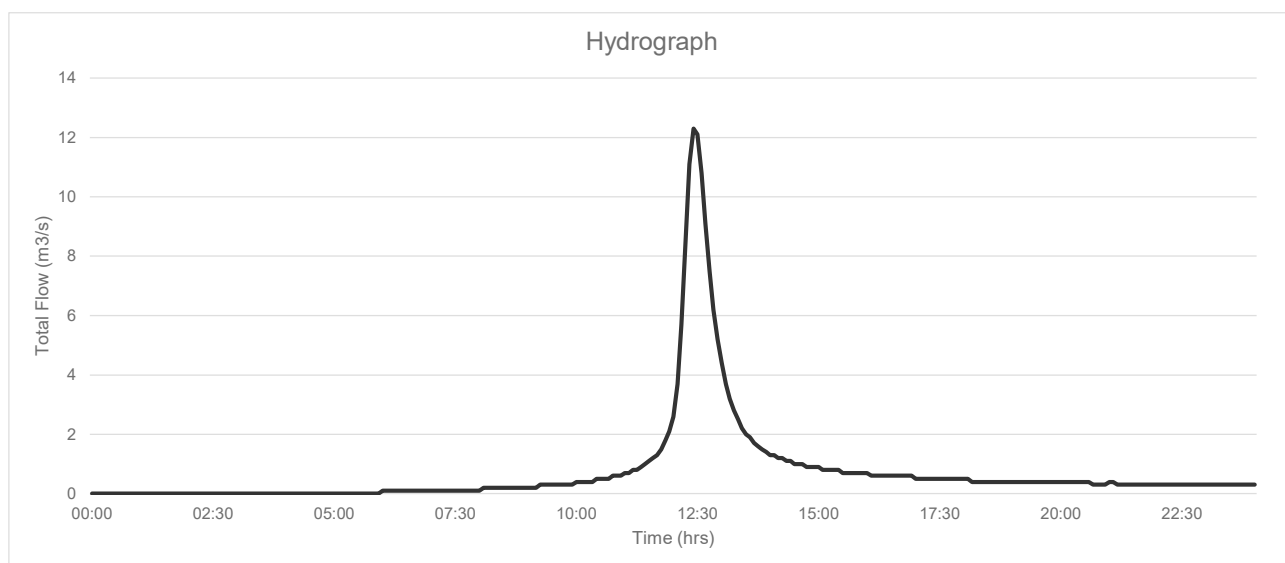
Initial abstraction normal **7.4** mm $I_a = 0.1 \cdot S$

Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{I^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A **0.60** km² where; I **1.765** m
MAP **549.9649** mm S **73.9** mm
y **21.44** % y **21.44** %
I₃₀ **35.3** mm/hr L **0.30** hrs
L **0.37** hrs

RESULTS:

100 yr Peak Flow **12.30** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
Project Title **Olifant**
River **Olifants Tributary 5**

Calculated by: **Wian Lombard**
Date: **08/01/2025**

INPUT DATA: Catchment characteristics

Total catchment area **0.49** km²
Length of watercourse (L) **2.11** km
Watercourse slope (10/85) **0.09** m/m

Location Lat **24** Deg
Long **30** Min
Catchment slope: **0.17** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **549.96** mm
1-day point design rainfall (mm) **53** ARF = **100.0%**
1-day areal design rainfall (mm) **64**

Recurrence Interval		Storm duration	
years	AEP (%)	1-day	24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: **Obtained from Soils Group map**
Gridded Curve Number: **82.33**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: **Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%**

Overland flow: **0%**
Channel flow: **100%**
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) **0.85** hours
r Roughness coefficient Medium grass cover **0.4**
L Hydraulic length of catchment **2.113992** km
S Overland slope **0.168145** m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) **0.30** hours
L Hydraulic length of catchment **2.11** km
S Average channel slope **0.0895** m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration **0.30** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: **0.37** hours
Storm Type: **2** 22.32 minutes
Areal Reduction Factor **100.0%**

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall **53.2** mm 30min factor **0.664**
Aerial rainfall **53.2** mm 2-year 30min rainfall **35.3** mm/hr

Soil retention normal **54.5** mm $S = \frac{25400}{CN} - 254$

Initial abstraction normal **5.5** mm $I_a = 0.1 \cdot S$

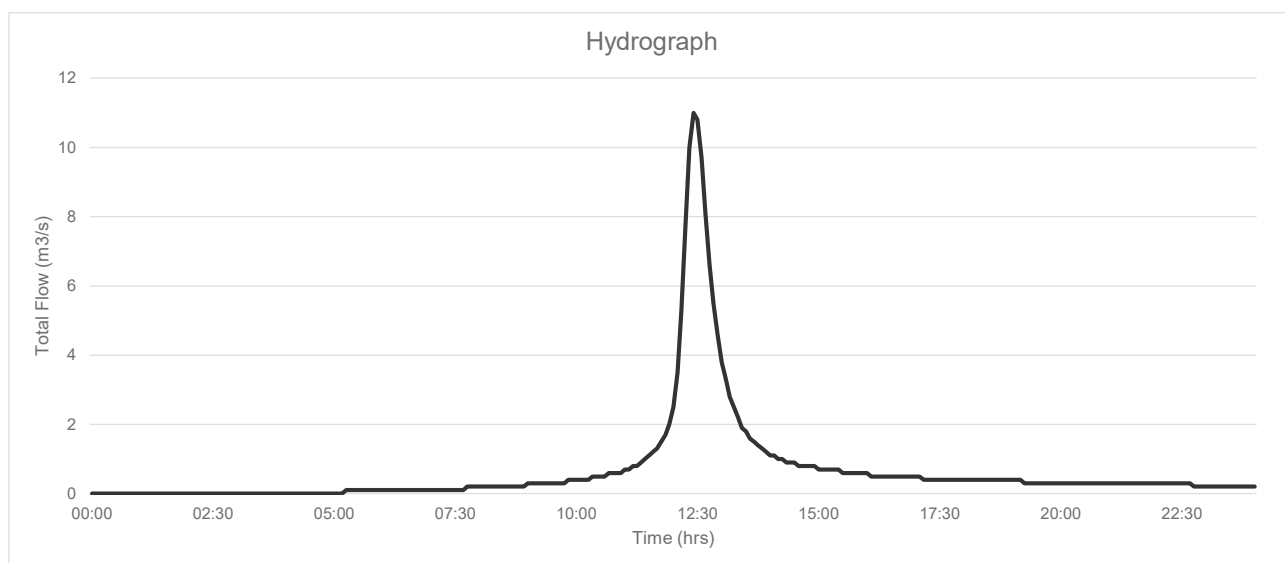
Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A **0.49** km²
MAP **549.9649** mm
y **16.81** %
I₃₀ **35.3** mm/hr
L **0.37** hrs

where; l **2,114** m
S **54.5** mm
y **16.81** %
L **0.34** hrs

RESULTS:

100 yr Peak Flow **11.00** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Wian Lombard
Project Title	Olifant	Date: 08/01/2025
River	Olifants Tributary 6	

INPUT DATA:	Catchment characteristics
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Total catchment area	0.27 km ²			
Length of watercourse (L)	1.63 km	Location Lat	24	41
		Long	30	11
<u>Watercourse slope (10/85)</u>	0.04 m/m	<u>Catchment slope:</u>	0.05	Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA:	Landuse and Runoff Curve Number (CN) coefficients
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Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 86.31

CALCULATIONS:	Time of concentration
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Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:	30%
Channel flow:	70%
	100%

<u>Overland flow (over fairly even and flat ground)</u>	where;	T _c	Time of concentration (overland)	1.02 hours
$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$		r	Roughness coefficient	Medium grass cover 0.4
		L	Hydraulic length of catchment	1.633969 km
		S	Overland slope	0.046221 m/m

Channel flow

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

where; T_c Time of concentration (channel) 0.35 hours
 L Hydraulic length of catchment 1.63 km
 S Average channel slope 0.0365 m/m

Table 1. <i>Continued</i>	0.55
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Total time of concentration	0.55 hours
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CALCULATIONS:	Catchment response
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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466
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For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:	well vegetated	----->	Lag time:	0.45 hours
Storm Type:	2			26.70 minutes
Areal Reduction Factor	100.0%			

<u>Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation</u>			
2-year 1-day rainfall	59.2	30 min rainfall intensity	3.334

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

Soil retention	normal	40.3 mm	$S = \frac{25400}{CN} - 254$
Initial penetration	normal	1.0 mm	

<u>initial abstraction</u>	normal	4.0 mm	$I_a = 0.1 \cdot S$
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$$A^{0.35} MAP^{1.1} \quad l^{0.8} (S + 25.4)^{0.7}$$

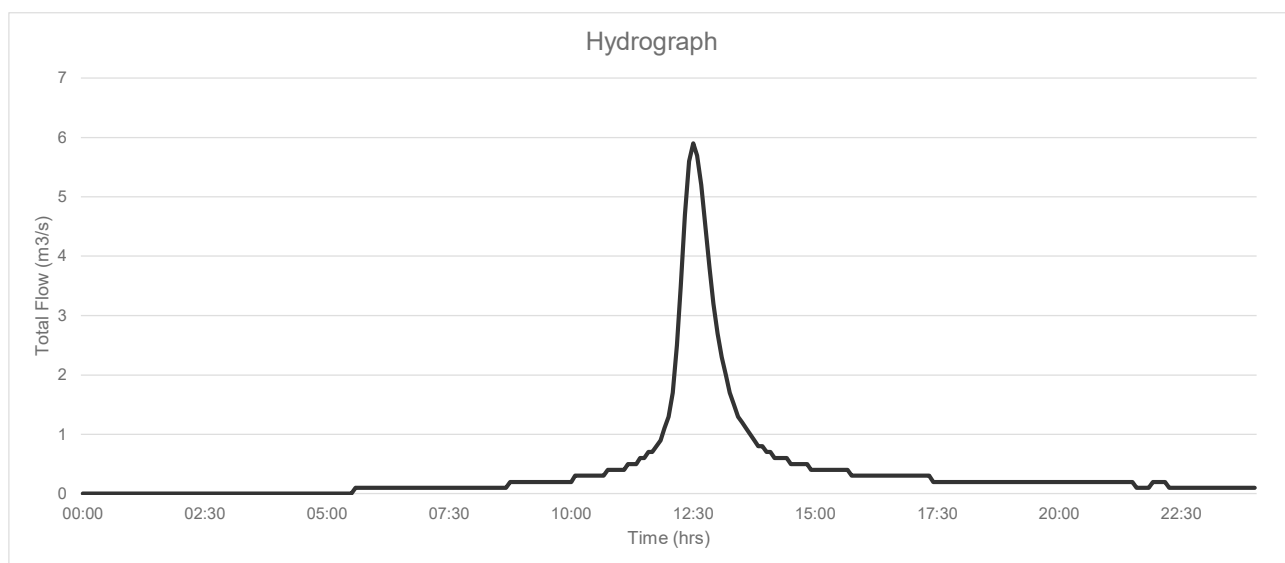
SA:	$L = \frac{1}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$	USA:	$L = \frac{1}{7069 \cdot y^{0.5}}$
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where; A	0.27 km ²	where; l	1,634 m
MAP	549.9649 mm	S	40.3 mm
v	4.62 %	v	4.62 %

I_{30}	35.3 mm/hr	L	0.46 hrs
L	0.45 hrs		

RESULTS:

100 yr Peak Flow **5.90** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Wian Lombard
Project Title	Olifant	Date: 08/01/2025
River	Olifants Tributary 7	

INPUT DATA:	Catchment characteristics
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Total catchment area	2.38 km ²			
Length of watercourse (L)	4.55 km	Location Lat	24	41
		Long	30	11
<u>Watercourse slope (10/85)</u>	0.04 m/m	<u>Catchment slope:</u>	0.19	Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 81.40

CALCULATIONS:	Time of concentration
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Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow:	30%
Channel flow:	70%
	100%

<u>Overland flow (over fairly even and flat ground)</u>	where;	T _c	Time of concentration (overland)	1.17 hours
$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$		r	Roughness coefficient	Medium grass cover 0.4
		L	Hydraulic length of catchment	4.55024 km
		S	Overland slope	0.194344 m/m

[illegible]

$T_c = \left(\frac{0.87 \cdot L^2}{g} \right)^{0.385}$	where;	T_c	Time of concentration (channel)	0.71 hours
		L	Hydraulic length of catchment	4.55 km
		g	Gravitational acceleration	9.81 m/s ²

$\tau_c = (1000 \cdot S_{av})$	S	Average channel slope	0.0437 m/m
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Total time of concentration	0.85 hours
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CALCULATIONS:	Catchment response
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For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

<u>Catchment type:</u>	Well vegetated	----->	Lag time:	0.62 hours
Storm Type:	2			37.24 minutes

Areal Reduction Factor	100.0%
Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation	

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

Soil retention	normal	58.0 mm	$S = \frac{25400}{CN} - 254$
Initial abstraction	normal	5.8 mm	$I = 0.1 \cdot S$

$$I_d = 0.1 \pm 0.05$$

Lagtime SA: $l = \frac{A^{0.35} MAP^{1.1}}{0.0001}$ USA: $l = \frac{l^{0.8}(S + 25.4)^{0.7}}{0.0001}$

$$41.67 \cdot y^{0.3} I_{30min}^{0.87} \quad - \quad 7069 \cdot y^{0.5}$$

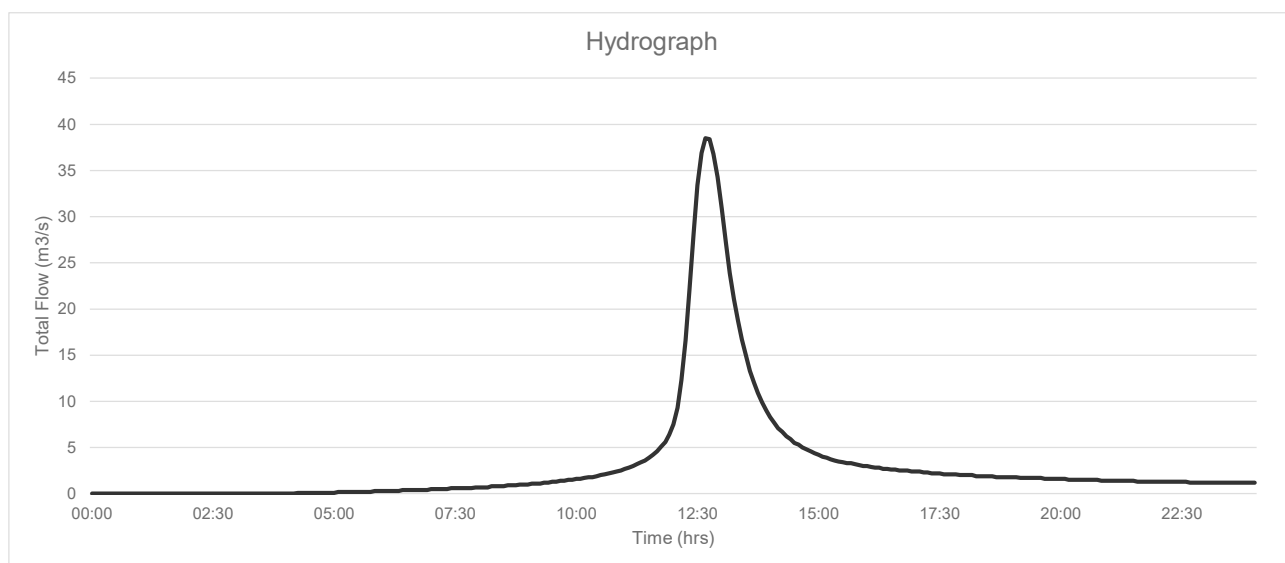
where; A	2.38 km ²	where; I	4,550 m
MAP	549.9649 mm	S	58.0 mm

y	19.43 %	y	19.43 %
I_{30}	35.3 mm/hr	L	0.60 hrs
L	0.62 hrs		

0.02 m/s

RESULTS:

100 yr Peak Flow **38.50** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Wian Lombard
Project Title	Olifant	Date: 08/01/2025
River	Olifants Tributary 8	

INPUT DATA:	Catchment characteristics
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Total catchment area	0.58 km ²			
Length of watercourse (L)	2.34 km	Location Lat	24	41
		Long	30	11
<u>Watercourse slope (10/85)</u>	0.04 m/m	<u>Catchment slope:</u>	0.09	Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA:	Landuse and Runoff Curve Number (CN) coefficients
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Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 80.34

CALCULATIONS:	Time of concentration
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Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:	30%
Channel flow:	70%
	100%

<u>Overland flow (over fairly even and flat ground)</u>	where;	T _c	Time of concentration (overland)	1.03 hours
$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$		r	Roughness coefficient	Medium grass cover 0.4
		L	Hydraulic length of catchment	2.337723 km
		S	Overland slope	0.090057 m/m

Channel flow

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

where; T_c Time of concentration (channel) 0.45 hours
 L Hydraulic length of catchment 2.34 km
 S Average channel slope 0.0389 m/m

Total time of concentration	0.62 hours
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CALCULATIONS:	Catchment response
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For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

<u>Catchment type:</u>	Well vegetated	----->	Lag time:	0.48 hours
Storm Type:	2			28.57 minutes

Areal Reduction Factor	100.0%
------------------------	--------

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

<u>Soil retention</u>	normal	62.2 mm	$S = \frac{25400}{CN} - 254$
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<u>Initial abstraction</u>	normal	6.2 mm	$I_a = 0.1 \cdot S$
----------------------------	--------	--------	---------------------

Lagtime	40.35 M 4 D 1.1	70.8 (S 1 25 A) 0.7
---------	-----------------	---------------------

$$\text{SA: } L = \frac{A_{\text{MAP}}}{41.67 \cdot \gamma^{0.3} I_{30\text{min}}^{0.87}} \quad \text{USA: } L = \frac{t^{(S+23.4)}}{7069 \cdot \gamma^{0.5}}$$

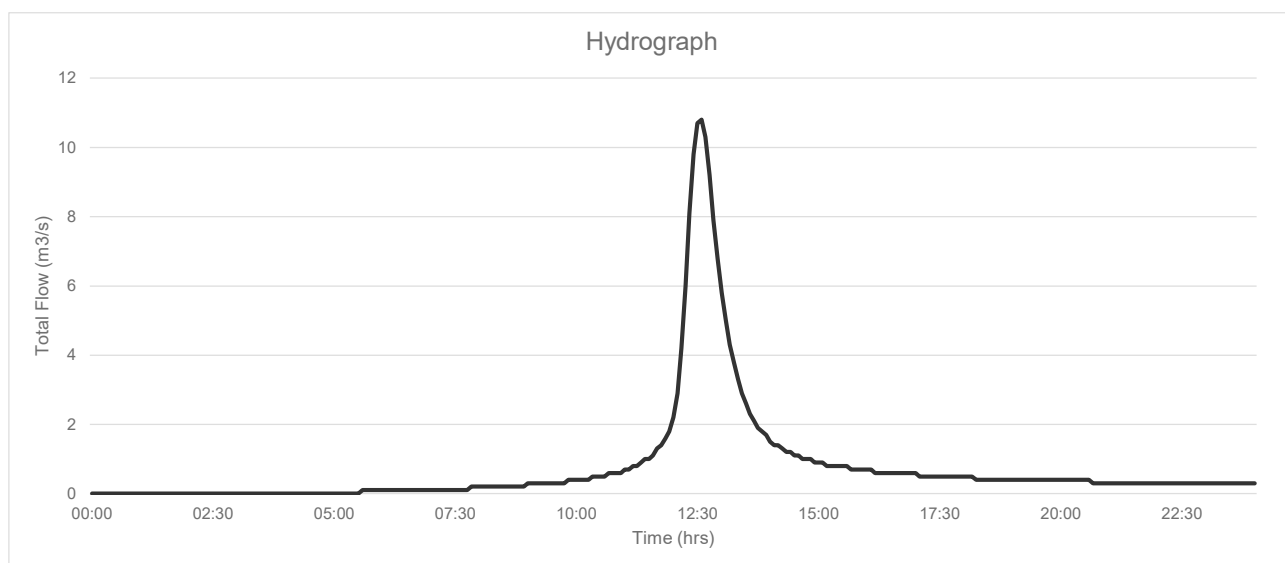
where; A	0.58 km ²	where; I	2,338 m
----------	----------------------	----------	---------

MAP	549.9649 mm	S	62.2 mm
y	9.01 %	y	9.01 %
I ₃₀	35.3 mm/hr	L	0.53 hrs
L	0.48 hrs		

[illegible]

RESULTS:

100 yr Peak Flow **10.80** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Wian Lombard
Project Title	Olifant	Date: 08/01/2025
River	Olifants Tributary 9	

INPUT DATA:	Catchment characteristics
--------------------	---------------------------

Total catchment area	0.34 km ²			
Length of watercourse (L)	1.38 km	Location Lat	24	41
		Long	30	11
<u>Watercourse slope (10/85)</u>	0.04 m/m	<u>Catchment slope:</u>	0.09	Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		
years	AEP (%)	1-day	24 hours	24 hours
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 80.26

CALCULATIONS:	Time of concentration
----------------------	-----------------------

Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%.

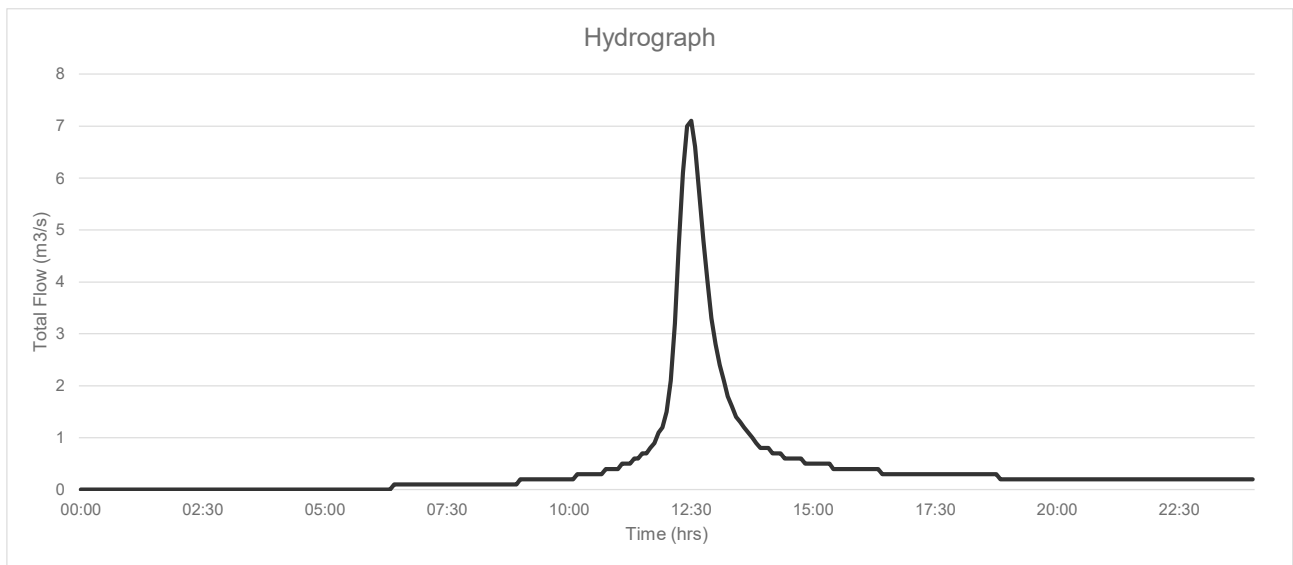
Percentage of longest watercourse:		Note: Overland flow should usually only be allowed for in catchments <5km ² and areas flatter than 5%	
Overland flow:	30%		
Channel flow:	70%		
	100%		
<u>Overland flow (over fairly even and flat ground)</u>		where;	
$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$	T _c	Time of concentration (overland)	0.81 hours
	r	Roughness coefficient	Medium grass cover 0.4
	L	Hydraulic length of catchment	1.379822 km
	S	Overland slope	0.088139 m/m
<u>Channel flow</u>		where;	
$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$	T _c	Time of concentration (channel)	0.30 hours
	L	Hydraulic length of catchment	1.38 km
	S	Average channel slope	0.0364 m/m
Total time of concentration			0.46 hours

CALCULATIONS:	Catchment response
----------------------	--------------------

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method				
<u>Catchment type:</u>	Well vegetated	----->	Lag time:	0.40 hours
<u>Storm Type:</u>	2			23.89 minutes
<u>Areal Reduction Factor</u>	100.0%			
<u>Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation</u>				
2-year 1-day rainfall	53.2 mm		30min factor	0.664
Aerial rainfall	53.2 mm		2-year 30min rainfall	35.3 mm/hr
<u>Soil retention</u>	normal	62.5 mm	$S = \frac{25400}{CN} - 254$	
<u>Initial abstraction</u>	normal	6.2 mm	$I_a = 0.1 \cdot S$	
<u>Lagtime</u>	SA:		USA:	
	$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$		$L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$	
where; A	0.34 km2		where; l	1,380 m
MAP	549.9649 mm		S	62.5 mm
y	8.81 %		y	8.81 %
I ₃₀	35.3 mm/hr		L	0.36 hrs
L	0.40 hrs			

RESULTS:

100 yr Peak Flow **7.10** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No
Project Title
River

1002569
Olifant
Olifants Tributary 10

Calculated by: Wian Lombard

Date: 08/01/2025

INPUT DATA:

Catchment characteristics

Total catchment area
Length of watercourse (L)

Watercourse slope (10/85)

0.22 km²
1.41 km

0.07 m/m

Location Lat
Long

Catchment slope:

Deg
Min
Sec

Average slope (m/m)

24
30

0.08

41
11

24
44

INPUT DATA:

Rainfall

Mean Annual Precipitation
1-day point design rainfall (mm)

549.96 mm

ARF = 100.0%
1-day areal design rainfall (mm)

Recurrence Interval years	AEP (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map
Gridded Curve Number:

84.34

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:
Overland flow:
Channel flow:

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%
0%
100%
100%

Overland flow (over fairly even and flat ground)

where;

Tc
r

L
S

Time of concentration (overland)
Roughness coefficient

Hydraulic length of catchment
Overland slope

0.84 hours
Medium grass cover
0.4
1.411289 km
0.07726 m/m

Channel flow

where;

Tc
L
S

Time of concentration (channel)
Hydraulic length of catchment
Average channel slope

0.23 hours
1.41 km
0.0747 m/m

Total time of concentration

0.23 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:
Storm Type:
Areal Reduction Factor
Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

Well vegetated
2
100.0%

Lag time:
21.40 minutes

0.36 hours

2-year 1-day rainfall
Aerial rainfall

53.2 mm
53.2 mm

30min factor
2-year 30min rainfall

0.664
35.3 mm/hr

Soil retention
Initial abstraction

normal
normal

47.2 mm
4.7 mm

S = $\frac{25400}{CN} - 254$
I_a = 0.1 · S

Lagtime

SA:

L = $\frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

USA:

L = $\frac{I^{0.8}(S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A
MAP
y
I₃₀
L

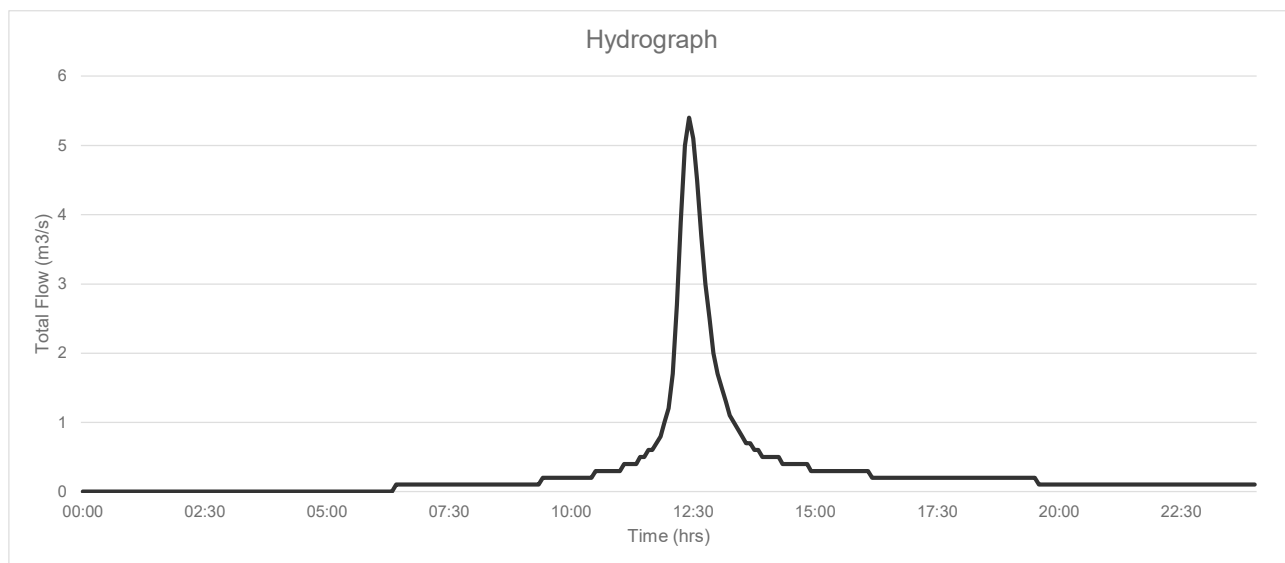
0.22 km2
549.9649 mm
7.73 %
35.3 mm/hr
0.36 hrs

where; I
S
y
L

1,411 m
47.2 mm
7.73 %
0.34 hrs

RESULTS:

100 yr Peak Flow **5.40** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No
Project Title
River

1002569
Olifant
Olifants Tributary 11

Calculated by: Wian Lombard
Date: 08/01/2025

INPUT DATA:

Catchment characteristics

Total catchment area
Length of watercourse (L)

Watercourse slope (10/85)

0.33 km²
1.31 km

0.08 m/m

Location Lat
Long

Deg
30

Min
41
Sec
44

Catchment slope:

0.09 Average slope (m/m)

INPUT DATA:

Rainfall

Mean Annual Precipitation
1-day point design rainfall (mm)

549.96 mm

ARF =
1-day areal design rainfall (mm)

100.0%

Recurrence Interval		Storm duration	
years	AEP (%)	1-day	24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

24 hours
64
87
104
121
146
165
185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map
Gridded Curve Number: 83.73

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:
Overland flow:
Channel flow:

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%
0%
100%
100%

Overland flow (over fairly even and flat ground)

where;

Tc
r

L
S

Time of concentration (overland)
Roughness coefficient

Hydraulic length of catchment
Overland slope

0.77 hours
Medium grass cover
0.4
1.310301 km
0.09457 m/m

Channel flow

where;

Tc
L
S

Time of concentration (channel)
Hydraulic length of catchment
Average channel slope

0.21 hours
1.31 km
0.0829 m/m

Total time of concentration

0.21 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:
Storm Type:
Areal Reduction Factor
Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

Well vegetated
2
100.0%

Lag time:
23.12 minutes

2-year 1-day rainfall
Aerial rainfall

53.2 mm
53.2 mm

30min factor
2-year 30min rainfall

0.664
35.3 mm/hr

Soil retention
Initial abstraction

normal
normal

49.4 mm
4.9 mm

S = $\frac{25400}{CN} - 254$
I_a = 0.1 · S

Lagtime

SA:

L = $\frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

USA:

L = $\frac{l^{0.8}(S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A
MAP
y
I₃₀
L

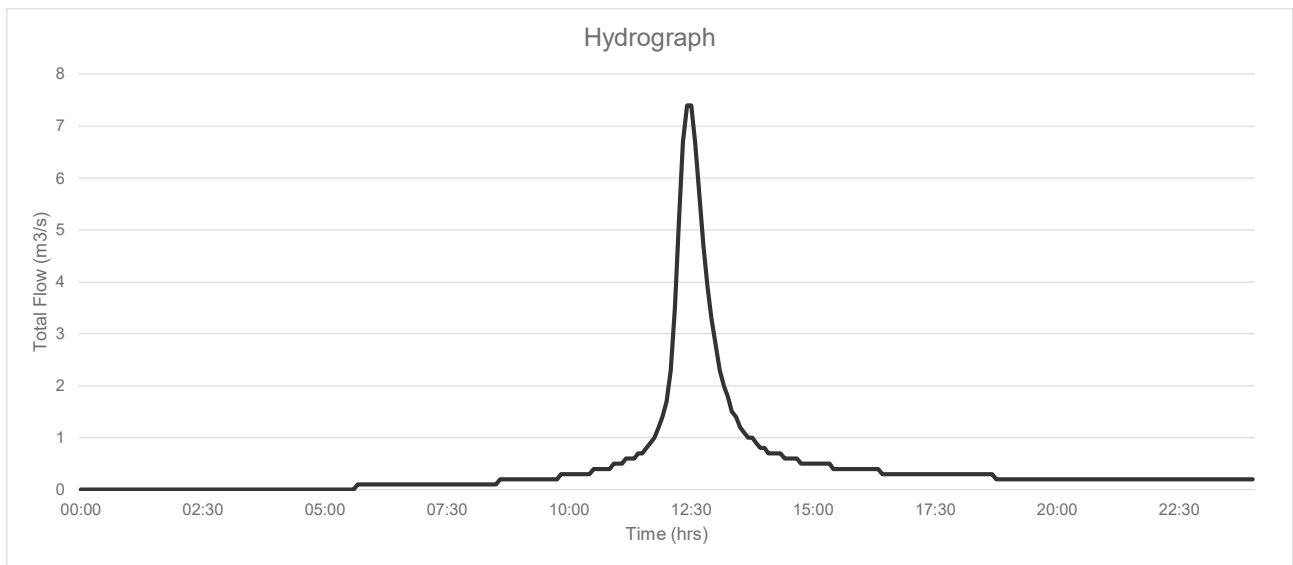
0.33 km2
549.9649 mm
9.46 %
35.3 mm/hr
0.39 hrs

where; l
S
y
L

1,310 m
49.4 mm
9.46 %
0.29 hrs

RESULTS:

100 yr Peak Flow **7.40** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No
Project Title
River

1002569
Olifant
Olifants Tributary 12

Calculated by: Wian Lombard
Date: 08/01/2025

INPUT DATA:

Catchment characteristics

Total catchment area
Length of watercourse (L)

Watercourse slope (10/85)

0.17 km²
4.15 km

0.05 m/m

Location Lat
Long

Deg
30

Min
41
Sec
44

Catchment slope:

0.07 Average slope (m/m)

INPUT DATA:

Rainfall

Mean Annual Precipitation
1-day point design rainfall (mm)

549.96 mm

ARF = 100.0%

1-day areal design rainfall (mm)

Recurrence Interval		Storm duration		
years	AEP (%)	1-day	24 hours	24 hours
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map
Gridded Curve Number:

82.16

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:
Overland flow:
Channel flow:

30%
70%
100%

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow (over fairly even and flat ground)

where;

Tc
r

L
S

Time of concentration (overland)
Roughness coefficient

Hydraulic length of catchment
Overland slope

1.40 hours
Medium grass cover
0.4
4.145963 km
0.074391 m/m

Channel flow

where;

Tc
L
S

Time of concentration (channel)
Hydraulic length of catchment
Average channel slope

0.62 hours
4.15 km
0.0519 m/m

Total time of concentration

0.85 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:
Storm Type:
Areal Reduction Factor
Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

Well vegetated
2
100.0%

----->
Lag time:

0.33 hours
19.61 minutes

2-year 1-day rainfall
Aerial rainfall

53.2 mm
53.2 mm

30min factor
2-year 30min rainfall

0.664
35.3 mm/hr

Soil retention
Initial abstraction

normal
normal

55.1 mm
5.5 mm

S = $\frac{25400}{CN} - 254$
I_a = 0.1 · S

Lagtime

SA:

L = $\frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

USA:

L = $\frac{l^{0.8}(S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A
MAP
y
I₃₀
L

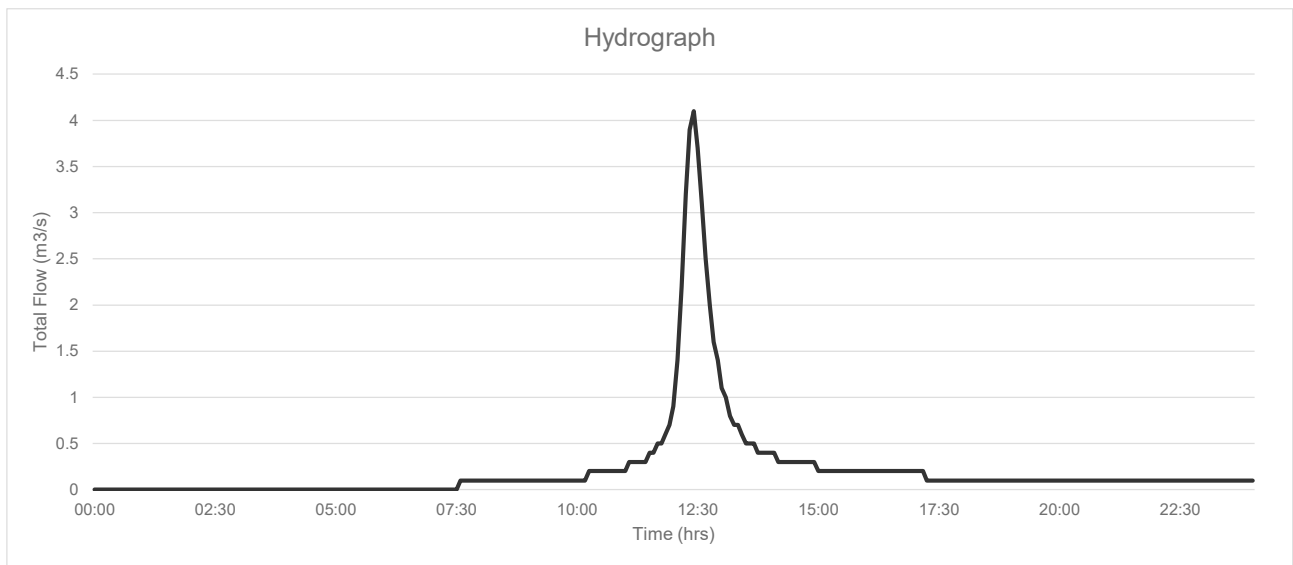
0.17 km2
549.9649 mm
7.44 %
35.3 mm/hr
0.33 hrs

where; l
S
y
L

4,146 m
55.1 mm
7.44 %
0.88 hrs

RESULTS:

100 yr Peak Flow **4.10** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No 1002569
Project Title Olifant
River Olifants Tributary 13

Calculated by: Wian Lombard
Date: 08/01/2025

INPUT DATA: Catchment characteristics

Total catchment area 0.23 km²
Length of watercourse (L) 4.84 km
Watercourse slope (10/85) 0.07 m/m

Location Lat 24
Long 30

Catchment slope: 0.10 Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation 549.96 mm
1-day point design rainfall (mm) ARF = 100.0%
1-day areal design rainfall (mm)

Recurrence Interval		Storm duration		
years	AEP (%)	1-day	24 hours	24 hours
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 84.80

CALCULATIONS: Time of concentration

Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow: 0%
Channel flow: 100%
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) 1.41 hours
r Roughness coefficient Medium grass cover 0.4
L Hydraulic length of catchment 4.839134 km
S Overland slope 0.099989 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) 0.63 hours
L Hydraulic length of catchment 4.84 km
S Average channel slope 0.0673 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration 0.63 hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: 0.33 hours
Storm Type: 2 20.07 minutes

Areal Reduction Factor 100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall 53.2 mm 30min factor 0.664
Aerial rainfall 53.2 mm 2-year 30min rainfall 35.3 mm/hr

Soil retention normal 45.5 mm $S = \frac{25400}{CN} - 254$

Initial abstraction normal 4.6 mm $I_a = 0.1 \cdot S$

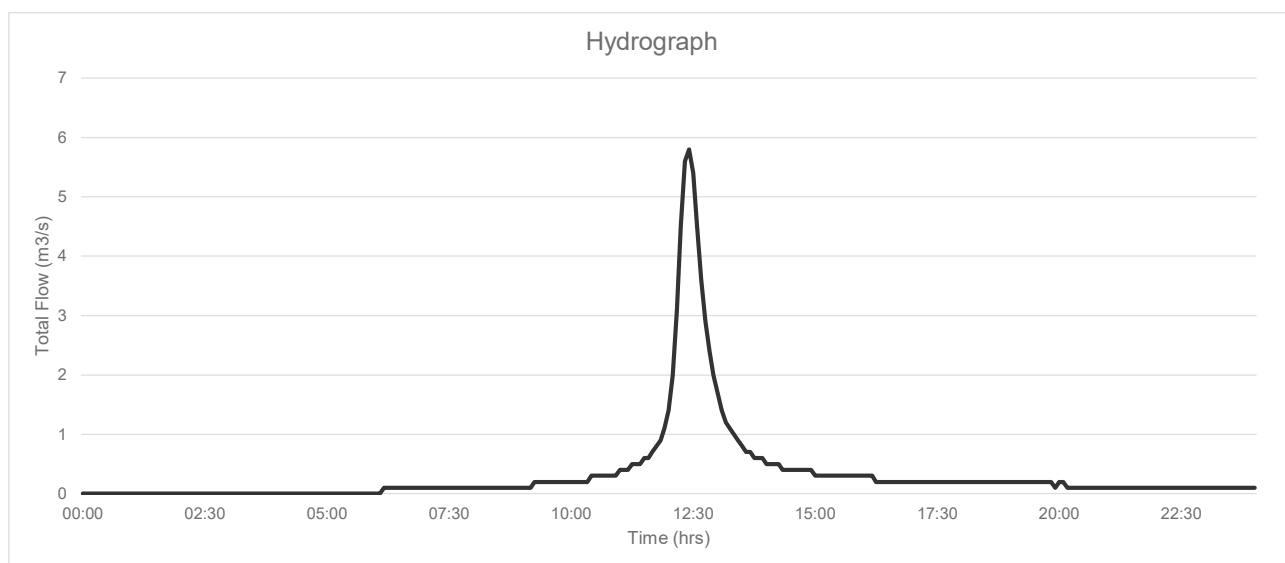
Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A 0.23 km²
MAP 549.9649 mm
y 10.00 %
I₃₀ 35.3 mm/hr
L 0.33 hrs

where; l 4.839 m
S 45.5 mm
y 10.00 %
L 0.78 hrs

RESULTS:

100 yr Peak Flow **5.80** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No Project Title River	1002569 Olifant Olifants Tributary 14	Calculated by: Wian Lombard Date: 08/01/2025
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INPUT DATA:

Catchment characteristics

Total catchment area	0.17 km ²			
Length of watercourse (L)	0.72 km	Location Lat	Deg	Min
		Long	24	41
			30	11
Watercourse slope (10/85)	0.01 m/m	Catchment slope:	0.05 Average slope (m/m)	

INPUT DATA:

Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		
years	AEP (%)	1-day	24 hours	
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:	Obtained from Soils Group map
	Gridded Curve Number: 84.68

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Overland flow: 30%
Channel flow: 70%

 100%

Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow (over fairly even and flat ground)
$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

where;
Tc Time of concentration (overland)
r Roughness coefficient
L Hydraulic length of catchment
S Overland slope

0.69 hours
Medium grass cover
0.4
0.71826 km
0.045845 m/m

Channel flow
$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

where;
Tc Time of concentration (channel)
L Hydraulic length of catchment
S Average channel slope

0.28 hours
0.72 km
0.0124 m/m

Total time of concentration

0.40 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:	Well vegetated	----->	Lag time:	0.38 hours
Storm Type:	2			22.80 minutes
Areal Reduction Factor	100.0%			

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

Soil retention normal 46.0 mm

$S = \frac{25400}{CN} - 254$

718 m

Initial abstraction normal 4.6 mm

$I_a = 0.1 \cdot S$

46.0 mm

Lagtime

SA:
$$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$$

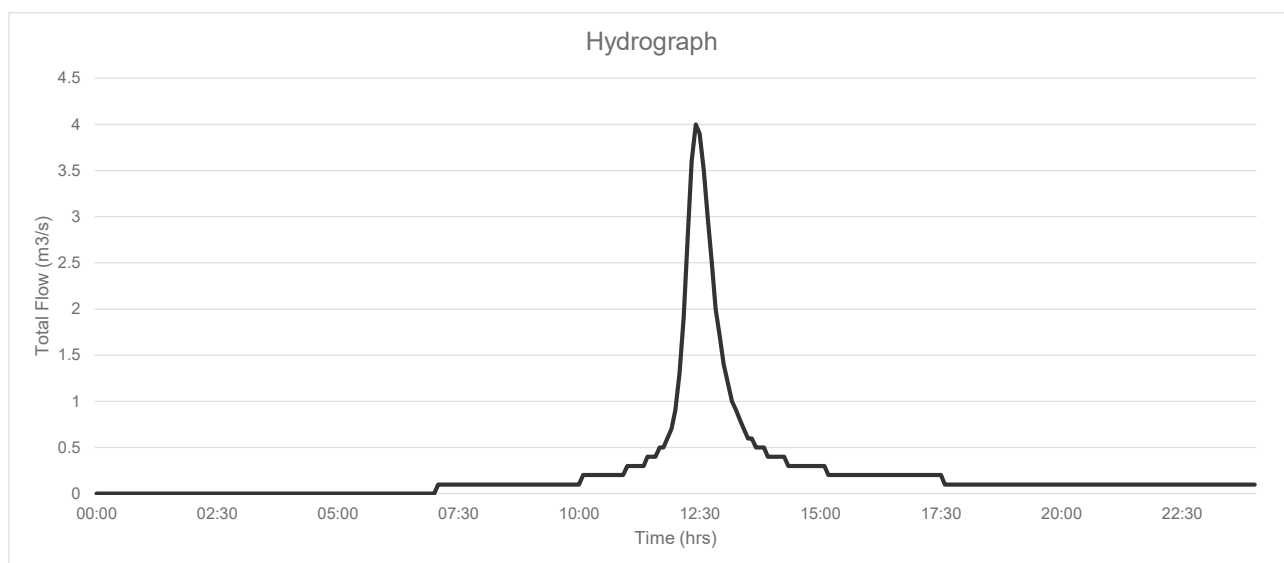
USA:
$$L = \frac{l^{0.8}(S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$$

where; A 0.17 km²
MAP 549.9649 mm
y 4.58 %
I₃₀ 35.3 mm/hr
L 0.38 hrs

where; l 718 m
S 46.0 mm
y 4.58 %
L 0.25 hrs

RESULTS:

100 yr Peak Flow **4.00** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No1002569

Project TitleOlifant

RiverPalangwe Catchment

Calculated by: Wian Lombard

Date: 08/01/2025

INPUT DATA: Catchment characteristics

Total catchment area108.64 km²

Length of watercourse (L)29.91 km

Watercourse slope (10/85)0.02 m/m

Location Lat24

Long30

Catchment slope:0.19 Average slope (m/m)

Deg24

Min41

Sec24

INPUT DATA: Rainfall

Mean Annual Precipitation549.96 mm

1-day point design rainfall (mm)

ARF = 93.6%

1-day areal design rainfall (mm)

Recurrence Interval

years

AEP (%)

Storm duration

1-day

24 hours

2yr

50%

53

64

5yr

20%

73

87

10yr

10%

87

104

20yr

5%

101

121

50yr

2%

122

146

100yr

1%

138

165

200yr

0.5%

155

185

24 hours

60

82

98

114

136

154

174

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:82.82

CALCULATIONS: Time of concentration

Percentage of longest watercourse:

Overland flow:0%

Channel flow:100%

100%

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow (over fairly even and flat ground)

where;

Tc

r

L

S

Time of concentration (overland)

Roughness coefficient

Hydraulic length of catchment

Overland slope

2.83 hours

Medium grass cover

0.4

29.91127 km

0.19275 m/m

$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$

Channel flow

where;

Tc

L

S

Time of concentration (channel)

Hydraulic length of catchment

Average channel slope

4.38 hours

29.91 km

0.0168 m/m

$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$

Total time of concentration

4.38 hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:Well vegetated

Storm Type:2

Areal Reduction Factor93.6%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall53.2 mm

Aerial rainfall49.8 mm

30min factor0.664

2-year 30min rainfall33.1 mm/hr

Soil retentionnormal

52.7 mm

$S = \frac{25400}{CN} - 254$

Initial abstractionnormal

5.3 mm

$I_a = 0.1 \cdot S$

Lagtime

SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A108.64 km²

MAP549.9649 mm

y19.28 %

I₃₀33.1 mm/hr

L2.51 hrs

where; l29,911 m

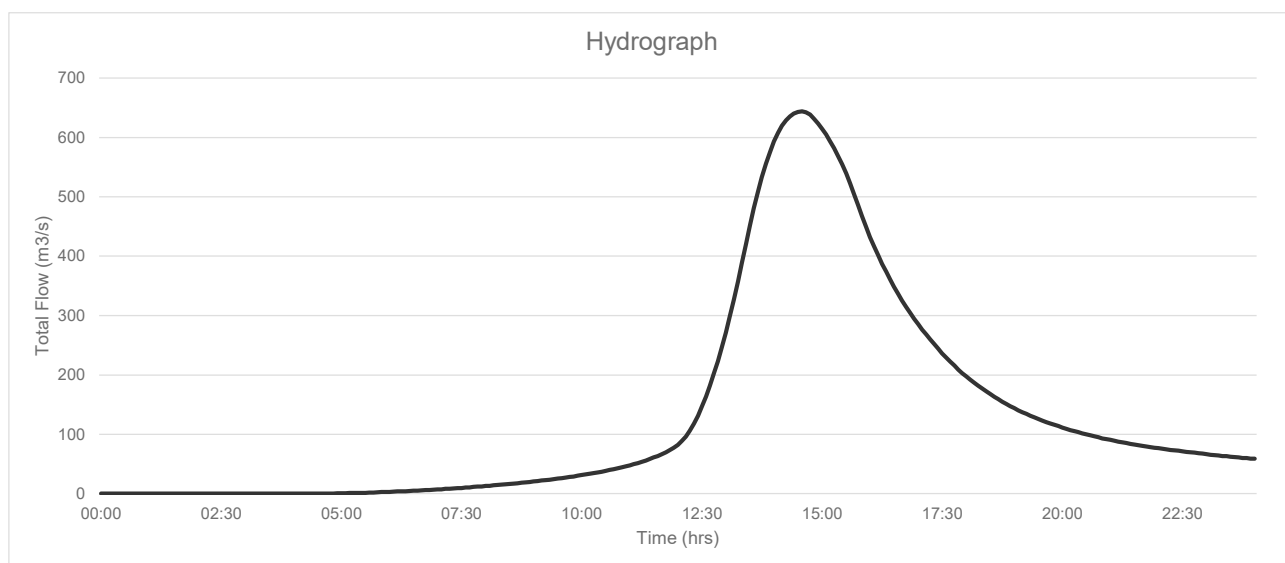
S52.7 mm

y19.28 %

L2.59 hrs

RESULTS:

100 yr Peak Flow **644.10** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
 Project Title **Olifant**
 River **Olifants Tributary 16**

Calculated by: **Wian Lombard**
 Date: **08/01/2025**

INPUT DATA: Catchment characteristics

Total catchment area **0.62** km²
 Length of watercourse (L) **2.26** km
 Watercourse slope (10/85) **0.02** m/m

Location Lat **24** Deg **41** Min **24** Sec
 Long **30** **11** **44**
 Catchment slope: **0.12** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **549.96** mm ARF = **100.0%**
 1-day point design rainfall (mm) **53** 1-day areal design rainfall (mm) **64**

Recurrence Interval		Storm duration		
years	AEP (%)	1-day	24 hours	24 hours
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: **Obtained from Soils Group map**
 Gridded Curve Number: **80.97**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: **Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%**

Overland flow: **30%**
 Channel flow: **70%**
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) **0.94** hours
 r Roughness coefficient Medium grass cover **0.4**
 L Hydraulic length of catchment **2.262198** km
 S Overland slope **0.121166** m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) **0.54** hours
 L Hydraulic length of catchment **2.26** km
 S Average channel slope **0.0217** m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration **0.66** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

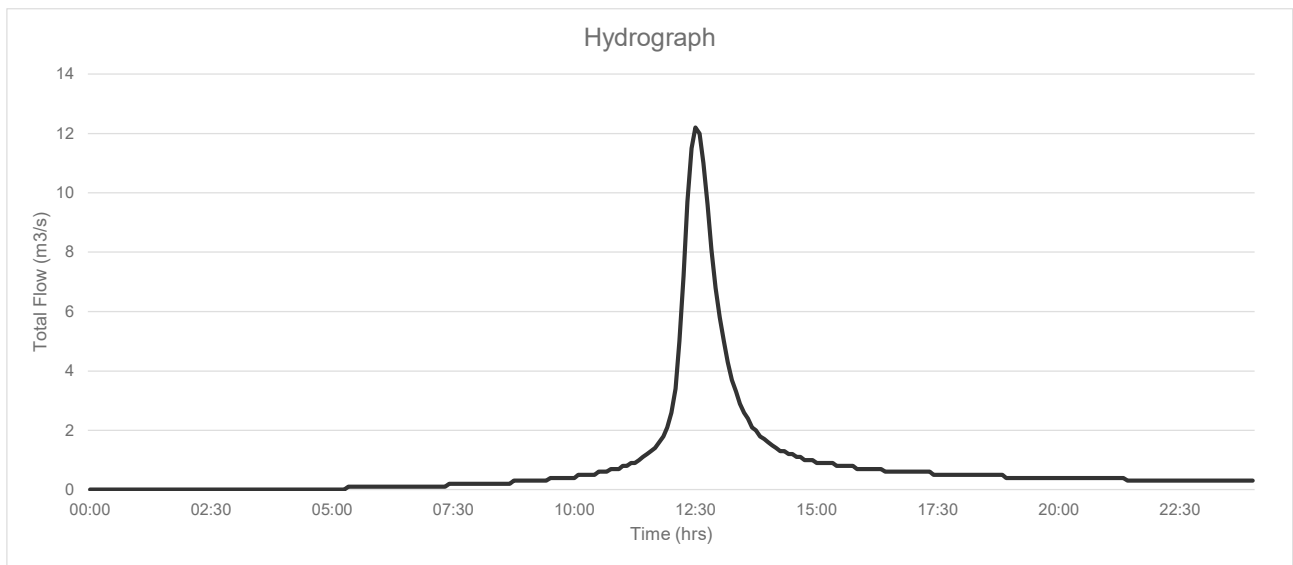
Catchment type: Well vegetated -----> Lag time: **0.45** hours
 Storm Type: **2** **26.74** minutes
 Areal Reduction Factor **100.0%**
 Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation
 2-year 1-day rainfall **53.2** mm 30min factor **0.664**
 Aerial rainfall **53.2** mm 2-year 30min rainfall **35.3** mm/hr

Soil retention normal **59.7** mm $S = \frac{25400}{CN} - 254$
 Initial abstraction normal **6.0** mm $I_a = 0.1 \cdot S$

Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$
 where; A **0.62** km² where; l **2,262** m
 MAP **549.9649** mm S **59.7** mm
 y **12.12** % y **12.12** %
 I₃₀ **35.3** mm/hr L **0.44** hrs
 L **0.45** hrs

RESULTS:

100 yr Peak Flow **12.20** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No 1002569
Project Title Olifant
River Olifants Tributary 17

Calculated by: Wian Lombard
Date: 08/01/2025

INPUT DATA: Catchment characteristics

Total catchment area 0.33 km²
Length of watercourse (L) 1.92 km
Watercourse slope (10/85) 0.03 m/m

Location Lat 24
Long 30

Catchment slope: 0.15 Average slope (m/m)

Deg 24
Min 41
Sec 24

INPUT DATA: Rainfall

Mean Annual Precipitation 549.96 mm
1-day point design rainfall (mm) 100.0%
1-day areal design rainfall (mm) ARF = 100.0%

Recurrence Interval		Storm duration	
years	AEP (%)	1-day	24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 80.18

CALCULATIONS: Time of concentration

Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow: 30%
Channel flow: 70%
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) 0.83 hours
r Roughness coefficient Medium grass cover 0.4
L Hydraulic length of catchment 1.917224 km
S Overland slope 0.151963 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) 0.42 hours
L Hydraulic length of catchment 1.92 km
S Average channel slope 0.0299 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration 0.54 hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: 0.34 hours
Storm Type: 2 20.13 minutes

Areal Reduction Factor 100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall 53.2 mm 30min factor 0.664
Aerial rainfall 53.2 mm 2-year 30min rainfall 35.3 mm/hr

Soil retention normal 62.8 mm $S = \frac{25400}{CN} - 254$

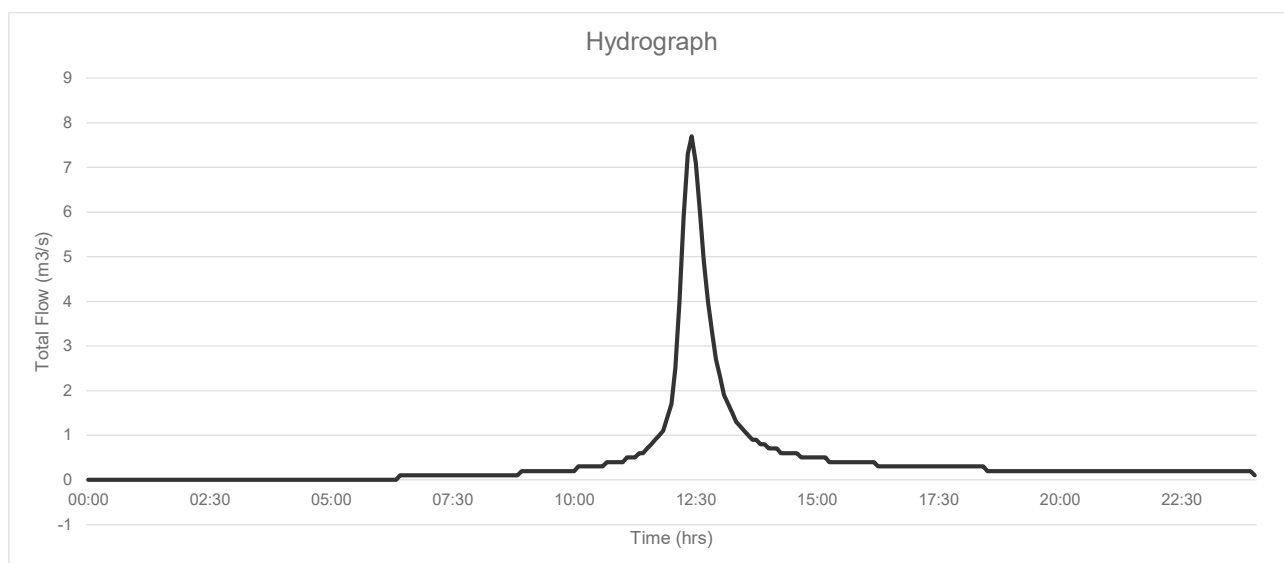
Initial abstraction normal 6.3 mm $I_a = 0.1 \cdot S$

Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A 0.33 km² where; l 1.917 m
MAP 549.9649 mm S 62.8 mm
y 15.20 % y 15.20 %
I₃₀ 35.3 mm/hr L 0.35 hrs
L 0.34 hrs

RESULTS:

100 yr Peak Flow **7.70** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No 1002569
Project Title Olifant
River Olifants Tributary 18

Calculated by: Wian Lombard
Date: 08/01/2025

INPUT DATA: Catchment characteristics

Total catchment area 0.15 km²
Length of watercourse (L) 1.07 km
Watercourse slope (10/85) 0.03 m/m

Location Lat 24
Long 30
Catchment slope: 0.12 Average slope (m/m)

Deg 24
Min 41
Sec 24

INPUT DATA: Rainfall

Mean Annual Precipitation 549.96 mm
1-day point design rainfall (mm) ARF = 100.0%
1-day areal design rainfall (mm)

Recurrence Interval		Storm duration		
years	AEP (%)	1-day	24 hours	24 hours
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 65.72

CALCULATIONS: Time of concentration

Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow: 30%
Channel flow: 70%
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) 0.66 hours
r Roughness coefficient Medium grass cover 0.4
L Hydraulic length of catchment 1.06614 km
S Overland slope 0.124136 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) 0.26 hours
L Hydraulic length of catchment 1.07 km
S Average channel slope 0.0334 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration 0.38 hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: 0.27 hours
Storm Type: 2 16.06 minutes
Areal Reduction Factor 100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall 53.2 mm 30min factor 0.664
Aerial rainfall 53.2 mm 2-year 30min rainfall 35.3 mm/hr

Soil retention normal 132.5 mm $S = \frac{25400}{CN} - 254$

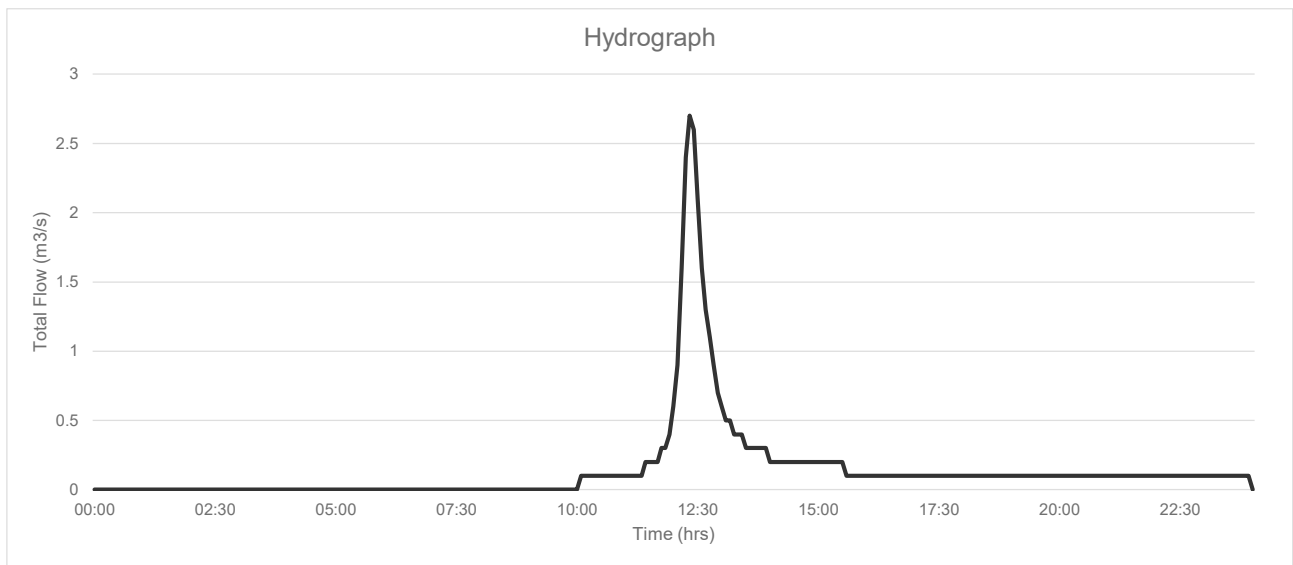
Initial abstraction normal 13.3 mm $I_a = 0.1 \cdot S$

Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A 0.15 km² where; l 1.066 m
MAP 549.9649 mm S 132.5 mm
y 12.41 % y 12.41 %
I₃₀ 35.3 mm/hr L 0.37 hrs
L 0.27 hrs

RESULTS:

100 yr Peak Flow **2.70** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
 Project Title **Olifant**
 River **Monametsi Tributary 1**

Calculated by: **Wian Lombard**
 Date: **08/01/2025**

INPUT DATA: Catchment characteristics

Total catchment area **0.34** km²
 Length of watercourse (L) **1.11** km
Watercourse slope (10/85) **0.09** m/m
 Location Lat **24** Deg **41** Min **24** Sec
 Long **30** **11** **44**
Catchment slope: **0.17** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **549.96** mm ARF = **100.0%**
 1-day point design rainfall (mm) 1-day areal design rainfall (mm)

Recurrence Interval years	AEP (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
 Gridded Curve Number: **70.48**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow: 0%
 Channel flow: 100%
 100%

Overland flow (over fairly even and flat ground) where; Tc Time of concentration (overland) **0.63** hours
 r Roughness coefficient Medium grass cover **0.4**

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$
 L Hydraulic length of catchment **1.106434** km
 S Overland slope **0.166347** m/m

Channel flow where; Tc Time of concentration (channel) **0.18** hours
 L Hydraulic length of catchment **1.106434** km
 S Average channel slope **0.0858** m/m

Total time of concentration **0.18** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: **0.33** hours
Storm Type: 2 19.84 minutes

Areal Reduction Factor 100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall **53.2** mm 30min factor **0.664**
 Aerial rainfall **53.2** mm 2-year 30min rainfall **35.3** mm/hr

Soil retention normal **106.4** mm $S = \frac{25400}{CN} - 254$

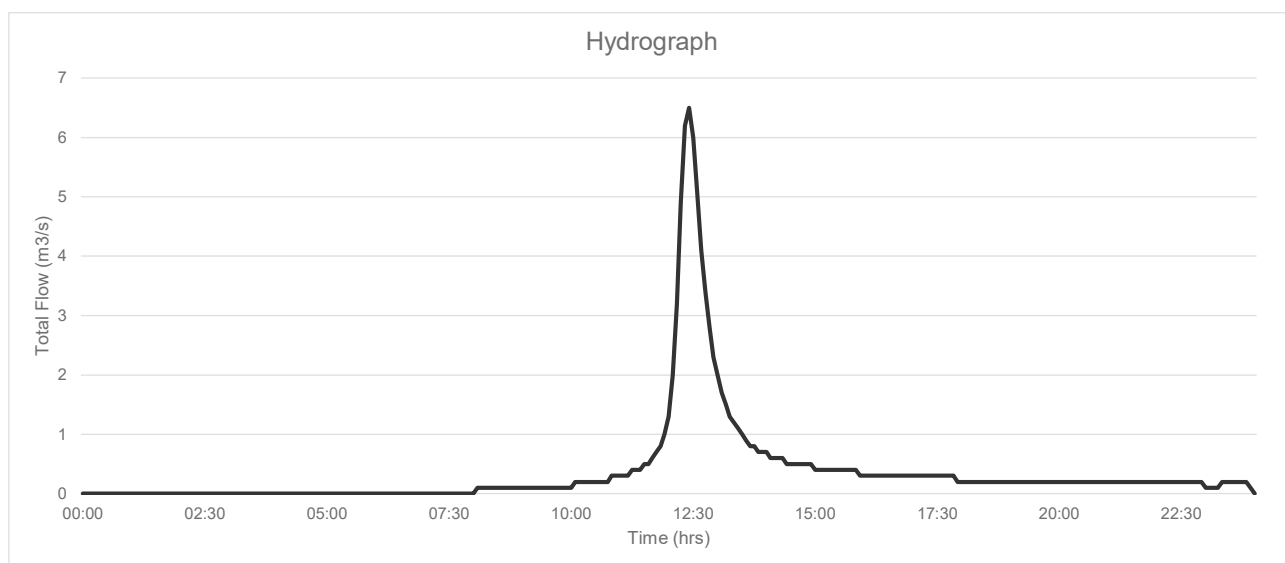
Initial abstraction normal **10.6** mm $I_a = 0.1 \cdot S$

Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{I^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A **0.34** km² where; I **1,106** m
 MAP **549.9649** mm S **106.4** mm
 y **16.63** % y **16.63** %
 I₃₀ **35.3** mm/hr L **0.29** hrs
 L **0.33** hrs

RESULTS:

100 yr Peak Flow **6.50** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No 1002569
Project Title Olifant
River Monametsi Tributary 2

Calculated by: Wian Lombard
Date: 08/01/2025

INPUT DATA: Catchment characteristics

Total catchment area 0.63 km²
Length of watercourse (L) 1.17 km
Watercourse slope (10/85) 0.10 m/m

Location Lat 24
Long 30
Catchment slope: 0.16 Average slope (m/m)

Deg 24
Min 41
Sec 24

INPUT DATA: Rainfall

Mean Annual Precipitation 549.96 mm
1-day point design rainfall (mm) 100.0%
1-day areal design rainfall (mm) ARF = 100.0%

Recurrence Interval years	AEP (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 79.95

CALCULATIONS: Time of concentration

Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow: 0%
Channel flow: 100%
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) 0.65 hours
r Roughness coefficient Medium grass cover 0.4
L Hydraulic length of catchment 1.167538 km
S Overland slope 0.164136 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) 0.18 hours
L Hydraulic length of catchment 1.167538 km
S Average channel slope 0.1031 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration 0.18 hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: 0.41 hours
Storm Type: 2 24.59 minutes
Areal Reduction Factor 100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall 53.2 mm 30min factor 0.664
Aerial rainfall 53.2 mm 2-year 30min rainfall 35.3 mm/hr

Soil retention normal 63.7 mm $S = \frac{25400}{CN} - 254$

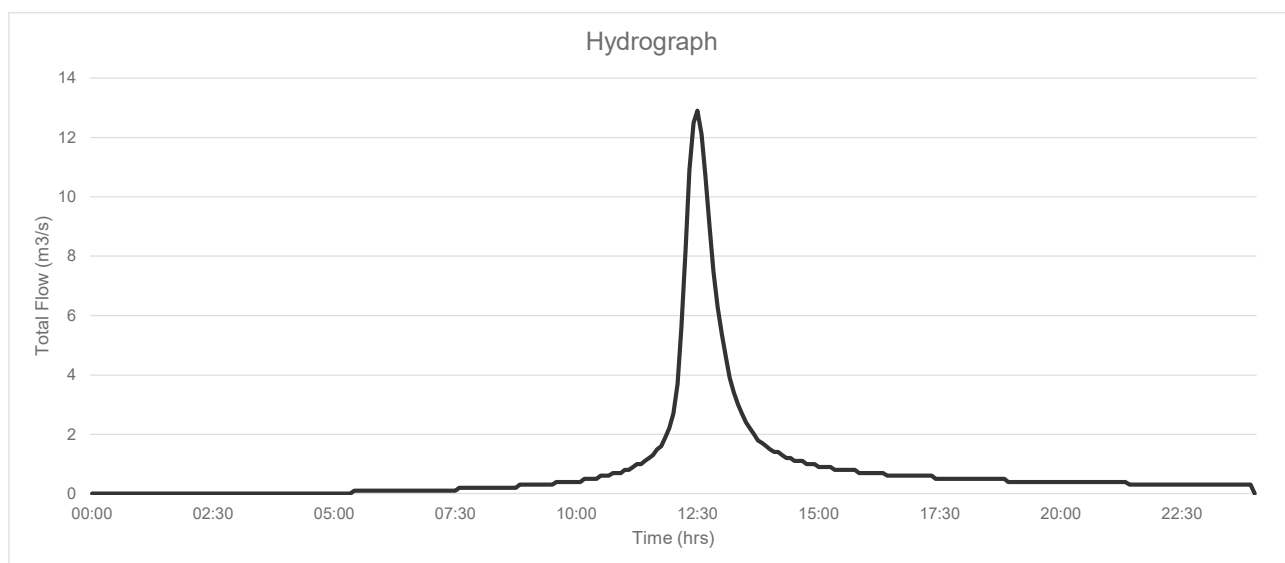
Initial abstraction normal 6.4 mm $I_a = 0.1 \cdot S$

Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A 0.63 km² where; l 1.168 m
MAP 549.9649 mm S 63.7 mm
y 16.41 % y 16.41 %
I₃₀ 35.3 mm/hr L 0.23 hrs
L 0.41 hrs

RESULTS:

100 yr Peak Flow **12.90** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Wian Lombard
Project Title	Olifant	Date: 08/01/2025
River	Monametsi Tributary 3	

INPUT DATA:	Catchment characteristics
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Total catchment area	0.22 km ²			
Length of watercourse (L)	0.81 km	Location Lat	24	24
		Long	30	44
<u>Watercourse slope (10/85)</u>	0.02 m/m	<u>Catchment slope:</u>	0.07	Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA:	Landuse and Runoff Curve Number (CN) coefficients
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Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 61.82

CALCULATIONS:	Time of concentration
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Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow:	30%
Channel flow:	70%
	100%

<u>Overland flow (over fairly even and flat ground)</u>	where;	Tc	Time of concentration (overland)	0.66 hours
$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$		r	Roughness coefficient	Medium grass cover 0.4
		L	Hydraulic length of catchment	0.811111 km
		S	Overland slope	0.074204 m/m

[illegible]

$T_c = \left(\frac{0.87 \cdot L^2}{g} \right)^{0.385}$	where;	t_c	Time of concentration (channel)	0.25 hours
		L	Hydraulic length of catchment	0.811111 km
		g	Gravitational acceleration	9.80665 m/s ²

τ_c	$(1000 \cdot S_{av})$	S	Average channel slope	0.0201 m/m
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Total time of concentration	0.37 hours
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CALCULATIONS:	Catchment response
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For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

<u>Catchment type:</u>	Well vegetated	----->	Lag time:	0.36 hours
Storm Type:	2			21.65 minutes

Areal Reduction Factor	100.0%
Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation	

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

Soil retention	normal	156.8 mm	$S = \frac{25400}{CN} - 254$
Initial abstraction	normal	15.7 mm	$I = 0.1 \cdot S$

$$t_a = 0.1 \pm 0.5$$
$$\text{SA: } l = \frac{A^{0.35} MAP^{1.1}}{25.4} \quad \text{USA: } l = \frac{l^{0.8} (S + 25.4)^{0.7}}{25.4}$$

$$41.67 \cdot y^{0.3} I_{30min}^{0.87} \quad - \quad 7069 \cdot y^{0.5}$$

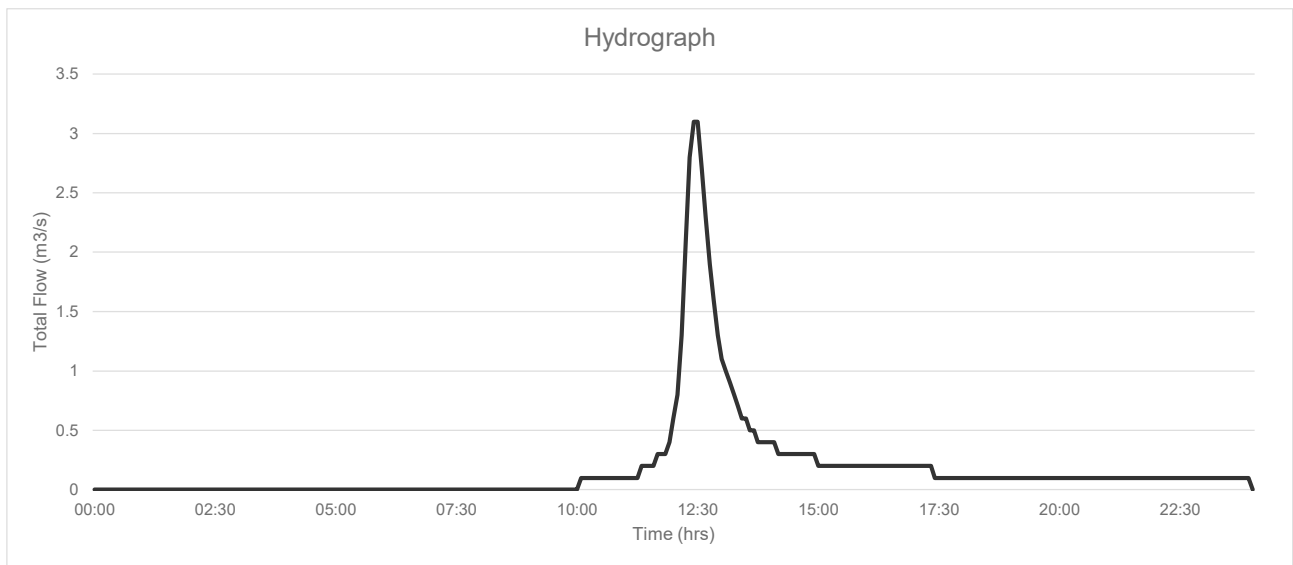
where; A	0.22 km ²	where; l	811 m
MAP	549.9649 mm	S	156.8 mm

y	7.42 %	y	7.42 %
I_{30}	35.3 mm/hr	L	0.42 hrs
I	0.36 hrs		

0.00 hrs	
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RESULTS:

100 yr Peak Flow **3.10** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
Project Title **Olifant**
River **Monametsi Tributary 4**

Calculated by: **Wian Lombard**
Date: **08/01/2025**

INPUT DATA: Catchment characteristics

Total catchment area **4.31** km²
Length of watercourse (L) **3.94** km
Watercourse slope (10/85) **0.11** m/m

Location Lat **24** Deg
Long **30** Min
Catchment slope: **0.27** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **549.96** mm
1-day point design rainfall (mm) **ARF = 100.0%**
1-day areal design rainfall (mm)

Recurrence Interval		Storm duration	
years	AEP (%)	1-day	24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: **Obtained from Soils Group map**
Gridded Curve Number: **78.17**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: **Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%**

Overland flow: **0%**
Channel flow: **100%**
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) **1.01** hours
 $T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$ r Roughness coefficient Medium grass cover **0.4**
 L Hydraulic length of catchment **3.940647** km
 S Overland slope **0.270508** m/m

Channel flow where; T_c Time of concentration (channel) **0.45** hours
 $T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$ L Hydraulic length of catchment **3.940647** km
 S Average channel slope **0.1074** m/m

Total time of concentration **0.45** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: **0.69** hours
Storm Type: **2** 41.53 minutes

Areal Reduction Factor **100.0%**

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall **53.2** mm 30min factor **0.664**
Aerial rainfall **53.2** mm 2-year 30min rainfall **35.3** mm/hr

Soil retention normal **70.9** mm $S = \frac{25400}{CN} - 254$

Initial abstraction normal **7.1** mm $I_a = 0.1 \cdot S$

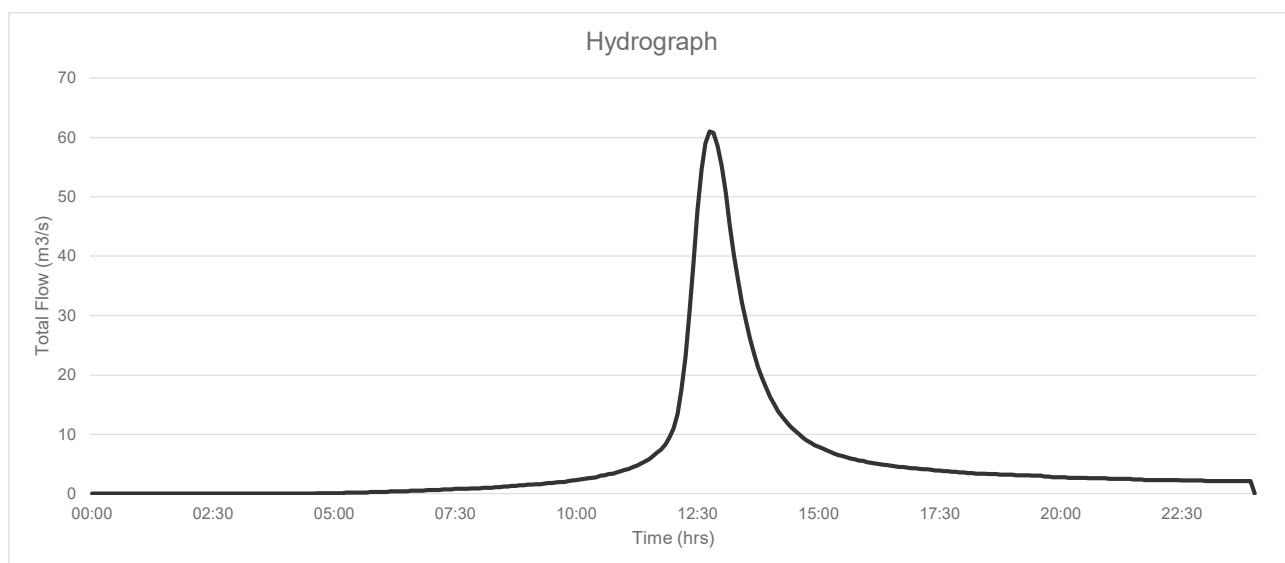
Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A **4.31** km²
MAP **549.9649** mm
y **27.05** %
 I_{30} **35.3** mm/hr
L **0.69** hrs

where; l **3.941** m
S **70.9** mm
y **27.05** %
L **0.50** hrs

RESULTS:

100 yr Peak Flow **61.00** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No
Project Title
River

1002569
Olifant
Monametsi Tributary 5

Calculated by: Wian Lombard
Date: 08/01/2025

INPUT DATA:

Catchment characteristics

Total catchment area
Length of watercourse (L)

Watercourse slope (10/85)

2.85 km²
3.15 km

0.16 m/m

Location Lat
Long

24
30

Deg
Min
Sec

41
11
44

Catchment slope:
Average slope (m/m)

0.32

INPUT DATA:

Rainfall

Mean Annual Precipitation
1-day point design rainfall (mm)

549.96 mm

ARF = 100.0%

1-day areal design rainfall (mm)

Recurrence Interval years	AEP (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map
Gridded Curve Number:

83.23

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:
Overland flow:
Channel flow:

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%
0%
100%
100%

Overland flow (over fairly even and flat ground)

where;

Tc
r

L
S

Time of concentration (overland)
Roughness coefficient

Hydraulic length of catchment
Overland slope

0.88 hours
Medium grass cover
0.4
3.145612 km
0.321098 m/m

Channel flow

where;

Tc
L
S

Time of concentration (channel)
Hydraulic length of catchment
Average channel slope

0.32 hours
3.145612 km
0.1601 m/m

Total time of concentration

0.32 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:
Storm Type:
Areal Reduction Factor
Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

Well vegetated
2
100.0%

Lag time:
34.13 minutes

2-year 1-day rainfall
Aerial rainfall

53.2 mm
53.2 mm

30min factor
2-year 30min rainfall

0.664
35.3 mm/hr

Soil retention
Initial abstraction

normal
normal

51.2 mm
5.1 mm

S = $\frac{25400}{CN} - 254$
I_a = 0.1 · S

Lagtime

SA:

L = $\frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

USA:

L = $\frac{l^{0.8}(S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A
MAP
y
I₃₀
L

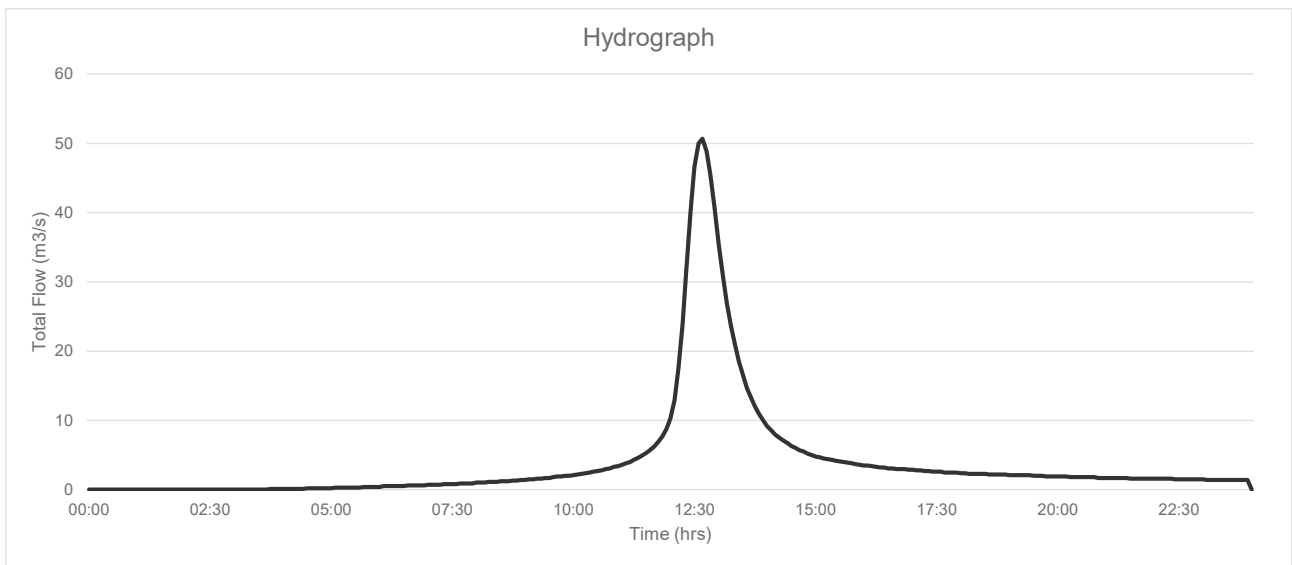
2.85 km2
549.9649 mm
32.11 %
35.3 mm/hr
0.57 hrs

where; l
S
y
L

3,146 m
51.2 mm
32.11 %
0.33 hrs

RESULTS:

100 yr Peak Flow **50.70** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No1002569

Project TitleOlifant

RiverMonametsi Tributary 6

Calculated by: Wian Lombard

Date: 08/01/2025

INPUT DATA:

Catchment characteristics

Total catchment area3.44 km²

Length of watercourse (L)3.08 km

Watercourse slope (10/85)0.12 m/m

Location Lat24

Long30

Catchment slope:0.29

Deg24

Min41

Sec24

Average slope (m/m)44

INPUT DATA:

Rainfall

Mean Annual Precipitation549.96 mm

1-day point design rainfall (mm)

ARF = 100.0%

1-day areal design rainfall (mm)

Recurrence Interval years	AEP (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:82.38

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Overland flow:0%

Channel flow:100%

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow (over fairly even and flat ground)

where;

Tc

r

L

S

Time of concentration (overland)

Roughness coefficient

Hydraulic length of catchment

Overland slope

0.89 hours

Medium grass cover

0.4

3.083037 km

0.294893 m/m

Channel flow

where;

Tc

L

S

Time of concentration (channel)

Hydraulic length of catchment

Average channel slope

0.36 hours

3.083037 km

0.1191 m/m

Total time of concentration

0.36 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:Well vegetated

Storm Type:2

Areal Reduction Factor100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

Lag time:0.62 hours

37.41 minutes

2-year 1-day rainfall53.2 mm

Aerial rainfall53.2 mm

30min factor0.664

2-year 30min rainfall35.3 mm/hr

Soil retentionnormal

Initial abstractionnormal

54.3 mm

5.4 mm

$S = \frac{25400}{CN} - 254$

$I_a = 0.1 \cdot S$

Lagtime

SA:

USA:

$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

$L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A3.44 km2

MAP549.9649 mm

y29.49 %

I3035.3 mm/hr

L0.62 hrs

where; l3.083 m

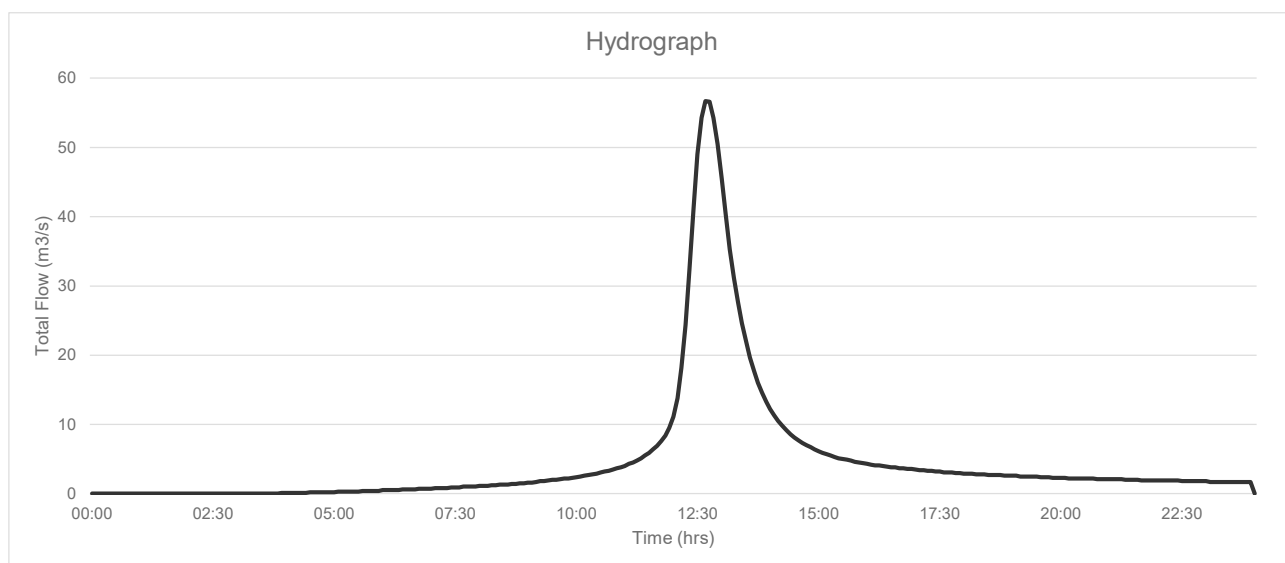
S54.3 mm

y29.49 %

L0.35 hrs

RESULTS:

100 yr Peak Flow **56.70** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No 1002569
Project Title Olifant
River Monametsi Tributary 7

Calculated by: Wian Lombard
Date: 08/01/2025

INPUT DATA: Catchment characteristics

Total catchment area 0.65 km²
Length of watercourse (L) 1.70 km
Watercourse slope (10/85) 0.06 m/m

Location Lat 24
Long 30
Catchment slope: 0.14 Average slope (m/m)

Deg 24
Min 41
Sec 24

INPUT DATA: Rainfall

Mean Annual Precipitation 549.96 mm
1-day point design rainfall (mm) 100.0%
1-day areal design rainfall (mm) ARF = 100.0%

Recurrence Interval		Storm duration	
years	AEP (%)	1-day	24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 78.96

CALCULATIONS: Time of concentration

Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow: 0%
Channel flow: 100%
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) 0.80 hours
r Roughness coefficient Medium grass cover 0.4
L Hydraulic length of catchment 1.700057 km
S Overland slope 0.138836 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) 0.29 hours
L Hydraulic length of catchment 1.700057 km
S Average channel slope 0.0610 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration 0.29 hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: 0.43 hours
Storm Type: 2 26.10 minutes

Areal Reduction Factor 100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall 53.2 mm 30min factor 0.664
Aerial rainfall 53.2 mm 2-year 30min rainfall 35.3 mm/hr

Soil retention normal 67.7 mm $S = \frac{25400}{CN} - 254$

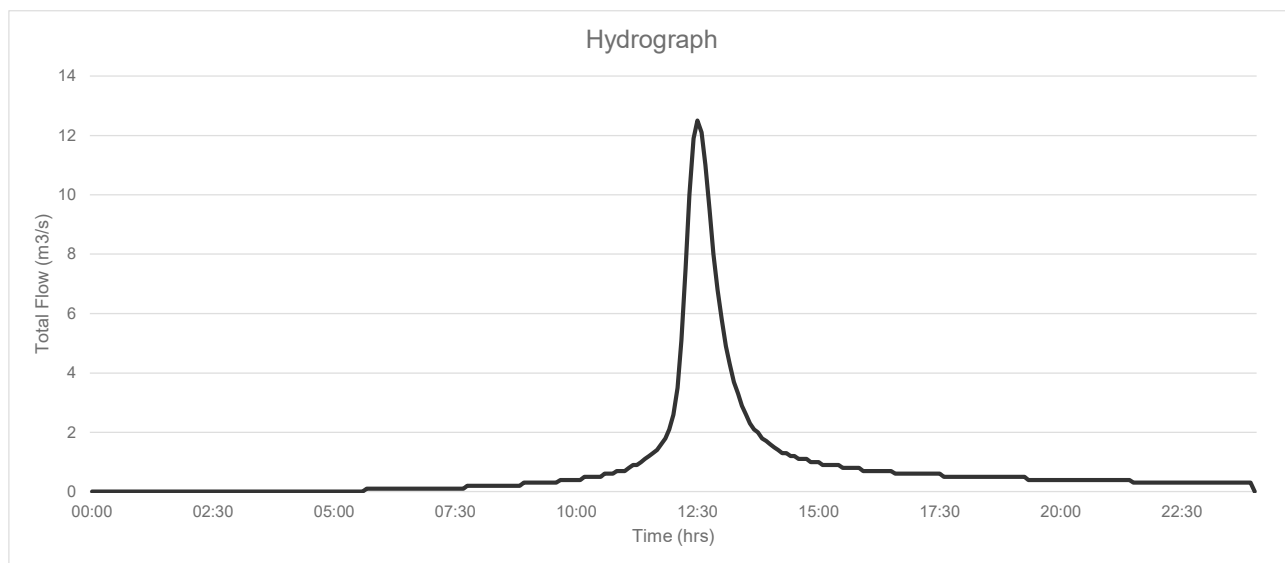
Initial abstraction normal 6.8 mm $I_a = 0.1 \cdot S$

Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A 0.65 km² where; l 1,700 m
MAP 549.9649 mm S 67.7 mm
y 13.88 % y 13.88 %
I₃₀ 35.3 mm/hr L 0.35 hrs
L 0.43 hrs

RESULTS:

100 yr Peak Flow **12.50** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No 1002569
Project Title Olifant
River Monametsi Tributary 8

Calculated by: Wian Lombard
Date: 08/01/2025

INPUT DATA: Catchment characteristics

Total catchment area 1.40 km²
Length of watercourse (L) 2.25 km
Watercourse slope (10/85) 0.17 m/m

Location Lat 24
Long 30

Catchment slope: 0.33 Average slope (m/m)

Deg 24
Min 41
Sec 24

INPUT DATA: Rainfall

Mean Annual Precipitation 549.96 mm
1-day point design rainfall (mm) 100.0%
1-day areal design rainfall (mm) ARF = 100.0%

Recurrence Interval years	AEP (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 82.27

CALCULATIONS: Time of concentration

Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow: 0%
Channel flow: 100%
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) 0.74 hours
r Roughness coefficient Medium grass cover 0.4
L Hydraulic length of catchment 2.247205 km
S Overland slope 0.32923 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) 0.24 hours
L Hydraulic length of catchment 2.247205 km
S Average channel slope 0.1731 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration 0.24 hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: 0.44 hours
Storm Type: 2 26.38 minutes

Areal Reduction Factor 100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall 53.2 mm 30min factor 0.664
Aerial rainfall 53.2 mm 2-year 30min rainfall 35.3 mm/hr

Soil retention normal 54.8 mm $S = \frac{25400}{CN} - 254$

Initial abstraction normal 5.5 mm $I_a = 0.1 \cdot S$

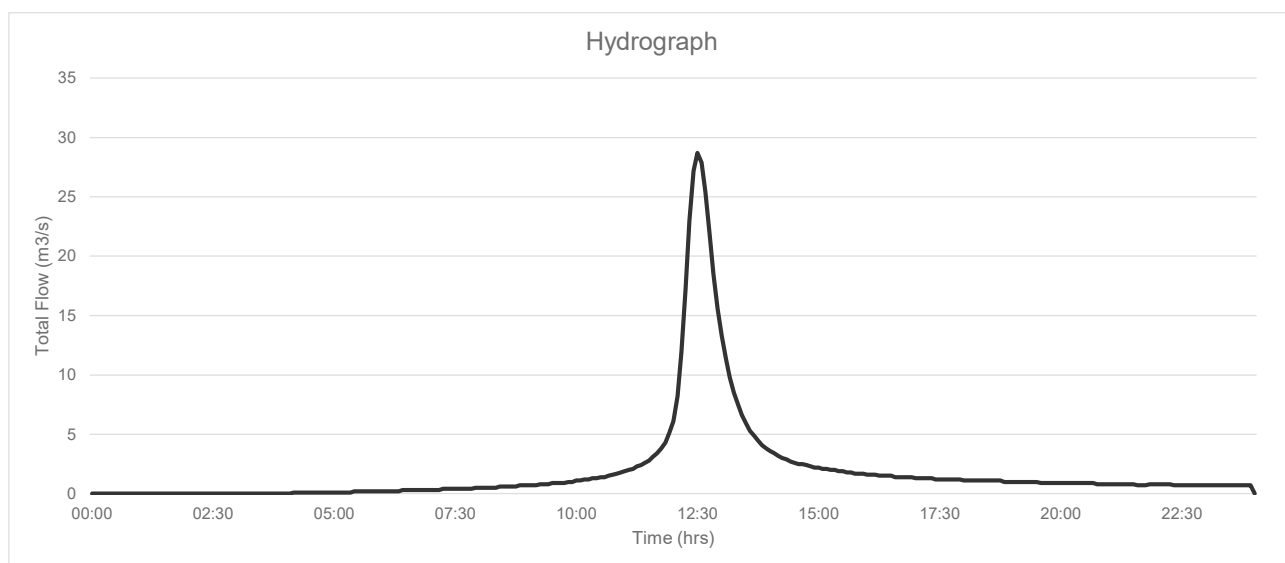
Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A 1.40 km²
MAP 549.9649 mm
y 32.92 %
I₃₀ 35.3 mm/hr
L 0.44 hrs

where; l 2.247 m
S 54.8 mm
y 32.92 %
L 0.25 hrs

RESULTS:

100 yr Peak Flow **28.70** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Wian Lombard
Project Title	Olifant	Date: 08/01/2025
River	Monametsi Tributary 9	

INPUT DATA:	Catchment characteristics
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Total catchment area	0.83 km ²			
Length of watercourse (L)	1.55 km	Location Lat	24	41
		Long	30	11
<u>Watercourse slope (10/85)</u>	0.10 m/m	<u>Catchment slope:</u>	0.26	Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA:	Landuse and Runoff Curve Number (CN) coefficients
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Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 80.50

CALCULATIONS:	Time of concentration
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Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:	0%
Channel flow:	100%
	100%

<u>Overland flow (over fairly even and flat ground)</u>	where;	T _c	Time of concentration (overland)	0.66 hours
$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$		r	Roughness coefficient	Medium grass cover 0.4
		L	Hydraulic length of catchment	1.553641 km
		S	Overland slope	0.262135 m/m

S	Overland slope	0.262135 m/m
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Channel flow				
$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$	where;	Tc	Time of concentration (channel)	0.22 hours
		L	Hydraulic length of catchment	1.553641 km
		S	Average channel slope	0.1037 m/m

Total time of concentration	0.22 hours
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CALCULATIONS:	Catchment response
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For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

<u>Catchment type:</u>	Well vegetated	----->	Lag time:	0.39 hours
Storm Type:	2			23.57 minutes

Areal Reduction Factor	100.0%
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Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

<u>Soil retention</u>	normal	61.5 mm	$S = \frac{25400}{CN} - 254$
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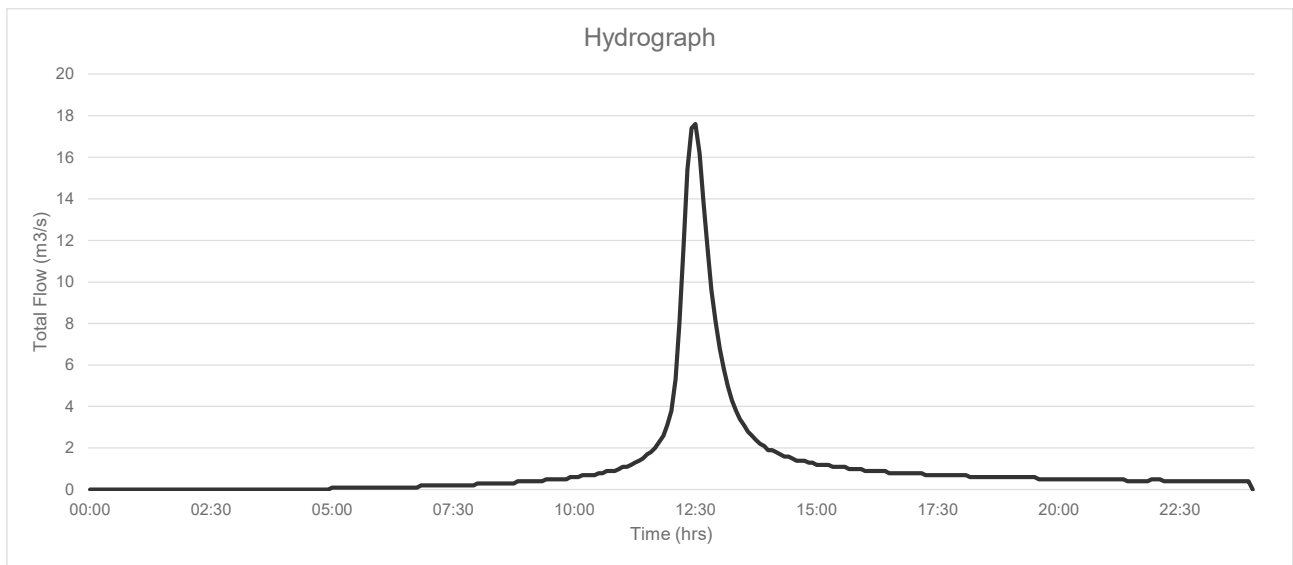
<u>Initial abstraction</u>	normal	6.2 mm	$I_a = 0.1 \cdot S$
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<u>Lagtime</u>	SA:	$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{20min}^{0.87}}$	USA:	$L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$
----------------	-----	---	------	---

where; A		where; I	
MAP	0.83 km ²	S	1,554 m
y	549.9649 mm	y	61.5 mm
I ₃₀	26.21 %	L	26.21 %
L	35.3 mm/hr		0.22 hrs
	0.39 hrs		

RESULTS:

100 yr Peak Flow **17.60** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Wian Lombard
Project Title	Olifant	Date: 08/01/2025
River	Monametsi Tributary 10	

INPUT DATA:	Catchment characteristics
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Total catchment area	2.90 km ²			
Length of watercourse (L)	2.63 km	Location Lat	24	41
		Long	30	11
<u>Watercourse slope (10/85)</u>	0.13 m/m	<u>Catchment slope:</u>	0.32	Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA:	Landuse and Runoff Curve Number (CN) coefficients
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Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 81.86

Gridded Curve Number: 81.86

CALCULATIONS:	Time of concentration
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Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow:	0%
Channel flow:	100%
	<u>100%</u>

Overland flow (over fairly even and flat ground) where: T_c Time of concentration (overland) 0.81 hours

$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$	r	Roughness coefficient	Medium grass cover 0.4
	L	Hydraulic length of catchment	2.625933 km

S	Overland slope	0.316788 m/m
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Channel flow

$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$	where;	Tc	Time of concentration (channel)	0.31 hours
		L	Hydraulic length of catchment	2.625933 km
		S	Average channel slope	0.1303 m/m

Total time of concentration	0.31 hours
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CALCULATIONS: Catchment response	
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For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: 0.57 hours

Storm Type:	2	34.49 minutes
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<u>Areal Reduction Factor</u>	100.0%
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Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

Soil retention	normal	56.3 mm	6	25400	354
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$$S = \frac{CN}{254}$$

<u>Initial abstraction</u>	normal	5.6 mm	$I_a = 0.1 \cdot S$
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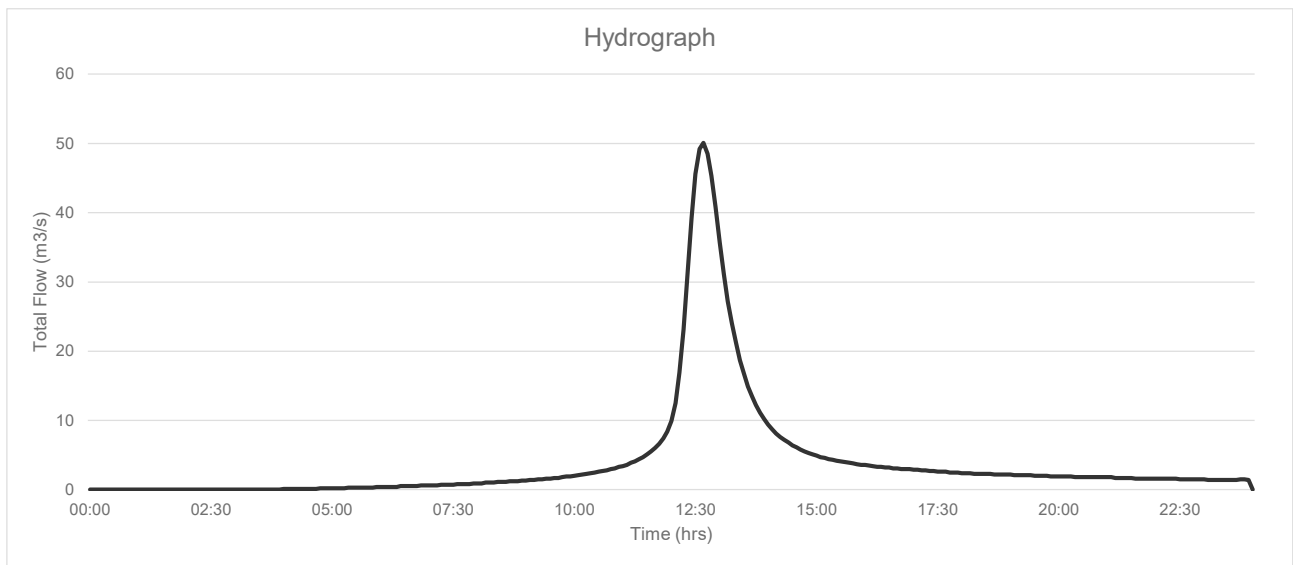
Lagtime	40.35 M 4 D 1.1	70.8 (S 1 25 A) 0.7
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$$\text{SA: } L = \frac{A \cdot \text{MAP}}{41.67 \cdot \gamma^{0.3} /_{20\text{min}}^{0.87}} \quad \text{USA: } L = \frac{t^{0.75} (3 + 25.4)}{7069 \cdot \gamma^{0.5}}$$

where; A	2.90 km ²	where; I	2,626 m
MAP	549.9649 mm	S	56.3 mm
y	31.68 %	y	31.68 %
I ₃₀	35.3 mm/hr	L	0.30 hrs
L	0.57 hrs		

RESULTS:

100 yr Peak Flow **50.10** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Monametsi Tributary 11

Calculated by: Wian Lombard

Date: 08/01/2025

INPUT DATA:

Catchment characteristics

Total catchment area

0.48 km²

Length of watercourse (L)

1.96 km

Watercourse slope (10/85)

0.03 m/m

Location

Lat

24

Long

30

Catchment slope:

0.04

Average slope (m/m)

INPUT DATA:

Rainfall

Mean Annual Precipitation

549.96 mm

ARF =

100.0%

1-day point design rainfall (mm)

1-day areal design rainfall (mm)

Recurrence Interval	Storm duration	
years	1-day	24 hours
2yr	50%	53
5yr	20%	73
10yr	10%	87
20yr	5%	101
50yr	2%	122
100yr	1%	138
200yr	0.5%	155

24 hours
64
87
104
121
146
165
185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

78.88

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Overland flow:

Channel flow:

100%

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

1.18 hours

r

Roughness coefficient

Medium grass cover

0.4

L

Hydraulic length of catchment

1.959995 km

S

Overland slope

0.035432 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow

where;

Tc

Time of concentration (channel)

0.45 hours

L

Hydraulic length of catchment

1.959995 km

S

Average channel slope

0.0268 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration

0.67 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

----->

Lag time:

0.59 hours

Storm Type:

2

35.33 minutes

Areal Reduction Factor

100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

Soil retention

normal

68.0 mm

S = $\frac{25400}{CN} - 254$

Initial abstraction

normal

6.8 mm

I_a = 0.1 · S

Lagtime

SA:

L = $\frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

USA:

L = $\frac{I^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A

0.48 km2

where; I

1,960 m

MAP

549.9649 mm

S

68.0 mm

y

3.54 %

y

3.54 %

I₃₀

35.3 mm/hr

L

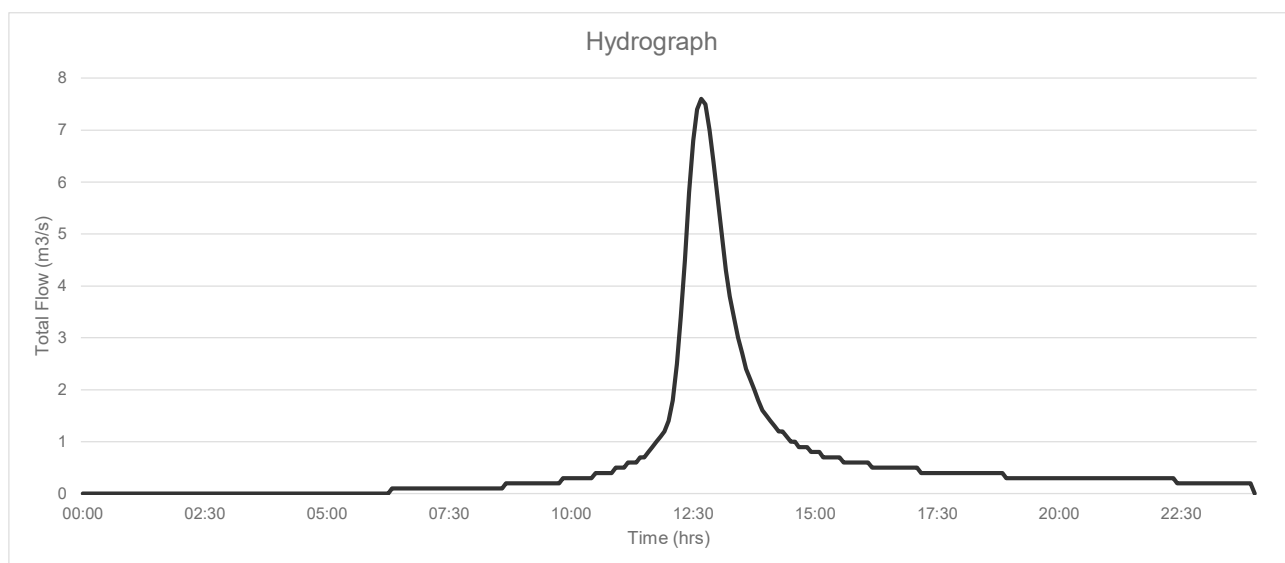
0.59 hrs

L

0.77 hrs

RESULTS:

100 yr Peak Flow **7.60** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
 Project Title **Olifant**
 River **Monametsi Tributary 12**

Calculated by: **Wian Lombard**
 Date: **08/01/2025**

INPUT DATA: Catchment characteristics

Total catchment area **2.80** km²
 Length of watercourse (L) **2.53** km
 Watercourse slope (10/85) **0.15** m/m

Location Lat **24** Deg
 Long **30** Min
44 Sec
 Catchment slope: **0.24** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **549.96** mm
 1-day point design rainfall (mm) **ARF = 100.0%**
 1-day areal design rainfall (mm)

Recurrence Interval		Storm duration		
years	AEP (%)	1-day	24 hours	24 hours
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: **Obtained from Soils Group map**
 Gridded Curve Number: **83.37**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: **Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%**

Overland flow: **0%**
 Channel flow: **100%**
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) **0.84** hours
 r Roughness coefficient Medium grass cover **0.4**
 L Hydraulic length of catchment **2.533438** km
 S Overland slope **0.244365** m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) **0.28** hours
 L Hydraulic length of catchment **2.533438** km
 S Average channel slope **0.1485** m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration **0.28** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: **0.61** hours
 Storm Type: **2** **36.82** minutes
 Areal Reduction Factor **100.0%**

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall **53.2** mm 30min factor **0.664**
 Aerial rainfall **53.2** mm 2-year 30min rainfall **35.3** mm/hr

Soil retention normal **50.7** mm $S = \frac{25400}{CN} - 254$

Initial abstraction normal **5.1** mm $I_a = 0.1 \cdot S$

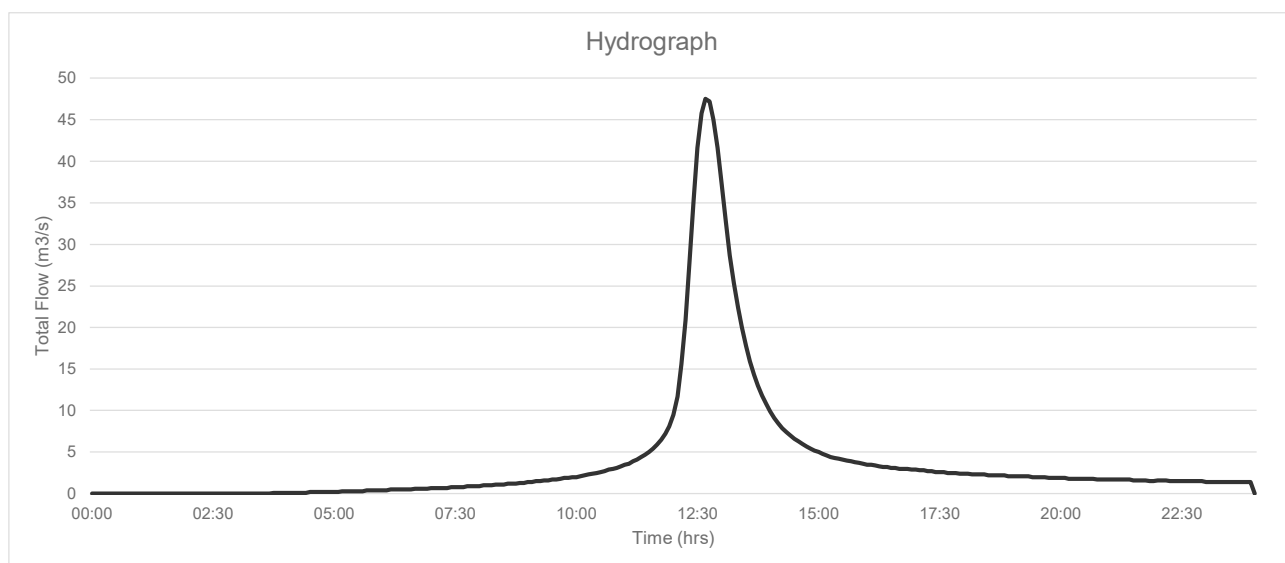
Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A **2.80** km²
 MAP **549.9649** mm
 y **24.44** %
 I_{30} **35.3** mm/hr
 L **0.61** hrs

where; l **2.533** m
 S **50.7** mm
 y **24.44** %
 L **0.31** hrs

RESULTS:

100 yr Peak Flow **47.50** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No1002569

Project TitleOlifant

RiverMonametsi Tributary 13

Calculated by: Wian Lombard

Date: 08/01/2025

INPUT DATA:

Catchment characteristics

Total catchment area2.03 km²

Length of watercourse (L)2.73 km

Watercourse slope (10/85)0.19 m/m

Location Lat24

Long30

Catchment slope:0.31

Deg24

Min41

Sec24

Average slope (m/m)44

INPUT DATA:

Rainfall

Mean Annual Precipitation549.96 mm

1-day point design rainfall (mm)

ARF = 100.0%

1-day areal design rainfall (mm)

Recurrence Interval	Storm duration
years	1-day24 hours
2yr	50%5364
5yr	20%7387
10yr	10%87104
20yr	5%101121
50yr	2%122146
100yr	1%138165
200yr	0.5%155185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:80.58

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Overland flow:0%

Channel flow:100%

100%

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

0.83 hours

$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}}\right)^{0.467}$

r

Roughness coefficient

Medium grass cover

0.4

L

Hydraulic length of catchment

2.733608 km

S

Overland slope

0.306341 m/m

Channel flow

where;

Tc

Time of concentration (channel)

0.27 hours

$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}}\right)^{0.385}$

L

Hydraulic length of catchment

2.733608 km

S

Average channel slope

0.1914 m/m

Total time of concentration

0.27 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:Well vegetated

Storm Type:2

Areal Reduction Factor100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

Lag time:0.51 hours

30.75 minutes

2-year 1-day rainfall53.2 mm

Aerial rainfall53.2 mm

30min factor0.664

2-year 30min rainfall35.3 mm/hr

Soil retentionnormal

61.2 mm

$S = \frac{25400}{CN} - 254$

Initial abstractionnormal

6.1 mm

$I_a = 0.1 \cdot S$

Lagtime

SA:

$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

USA:

$L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A2.03 km²

MAP549.9649 mm

y30.63 %

I₃₀35.3 mm/hr

L0.51 hrs

where; l2.734 m

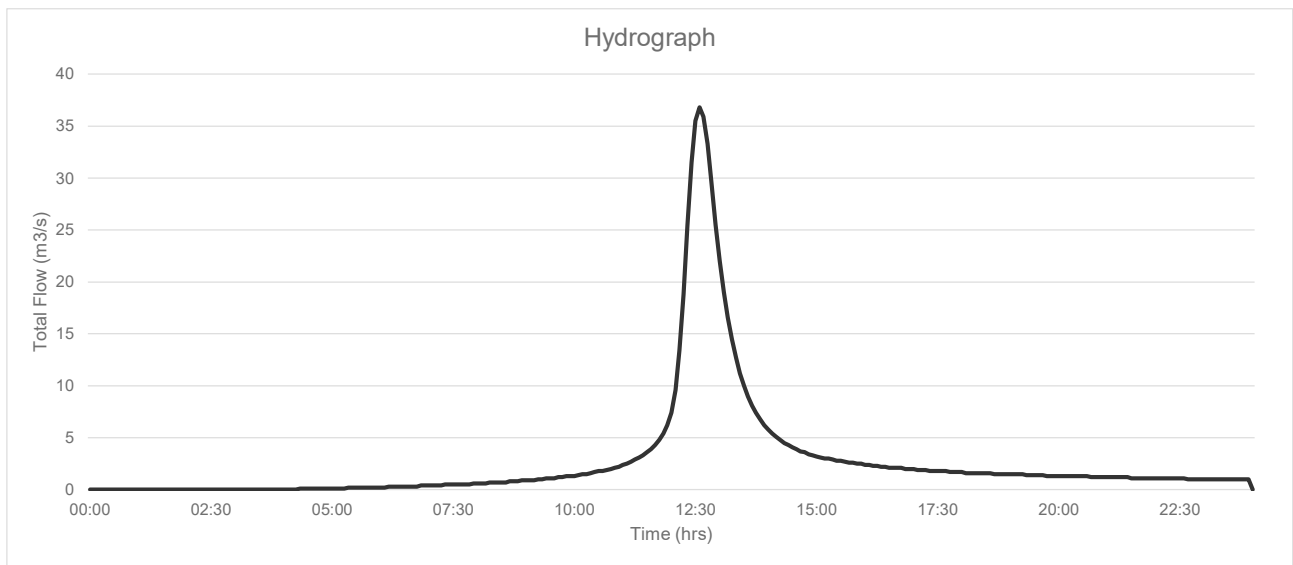
S61.2 mm

y30.63 %

L0.33 hrs

RESULTS:

100 yr Peak Flow **36.80** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Wian Lombard
Project Title	Olifant	Date: 08/01/2025
River	Monametsi Tributary 14	

INPUT DATA:	Catchment characteristics
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Total catchment area	1.35 km ²			
Length of watercourse (L)	2.14 km	Location Lat	24	41
		Long	30	11
<u>Watercourse slope (10/85)</u>	0.26 m/m	<u>Catchment slope:</u>	0.35	Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	53	64	64
5yr	20%	73	87	87
10yr	10%	87	104	104
20yr	5%	101	121	121
50yr	2%	122	146	146
100yr	1%	138	165	165
200yr	0.5%	155	185	185

INPUT DATA:	Landuse and Runoff Curve Number (CN) coefficients
--------------------	---

Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 80.82

CALCULATIONS:	Time of concentration
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Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow:	0%
Channel flow:	100%
	100%

<u>Overland flow (over fairly even and flat ground)</u>	where;	T _c	Time of concentration (overland)	0.72 hours
$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$		r	Roughness coefficient	Medium grass cover 0.4
		L	Hydraulic length of catchment	2.136022 km
		S	Overland slope	0.346727 m/m

<u>Channel flow</u>	98%
---------------------	-----

$T_c = \left(\frac{0.87 \cdot L^2}{C} \right)^{0.385}$	where;	T_c	Time of concentration (channel)	0.20 hours
		L	Hydraulic length of catchment	2.136022 km
		C	Channel roughness coefficient	0.0573 s/m ^{1/3}

$\tau_c = (1000 \cdot S_{av})$	S	Average channel slope	0.25/6 m/m
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Total time of concentration	0.20 hours
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CALCULATIONS:	Catchment response
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For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

<u>Catchment type:</u>	Well vegetated	----->	Lag time:	0.43 hours
Storm Type:	2			25.66 minutes

Areal Reduction Factor	100.0%
Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation	

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

Soil retention	normal	60.3 mm	$S = \frac{25400}{CN} - 254$
Initial abstraction	normal	6.0 mm	$I_a = 0.1 \cdot S$

$$t_a = 0.1 \pm 0.5$$
$$\text{SA: } l = \frac{A^{0.35} MAP^{1.1}}{25.4} \quad \text{USA: } l = \frac{l^{0.8} (S + 25.4)^{0.7}}{25.4}$$

$$41.67 \cdot y^{0.3} I_{30min}^{0.87} \quad - \quad 7069 \cdot y^{0.5}$$

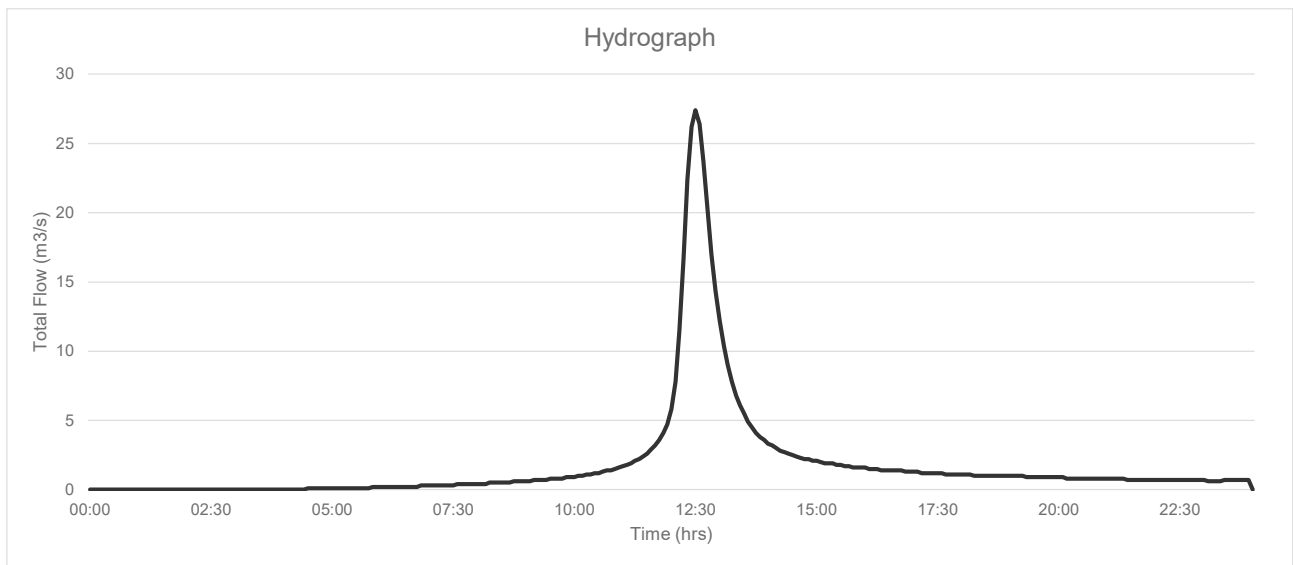
where; A	1.35 km2	where; l	2,136 m
MAP	549.9649 mm	S	60.3 mm

y	34.67 %	y	34.67 %
I ₃₀	35.3 mm/hr	L	0.25 hrs
I	0.43 hrs		

$\frac{1}{2} \times 0.45 \text{ m/s}$ $\frac{1}{2} \times 0.45 \text{ m/s}$	$\frac{1}{2} \times 0.45 \text{ m/s}$ $\frac{1}{2} \times 0.45 \text{ m/s}$
---	---

RESULTS:

100 yr Peak Flow **27.40** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Calculated by: Wian Lombard

Project Title

Olifant

Date: 08/01/2025

River

Monametsi Tributary 15

INPUT DATA:

Catchment characteristics

Total catchment area

0.42 km²

Length of watercourse (L)

1.42 km

Watercourse slope (10/85)

0.21 m/m

Location

Lat

24

Long

30

Catchment slope:

0.29 Average slope (m/m)

Deg

24

Min

41

Sec

24

INPUT DATA:

Rainfall

Mean Annual Precipitation

549.96 mm

ARF =

100.0%

1-day point design rainfall (mm)

1-day areal design rainfall (mm)

Recurrence Interval	Storm duration	
years	1-day	24 hours
2yr	53	64
5yr	73	87
10yr	87	104
20yr	101	121
50yr	122	146
100yr	138	165
200yr	155	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

82.31

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Overland flow:

Channel flow:

0%

100%

100%

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

0.62 hours

r

Roughness coefficient

Medium grass cover

0.4

L

Hydraulic length of catchment

1.423337 km

S

Overland slope

0.29493 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow

where;

Tc

Time of concentration (channel)

0.16 hours

L

Hydraulic length of catchment

1.423337 km

S

Average channel slope

0.2062 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration

0.16 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

----->

Lag time:

0.30 hours

Storm Type:

2

17.98 minutes

Areal Reduction Factor

100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

Soil retention

normal

54.6 mm

$S = \frac{25400}{CN} - 254$

Initial abstraction

normal

5.5 mm

$I_a = 0.1 \cdot S$

Lagtime

SA:

$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

USA:

$L = \frac{I^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A

0.42 km2

where; I

1,423 m

MAP

549.9649 mm

S

54.6 mm

y

29.49 %

y

29.49 %

I₃₀

35.3 mm/hr

L

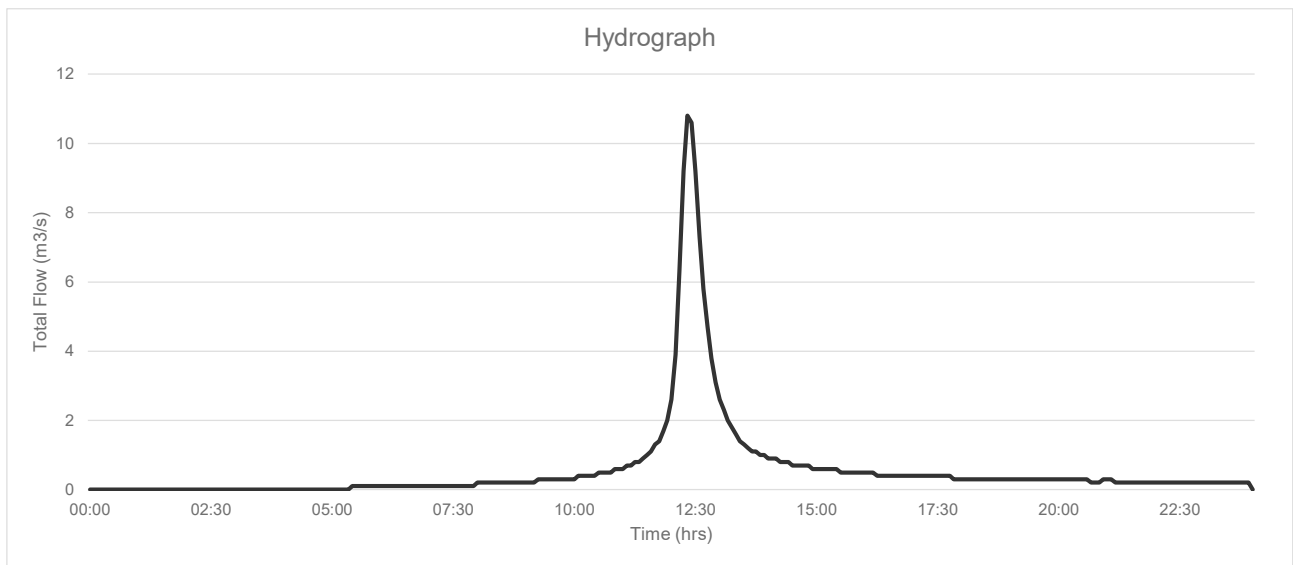
0.19 hrs

L

0.30 hrs

RESULTS:

100 yr Peak Flow **10.80** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Monametsi Tributary 16

Calculated by: Wian Lombard

Date: 08/01/2025

INPUT DATA:

Catchment characteristics

Total catchment area

0.88 km²

Length of watercourse (L)

2.17 km

Watercourse slope (10/85)

0.15 m/m

Location

Lat

24

Long

30

Catchment slope:

0.24 Average slope (m/m)

Deg

24

Min

41

Sec

24

INPUT DATA:

Rainfall

Mean Annual Precipitation

549.96 mm

ARF =

100.0%

1-day point design rainfall (mm)

1-day areal design rainfall (mm)

Recurrence Interval years	AEP (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

82.77

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Overland flow:

Channel flow:

0%

100%

100%

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

0.79 hours

r

Roughness coefficient

Medium grass cover

0.4

L

Hydraulic length of catchment

2.170985 km

S

Overland slope

0.241548 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow

where;

Tc

Time of concentration (channel)

0.25 hours

L

Hydraulic length of catchment

2.170985 km

S

Average channel slope

0.1549 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration

0.25 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

----->

Lag time:

0.41 hours

Storm Type:

2

24.66 minutes

Areal Reduction Factor

100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall

53.2 mm

30min factor

0.664

Aerial rainfall

53.2 mm

2-year 30min rainfall

35.3 mm/hr

Soil retention

normal

52.9 mm

$$S = \frac{25400}{CN} - 254$$

Initial abstraction

normal

5.3 mm

$$I_a = 0.1 \cdot S$$

Lagtime

SA:

$$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$$

USA:

$$L = \frac{I^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$$

where; A

0.88 km2

where; I

2,171 m

MAP

549.9649 mm

S

52.9 mm

y

24.15 %

y

35.3 mm/hr

L

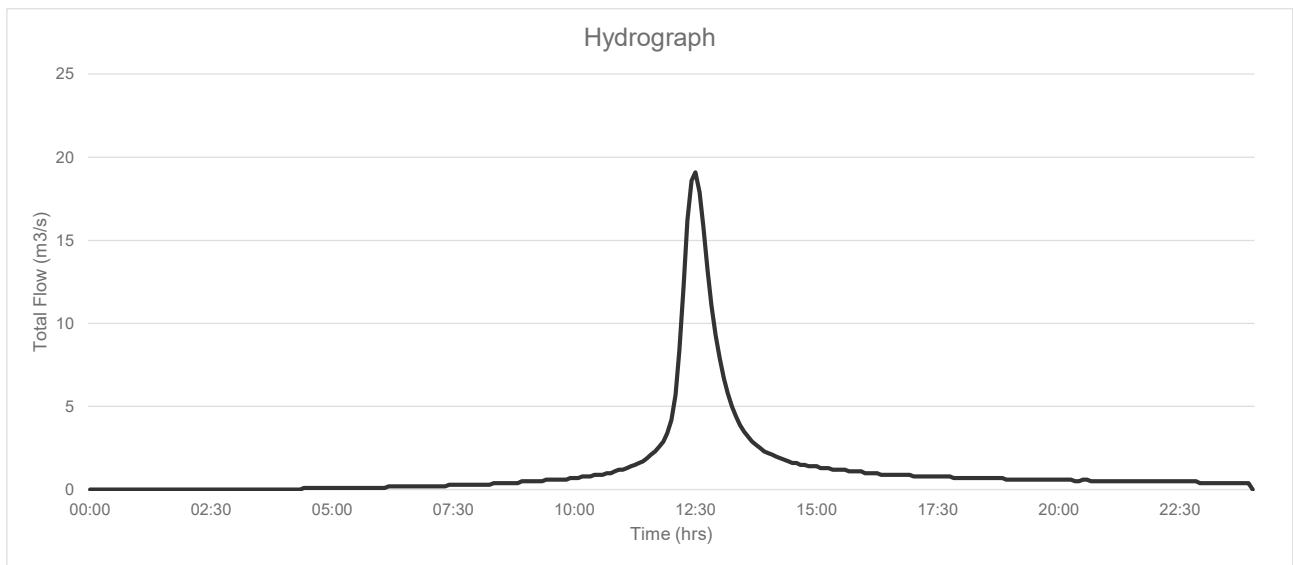
0.41 hrs

L

0.28 hrs

RESULTS:

100 yr Peak Flow **19.10** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No
Project Title
River

1002569
Olifant
Monametsi Tributary 17

Calculated by: Wian Lombard
Date: 08/01/2025

INPUT DATA:

Catchment characteristics

Total catchment area
Length of watercourse (L)

Watercourse slope (10/85)

0.45 km²
0.94 km

0.03 m/m

Location Lat
Long

24
30

Deg
Min
Sec

41
11
44

Catchment slope:
Average slope (m/m)

0.14

INPUT DATA:

Rainfall

Mean Annual Precipitation
1-day point design rainfall (mm)

549.96 mm

ARF = 100.0%

1-day areal design rainfall (mm)

Recurrence Interval years	AEP (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map
Gridded Curve Number:

81.58

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:
Overland flow:
Channel flow:

30%
70%
100%

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow (over fairly even and flat ground)

where;

Tc
r

L
S

Time of concentration (overland)
Roughness coefficient

Hydraulic length of catchment
Overland slope

0.61 hours
Medium grass cover
0.4
0.942345 km
0.136068 m/m

Channel flow

where;

Tc
L
S

Time of concentration (channel)
Hydraulic length of catchment
Average channel slope

0.25 hours
0.942345 km
0.0290 m/m

Total time of concentration

0.36 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:
Storm Type:
Areal Reduction Factor
Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

Well vegetated
2
100.0%

Lag time:
23.19 minutes

2-year 1-day rainfall
Aerial rainfall

53.2 mm
53.2 mm

30min factor
2-year 30min rainfall

0.664
35.3 mm/hr

Soil retention
Initial abstraction

normal
normal

57.4 mm
5.7 mm

S = $\frac{25400}{CN} - 254$
I_a = 0.1 · S

Lagtime

SA:

L = $\frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

USA:

L = $\frac{l^{0.8}(S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A
MAP
y
I₃₀
L

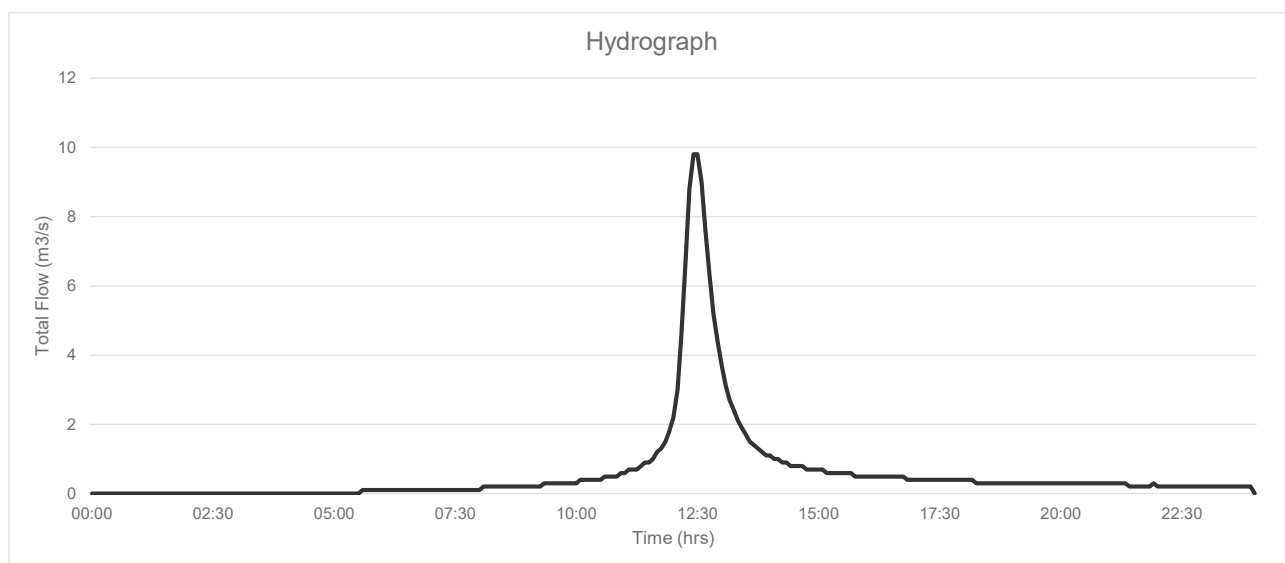
0.45 km2
549.9649 mm
13.61 %
35.3 mm/hr
0.39 hrs

where; l
S
y
L

942 m
57.4 mm
13.61 %
0.20 hrs

RESULTS:

100 yr Peak Flow **9.80** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Monametsi Tributary 18

Calculated by: Wian Lombard

Date: 08/01/2025

INPUT DATA:

Catchment characteristics

Total catchment area

1.97 km²

Length of watercourse (L)

2.47 km

Watercourse slope (10/85)

0.24 m/m

Location Lat

24

Long

30

Catchment slope:

0.32 Average slope (m/m)

Deg

24

Min

41

Sec

24

INPUT DATA:

Rainfall

Mean Annual Precipitation

549.96 mm

1-day point design rainfall (mm)

ARF = 100.0%

1-day areal design rainfall (mm)

Recurrence Interval years	AEF (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

81.95

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:

0%

Channel flow:

100%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

0.78 hours

r

Roughness coefficient

Medium grass cover 0.4

L

Hydraulic length of catchment

2.466861 km

S

Overland slope

0.318102 m/m

Channel flow

where;

Tc

Time of concentration (channel)

0.23 hours

L

Hydraulic length of catchment

2.466861 km

S

Average channel slope

0.2366 m/m

Total time of concentration

0.23 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

Storm Type:

2

Areal Reduction Factor

100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall

53.2 mm

30min factor

0.664

Aerial rainfall

53.2 mm

2-year 30min rainfall

35.3 mm/hr

Soil retention

normal

55.9 mm

S = $\frac{25400}{CN} - 254$

Initial abstraction

normal

5.6 mm

I_a = 0.1 · S

Lagtime

SA:

L = $\frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

where; A

1.97 km2

MAP

549.9649 mm

y

31.81 %

I₃₀

35.3 mm/hr

L

0.50 hrs

USA:

L = $\frac{I^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; I

2.467 m

S

55.9 mm

y

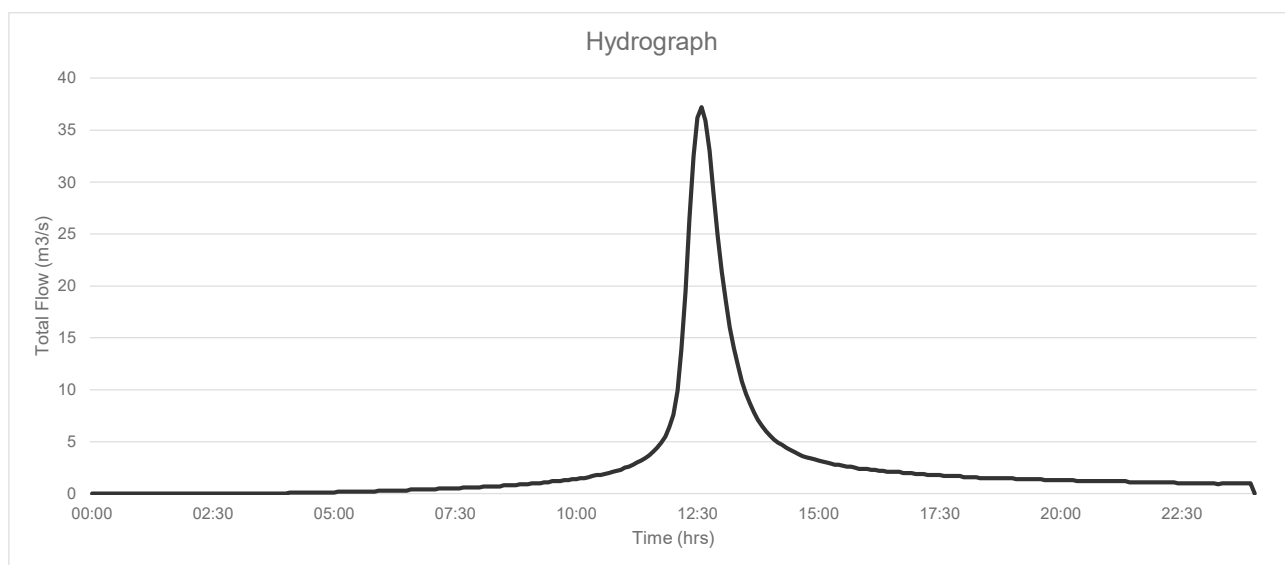
31.81 %

L

0.28 hrs

RESULTS:

100 yr Peak Flow **37.20** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Monametsi Tributary 19

Calculated by: Wian Lombard

Date: 08/01/2025

INPUT DATA: Catchment characteristics

Total catchment area

0.91 km²

Length of watercourse (L)

1.11 km

Watercourse slope (10/85)

0.09 m/m

Location Lat

24

Long

30

Catchment slope:

0.18 Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation

549.96 mm

ARF =

100.0%

1-day point design rainfall (mm)

1-day areal design rainfall (mm)

Recurrence Interval years	AEF (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

81.32

CALCULATIONS: Time of concentration

Percentage of longest watercourse:

Overland flow: 0%

Channel flow: 100%

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

0.62 hours

r

Roughness coefficient

Medium grass cover 0.4

L

Hydraulic length of catchment

1.111033 km

S

Overland slope

0.182611 m/m

Channel flow

where;

Tc

Time of concentration (channel)

0.18 hours

L

Hydraulic length of catchment

1.111033 km

S

Average channel slope

0.0875 m/m

Total time of concentration

0.18 hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

----->

Lag time:

0.45 hours

Storm Type:

2

27.06 minutes

Areal Reduction Factor

100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall

53.2 mm

30min factor

0.664

Aerial rainfall

53.2 mm

2-year 30min rainfall

35.3 mm/hr

Soil retention

normal

58.4 mm

S = $\frac{25400}{CN} - 254$

Initial abstraction

normal

5.8 mm

I_a = 0.1 · S

Lagtime

SA:

L = $\frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

where; A

0.91 km2

MAP

549.9649 mm

y

18.26 %

I₃₀

35.3 mm/hr

L

0.45 hrs

USA:

L = $\frac{I^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; I

1,111 m

S

58.4 mm

y

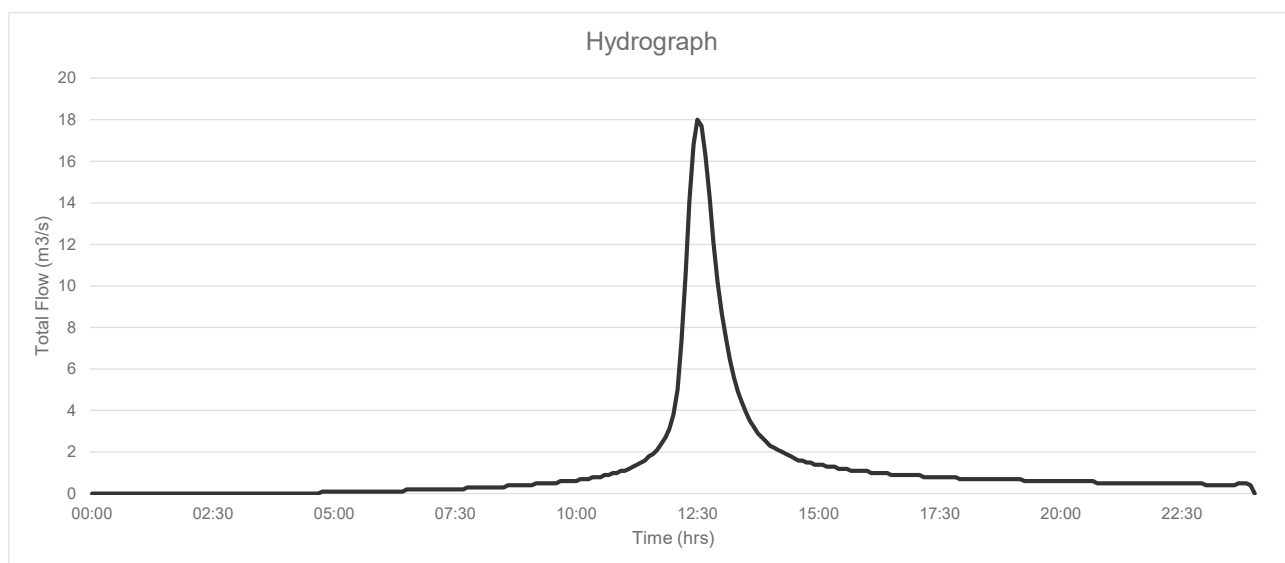
18.26 %

L

0.20 hrs

RESULTS:

100 yr Peak Flow **18.00** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Monametsi Tributary 20

Calculated by: Wian Lombard

Date: 08/01/2025

INPUT DATA:

Catchment characteristics

Total catchment area

5.87 km²

Length of watercourse (L)

4.26 km

Watercourse slope (10/85)

0.12 m/m

Location Lat

24

Long

30

Catchment slope:

0.29 Average slope (m/m)

Deg

24

Min

41

Sec

24

INPUT DATA:

Rainfall

Mean Annual Precipitation

549.96 mm

1-day point design rainfall (mm)

ARF = 99.9%

1-day areal design rainfall (mm)

Recurrence Interval years	AEF (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

81.57

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Overland flow: 0%

Channel flow: 100%

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

1.04 hours

r

Roughness coefficient

Medium grass cover 0.4

L

Hydraulic length of catchment

4.26067 km

S

Overland slope

0.287885 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow

where;

Tc

Time of concentration (channel)

0.45 hours

L

Hydraulic length of catchment

4.26067 km

S

Average channel slope

0.1233 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration

0.45 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

----->

Lag time:

0.76 hours

Storm Type:

2

45.43 minutes

Areal Reduction Factor

99.9%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall

53.2 mm

30min factor

0.664

Aerial rainfall

53.2 mm

2-year 30min rainfall

35.3 mm/hr

Soil retention

normal

57.4 mm

$$S = \frac{25400}{CN} - 254$$

Initial abstraction

normal

5.7 mm

$$I_a = 0.1 \cdot S$$

Lagtime

SA:

$$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$$

USA:

$$L = \frac{I^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$$

where; A

5.87 km2

where; I

4.261 m

MAP

549.9649 mm

S

57.4 mm

y

28.79 %

y

28.79 %

I₃₀

35.3 mm/hr

L

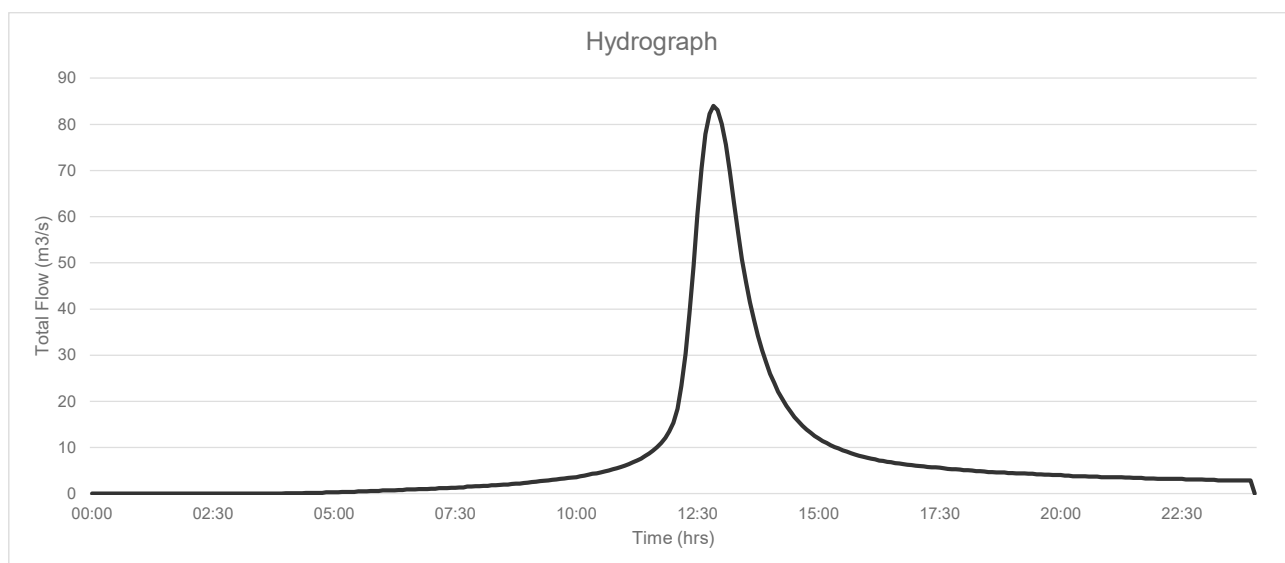
0.46 hrs

L

0.76 hrs

RESULTS:

100 yr Peak Flow **84.00** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
 Project Title **Olifant**
 River **Monametsi Tributary 21**

Calculated by: **Wian Lombard**
 Date: **08/01/2025**

INPUT DATA: Catchment characteristics

Total catchment area **0.12** km²
 Length of watercourse (L) **0.61** km
 Watercourse slope (10/85) **0.02** m/m

Location Lat **24** Deg
 Long **30** Min
 Catchment slope: **0.03** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **549.96** mm
 1-day point design rainfall (mm) **ARF = 100.0%**
 1-day areal design rainfall (mm)

Recurrence Interval		Storm duration	
years	AEP (%)	1-day	24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: **Obtained from Soils Group map**
 Gridded Curve Number: **78.72**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: **Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%**

Overland flow: **30%**
 Channel flow: **70%**
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) **0.73** hours
 r Roughness coefficient Medium grass cover **0.4**
 L Hydraulic length of catchment **0.606994** km
 S Overland slope **0.025526** m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) **0.19** hours
 L Hydraulic length of catchment **0.606994** km
 S Average channel slope **0.0235** m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration **0.35** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: **0.40** hours
Storm Type: 2 24.07 minutes
Areal Reduction Factor 100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall **53.2** mm 30min factor **0.664**
 Aerial rainfall **53.2** mm 2-year 30min rainfall **35.3** mm/hr

Soil retention normal **68.7** mm $S = \frac{25400}{CN} - 254$

Initial abstraction normal **6.9** mm $I_a = 0.1 \cdot S$

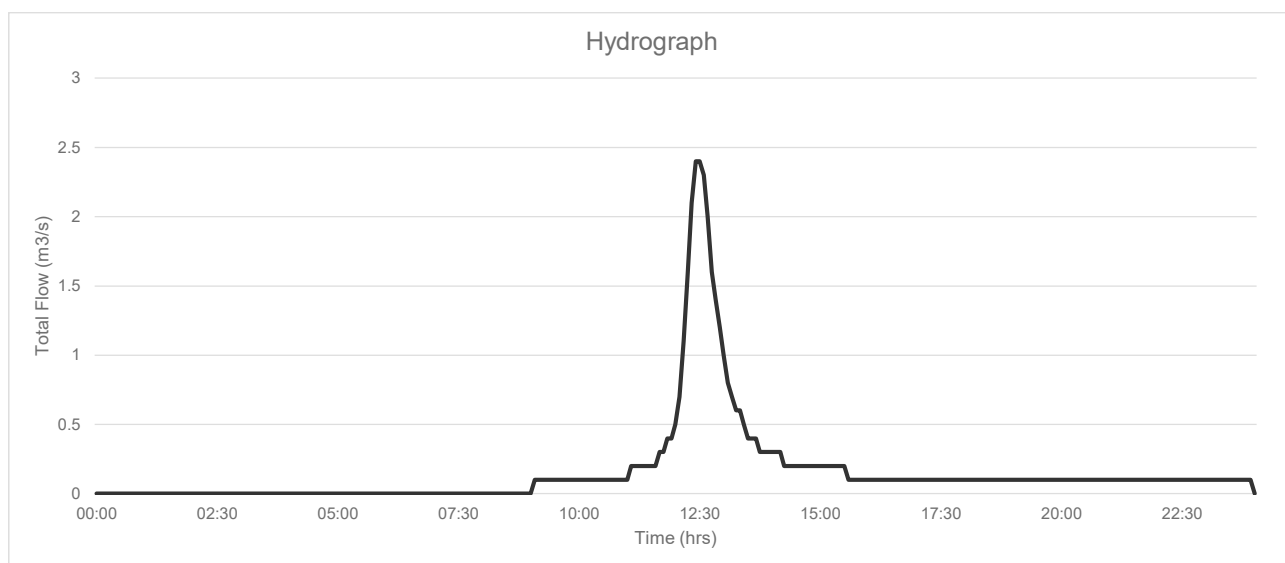
Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A **0.12** km²
 MAP **549.9649** mm
 y **2.55** %
 I_{30} **35.3** mm/hr
 L **0.40** hrs

where; l **607** m
 S **68.7** mm
 y **2.55** %
 L **0.36** hrs

RESULTS:

100 yr Peak Flow **2.40** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
Project Title **Olifant**
River **Monametsi Tributary 22**

Calculated by: **Wian Lombard**
Date: **08/01/2025**

INPUT DATA: Catchment characteristics

Total catchment area **0.19** km²
Length of watercourse (L) **0.77** km
Watercourse slope (10/85) **0.03** m/m

Location Lat **24** Deg
Long **30** Min
Catchment slope: **0.05** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **549.96** mm
1-day point design rainfall (mm) **ARF = 100.0%**
1-day areal design rainfall (mm)

Recurrence Interval		Storm duration	
years	AEP (%)	1-day	24 hours
2yr	50%	53	64
5yr	20%	73	87
10yr	10%	87	104
20yr	5%	101	121
50yr	2%	122	146
100yr	1%	138	165
200yr	0.5%	155	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: **Obtained from Soils Group map**
Gridded Curve Number: **78.97**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: **Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%**

Overland flow: **30%**
Channel flow: **70%**
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) **0.69** hours
 r Roughness coefficient Medium grass cover **0.4**
 L Hydraulic length of catchment **0.773296** km
 S Overland slope **0.05411** m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) **0.22** hours
 L Hydraulic length of catchment **0.773296** km
 S Average channel slope **0.0275** m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration **0.36** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: **0.38** hours
Storm Type: **2** 22.57 minutes
Areal Reduction Factor **100.0%**

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall **53.2** mm 30min factor **0.664**
Aerial rainfall **53.2** mm 2-year 30min rainfall **35.3** mm/hr

Soil retention normal **67.7** mm $S = \frac{25400}{CN} - 254$

Initial abstraction normal **6.8** mm $I_a = 0.1 \cdot S$

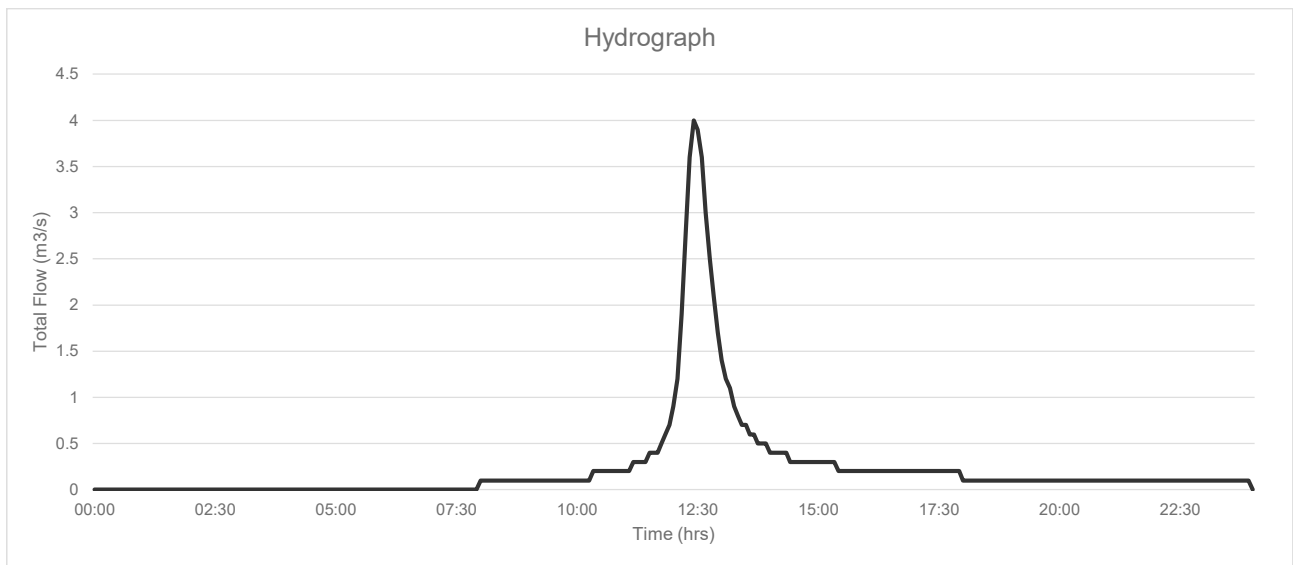
Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A **0.19** km²
MAP **549.9649** mm
y **5.41** %
 I_{30} **35.3** mm/hr
L **0.38** hrs

where; l **773** m
S **67.7** mm
y **5.41** %
L **0.30** hrs

RESULTS:

100 yr Peak Flow **4.00** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No Project Title River	1002569 Olifant Monametsi Tributary 23	Calculated by: Wian Lombard Date: 08/01/2025
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INPUT DATA: Catchment characteristics

Total catchment area	1.35 km ²	Location Lat	Deg	Min	Sec
Length of watercourse (L)	2.62 km	Long	24	41	24
<u>Watercourse slope (10/85)</u>	0.06 m/m	<u>Catchment slope:</u>	30	11	44
			0.12 Average slope (m/m)		

INPUT DATA: Rainfall

Mean Annual Precipitation	549.96 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	
<table border="1" style="font-size: small; width: 100%;">Recurrence Interval years AEP (%) Storm duration 1-day Storm duration 24 hours</table>		<table border="1" style="font-size: small; width: 100%;">Storm duration 24 hours</table>	
2yr 50% 53 64		64	
5yr 20% 73 87		87	
10yr 10% 87 104		104	
20yr 5% 101 121		121	
50yr 2% 122 146		146	
100yr 1% 138 165		165	
200yr 0.5% 155 185		185	

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

<u>Hydrological Soil Group:</u>	Obtained from Soils Group map
	Gridded Curve Number: 84.56

CALCULATIONS: Time of concentration

Percentage of longest watercourse: Overland flow: 0% Channel flow: 100% <u>100%</u>		Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%
<u>Overland flow (over fairly even and flat ground)</u>	where;	Tc Time of concentration (overland) r Roughness coefficient
$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$	L Hydraulic length of catchment S Overland slope	1.02 hours Medium grass cover 0.4 2.623845 km 0.116472 m/m
<u>Channel flow</u>	where;	Tc Time of concentration (channel) L Hydraulic length of catchment S Average channel slope
$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$		0.41 hours 2.623845 km 0.0605 m/m
Total time of concentration	0.41 hours	

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

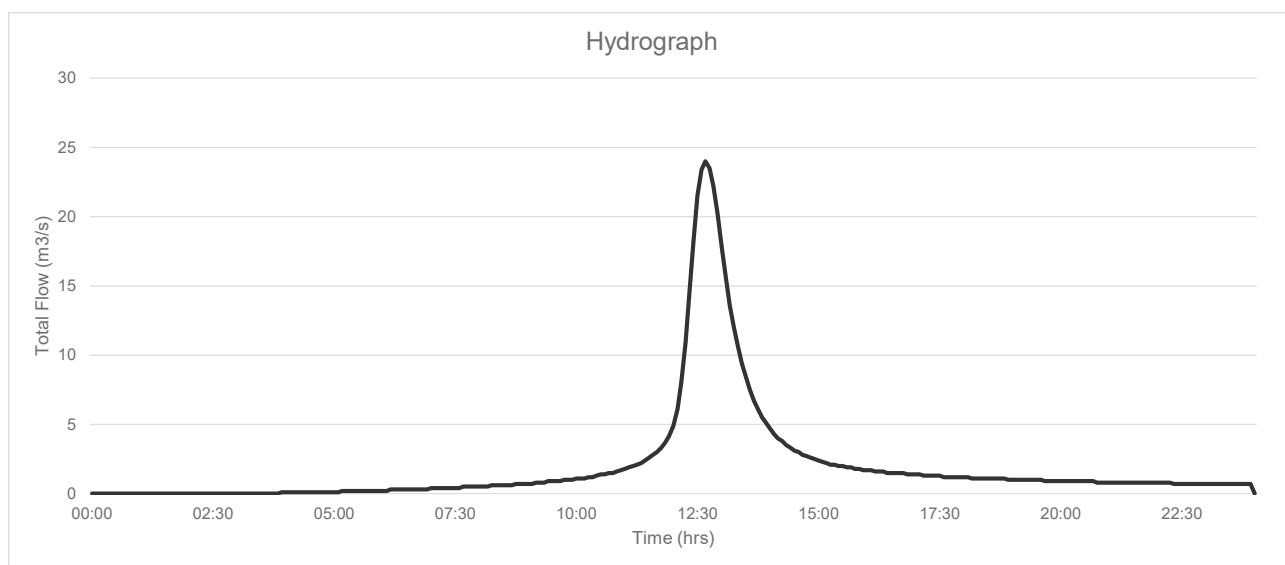
<u>Catchment type:</u>	Well vegetated	>>>>>	Lag time: 0.59 hours
<u>Storm Type:</u>	2		35.63 minutes
<u>Areal Reduction Factor</u>	100.0%		
<u>Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation</u>			
2-year 1-day rainfall	53.2 mm	30min factor	0.664
Aerial rainfall	53.2 mm	2-year 30min rainfall	35.3 mm/hr

<u>Soil retention</u>	normal	46.4 mm	$S = \frac{25400}{CN} - 254$
<u>Initial abstraction</u>	normal	4.6 mm	I _a = 0.1 · S

<u>Lagtime</u>	SA:	$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$	USA:	$L = \frac{l^{0.8}(S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$
	where; A	1.35 km²	where; l	2,624 m
	MAP	549.9649 mm	y	46.4 mm
	y	11.65 %	y	11.65 %
	I ₃₀	35.3 mm/hr	L	0.45 hrs
	L	0.59 hrs		

RESULTS:

100 yr Peak Flow **24.00** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Moopesti main

Calculated by: Karien van Heerden

Date: 07/11/2024

INPUT DATA:

Catchment characteristics

Total catchment area

123.34 km²

Length of watercourse (L)

28.93 km

Watercourse slope (10/85)

0.01 m/m

Location Lat

24

Long

30

Catchment slope:

0.19 Average slope (m/m)

Deg

24

Min

41

Sec

24

INPUT DATA:

Rainfall

Mean Annual Precipitation

578.42 mm

1-day point design rainfall (mm)

ARF = 93.4%

1-day areal design rainfall (mm)

Recurrence Interval years	AEF (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	52	63
5yr	20%	72	86
10yr	10%	86	103
20yr	5%	101	121
50yr	2%	121	145
100yr	1%	137	165
200yr	0.5%	154	185

24 hours
59
81
97
113
136
154
173

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

87.04

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:

0%

Channel flow:

100%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

2.80 hours

r

Roughness coefficient

Medium grass cover 0.4

L

Hydraulic length of catchment

28.92923 km

S

Overland slope

0.18857 m/m

Channel flow

where;

Tc

Time of concentration (channel)

4.97 hours

L

Hydraulic length of catchment

28.92923 km

S

Average channel slope

0.0113 m/m

Total time of concentration

4.97 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

Storm Type:

2

Areal Reduction Factor

93.4%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall

52.2 mm

Aerial rainfall

48.8 mm

30min factor

0.664

2-year 30min rainfall

32.4 mm/hr

Soil retention

normal

37.8 mm

Initial abstraction

normal

3.8 mm

SA:

Lagtime

L

25400

CN

254

USA:

L

7069

y^{0.5}

2.20 hrs

where; A

123.34 km2

MAP

578.4173 mm

y

18.86 %

I₃₀

32.4 mm/hr

L

2.84 hrs

where; I

28,929 m

S

37.8 mm

y

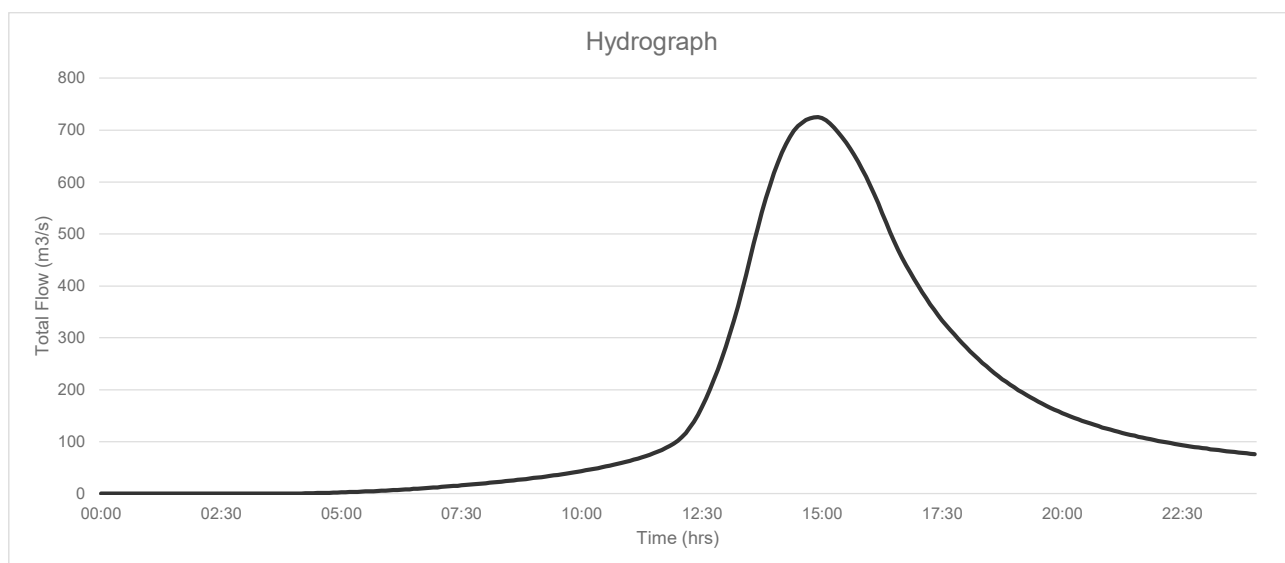
18.86 %

L

2.20 hrs

RESULTS:

100 yr Peak Flow **725.10** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Motse Main

Calculated by: Karien van Heerden

Date: 07/11/2024

INPUT DATA:

Catchment characteristics

Total catchment area

129.18 km²

Length of watercourse (L)

30.10 km

Watercourse slope (10/85)

0.03 m/m

Location Lat

24

Long

30

Catchment slope:

0.28 Average slope (m/m)

Deg

24

Min

41

Sec

24

INPUT DATA:

Rainfall

Mean Annual Precipitation

578.42 mm

1-day point design rainfall (mm)

ARF = 91.6%

1-day areal design rainfall (mm)

Recurrence Interval years	AEF (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	52	63
5yr	20%	72	86
10yr	10%	86	103
20yr	5%	101	121
50yr	2%	121	145
100yr	1%	137	165
200yr	0.5%	154	185

24 hours
57
79
95
111
133
151
170

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

84.51

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:

0%

Channel flow:

100%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

2.60 hours

r

Roughness coefficient

Medium grass cover 0.4

L

Hydraulic length of catchment

30.09669 km

S

Overland slope

0.27876 m/m

Channel flow

where;

Tc

Time of concentration (channel)

3.49 hours

L

Hydraulic length of catchment

30.09669 km

S

Average channel slope

0.0306 m/m

Total time of concentration

3.49 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

----->

Lag time:

2.61 hours

Storm Type:

2

156.81 minutes

Areal Reduction Factor

91.6%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall

52.2 mm

30min factor

0.664

Aerial rainfall

47.8 mm

2-year 30min rainfall

31.8 mm/hr

Soil retention

normal

46.6 mm

S = $\frac{25400}{CN} - 254$

Initial abstraction

normal

4.7 mm

I_a = 0.1 · S

Lagtime

SA:

L = $\frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

where; A

129.18 km2

MAP

578.4173 mm

y

27.88 %

I₃₀

31.8 mm/hr

L

2.61 hrs

USA:

L = $\frac{I^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; I

30,097 m

S

46.6 mm

y

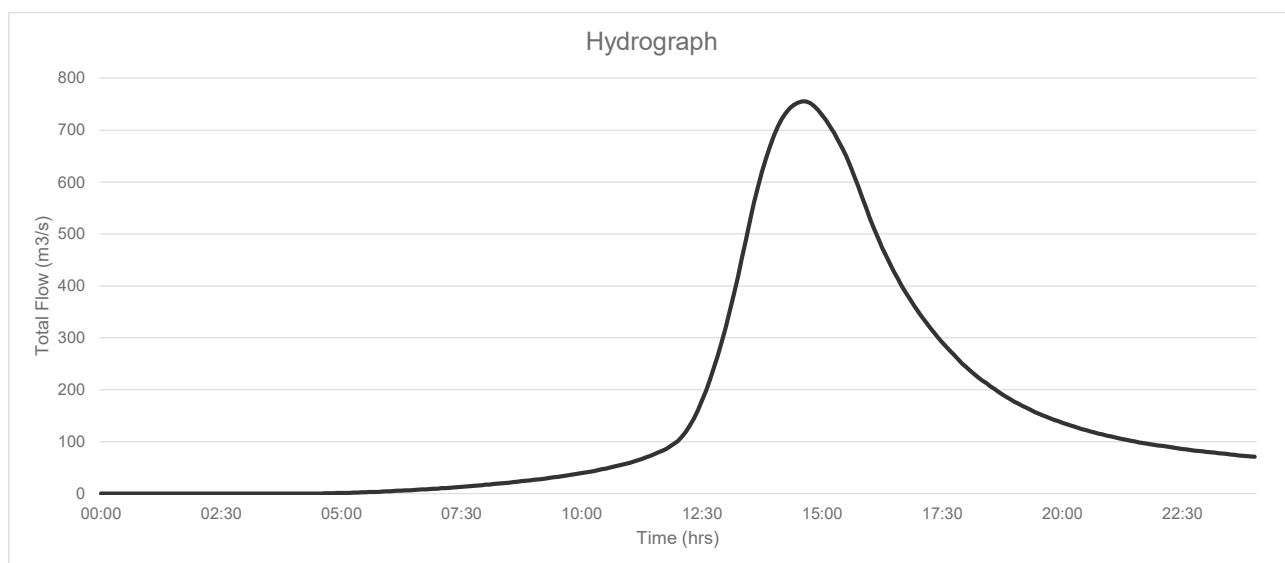
27.88 %

L

2.05 hrs

RESULTS:

100 yr Peak Flow **755.30** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
 Project Title **Olifant**
 River **Motse Main Tributary 1.1**

Calculated by: **Karien van Heerden**
 Date: **07/11/2024**

INPUT DATA: Catchment characteristics

Total catchment area **63.32** km²
 Length of watercourse (L) **18.62** km
 Watercourse slope (10/85) **0.01** m/m

Location Lat **24** Deg **41** Min **24** Sec
 Long **30** **11** **44**
 Catchment slope: **0.19** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **578.42** mm ARF = **95.8%**
 1-day point design rainfall (mm) 1-day areal design rainfall (mm)

Recurrence Interval		Storm duration		
years	AEP (%)	1-day	24 hours	24 hours
2yr	50%	52	63	60
5yr	20%	72	86	83
10yr	10%	86	103	99
20yr	5%	101	121	116
50yr	2%	121	145	139
100yr	1%	137	165	158
200yr	0.5%	154	185	177

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
 Gridded Curve Number: **85.05**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow: 0%
 Channel flow: 100%
 100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) **2.26** hours
 r Roughness coefficient Medium grass cover 0.4
 L Hydraulic length of catchment 18.62388 km
 S Overland slope 0.19446 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) **3.62** hours
 L Hydraulic length of catchment 18.62388 km
 S Average channel slope 0.0107 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration **3.62** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: **2.18** hours
 Storm Type: 2 130.94 minutes
 Areal Reduction Factor 95.8%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall 52.2 mm 30min factor 0.664
 Aerial rainfall 50.0 mm 2-year 30min rainfall 33.2 mm/hr

Soil retention normal 44.6 mm $S = \frac{25400}{CN} - 254$

Initial abstraction normal 4.5 mm $I_a = 0.1 \cdot S$

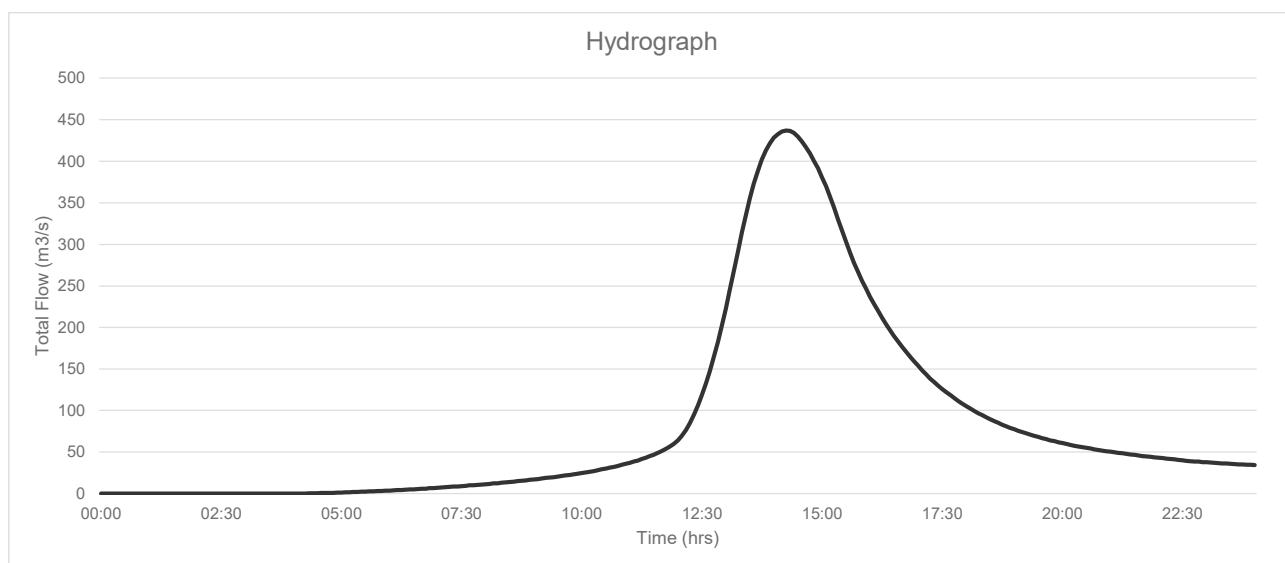
Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A 63.32 km²
 MAP 578.4173 mm
 y 19.45 %
 I₃₀ 33.2 mm/hr
 L 2.18 hrs

where; l 18,624 m
 S 44.6 mm
 y 19.45 %
 L 1.64 hrs

RESULTS:

100 yr Peak Flow **437.10** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569** Calculated by: Karien van Heerden
 Project Title **Olifant** Date: 07/11/2024
 River **Motse Main Tributary 1.2**
 This catchment was calculated using the HEC-HMS model for the South Major Catchments

INPUT DATA: Catchment characteristics

Total catchment area **40.79** km²
 Length of watercourse (L) **10.83** km
 Location Lat **24** Deg **41** Min **24** Sec
 Long **30** 11 44
 Watercourse slope (10/85) **0.06** m/m Catchment slope: **0.21** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **578.42** mm ARF = 93.6%
 1-day point design rainfall (mm) 1-day areal design rainfall (mm)

Recurrence Interval years	AEP (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	52	63
5yr	20%	72	86
10yr	10%	86	103
20yr	5%	101	121
50yr	2%	121	145
100yr	1%	137	165
200yr	0.5%	154	185

24 hours
59
81
97
113
136
154
173

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
 Gridded Curve Number: **84.66**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow: 0%
 Channel flow: $\frac{100\%}{100\%}$

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) **1.72** hours

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$
r Roughness coefficient Medium grass cover 0.4
L Hydraulic length of catchment 10.83142 km
S Overland slope 0.21 m/m

Channel flow where; T_c Time of concentration (channel) **1.23** hours

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$
L Hydraulic length of catchment 10.83142 km
S Average channel slope 0.0598 m/m

Total time of concentration **1.23** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated Lag time: **1.87** hours
Storm Type: 2 111.91 minutes

Areal Reduction Factor 93.6%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall	52.2 mm	30min factor	0.664
Aerial rainfall	48.9 mm	2-year 30min rainfall	32.5 mm/hr

Soil retention normal 46.0 mm $S = \frac{25400}{CN} - 254$

Initial abstraction normal 4.6 mm $I_a = 0.1 \cdot S$

Lagtime

SA:
$$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$$

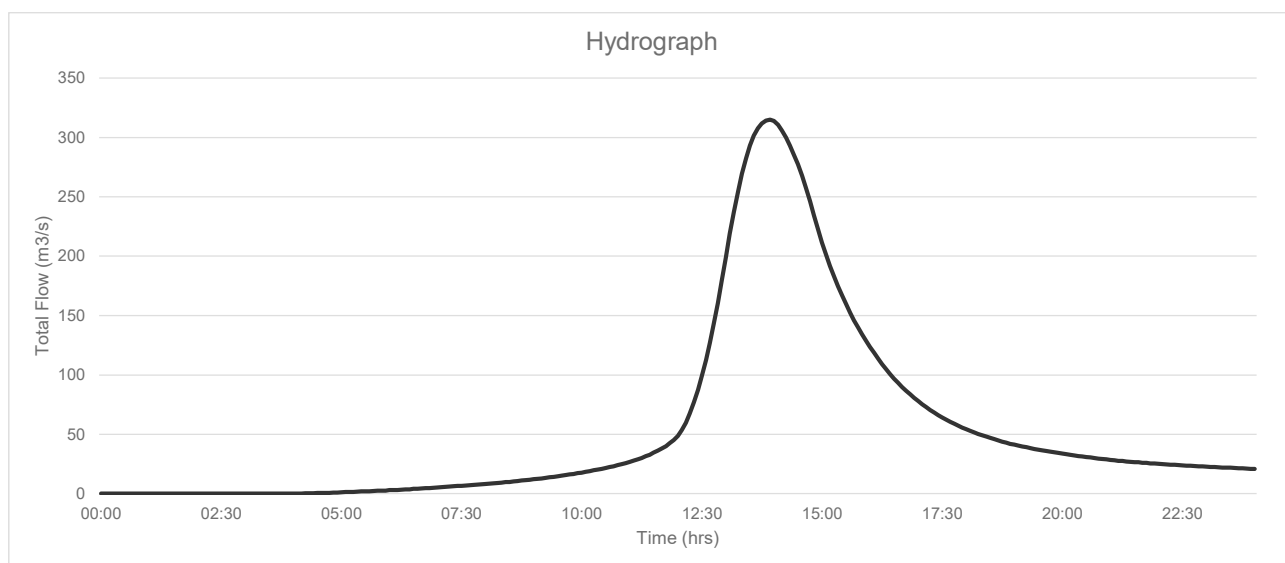
USA:
$$L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$$

where; A 40.79 km²
 MAP 578.4173 mm
 y 21.00 %
 I₃₀ 32.5 mm/hr
 L **1.87** hrs

where; l 10,831 m
 S 46.0 mm
 y 21.00 %
 L **1.04** hrs

RESULTS:

100 yr Peak Flow **315.10** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
 Project Title **Olifant**
 River **Motse Main Tributary 1.3**

Calculated by: **Karien van Heerden**
 Date: **07/11/2024**

INPUT DATA: Catchment characteristics

Total catchment area **3.20** km²
 Length of watercourse (L) **3.08** km
 Watercourse slope (10/85) **0.03** m/m

Location Lat **24** Deg **41** Min **24** Sec
 Long **30** **11** **44**
 Catchment slope: **0.12** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **578.42** mm ARF = **100.0%**
 1-day point design rainfall (mm) 1-day areal design rainfall (mm)

Recurrence Interval		Storm duration		
years	AEP (%)	1-day	24 hours	24 hours
2yr	50%	52	63	63
5yr	20%	72	86	86
10yr	10%	86	103	103
20yr	5%	101	121	121
50yr	2%	121	145	145
100yr	1%	137	165	165
200yr	0.5%	154	185	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
 Gridded Curve Number: **85.72**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow: 30%
 Channel flow: 70%
 100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) **1.09** hours
 r Roughness coefficient Medium grass cover 0.4
 L Hydraulic length of catchment 3.081435 km
 S Overland slope 0.1219 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) **0.64** hours
 L Hydraulic length of catchment 3.081435 km
 S Average channel slope 0.0260 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration **0.78** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: **0.85** hours
 Storm Type: 2 51.02 minutes

Areal Reduction Factor 100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall 52.2 mm 30min factor 0.664
 Aerial rainfall 52.2 mm 2-year 30min rainfall 34.7 mm/hr

Soil retention normal 42.3 mm $S = \frac{25400}{CN} - 254$

Initial abstraction normal 4.2 mm $I_a = 0.1 \cdot S$

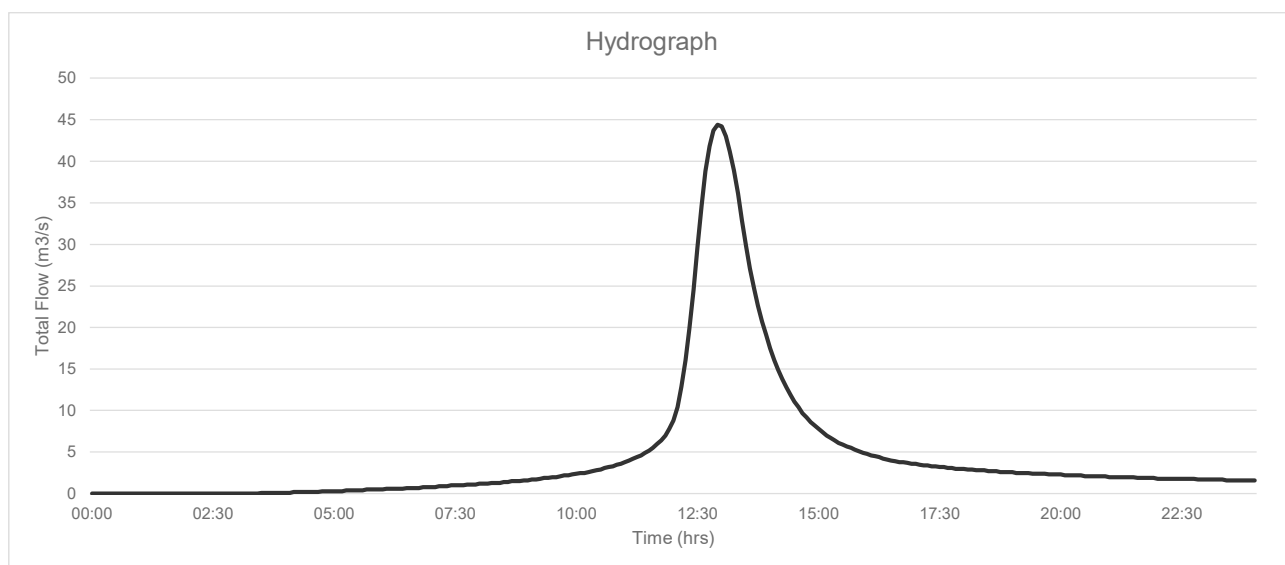
Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A 3.20 km²
 MAP 578.4173 mm
 y 12.19 %
 I₃₀ 34.7 mm/hr
 L 0.85 hrs

where; l 3.081 m
 S 42.3 mm
 y 12.19 %
 L 0.48 hrs

RESULTS:

100 yr Peak Flow **44.40** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
 Project Title **Olifant**
 River **Motse Tributary 1**

Calculated by: **Karien van Heerden**
 Date: **07/11/2024**

INPUT DATA: Catchment characteristics

Total catchment area **1.00** km²
 Length of watercourse (L) **2.79** km
 Watercourse slope (10/85) **0.02** m/m

Location Lat **24** Deg **41** Min **24** Sec
 Long **30** **11** **44**
 Catchment slope: **0.21** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **578.42** mm ARF = **100.0%**
 1-day point design rainfall (mm) 1-day areal design rainfall (mm)

Recurrence Interval		Storm duration		
years	AEP (%)	1-day	24 hours	24 hours
2yr	50%	52	63	63
5yr	20%	72	86	86
10yr	10%	86	103	103
20yr	5%	101	121	121
50yr	2%	121	145	145
100yr	1%	137	165	165
200yr	0.5%	154	185	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: Obtained from Soils Group map
 Gridded Curve Number: **80.08**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow: 30%
 Channel flow: 70%
 100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) **0.92** hours
 r Roughness coefficient Medium grass cover 0.4
 L Hydraulic length of catchment 2.792122 km
 S Overland slope 0.2051 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) **0.69** hours
 L Hydraulic length of catchment 2.792122 km
 S Average channel slope 0.0180 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration **0.76** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: **0.48** hours
 Storm Type: 2 29.02 minutes
 Areal Reduction Factor 100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall 52.2 mm 30min factor 0.664
 Aerial rainfall 52.2 mm 2-year 30min rainfall 34.7 mm/hr

Soil retention normal 63.2 mm $S = \frac{25400}{CN} - 254$

Initial abstraction normal 6.3 mm $I_a = 0.1 \cdot S$

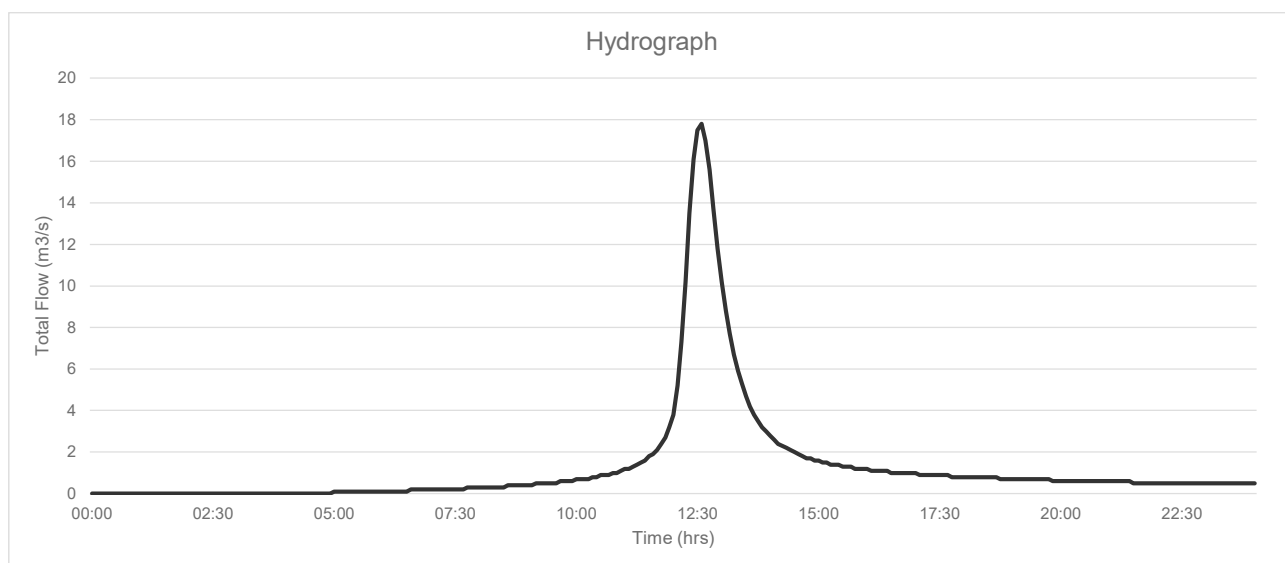
Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A 1.00 km²
 MAP 578.4173 mm
 y 20.51 %
 I₃₀ 34.7 mm/hr
 L 0.48 hrs

where; l 2.792 m
 S 63.2 mm
 y 20.51 %
 L 0.41 hrs

RESULTS:

100 yr Peak Flow **17.80** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Motse Tributary 2

Calculated by: Karien van Heerden

Date: 07/11/2024

INPUT DATA:

Catchment characteristics

Total catchment area

0.99 km²

Length of watercourse (L)

2.59 km

Watercourse slope (10/85)

0.01 m/m

Location Lat

24

Long

30

Catchment slope:

0.02 Average slope (m/m)

Deg

24

Min

41

Sec

24

INPUT DATA:

Rainfall

Mean Annual Precipitation

578.42 mm

1-day point design rainfall (mm)

ARF = 100.0%

1-day areal design rainfall (mm)

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	52	63	63
5yr	20%	72	86	86
10yr	10%	86	103	103
20yr	5%	101	121	121
50yr	2%	121	145	145
100yr	1%	137	165	165
200yr	0.5%	154	185	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

85.46

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:

30%

Channel flow:

70%

100%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

1.46 hours

r

Roughness coefficient

Medium grass cover

0.4

L

Hydraulic length of catchment

2.594149 km

S

Overland slope

0.0248 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow

where;

Tc

Time of concentration (channel)

0.74 hours

L

Hydraulic length of catchment

2.594149 km

S

Average channel slope

0.0127 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration

0.96 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

----->

Lag time:

0.91 hours

Storm Type:

2

54.57 minutes

Areal Reduction Factor

100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall

52.2 mm

30min factor

0.664

Aerial rainfall

52.2 mm

2-year 30min rainfall

34.7 mm/hr

Soil retention

normal

43.2 mm

$$S = \frac{25400}{CN} - 254$$

Initial abstraction

normal

4.3 mm

$$I_a = 0.1 \cdot S$$

Lagtime

SA:

$$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$$

USA:

$$L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$$

where; A

0.99 km2

where; l

2.594 m

MAP

578.4173 mm

S

43.2 mm

y

2.48 %

y

2.48 %

I₃₀

34.7 mm/hr

L

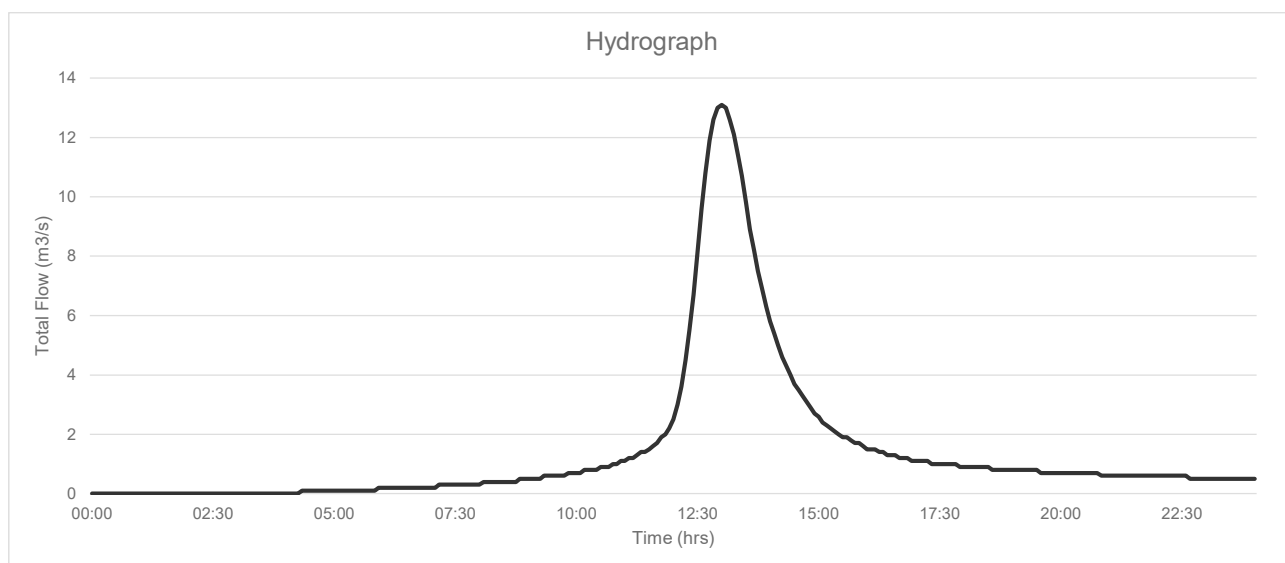
0.93 hrs

L

0.91 hrs

RESULTS:

100 yr Peak Flow **13.10** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Motse Tributary 3

Calculated by: Karien van Heerden

Date: 07/11/2024

INPUT DATA:

Catchment characteristics

Total catchment area

4.96 km²

Length of watercourse (L)

4.50 km

Watercourse slope (10/85)

0.17 m/m

Location Lat

24

Long

30

Catchment slope:

0.32 Average slope (m/m)

Deg

24

Min

41

Sec

24

INPUT DATA:

Rainfall

Mean Annual Precipitation

578.42 mm

1-day point design rainfall (mm)

ARF = 100.0%

1-day areal design rainfall (mm)

Recurrence Interval	Storm duration	
years	1-day	24 hours
2yr	52	63
5yr	72	86
10yr	86	103
20yr	101	121
50yr	121	145
100yr	137	165
200yr	154	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

82.54

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:

0%

Channel flow:

100%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

1.04 hours

r

Roughness coefficient

Medium grass cover

0.4

L

Hydraulic length of catchment

4.495389 km

S

Overland slope

0.316 m/m

Channel flow

where;

Tc

Time of concentration (channel)

0.42 hours

L

Hydraulic length of catchment

4.495389 km

S

Average channel slope

0.1696 m/m

Total time of concentration

0.42 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

----->

Lag time:

0.75 hours

Storm Type:

2

44.71 minutes

Areal Reduction Factor

100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall

52.2 mm

30min factor

0.664

Aerial rainfall

52.2 mm

2-year 30min rainfall

34.7 mm/hr

Soil retention

normal

53.7 mm

S = $\frac{25400}{CN} - 254$

Initial abstraction

normal

5.4 mm

I_a = 0.1 · S

Lagtime

SA:

A

4.96 km2

MAP

578.4173 mm

y

31.60 %

I₃₀

34.7 mm/hr

L

0.75 hrs

USA:

l^{0.8}(S + 25.4)^{0.7}

7069 · y^{0.5}

where; l

4.495 m

S

53.7 mm

y

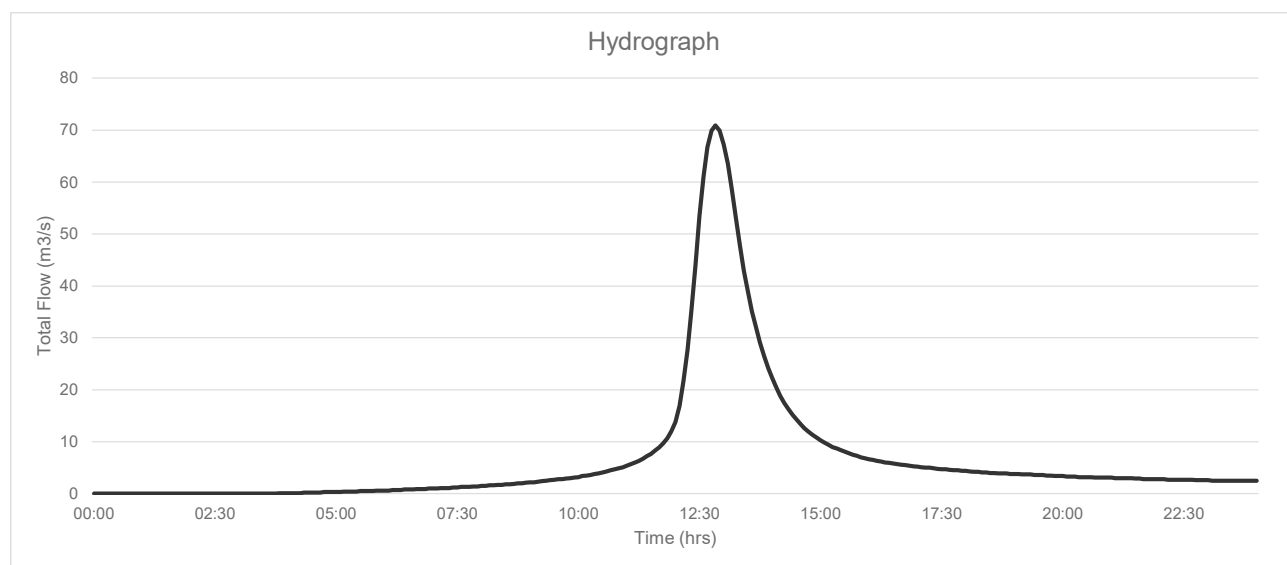
31.60 %

L

0.45 hrs

RESULTS:

100 yr Peak Flow **70.90** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Karien van Heerden Date: 07/11/2024
Project Title	Olifant	
River	Motse Tributary 4	

INPUT DATA:	Catchment characteristics
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Total catchment area	2.03 km ²			
Length of watercourse (L)	3.47 km	Location Lat	24	41
		Long	30	11
<u>Watercourse slope (10/85)</u>	0.18 m/m	<u>Catchment slope:</u>	0.28	Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation	578.42 mm	ARF =	100.0%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	52	63	63
5yr	20%	72	86	86
10yr	10%	86	103	103
20yr	5%	101	121	121
50yr	2%	121	145	145
100yr	1%	137	165	165
200yr	0.5%	154	185	185

INPUT DATA:	Landuse and Runoff Curve Number (CN) coefficients
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Hydrological Soil Group: Obtained from Soils Group map
Gridded Curve Number: 86.30

CALCULATIONS:	Time of concentration
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Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:	0%
Channel flow:	100%
	100%

<u>Overland flow (over fairly even and flat ground)</u>	where;	T _c	Time of concentration (overland)	0.95 hours
$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$		r	Roughness coefficient	Medium grass cover 0.4
		L	Hydraulic length of catchment	3.473074 km
		S	Overland slope	0.2805 m/m

S	Overland slope	0.2805 m/m
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Channel flow				
$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$	where;	Tc	Time of concentration (channel)	0.34 hours
		L	Hydraulic length of catchment	3.473074 km
		S	Average channel slope	0.1766 m/m

Total time of concentration	0.34 hours
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CALCULATIONS:	Catchment response
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For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

<u>Catchment type:</u>	Well vegetated	----->	Lag time:	0.56 hours
Storm Type:	2			33.89 minutes

Areal Reduction Factor	100.0%
------------------------	--------

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall	52.2 mm	30min factor	0.664
Aerial rainfall	52.2 mm	2-year 30min rainfall	34.7 mm/hr

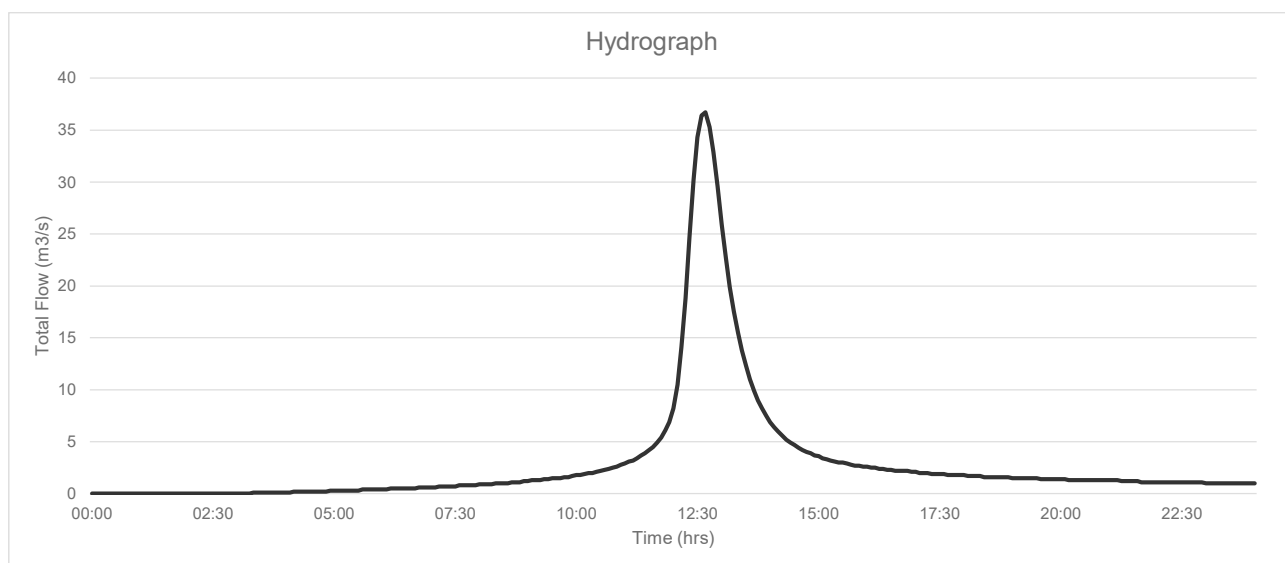
<u>Soil retention</u>	normal	40.3 mm	$S = \frac{25400}{CN} - 254$
<u>Initial abstraction</u>	normal	4.0 mm	$I_a = 0.1 \cdot S$

<u>Lagtime</u>	SA:	$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$	USA:	$L = \frac{I^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$
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where; A	2.03 km ²	where; I	3,473 m
MAP	578.4173 mm	S	40.3 mm
y	28.05 %	y	28.05 %
I ₃₀	34.7 mm/hr	L	0.34 hrs
L	0.56 hrs		

RESULTS:

100 yr Peak Flow **36.70** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Motse Tributary 5

Calculated by: Karien van Heerden

Date: 07/11/2024

INPUT DATA:

Catchment characteristics

Total catchment area

0.81 km²

Length of watercourse (L)

1.90 km

Watercourse slope (10/85)

0.02 m/m

Location

Lat

24

Long

30

Catchment slope:

0.12 Average slope (m/m)

Deg

24

Min

41

Sec

24

INPUT DATA:

Rainfall

Mean Annual Precipitation

578.42 mm

1-day point design rainfall (mm)

ARF = 100.0%

1-day areal design rainfall (mm)

Recurrence Interval	Storm duration	
years	1-day	24 hours
2yr	52	63
5yr	72	86
10yr	86	103
20yr	101	121
50yr	121	145
100yr	137	165
200yr	154	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

89.16

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:

30%

Channel flow:

70%

100%

Overland flow (over fairly even and flat ground)

where;

T_c

Time of concentration (overland)

0.87 hours

r

Roughness coefficient

Medium grass cover

0.4

L

Hydraulic length of catchment

1.902396 km

S

Overland slope

0.1243 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow

where;

T_c

Time of concentration (channel)

0.54 hours

L

Hydraulic length of catchment

1.902396 km

S

Average channel slope

0.0158 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration

0.64 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

----->

Lag time:

0.52 hours

Storm Type:

2

31.32 minutes

Areal Reduction Factor

100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall

52.2 mm

30min factor

0.664

Aerial rainfall

52.2 mm

2-year 30min rainfall

34.7 mm/hr

Soil retention

normal

30.9 mm

$$S = \frac{25400}{CN} - 254$$

Initial abstraction

normal

3.1 mm

$$I_a = 0.1 \cdot S$$

Lagtime

SA:

$$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$$

USA:

$$L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$$

where; A

0.81 km2

where; l

1,902 m

MAP

578.4173 mm

S

30.9 mm

y

12.43 %

y

12.43 %

I₃₀

34.7 mm/hr

L

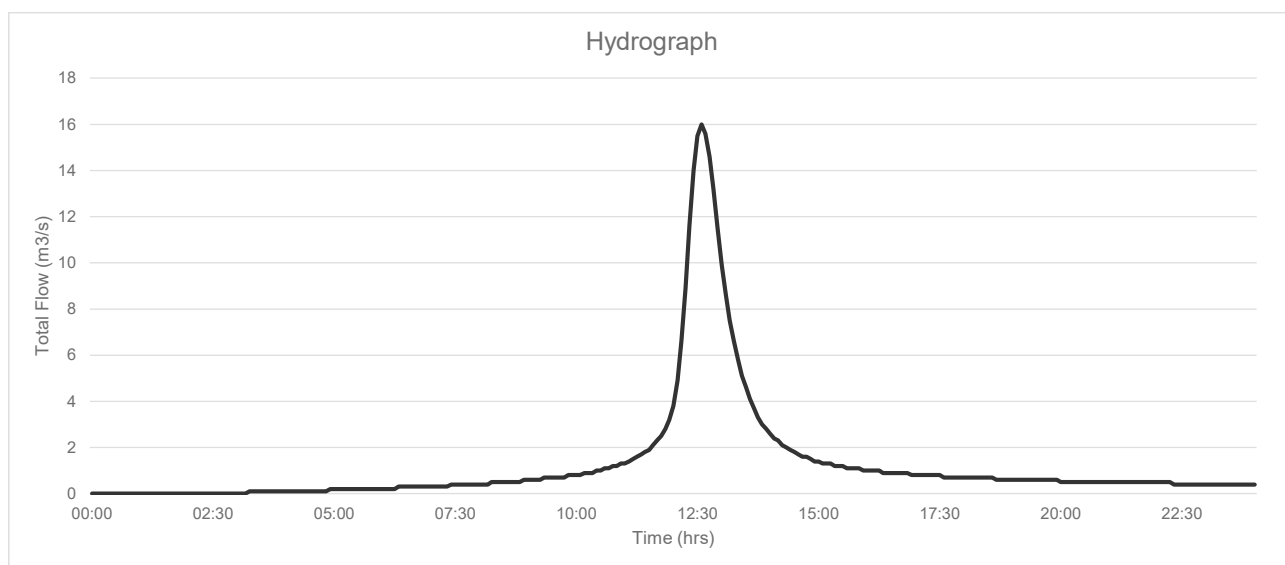
0.28 hrs

L

0.52 hrs

RESULTS:

100 yr Peak Flow **16.00** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Motse Tributary 6

Calculated by: Karien van Heerden

Date: 07/11/2024

INPUT DATA:

Catchment characteristics

Total catchment area

5.61 km²

Length of watercourse (L)

5.32 km

Watercourse slope (10/85)

0.14 m/m

Location

Lat

24

Long

30

Catchment slope:

0.30

Average slope (m/m)

INPUT DATA:

Rainfall

Mean Annual Precipitation

578.42 mm

1-day point design rainfall (mm)

ARF = 100.0%

1-day areal design rainfall (mm)

Recurrence Interval	Storm duration	
years	1-day	24 hours
2yr	52	63
5yr	72	86
10yr	86	103
20yr	101	121
50yr	121	145
100yr	137	165
200yr	154	185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

82.13

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:

0%

Channel flow:

100%

100%

Overland flow (over fairly even and flat ground)

where;

T_c

Time of concentration (overland)

1.14 hours

r

Roughness coefficient

Medium grass cover

0.4

L

Hydraulic length of catchment

5.320412 km

S

Overland slope

0.3037 m/m

Channel flow

where;

T_c

Time of concentration (channel)

0.51 hours

L

Hydraulic length of catchment

5.320412 km

S

Average channel slope

0.1408 m/m

Total time of concentration

0.51 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

----->

Lag time:

0.79 hours

Storm Type:

2

47.23 minutes

Areal Reduction Factor

100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall

52.2 mm

30min factor

0.664

Aerial rainfall

52.2 mm

2-year 30min rainfall

34.7 mm/hr

Soil retention

normal

55.3 mm

S = $\frac{25400}{CN} - 254$

Initial abstraction

normal

5.5 mm

I_a = 0.1 · S

Lagtime

SA:

L = $\frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

USA:

L = $\frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A

5.61 km2

where; l

5,320 m

MAP

578.4173 mm

S

55.3 mm

y

30.37 %

y

30.37 %

I₃₀

34.7 mm/hr

L

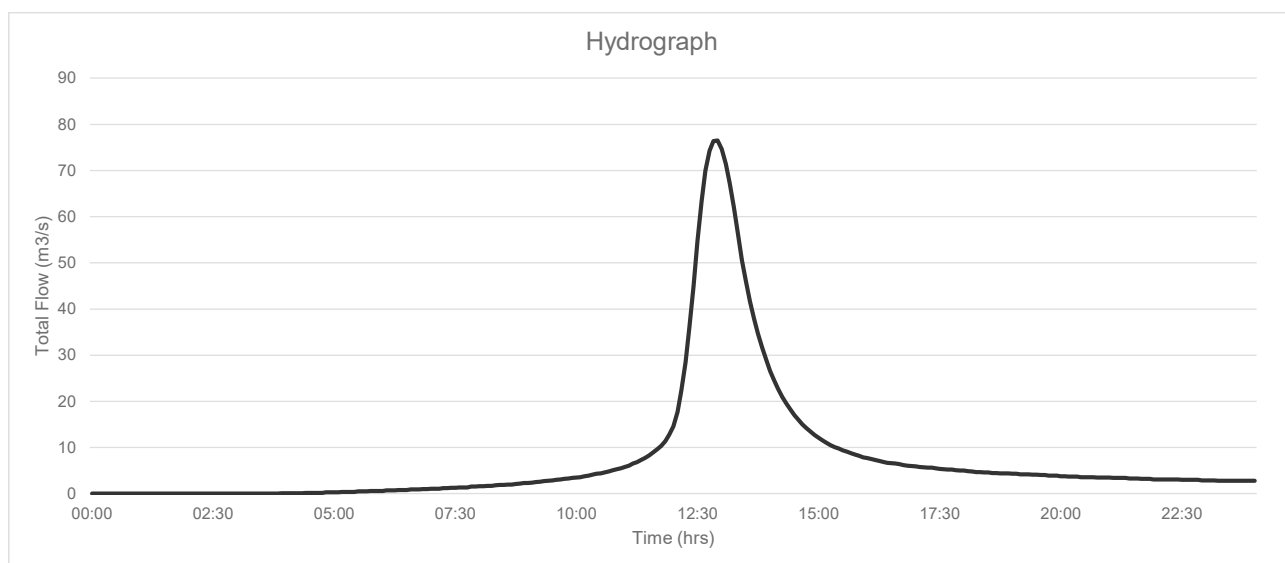
0.79 hrs

L

0.53 hrs

RESULTS:

100 yr Peak Flow **76.50** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No	1002569	Calculated by: Karien van Heerden
Project Title	Olifant	Date: 07/11/2024
River	Motse Tributary 7	

INPUT DATA:	Catchment characteristics
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Total catchment area	5.34 km ²				
Length of watercourse (L)	3.96 km	Location Lat	24	41	24
		Long	30	11	44
<u>Watercourse slope (10/85)</u>	0.17 m/m	<u>Catchment slope:</u>	0.25	Average slope (m/m)	

INPUT DATA: Rainfall

Mean Annual Precipitation	578.42 mm	ARF =	99.7%
1-day point design rainfall (mm)		1-day areal design rainfall (mm)	

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	52	63	63
5yr	20%	72	86	86
10yr	10%	86	103	103
20yr	5%	101	121	120
50yr	2%	121	145	145
100yr	1%	137	165	164
200yr	0.5%	154	185	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

<u>Hydrological Soil Group:</u>	Obtained from Soils Group map Gridded Curve Number: 82.76
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CALCULATIONS:	Time of concentration
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Percentage of longest watercourse: Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%

Overland flow:	0%
Channel flow:	100%
	100%

<u>Overland flow (over fairly even and flat ground)</u>	where;	T _c	Time of concentration (overland)	1.03 hours
$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$		r	Roughness coefficient	Medium grass cover 0.4
		L	Hydraulic length of catchment	3.961532 km
		S	Overland slope	0.251 m/m

Channel flow

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

where; Tc Time of concentration (channel) 0.38 hours
 L Hydraulic length of catchment 3.961532 km
 S Average channel slope 0.1722 m/m

Total time of concentration	0.38 hours
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CALCULATIONS:	Catchment response
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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466
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For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

<u>Catchment type:</u>	Well vegetated	----->	Lag time:	0.82 hours
<u>Storm Type:</u>	2			49.30 minutes
Areal Reduction Factor	99.7%			

<u>Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation</u>			
2-year 1-day rainfall	58.2	30-min rainfall intensity	3.884

2-year 1-day rainfall	52.2 mm	30min factor	0.664
Aerial rainfall	52.1 mm	2-year 30min rainfall	34.6 mm/hr

Soil retention	normal	52.9 mm	$S = \frac{25400}{CN} - 254$
Initial abstraction	normal	5.0 mm	

<u>initial abstraction</u>	normal	5.3 mm	$I_a = 0.1 \cdot S$
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$$\text{Lagtime} = 0.0001 A^{0.35} MAP^{1.1} \quad \text{USA} \quad \text{Lagtime} = 0.0001 l^{0.8} (S + 25.4)^{0.7}$$

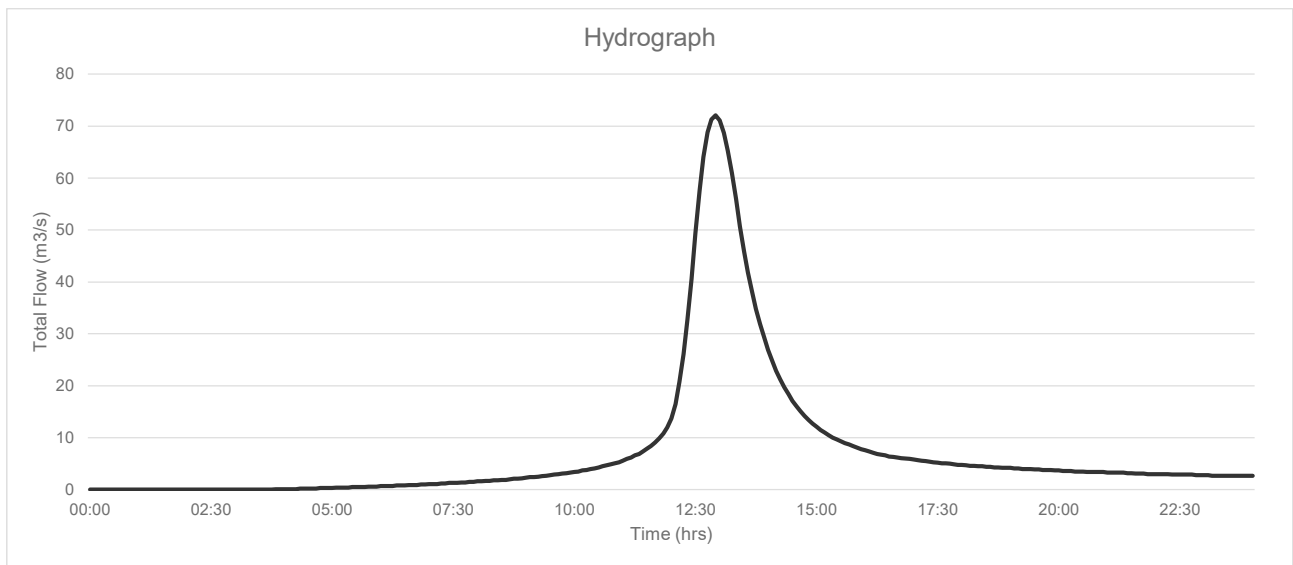
SA:	$L = \frac{1}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$	USA:	$L = \frac{1}{7069 \cdot y^{0.5}}$
-----	--	------	------------------------------------

where; A	5.34 km ²	where; l	3,962 m
MAP	578.4173 mm	S	52.9 mm
v	25.10 %	v	25.10 %

I_{30}	34.6 mm/hr	L	0.45 hrs
L	0.82 hrs		

RESULTS:

100 yr Peak Flow **72.10** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
 Project Title **Olifant**
 River **Motse Tributary 8**

Calculated by: **Karien van Heerden**
 Date: **07/11/2024**

INPUT DATA: Catchment characteristics

Total catchment area **0.45 km²**
 Length of watercourse (L) **1.35 km**
Watercourse slope (10/85) **0.07 m/m**

Location Lat **24** Deg **41** Min **24** Sec
 Long **30** **11** **44**
Catchment slope: **0.17** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **578.42 mm** ARF = **100.0%**
 1-day point design rainfall (mm) **578.42** 1-day areal design rainfall (mm) **578.42**

Recurrence Interval		Storm duration		24 hours
years	AEP (%)	1-day	24 hours	
2yr	50%	52	63	63
5yr	20%	72	86	86
10yr	10%	86	103	103
20yr	5%	101	121	121
50yr	2%	121	145	145
100yr	1%	137	165	165
200yr	0.5%	154	185	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: **Obtained from Soils Group map**
 Gridded Curve Number: **86.90**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: **Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%**

Overland flow: **0%**
 Channel flow: **100%**
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) **0.68** hours
 r Roughness coefficient Medium grass cover **0.4**
 L Hydraulic length of catchment **1.353787 km**
 S Overland slope **0.1723 m/m**

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) **0.23** hours
 L Hydraulic length of catchment **1.353787 km**
 S Average channel slope **0.0749 m/m**

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration **0.23** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: **0.39** hours
Storm Type: **2** **23.15** minutes
Areal Reduction Factor **100.0%**

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall **52.2 mm** 30min factor **0.664**
 Aerial rainfall **52.2 mm** 2-year 30min rainfall **34.7 mm/hr**

Soil retention normal **38.3 mm** $S = \frac{25400}{CN} - 254$

Initial abstraction normal **3.8 mm** $I_a = 0.1 \cdot S$

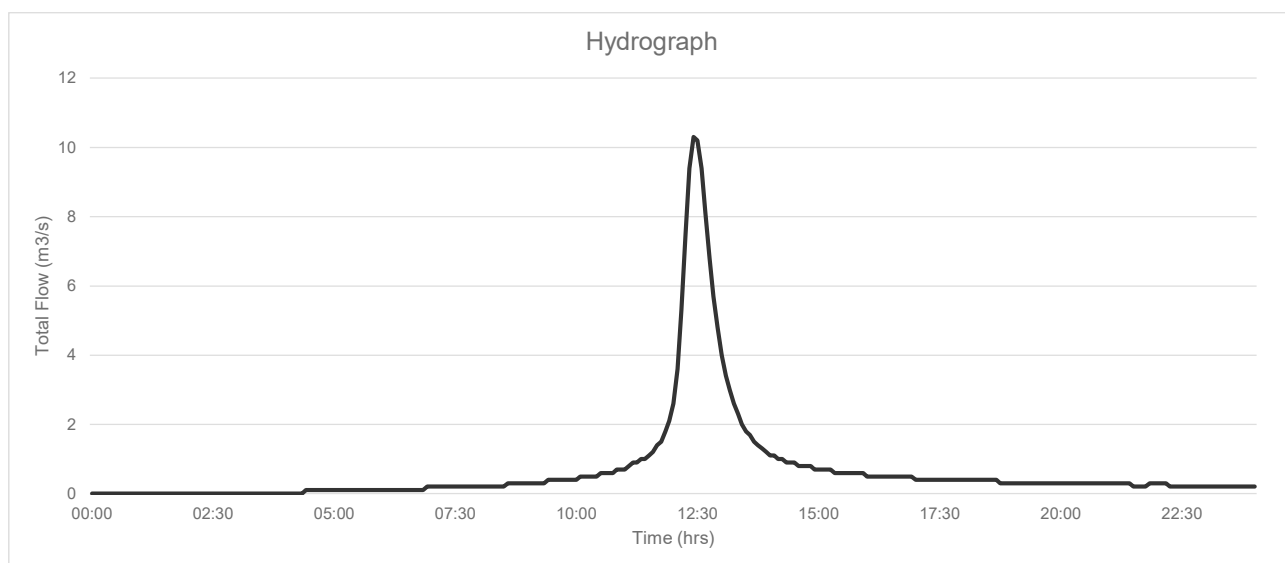
Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A **0.45 km²**
 MAP **578.4173 mm**
 y **17.23 %**
 I_{30} **34.7 mm/hr**
 L **0.39 hrs**

where; l **1.354 m**
 S **38.3 mm**
 y **17.23 %**
 L **0.20 hrs**

RESULTS:

100 yr Peak Flow **10.30** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Matadi Main

Calculated by: Karien van Heerden

Date: 07/11/2024

INPUT DATA: Catchment characteristics

Total catchment area

70.88 km²

Length of watercourse (L)

23.82 km

Watercourse slope (10/85)

0.02 m/m

Location Lat

24

Long

30

Catchment slope:

0.18 Average slope (m/m)

Deg

24

Min

37

Sec

0

INPUT DATA: Rainfall

Mean Annual Precipitation

578.42 mm

1-day point design rainfall (mm)

ARF = 95.3%

1-day areal design rainfall (mm)

Recurrence Interval years	AEF (%)	Storm duration 1-day	Storm duration 24 hours
2yr	50%	52	63
5yr	20%	72	86
10yr	10%	86	103
20yr	5%	101	121
50yr	2%	121	145
100yr	1%	137	165
200yr	0.5%	154	185

24 hours

60

82

99

115

138

157

176

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

83.51

CALCULATIONS: Time of concentration

Percentage of longest watercourse:

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:

0%

Channel flow:

100%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

2.59 hours

r

Roughness coefficient

Medium grass cover

0.4

L

Hydraulic length of catchment

23.82 km

S

Overland slope

0.1788 m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow

where;

Tc

Time of concentration (channel)

3.73 hours

L

Hydraulic length of catchment

23.8188 km

S

Average channel slope

0.0161 m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration

3.73 hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

----->

Lag time:

2.34 hours

Storm Type:

2

140.31 minutes

Areal Reduction Factor

95.3%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall

52.2 mm

30min factor

0.664

Aerial rainfall

49.8 mm

2-year 30min rainfall

33.0 mm/hr

Soil retention

normal

50.1 mm

$$S = \frac{25400}{CN} - 254$$

Initial abstraction

normal

5.0 mm

$$I_a = 0.1 \cdot S$$

Lagtime

SA:

$$L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$$

USA:

$$L = \frac{I^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$$

where; A

70.88 km2

where; I

23,819 m

MAP

578.4173 mm

S

50.1 mm

y

17.88 %

y

17.88 %

I₃₀

33.0 mm/hr

L

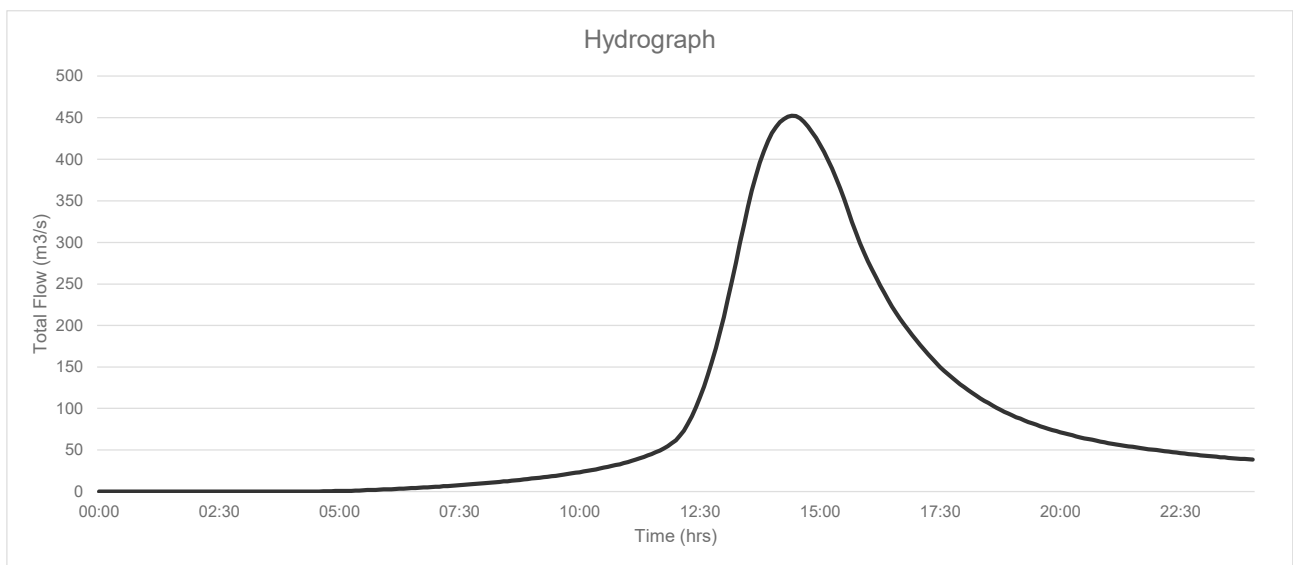
2.19 hrs

L

2.34 hrs

RESULTS:

100 yr Peak Flow **452.50** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No **1002569**
Project Title **Olifant**
River **Matadi Tributary 1**

Calculated by: **Karien van Heerden**
Date: **07/11/2024**

INPUT DATA: Catchment characteristics

Total catchment area **2.32** km²
Length of watercourse (L) **3.12** km
Watercourse slope (10/85) **0.04** m/m

Location Lat **24** Deg **37** Min **0** Sec
Long **30** **8** **0**
Catchment slope: **0.13** Average slope (m/m)

INPUT DATA: Rainfall

Mean Annual Precipitation **578.42** mm ARF = **100.0%**
1-day point design rainfall (mm) **52** 1-day areal design rainfall (mm) **103**

Recurrence Interval		Storm duration		
years	AEP (%)	1-day	24 hours	24 hours
2yr	50%	52	63	63
5yr	20%	72	86	86
10yr	10%	86	103	103
20yr	5%	101	121	121
50yr	2%	121	145	145
100yr	1%	137	165	165
200yr	0.5%	154	185	185

INPUT DATA: Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group: **Obtained from Soils Group map**
Gridded Curve Number: **82.68**

CALCULATIONS: Time of concentration

Percentage of longest watercourse: **Note: Overland flow should usually only be allowed for in catchments <5km² and areas flatter than 5%**

Overland flow: **30%**
Channel flow: **70%**
100%

Overland flow (over fairly even and flat ground) where; T_c Time of concentration (overland) **1.08** hours
r Roughness coefficient Medium grass cover **0.4**
L Hydraulic length of catchment **3.12** km
S Overland slope **0.1292** m/m

$$T_c = 0.604 \cdot \left(\frac{r \cdot L}{S^{0.5}} \right)^{0.467}$$

Channel flow where; T_c Time of concentration (channel) **0.56** hours
L Hydraulic length of catchment **3.119218** km
S Average channel slope **0.0390** m/m

$$T_c = \left(\frac{0.87 \cdot L^2}{1000 \cdot S_{av}} \right)^{0.385}$$

Total time of concentration **0.71** hours

CALCULATIONS: Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type: Well vegetated -----> Lag time: **0.75** hours
Storm Type: **2** **44.80** minutes
Areal Reduction Factor **100.0%**

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall **52.2** mm 30min factor **0.664**
Aerial rainfall **52.2** mm 2-year 30min rainfall **34.7** mm/hr

Soil retention normal **53.2** mm $S = \frac{25400}{CN} - 254$

Initial abstraction normal **5.3** mm $I_a = 0.1 \cdot S$

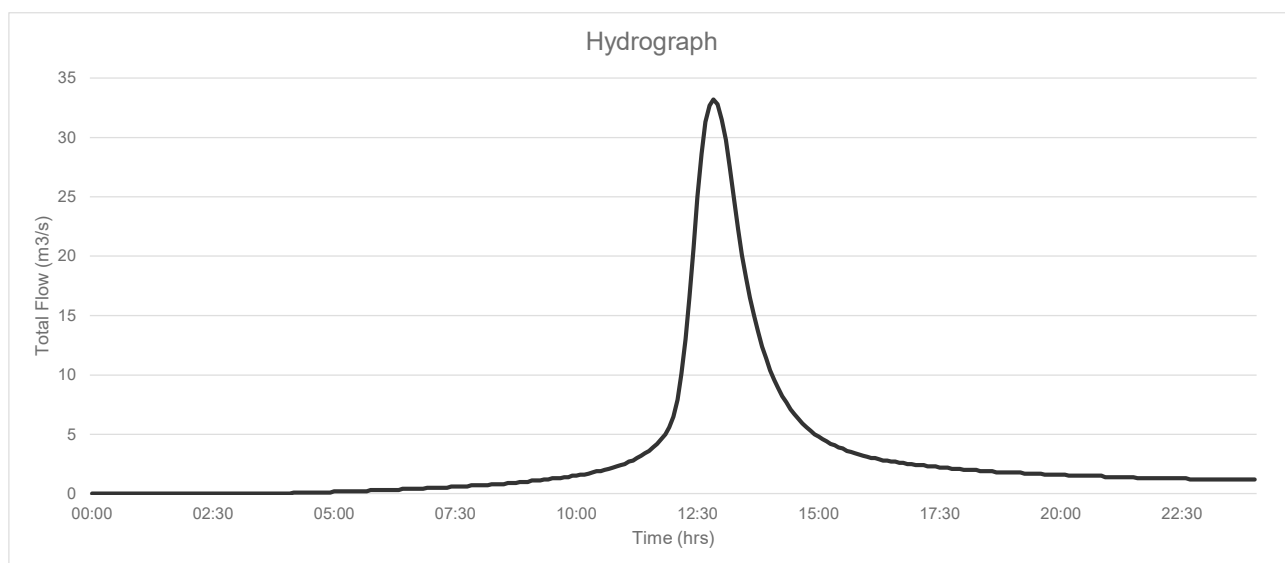
Lagtime SA: $L = \frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$ USA: $L = \frac{l^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; A **2.32** km²
MAP **578.4173** mm
y **12.92** %
I₃₀ **34.7** mm/hr
L **0.75** hrs

where; l **3,119** m
S **53.2** mm
y **12.92** %
L **0.52** hrs

RESULTS:

100 yr Peak Flow **33.20** m³/s



FLOOD HYDROLOGY: SCS METHOD INPUT

Project No

1002569

Project Title

Olifant

River

Matadi Tributary 2

Calculated by: Karien van Heerden

Date: 07/11/2024

INPUT DATA:

Catchment characteristics

Total catchment area

5.83 km²

Length of watercourse (L)

6.54 km

Watercourse slope (10/85)

0.03 m/m

Location

Lat

24

Long

30

Catchment slope:

0.14

Average slope (m/m)

INPUT DATA:

Rainfall

Mean Annual Precipitation

578.42 mm

1-day point design rainfall (mm)

ARF = 100.0%

1-day areal design rainfall (mm)

Recurrence Interval	Storm duration	
years	1-day	24 hours
2yr	50%	52
5yr	20%	72
10yr	10%	86
20yr	5%	101
50yr	2%	121
100yr	1%	137
200yr	0.5%	154

24 hours
63
86
103
121
145
165
185

INPUT DATA:

Landuse and Runoff Curve Number (CN) coefficients

Hydrological Soil Group:

Obtained from Soils Group map

Gridded Curve Number:

88.05

CALCULATIONS:

Time of concentration

Percentage of longest watercourse:

Note: Overland flow should usually only be allowed for in catchments <5km2 and areas flatter than 5%

Overland flow:

0%

Channel flow:

100%

100%

Overland flow (over fairly even and flat ground)

where;

Tc

Time of concentration (overland)

1.50 hours

r

Roughness coefficient

Medium grass cover

0.4

L

Hydraulic length of catchment

6.537376 km

S

Overland slope

0.1409 m/m

Channel flow

where;

Tc

Time of concentration (channel)

1.14 hours

L

Hydraulic length of catchment

6.537376 km

S

Average channel slope

0.0265 m/m

Total time of concentration

1.14 hours

CALCULATIONS:

Catchment response

For a well vegetated catchment use the South African Lag Time equation. For more arid conditions use the American SCS method

Catchment type:

Well vegetated

----->

Lag time:

1.00 hours

Storm Type:

2

60.30 minutes

Areal Reduction Factor

100.0%

Convert 2-year 1-day rainfall to 30min rainfall intensity for lagtime equation

2-year 1-day rainfall

52.2 mm

30min factor

0.664

Aerial rainfall

52.2 mm

2-year 30min rainfall

34.7 mm/hr

Soil retention

normal

34.5 mm

S = $\frac{25400}{CN} - 254$

Initial abstraction

normal

3.4 mm

I_a = 0.1 · S

Lagtime

SA:

L = $\frac{A^{0.35} MAP^{1.1}}{41.67 \cdot y^{0.3} I_{30min}^{0.87}}$

where; A

5.83 km2

MAP

578.4173 mm

y

14.09 %

I₃₀

34.7 mm/hr

L

1.00 hrs

USA:

L = $\frac{I^{0.8} (S + 25.4)^{0.7}}{7069 \cdot y^{0.5}}$

where; I

6,537 m

S

34.5 mm

y

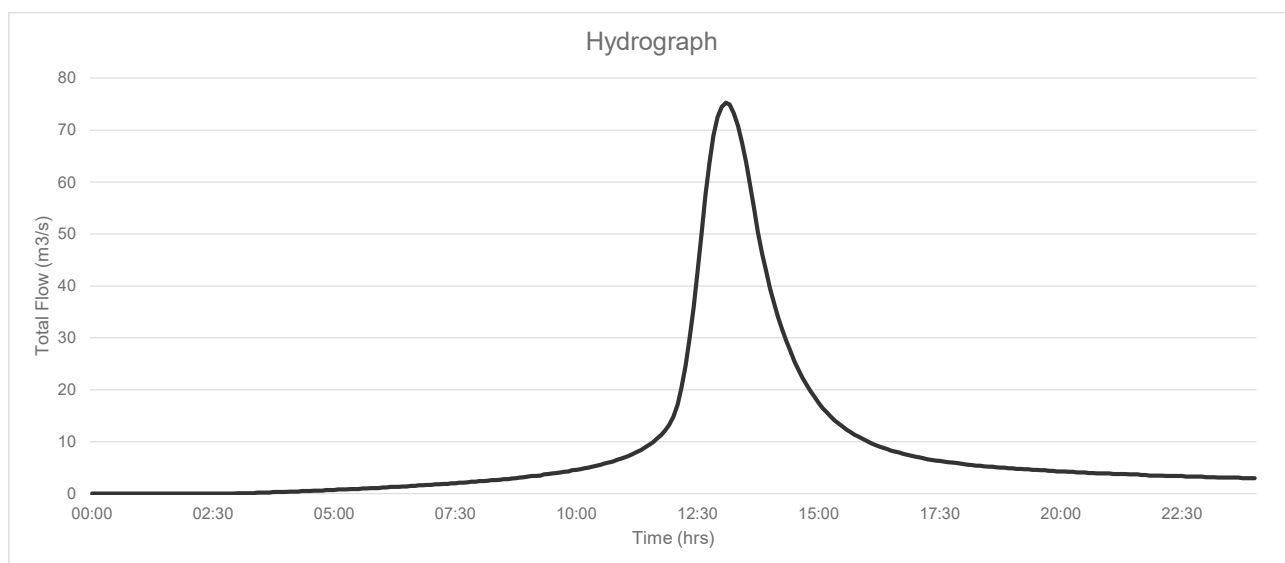
14.09 %

L

0.75 hrs

RESULTS:

100 yr Peak Flow **75.30** m³/s



Appendix B

Rational Method Calculation Sheets

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Olifants Tributary 1						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		0.60	km ²				Rainfall region			
Longest watercourse (L)		1.708	km				Area distribution factors			
10-85 Slope (S _{av})		0.02	m/m				Rural (α)		0.624	
Dolomite area (D _%)		0	%				Urban (β)		0.376	
Mean annual rainfall (MAP)		550.0	mm				Lakes (γ)		0.000	
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		0	0.01	0.000	Lawns					
Flat areas (3-10%)		54	0.06	0.032	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		28	0.12	0.034	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		18	0.22	0.040	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.106	Heavy soil,steep (>7%)		87	0.3	0.26	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		12.6	0.4	0.05	
Permeable (SCS Type B Soil)		17	0.06	0.010	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		20	0.12	0.024	Industry					
Impermeable (SCS Type D Soil)		63	0.21	0.132	Light industry		0.0	0.65	0	
Total (C _p)		100		0.167	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		30	0.07	0.021	Suburban			0.6	0	
Grasslands		9	0.17	0.015	Streets		0.0	0.825	0	
No vegetation		61	0.26	0.159	Maximum flood			1	0	
Total (C _v)		100	-	0.195	Total (C ₂)		100		0.3126	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.67		hours		ARF (%) = 100.00			
T _c =			0.42		hours		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.467	0.467	0.467	0.467	0.467	0.467
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.467	0.467	0.467	0.467	0.467	0.467
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.292	0.316	0.339	0.367	0.416	0.467
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.300	0.314	0.329	0.347	0.377	0.409
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					21	29	34	40	48	54
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					49.6	67.9	81.1	94.5	113.3	128.3
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					49.6	67.9	81.1	94.5	113.3	128.3
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					2.5	3.6	4.5	5.5	7.1	8.8

RATIONAL METHOD									
Description of the catchment				Rural					
River details				Olifants Tributary 2					
Calculated by				Wian Lombard			Date		2025-01-09
Physical characteristics									
Size of the catchment (A)		10.61		km ²				Rainfall region	
Longest watercourse (L)		6.622		km				Area distribution factors	
10-85 Slope (S _{av})		0.07		m/m				Rural (α)	
Dolomite area (D _%)		0		%				Urban (β)	
Mean annual rainfall (MAP)		550.0		mm				Lakes (γ)	
Rural				Urban					
Surface slope		%		Factor		C _s		Description	
Vleis and pans (0-3%)		0		0.01		0.000		Lawns	
Flat areas (3-10%)		49		0.06		0.029		Sandy, flat (<2%)	
Hilly (10-30%)		25		0.12		0.030		Sandy, steep (>7%)	
Steep areas (>30%)		26		0.22		0.058		Heavy soil, flat (<2%)	
Total (C _s)		100				0.117		Heavy soil,steep (>7%)	
Permeability		%		Factor		C _p		Residential area	
Very permeable (SCS Type A Soil)		0		0.03		0.000		Houses	
Permeable (SCS Type B Soil)		0		0.06		0.000		Flats	
Semi-permeable (SCS Type C Soil)		43		0.12		0.052		Industry	
Impermeable (SCS Type D Soil)		57		0.21		0.119		Light industry	
Total (C _p)		100				0.171		Heavy industry	
Vegetation		%		Factor		C _v		Business	
Thick bush & plantation		0		0.03		0.000		City centre	
Light bush and farmlands		66		0.07		0.047		Suburban	
Grasslands		16		0.17		0.027		Streets	
No vegetation		18		0.26		0.046		Maximum flood	
Total (C _v)		100				0.119		Total (C ₂)	
								100	
								0.3097	
Time of concentration (T _c)						Notes			
Overland flow			Defined watercourse						
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$						
T _c =			2.44			hours			
T _c =			0.79			hours			
Run-off coefficient									
Return period (years), T					2		5		10
Run-off coefficient C ₁					0.407		0.407		0.407
(C ₁ = C _s + C _p + C _v)					0.407		0.407		0.407
Adjusted for dolomite areas, C _{1D}					0.407		0.407		0.407
(=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))					0.407		0.407		0.407
Adjustment factor for initial saturation, F _t					0.625		0.675		0.725
(Taken as average of two set of values provided in DM)					0.625		0.675		0.725
Adjusted run-off coefficient, C _{1T}					0.254		0.275		0.295
(= C _{1D} x F _t)					0.254		0.275		0.295
Combined run-off coefficient C _t					0.258		0.277		0.296
(= αC _{1T} + βC ₂ + γC ₃)					0.258		0.277		0.296
Rainfall									
Return period (years), T					2		5		10
Point rainfall (mm), P _T					27		37		44
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					34.5		47.3		56.5
Area reduction factor (%), ARF _T					99.1		99.1		99.1
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					34.2		46.9		56.0
Peak flow									
Return period (years), T					2		5		10
Peak flow (m ³ /s)					26.0		38.3		48.8
$Q_T = \frac{C_T I_T A}{3.6}$					26.0		38.3		48.8

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Olifants Tributary 3						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		1.66	km ²					Rainfall region		
Longest watercourse (L)		2.998	km					Area distribution factors		
10-85 Slope (S _{av})		0.02	m/m					Rural (α)		0.950
Dolomite area (D _%)		0	%					Urban (β)		0.050
Mean annual rainfall (MAP)		550.0	mm					Lakes (γ)		0.000
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		0	0.01	0.000	Lawns					
Flat areas (3-10%)		66	0.06	0.039	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		26	0.12	0.031	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		8	0.22	0.018	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.089	Heavy soil,steep (>7%)		75	0.3	0.23	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		24.9	0.4	0.10	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		60	0.12	0.072	Industry					
Impermeable (SCS Type D Soil)		40	0.21	0.085	Light industry		0.0	0.65	0	
Total (C _p)		100		0.156	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		67	0.07	0.047	Suburban			0.6	0	
Grasslands		26	0.17	0.045	Streets		0.0	0.825	0	
No vegetation		7	0.26	0.017	Maximum flood			1	0	
Total (C _v)		100	-	0.109	Total (C ₂)		100		0.3249	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			2.16		hours		ARF (%) = 100.00			
			0.64		hours		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.355	0.355	0.355	0.355	0.355	0.355
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.355	0.355	0.355	0.355	0.355	0.355
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.222	0.239	0.257	0.278	0.316	0.355
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.227	0.244	0.260	0.281	0.316	0.353
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					25	34	41	48	57	65
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					38.8	53.2	63.5	74.1	88.7	100.5
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					38.8	53.2	63.5	74.1	88.7	100.5
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					4.1	6.0	7.6	9.6	13.0	16.4

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Olifants Tributary 4						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		0.60	km ²				Rainfall region			
Longest watercourse (L)		1.765	km				Area distribution factors			
10-85 Slope (S _{av})		0.15	m/m				Rural (α)		0.952	
Dolomite area (D _%)		0	%				Urban (β)		0.048	
Mean annual rainfall (MAP)		550.0	mm				Lakes (γ)		0.000	
Rural				Urban						
Surface slope		%	Factor	C _s	Description	%	Factor	C ₂		
Vleis and pans (0-3%)		0	0.01	0.000	Lawns					
Flat areas (3-10%)		52	0.06	0.031	Sandy, flat (<2%)		0.075	0		
Hilly (10-30%)		40	0.12	0.048	Sandy, steep (>7%)		0.175	0		
Steep areas (>30%)		9	0.22	0.019	Heavy soil, flat (<2%)		0.15	0		
Total (C _s)		100		0.098	Heavy soil,steep (>7%)	72	0.3	0.22		
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses	27.8	0.4	0.11		
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats		0.6	0		
Semi-permeable (SCS Type C Soil)		44	0.12	0.053	Industry					
Impermeable (SCS Type D Soil)		56	0.21	0.117	Light industry	0.0	0.65	0		
Total (C _p)		100		0.170	Heavy industry	0.0	0.75	0		
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre		0.825	0		
Light bush and farmlands		83	0.07	0.058	Suburban		0.6	0		
Grasslands		14	0.17	0.025	Streets	0.0	0.825	0		
No vegetation		3	0.26	0.007	Maximum flood		1	0		
Total (C _v)		100	-	0.090	Total (C ₂)	100		0.3278		
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.11	hours	ARF (%)			=	100.00	
			T _c =	0.22	hours	r			Thick grass cover = 0.80	
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.358	0.358	0.358	0.358	0.358	0.358
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.358	0.358	0.358	0.358	0.358	0.358
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.223	0.241	0.259	0.281	0.318	0.358
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.228	0.246	0.263	0.283	0.319	0.356
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					16	21	25	30	35	40
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					72.0	98.6	117.8	137.3	164.6	186.4
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					72.0	98.6	117.8	137.3	164.6	186.4
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					2.7	4.0	5.1	6.4	8.7	11.0

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Olifants Tributary 5						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		0.49	km ²				Rainfall region			
Longest watercourse (L)		2.114	km				Area distribution factors			
10-85 Slope (S _{av})		0.09	m/m				Rural (α)		1.000	
Dolomite area (D _%)		0	%				Urban (β)		0.000	
Mean annual rainfall (MAP)		550.0	mm				Lakes (γ)		0.000	
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		0	0.01	0.000	Lawns					
Flat areas (3-10%)		64	0.06	0.038	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		30	0.12	0.036	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		6	0.22	0.013	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.088	Heavy soil,steep (>7%)		0	0.3	0.00	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		0.0	0.4	0.00	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		58	0.12	0.070	Industry					
Impermeable (SCS Type D Soil)		42	0.21	0.088	Light industry		0.0	0.65	0	
Total (C _p)		100		0.158	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		86	0.07	0.061	Suburban			0.6	0	
Grasslands		12	0.17	0.021	Streets		0.0	0.825	0	
No vegetation		1	0.26	0.003	Maximum flood			1	0	
Total (C _v)		100	-	0.085	Total (C ₂)		0		0.0000	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.36		hours		ARF (%) = 100.00			
T _c =			0.30		hours		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.330	0.330	0.330	0.330	0.330	0.330
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.330	0.330	0.330	0.330	0.330	0.330
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.206	0.223	0.239	0.259	0.294	0.330
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.206	0.223	0.239	0.259	0.294	0.330
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					18	25	30	35	42	47
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					60.8	83.3	99.4	115.9	139.0	157.4
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					60.8	83.3	99.4	115.9	139.0	157.4
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					1.7	2.5	3.2	4.1	5.5	7.0

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Olifants Tributary 6						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		0.27	km ²					Rainfall region		
Longest watercourse (L)		1.634	km					Area distribution factors		
10-85 Slope (S _{av})		0.04	m/m							
Dolomite area (D _%)		0	%							
Mean annual rainfall (MAP)		550.0	mm							
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		0	0.01	0.000	Lawns					
Flat areas (3-10%)		94	0.06	0.056	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		6	0.12	0.007	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		0	0.22	0.000	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.064	Heavy soil,steep (>7%)		0	0.3	0.00	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		0.0	0.4	0.00	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		96	0.12	0.115	Industry					
Impermeable (SCS Type D Soil)		4	0.21	0.009	Light industry		0.0	0.65	0	
Total (C _p)		100		0.124	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		99	0.07	0.069	Suburban			0.6	0	
Grasslands		1	0.17	0.002	Streets		0.0	0.825	0	
No vegetation		0	0.26	0.001	Maximum flood			1	0	
Total (C _v)		100	-	0.072	Total (C ₂)		0		0.0000	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.48		hours		ARF (%) = 100.00			
			0.35		hours		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.259	0.259	0.259	0.259	0.259	0.259
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.259	0.259	0.259	0.259	0.259	0.259
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.162	0.175	0.188	0.203	0.231	0.259
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.162	0.175	0.188	0.203	0.231	0.259
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					19	26	31	37	44	50
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					55.5	76.0	90.8	105.9	126.9	143.7
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					55.5	76.0	90.8	105.9	126.9	143.7
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					0.7	1.0	1.3	1.6	2.2	2.8

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Olifants Tributary 7						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		2.38	km ²				Rainfall region			
Longest watercourse (L)		4.550	km				Area distribution factors			
10-85 Slope (S _{av})		0.04	m/m							
Dolomite area (D _%)		0	%							
Mean annual rainfall (MAP)		550.0	mm							
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		0	0.01	0.000	Lawns					
Flat areas (3-10%)		54	0.06	0.032	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		41	0.12	0.050	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		5	0.22	0.011	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.093	Heavy soil,steep (>7%)		0	0.3	0.00	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		0.0	0.4	0.00	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		9	0.12	0.011	Industry					
Impermeable (SCS Type D Soil)		91	0.21	0.191	Light industry		0.0	0.65	0	
Total (C _p)		100		0.202	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		76	0.07	0.053	Suburban			0.6	0	
Grasslands		24	0.17	0.041	Streets		0.0	0.825	0	
No vegetation		0	0.26	0.001	Maximum flood			1	0	
Total (C _v)		100	-	0.095	Total (C ₂)		0		0.0000	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			2.29		hours		ARF (%) = 100.00			
T _c =			0.71		hours		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.389	0.389	0.389	0.389	0.389	0.389
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.389	0.389	0.389	0.389	0.389	0.389
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.243	0.262	0.282	0.305	0.346	0.389
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.243	0.262	0.282	0.305	0.346	0.389
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					26	36	43	50	60	67
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					36.6	50.2	59.9	69.9	83.7	94.9
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					36.6	50.2	59.9	69.9	83.7	94.9
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					5.9	8.7	11.2	14.1	19.1	24.4

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Olifants Tributary 8						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		0.58	km ²					Rainfall region		
Longest watercourse (L)		2.338	km					Area distribution factors		
10-85 Slope (S _{av})		0.04	m/m					Rural (α)		1.000
Dolomite area (D _%)		0	%					Urban (β)		0.000
Mean annual rainfall (MAP)		550.0	mm					Lakes (γ)		0.000
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		0	0.01	0.000	Lawns					
Flat areas (3-10%)		84	0.06	0.051	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		15	0.12	0.018	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		1	0.22	0.002	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.070	Heavy soil,steep (>7%)		0	0.3	0.00	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		0.0	0.4	0.00	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		51	0.12	0.061	Industry					
Impermeable (SCS Type D Soil)		49	0.21	0.103	Light industry		0.0	0.65	0	
Total (C _p)		100		0.164	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		46	0.07	0.032	Suburban			0.6	0	
Grasslands		29	0.17	0.050	Streets		0.0	0.825	0	
No vegetation		25	0.26	0.064	Maximum flood			1	0	
Total (C _v)		100	-	0.146	Total (C ₂)		0		0.0000	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.73	hours	ARF (%)		=	100.00		
			T _c =	0.45	hours	r		Thick grass cover = 0.80		
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.380	0.380	0.380	0.380	0.380	0.380
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.380	0.380	0.380	0.380	0.380	0.380
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.238	0.257	0.276	0.299	0.339	0.380
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.238	0.257	0.276	0.299	0.339	0.380
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					21	29	35	41	49	55
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					48.1	65.9	78.7	91.8	110.0	124.6
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					48.1	65.9	78.7	91.8	110.0	124.6
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					1.8	2.7	3.5	4.4	6.0	7.6

RATIONAL METHOD												
Description of the catchment				Rural								
River details				Olifants Tributary 9								
Calculated by				Wian Lombard			Date		2025-01-09			
Physical characteristics												
Size of the catchment (A)		0.34		km ²		Rainfall region						
Longest watercourse (L)		1.380		km				Area distribution factors				
10-85 Slope (S _{av})		0.04		m/m						Rural (α)		0.987
Dolomite area (D _%)		0		%						Urban (β)		0.013
Mean annual rainfall (MAP)		550.0		mm						Lakes (γ)		0.000
Rural				Urban								
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂			
Vleis and pans (0-3%)		0	0.01	0.000	Lawns							
Flat areas (3-10%)		84	0.06	0.051	Sandy, flat (<2%)			0.075	0			
Hilly (10-30%)		15	0.12	0.018	Sandy, steep (>7%)			0.175	0			
Steep areas (>30%)		1	0.22	0.002	Heavy soil, flat (<2%)			0.15	0			
Total (C _s)		100		0.070	Heavy soil,steep (>7%)		0	0.3	0.00			
Permeability		%	Factor	C _p	Residential area							
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		100.0	0.4	0.40			
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0			
Semi-permeable (SCS Type C Soil)		83	0.12	0.100	Industry							
Impermeable (SCS Type D Soil)		17	0.21	0.035	Light industry		0.0	0.65	0			
Total (C _p)		100		0.135	Heavy industry		0.0	0.75	0			
Vegetation		%	Factor	C _v	Business							
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0			
Light bush and farmlands		46	0.07	0.032	Suburban			0.6	0			
Grasslands		27	0.17	0.046	Streets		0.0	0.825	0			
No vegetation		27	0.26	0.069	Maximum flood			1	0			
Total (C _v)		100	-	0.148	Total (C ₂)		100		0.4000			
Time of concentration (T _c)					Notes							
Overland flow			Defined watercourse									
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$									
T _c = 1.37 hours			T _c = 0.30 hours		ARF (%) = 100.00							
					r Thick grass cover = 0.80							
Run-off coefficient												
Return period (years), T					2	5	10	20	50	100		
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.353	0.353	0.353	0.353	0.353	0.353		
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))					0.353	0.353	0.353	0.353	0.353	0.353		
Adjustment factor for initial saturation, F _t (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000		
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _t)					0.220	0.238	0.256	0.277	0.314	0.353		
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.223	0.240	0.258	0.278	0.315	0.353		
Rainfall												
Return period (years), T					2	5	10	20	50	100		
Point rainfall (mm), P _T					18	25	30	35	42	47		
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					60.1	82.4	98.3	114.7	137.4	155.7		
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0		
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					60.1	82.4	98.3	114.7	137.4	155.7		
Peak flow												
Return period (years), T					2	5	10	20	50	100		
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					1.3	1.9	2.4	3.0	4.1	5.2		

RATIONAL METHOD									
Description of the catchment				Rural					
River details				Olifants Tributary 10					
Calculated by				Wian Lombard			Date		2025-01-09
Physical characteristics									
Size of the catchment (A)		0.22		km ²				Rainfall region	
Longest watercourse (L)		1.411		km				Area distribution factors	
10-85 Slope (S _{av})		0.07		m/m				Rural (α)	
Dolomite area (D _%)		0		%				Urban (β)	
Mean annual rainfall (MAP)		550.0		mm				Lakes (γ)	
Rural				Urban					
Surface slope		%		Factor		C _s		Description	
Vleis and pans (0-3%)		0		0.01		0.000		Lawns	
Flat areas (3-10%)		90		0.06		0.054		Sandy, flat (<2%)	
Hilly (10-30%)		10		0.12		0.012		Sandy, steep (>7%)	
Steep areas (>30%)		0		0.22		0.000		Heavy soil, flat (<2%)	
Total (C _s)		100				0.066		Heavy soil,steep (>7%)	
Permeability		%		Factor		C _p		Residential area	
Very permeable (SCS Type A Soil)		0		0.03		0.000		Houses	
Permeable (SCS Type B Soil)		0		0.06		0.000		Flats	
Semi-permeable (SCS Type C Soil)		61		0.12		0.073		Industry	
Impermeable (SCS Type D Soil)		39		0.21		0.082		Light industry	
Total (C _p)		100				0.155		Heavy industry	
Vegetation		%		Factor		C _v		Business	
Thick bush & plantation		0		0.03		0.000		City centre	
Light bush and farmlands		32		0.07		0.022		Suburban	
Grasslands		21		0.17		0.035		Streets	
No vegetation		48		0.26		0.124		Maximum flood	
Total (C _v)		100				0.182		Total (C ₂)	
								100	
								0.4000	
Time of concentration (T _c)				Notes					
Overland flow		Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$		$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =		1.17		hours		T _c =		0.23	
Run-off coefficient									
Return period (years), T				2		5		10	
Run-off coefficient C ₁				0.403		0.403		0.403	
(C ₁ = C _s + C _p + C _v)				0.403		0.403		0.403	
Adjusted for dolomite areas, C _{1D}				0.403		0.403		0.403	
(=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))				0.403		0.403		0.403	
Adjustment factor for initial saturation, F _t				0.625		0.675		0.725	
(Taken as average of two set of values provided in DM)				0.625		0.675		0.725	
Adjusted run-off coefficient, C _{1T}				0.252		0.272		0.292	
(= C _{1D} x F _t)				0.252		0.272		0.292	
Combined run-off coefficient C _t				0.264		0.282		0.301	
(= αC _{1T} + βC ₂ + γC ₃)				0.264		0.282		0.301	
Rainfall									
Return period (years), T				2		5		10	
Point rainfall (mm), P _T				16		22		27	
Point intensity (mm/hour), P _{IT} (= P _T / T _C)				69.8		95.7		114.2	
Area reduction factor (%), ARF _T				100.0		100.0		100.0	
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)				69.8		95.7		114.2	
Peak flow									
Return period (years), T				2		5		10	
Peak flow (m ³ /s)				1.1		1.7		2.1	
$Q_T = \frac{C_T I_T A}{3.6}$				1.1		1.7		2.1	

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Olifants Tributary 11						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		0.33	km ²				Rainfall region			
Longest watercourse (L)		1.310	km				Area distribution factors			
10-85 Slope (S _{av})		0.08	m/m				Rural (α)		0.835	
Dolomite area (D _%)		0	%				Urban (β)		0.165	
Mean annual rainfall (MAP)		550.0	mm				Lakes (γ)		0.000	
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		0	0.01	0.000	Lawns					
Flat areas (3-10%)		82	0.06	0.049	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		16	0.12	0.019	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		1	0.22	0.003	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.072	Heavy soil,steep (>7%)		83	0.3	0.25	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		17.0	0.4	0.07	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		77	0.12	0.092	Industry					
Impermeable (SCS Type D Soil)		23	0.21	0.049	Light industry		0.0	0.65	0	
Total (C _p)		100		0.141	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		34	0.07	0.024	Suburban			0.6	0	
Grasslands		29	0.17	0.050	Streets		0.0	0.825	0	
No vegetation		37	0.26	0.096	Maximum flood			1	0	
Total (C _v)		100	-	0.169	Total (C ₂)		100		0.3170	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.10		hours		ARF (%) = 100.00			
			T _c =		0.21		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.382	0.382	0.382	0.382	0.382	0.382
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.382	0.382	0.382	0.382	0.382	0.382
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.239	0.258	0.277	0.300	0.340	0.382
Combined run-off coefficient C _i (= αC _{1T} + βC ₂ + γC ₃)					0.252	0.268	0.284	0.303	0.336	0.372
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					15	21	25	29	35	40
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					72.3	99.0	118.2	137.9	165.2	187.2
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					72.3	99.0	118.2	137.9	165.2	187.2
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					1.7	2.4	3.1	3.8	5.1	6.3

RATIONAL METHOD												
Description of the catchment				Rural								
River details				Olifants Tributary 12								
Calculated by				Wian Lombard			Date		2025-01-09			
Physical characteristics												
Size of the catchment (A)		0.17	km ²				Rainfall region					
Longest watercourse (L)		4.146	km				Area distribution factors			Rural (α)		0.569
10-85 Slope (S _{av})		0.05	m/m							Urban (β)		0.431
Dolomite area (D _%)		0	%							Lakes (γ)		0.000
Mean annual rainfall (MAP)		550.0	mm									
Rural				Urban								
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂			
Vleis and pans (0-3%)		0	0.01	0.000	Lawns							
Flat areas (3-10%)		88	0.06	0.053	Sandy, flat (<2%)			0.075	0			
Hilly (10-30%)		11	0.12	0.013	Sandy, steep (>7%)			0.175	0			
Steep areas (>30%)		1	0.22	0.001	Heavy soil, flat (<2%)			0.15	0			
Total (C _s)		100		0.067	Heavy soil,steep (>7%)		90	0.3	0.27			
Permeability		%	Factor	C _p	Residential area							
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		10.1	0.4	0.04			
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0			
Semi-permeable (SCS Type C Soil)		100	0.12	0.120	Industry							
Impermeable (SCS Type D Soil)		0	0.21	0.000	Light industry		0.0	0.65	0			
Total (C _p)		100		0.120	Heavy industry		0.0	0.75	0			
Vegetation		%	Factor	C _v	Business							
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0			
Light bush and farmlands		28	0.07	0.020	Suburban			0.6	0			
Grasslands		36	0.17	0.061	Streets		0.0	0.825	0			
No vegetation		36	0.26	0.094	Maximum flood			1	0			
Total (C _v)		100	-	0.174	Total (C ₂)		100		0.3101			
Time of concentration (T _c)					Notes							
Overland flow			Defined watercourse									
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$									
T _c = 2.11 hours			T _c = 0.62 hours		ARF (%) = 100.00							
					r Thick grass cover = 0.80							
Run-off coefficient												
Return period (years), T					2	5	10	20	50	100		
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.362	0.362	0.362	0.362	0.362	0.362		
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))					0.362	0.362	0.362	0.362	0.362	0.362		
Adjustment factor for initial saturation, F _t (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000		
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _t)					0.226	0.244	0.262	0.284	0.322	0.362		
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.262	0.273	0.283	0.295	0.317	0.339		
Rainfall												
Return period (years), T					2	5	10	20	50	100		
Point rainfall (mm), P _T					25	34	40	47	56	64		
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					39.7	54.4	64.9	75.7	90.7	102.7		
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0		
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					39.7	54.4	64.9	75.7	90.7	102.7		
Peak flow												
Return period (years), T					2	5	10	20	50	100		
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					0.5	0.7	0.9	1.0	1.3	1.6		

RATIONAL METHOD											
Description of the catchment				Rural							
River details				Olifants Tributary 13							
Calculated by				Wian Lombard			Date		2025-01-09		
Physical characteristics											
Size of the catchment (A)		0.23		km ²				Rainfall region			
Longest watercourse (L)		4.839		km				Area distribution factors			
10-85 Slope (S _{av})		0.07		m/m				Rural (α)			
Dolomite area (D _%)		0		%				Urban (β)			
Mean annual rainfall (MAP)		550.0		mm				Lakes (γ)			
Rural				Urban							
Surface slope		%		Factor		C _s		Description			
Vleis and pans (0-3%)		0		0.01		0.000		Lawns			
Flat areas (3-10%)		82		0.06		0.049		Sandy, flat (<2%)			
Hilly (10-30%)		15		0.12		0.018		Sandy, steep (>7%)			
Steep areas (>30%)		3		0.22		0.007		Heavy soil, flat (<2%)			
Total (C _s)		100				0.074		Heavy soil,steep (>7%)			
Permeability		%		Factor		C _p		Residential area			
Very permeable (SCS Type A Soil)		0		0.03		0.000		Houses			
Permeable (SCS Type B Soil)		0		0.06		0.000		Flats			
Semi-permeable (SCS Type C Soil)		85		0.12		0.102		Industry			
Impermeable (SCS Type D Soil)		15		0.21		0.032		Light industry			
Total (C _p)		100				0.134		Heavy industry			
Vegetation		%		Factor		C _v		Business			
Thick bush & plantation		0		0.03		0.000		City centre			
Light bush and farmlands		36		0.07		0.025		Suburban			
Grasslands		28		0.17		0.047		Streets			
No vegetation		36		0.26		0.095		Maximum flood			
Total (C _v)		100				0.167		Total (C ₂)			
								100			
								0.3126			
Time of concentration (T _c)						Notes					
Overland flow			Defined watercourse								
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$								
T _c = 2.13 hours			T _c = 0.63 hours								
Run-off coefficient											
Return period (years), T						2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)						0.374	0.374	0.374	0.374	0.374	0.374
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))						0.374	0.374	0.374	0.374	0.374	0.374
Adjustment factor for initial saturation, F _t (Taken as average of two set of values provided in DM)						0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _t)						0.234	0.253	0.271	0.294	0.333	0.374
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)						0.263	0.275	0.287	0.301	0.325	0.351
Rainfall											
Return period (years), T						2	5	10	20	50	100
Point rainfall (mm), P _T						25	34	41	47	57	64
Point intensity (mm/hour), P _{IT} (= P _T / T _C)						39.2	53.8	64.2	74.8	89.7	101.6
Area reduction factor (%), ARF _T						100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)						39.2	53.8	64.2	74.8	89.7	101.6
Peak flow											
Return period (years), T						2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$						0.7	0.9	1.2	1.4	1.9	2.3

RATIONAL METHOD												
Description of the catchment				Rural								
River details				Olifants Tributary 14								
Calculated by				Wian Lombard			Date		2025-01-09			
Physical characteristics												
Size of the catchment (A)		0.17	km ²				Rainfall region					
Longest watercourse (L)		0.718	km				Area distribution factors			Rural (α)		0.435
10-85 Slope (S _{av})		0.01	m/m							Urban (β)		0.565
Dolomite area (D _%)		0	%							Lakes (γ)		0.000
Mean annual rainfall (MAP)		550.0	mm									
Rural				Urban								
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂			
Vleis and pans (0-3%)		0	0.01	0.000	Lawns							
Flat areas (3-10%)		93	0.06	0.056	Sandy, flat (<2%)			0.075	0			
Hilly (10-30%)		5	0.12	0.006	Sandy, steep (>7%)			0.175	0			
Steep areas (>30%)		1	0.22	0.003	Heavy soil, flat (<2%)			0.15	0			
Total (C _s)		100		0.065	Heavy soil,steep (>7%)		83	0.3	0.25			
Permeability		%	Factor	C _p	Residential area							
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		16.7	0.4	0.07			
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0			
Semi-permeable (SCS Type C Soil)		93	0.12	0.112	Industry							
Impermeable (SCS Type D Soil)		7	0.21	0.014	Light industry		0.0	0.65	0			
Total (C _p)		100		0.126	Heavy industry		0.0	0.75	0			
Vegetation		%	Factor	C _v	Business							
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0			
Light bush and farmlands		16	0.07	0.011	Suburban			0.6	0			
Grasslands		25	0.17	0.043	Streets		0.0	0.825	0			
No vegetation		59	0.26	0.153	Maximum flood			1	0			
Total (C _v)		100	-	0.207	Total (C ₂)		100		0.3167			
Time of concentration (T _c)					Notes							
Overland flow			Defined watercourse									
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$									
T _c = 1.30 hours			T _c = 0.28 hours		ARF (%) = 100.00							
					r Thick grass cover = 0.80							
Run-off coefficient												
Return period (years), T					2	5	10	20	50	100		
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.398	0.398	0.398	0.398	0.398	0.398		
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))					0.398	0.398	0.398	0.398	0.398	0.398		
Adjustment factor for initial saturation, F _t (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000		
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _t)					0.249	0.269	0.289	0.312	0.354	0.398		
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.287	0.296	0.304	0.315	0.333	0.352		
Rainfall												
Return period (years), T					2	5	10	20	50	100		
Point rainfall (mm), P _T					18	24	29	34	41	46		
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					63.6	87.1	104.0	121.3	145.3	164.6		
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0		
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					63.6	87.1	104.0	121.3	145.3	164.6		
Peak flow												
Return period (years), T					2	5	10	20	50	100		
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					0.9	1.2	1.5	1.8	2.3	2.7		

RATIONAL METHOD												
Description of the catchment				Rural								
River details				Palangwe Catchment								
Calculated by				Wian Lombard			Date	2025-01-09				
Physical characteristics												
Size of the catchment (A)	108.64	km ²					Rainfall region					
Longest watercourse (L)	29.911	km					Area distribution factors		Rural (α)	0.974		
10-85 Slope (S _{av})	0.02	m/m							Urban (β)	0.026		
Dolomite area (D _%)	0	%							Lakes (γ)	0.000		
Mean annual rainfall (MAP)	550.0	mm										
Rural				Urban								
Surface slope	%	Factor	C _s	Description	%	Factor	C ₂					
Vleis and pans (0-3%)	0	0.01	0.000	Lawns								
Flat areas (3-10%)	56	0.06	0.034	Sandy, flat (<2%)		0.075	0					
Hilly (10-30%)	38	0.12	0.046	Sandy, steep (>7%)		0.175	0					
Steep areas (>30%)	5	0.22	0.011	Heavy soil, flat (<2%)		0.15	0					
Total (C _s)	100		0.091	Heavy soil,steep (>7%)	92	0.3	0.27					
Permeability	%	Factor	C _p	Residential area								
Very permeable (SCS Type A Soil)	0	0.03	0.000	Houses	8.2	0.4	0.03					
Permeable (SCS Type B Soil)	0	0.06	0.000	Flats		0.6	0					
Semi-permeable (SCS Type C Soil)	27	0.12	0.033	Industry								
Impermeable (SCS Type D Soil)	72	0.21	0.152	Light industry	0.0	0.65	0					
Total (C _p)	100		0.185	Heavy industry	0.0	0.75	0					
Vegetation	%	Factor	C _v	Business								
Thick bush & plantation	2	0.03	0.001	City centre		0.825	0					
Light bush and farmlands	58	0.07	0.040	Suburban		0.6	0					
Grasslands	31	0.17	0.053	Streets	0.3	0.825	0.0021127					
No vegetation	9	0.26	0.023	Maximum flood		1	0					
Total (C _v)	100	-	0.117	Total (C ₂)	100		0.3095					
Time of concentration (T _c)				Notes								
Overland flow		Defined watercourse										
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$		$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$										
T _c =	6.91	hours	T _c =	4.38	hours							
				ARF (%) = 93.60								
				r Thick grass cover = 0.80								
Run-off coefficient												
Return period (years), T	2		5		10		20		50		100	
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)	0.393		0.393		0.393		0.393		0.393		0.393	
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))	0.393		0.393		0.393		0.393		0.393		0.393	
Adjustment factor for initial saturation, F _t (Taken as average of two set of values provided in DM)	0.625		0.675		0.725		0.785		0.890		1.000	
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _t)	0.246		0.265		0.285		0.309		0.350		0.393	
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)	0.247		0.267		0.286		0.309		0.349		0.391	
Rainfall												
Return period (years), T	2		5		10		20		50		100	
Point rainfall (mm), P _T	46		63		75		88		105		119	
Point intensity (mm/hour), P _{IT} (= P _T / T _C)	10.5		14.4		17.2		20.0		24.0		27.2	
Area reduction factor (%), ARF _T	93.6		93.6		93.6		93.6		93.6		93.6	
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)	9.8		13.5		16.1		18.8		22.5		25.5	
Peak flow												
Return period (years), T	2		5		10		20		50		100	
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$	73.4		108.4		138.7		174.7		236.7		300.5	

RATIONAL METHOD															
Description of the catchment				Rural											
River details				Olifants Tributary 16											
Calculated by				Wian Lombard			Date		2025-01-09						
Physical characteristics															
Size of the catchment (A)		0.62		km ²				Rainfall region							
Longest watercourse (L)		2.262		km				Area distribution factors							
10-85 Slope (S _{av})		0.02		m/m											
Dolomite area (D _%)		0		%											
Mean annual rainfall (MAP)		550.0		mm											
Rural				Urban											
Surface slope		%		Factor		C _s		Description							
Vleis and pans (0-3%)		0		0.01		0.000		Lawns							
Flat areas (3-10%)		76		0.06		0.046		Sandy, flat (<2%)							
Hilly (10-30%)		23		0.12		0.027		Sandy, steep (>7%)							
Steep areas (>30%)		2		0.22		0.003		Heavy soil, flat (<2%)							
Total (C _s)		100				0.076		Heavy soil, steep (>7%)							
Permeability		%		Factor		C _p		Residential area							
Very permeable (SCS Type A Soil)		0		0.03		0.000		Houses							
Permeable (SCS Type B Soil)		0		0.06		0.000		Flats							
Semi-permeable (SCS Type C Soil)		76		0.12		0.091		Industry							
Impermeable (SCS Type D Soil)		24		0.21		0.051		Light industry							
Total (C _p)		100				0.142		Heavy industry							
Vegetation		%		Factor		C _v		Business							
Thick bush & plantation		0		0.03		0.000		City centre							
Light bush and farmlands		64		0.07		0.044		Suburban							
Grasslands		24		0.17		0.040		Streets							
No vegetation		13		0.26		0.034		Maximum flood							
Total (C _v)		100				0.118		Total (C ₂)							
Time of concentration (T _c)				Notes											
Overland flow			Defined watercourse												
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$												
T _c = 1.95 hours			T _c = 0.54 hours												
						ARF (%) = 100.00									
						r Thick grass cover = 0.80									
Run-off coefficient															
Return period (years), T				2		5		10		20		50		100	
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)				0.336		0.336		0.336		0.336		0.336		0.336	
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))				0.336		0.336		0.336		0.336		0.336		0.336	
Adjustment factor for initial saturation, F _t (Taken as average of two set of values provided in DM)				0.625		0.675		0.725		0.785		0.890		1.000	
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _t)				0.210		0.227		0.243		0.264		0.299		0.336	
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)				0.247		0.258		0.268		0.281		0.304		0.328	
Rainfall															
Return period (years), T				2		5		10		20		50		100	
Point rainfall (mm), P _T				23		32		38		45		53		60	
Point intensity (mm/hour), P _{IT} (= P _T / T _C)				42.9		58.8		70.2		81.9		98.1		111.2	
Area reduction factor (%), ARF _T				100.0		100.0		100.0		100.0		100.0		100.0	
Average intensity (mm/hour), I _T (= P _{IT} x ARF _T)				42.9		58.8		70.2		81.9		98.1		111.2	
Peak flow															
Return period (years), T				2		5		10		20		50		100	
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$				1.8		2.6		3.2		3.9		5.1		6.2	

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Olifants Tributary 17						
Calculated by				Wian Lombard			Date		2025-01-09	
Physical characteristics										
Size of the catchment (A)		0.33		km ²				Rainfall region		
Longest watercourse (L)		1.917		km				Area distribution factors		
10-85 Slope (S _{av})		0.03		m/m				Rural (α)		
Dolomite area (D _%)		0		%				Urban (β)		
Mean annual rainfall (MAP)		550.0		mm				Lakes (γ)		
Rural				Urban						
Surface slope		%		Factor		C _s		Description		
Vleis and pans (0-3%)		0		0.01		0.000		Lawns		
Flat areas (3-10%)		68		0.06		0.041		Sandy, flat (<2%)		
Hilly (10-30%)		28		0.12		0.033		Sandy, steep (>7%)		
Steep areas (>30%)		4		0.22		0.010		Heavy soil, flat (<2%)		
Total (C _s)		100				0.084		Heavy soil,steep (>7%)		
Permeability		%		Factor		C _p		Residential area		
Very permeable (SCS Type A Soil)		0		0.03		0.000		Houses		
Permeable (SCS Type B Soil)		0		0.06		0.000		Flats		
Semi-permeable (SCS Type C Soil)		36		0.12		0.043		Industry		
Impermeable (SCS Type D Soil)		64		0.21		0.135		Light industry		
Total (C _p)		100				0.178		Heavy industry		
Vegetation		%		Factor		C _v		Business		
Thick bush & plantation		0		0.03		0.000		City centre		
Light bush and farmlands		64		0.07		0.045		Suburban		
Grasslands		29		0.17		0.049		Streets		
No vegetation		7		0.26		0.018		Maximum flood		
Total (C _v)		100				0.112		Total (C ₂)		
								100		
								0.3070		
Time of concentration (T _c)						Notes				
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 1.67 hours			T _c = 0.42 hours							
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.373	0.373	0.373	0.373	0.373	0.373
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))					0.373	0.373	0.373	0.373	0.373	0.373
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.233	0.252	0.271	0.293	0.332	0.373
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.247	0.263	0.278	0.296	0.327	0.360
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					21	29	34	40	48	54
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					49.5	67.8	80.9	94.4	113.1	128.1
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					49.5	67.8	80.9	94.4	113.1	128.1
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					1.1	1.6	2.1	2.6	3.4	4.3

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Olifants Tributary 18						
Calculated by				Wian Lombard			Date		2025-01-09	
Physical characteristics										
Size of the catchment (A)		0.15		km ²				Rainfall region		
Longest watercourse (L)		1.066		km				Area distribution factors		
10-85 Slope (S _{av})		0.03		m/m						
Dolomite area (D _%)		0		%						
Mean annual rainfall (MAP)		550.0		mm						
								Rural (α)		0.698
								Urban (β)		0.302
								Lakes (γ)		0.000
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		0	0.01	0.000	Lawns					
Flat areas (3-10%)		71	0.06	0.043	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		27	0.12	0.033	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		1	0.22	0.003	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.079	Heavy soil,steep (>7%)		70	0.3	0.21	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		29.6	0.4	0.12	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		36	0.12	0.043	Industry					
Impermeable (SCS Type D Soil)		64	0.21	0.135	Light industry		0.0	0.65	0	
Total (C _p)		100		0.178	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		61	0.07	0.043	Suburban			0.6	0	
Grasslands		25	0.17	0.042	Streets		0.0	0.825	0	
No vegetation		14	0.26	0.037	Maximum flood			1	0	
Total (C _v)		100	-	0.122	Total (C ₂)		100		0.3296	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 1.24 hours			T _c = 0.26 hours							
					ARF (%) = 100.00					
					r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.379	0.379	0.379	0.379	0.379	0.379
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))					0.379	0.379	0.379	0.379	0.379	0.379
Adjustment factor for initial saturation, F _t (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _t)					0.237	0.256	0.275	0.297	0.337	0.379
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.265	0.278	0.291	0.307	0.335	0.364
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					17	24	28	33	39	45
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					66.9	91.7	109.5	127.7	153.0	173.3
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					66.9	91.7	109.5	127.7	153.0	173.3
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					1	1	1	2	2	3

RATIONAL METHOD															
Description of the catchment				Rural											
River details				Monametsi Tributary 1											
Calculated by				Wian Lombard			Date		2025-01-09						
Physical characteristics															
Size of the catchment (A)		0.34		km ²				Rainfall region							
Longest watercourse (L)		1.475		km				Area distribution factors							
10-85 Slope (S _{av})		0.09		m/m				Rural (α)		0.610					
Dolomite area (D _%)		0		%				Urban (β)		0.390					
Mean annual rainfall (MAP)		550.0		mm				Lakes (γ)		0.000					
Rural				Urban											
Surface slope		%		Factor		C _s		Description		%		Factor		C ₂	
Vleis and pans (0-3%)		39		0.01		0.004		Lawns							
Flat areas (3-10%)		27		0.06		0.016		Sandy, flat (<2%)				0.075		0	
Hilly (10-30%)		29		0.12		0.035		Sandy, steep (>7%)				0.175		0	
Steep areas (>30%)		4		0.22		0.010		Heavy soil, flat (<2%)				0.15		0	
Total (C _s)		100				0.065		Heavy soil, steep (>7%)		99		0.3		0.30	
Permeability		%		Factor		C _p		Residential area							
Very permeable (SCS Type A Soil)		0		0.03		0.000		Houses		1.5		0.4		0.01	
Permeable (SCS Type B Soil)		20		0.06		0.012		Flats				0.6		0	
Semi-permeable (SCS Type C Soil)		17		0.12		0.020		Industry							
Impermeable (SCS Type D Soil)		63		0.21		0.133		Light industry		0.0		0.65		0	
Total (C _p)		100				0.165		Heavy industry		0.0		0.75		0	
Vegetation		%		Factor		C _v		Business							
Thick bush & plantation		0		0.03		0.000		City centre				0.825		0	
Light bush and farmlands		47		0.07		0.033		Suburban				0.6		0	
Grasslands		52		0.17		0.088		Streets		0.0		0.825		0	
No vegetation		2		0.26		0.005		Maximum flood				1		0	
Total (C _v)		100				0.125		Total (C ₂)		100				0.3015	
Time of concentration (T _c)						Notes									
Overland flow			Defined watercourse												
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$												
T _c = 1.16 hours			T _c = 0.23 hours			ARF (%) = 100.00 Thick grass cover = 0.80									
Run-off coefficient															
Return period (years), T					2	5	10	20	50	100					
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.355	0.355	0.355	0.355	0.355	0.355					
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (D _{factor} x C _{S%}))					0.355	0.355	0.355	0.355	0.355	0.355					
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000					
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.222	0.240	0.258	0.279	0.316	0.355					
Combined run-off coefficient C _i (= αC _{1T} + βC ₂ + γC ₃)					0.253	0.264	0.275	0.288	0.310	0.334					
Rainfall															
Return period (years), T					2	5	10	20	50	100					
Point rainfall (mm), P _T					16	22	26	31	37	42					
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					70.3	96.3	115.0	134.1	160.7	182.0					
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0					
Average intensity (mm/hour), I _T (= P _{IT} x ARF _T)					70.3	96.3	115.0	134.1	160.7	182.0					
Peak flow															
Return period (years), T					2	5	10	20	50	100					
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					1.7	2.4	3.0	3.7	4.8	5.8					

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 2						
Calculated by				Wian Lombard			Date		2025-01-09	
Physical characteristics										
Size of the catchment (A)		0.63		km ²		Rainfall region				
Longest watercourse (L)		1.557		km		Area distribution factors				
10-85 Slope (S _{av})		0.10		m/m		Rural (α)		0.493		
Dolomite area (D _%)		0		%		Urban (β)		0.507		
Mean annual rainfall (MAP)		550.0		mm		Lakes (γ)		0.000		
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		44	0.01	0.004	Lawns					
Flat areas (3-10%)		28	0.06	0.017	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		22	0.12	0.027	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		6	0.22	0.013	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.061	Heavy soil, steep (>7%)		97	0.3	0.29	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		2.9	0.4	0.01	
Permeable (SCS Type B Soil)		36	0.06	0.022	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		24	0.12	0.029	Industry					
Impermeable (SCS Type D Soil)		40	0.21	0.083	Light industry		0.1	0.65	0.0008	
Total (C _p)		100		0.134	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		53	0.07	0.037	Suburban			0.6	0	
Grasslands		46	0.17	0.078	Streets		0.0	0.825	0	
No vegetation		2	0.26	0.004	Maximum flood			1	0	
Total (C _v)		100	-	0.119	Total (C ₂)		100		0.3033	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 1.14 hours			T _c = 0.22 hours		ARF (%) = 100.00					
					r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.314	0.314	0.314	0.314	0.314	0.314
Adjusted for dolomitic areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (D _{factor} x C _S %))					0.314	0.314	0.314	0.314	0.314	0.314
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.196	0.212	0.227	0.246	0.279	0.314
Combined run-off coefficient C _i (= αC _{1T} + βC ₂ + γC ₃)					0.250	0.258	0.266	0.275	0.291	0.308
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					16	22	26	30	36	41
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					71.0	97.3	116.2	135.5	162.3	183.9
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} x ARF _T)					71.0	97.3	116.2	135.5	162.3	183.9
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					3	4	5	7	8	10

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 4						
Calculated by				Wian Lombard			Date		2025-01-09	
Physical characteristics										
Size of the catchment (A)		4.31		km ²				Rainfall region		
Longest watercourse (L)		5.254		km				Area distribution factors		
10-85 Slope (S _{av})		0.11		m/m						
Dolomite area (D _%)		0		%						
Mean annual rainfall (MAP)		550.0		mm						Rural (α)
								Urban (β)		0.070
								Lakes (γ)		0.000
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		23	0.01	0.002	Lawns					
Flat areas (3-10%)		23	0.06	0.014	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		43	0.12	0.051	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		12	0.22	0.026	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.093	Heavy soil, steep (>7%)		88	0.3	0.26	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		12.4	0.4	0.05	
Permeable (SCS Type B Soil)		27	0.06	0.016	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		10	0.12	0.013	Industry					
Impermeable (SCS Type D Soil)		62	0.21	0.131	Light industry		0.0	0.65	0	
Total (C _p)		100		0.160	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		7	0.03	0.002	City centre			0.825	0	
Light bush and farmlands		61	0.07	0.043	Suburban			0.6	0	
Grasslands		22	0.17	0.037	Streets		0.0	0.825	0	
No vegetation		11	0.26	0.028	Maximum flood			1	0	
Total (C _v)		100	-	0.109	Total (C ₂)		100		0.3124	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 1.99 hours			T _c = 0.56 hours		ARF (%) = 100.00					
					r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.362	0.362	0.362	0.362	0.362	0.362
Adjusted for dolomitic areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (D _{factor} x C _{S%}))					0.362	0.362	0.362	0.362	0.362	0.362
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.226	0.245	0.263	0.284	0.322	0.362
Combined run-off coefficient C _i (= αC _{1T} + βC ₂ + γC ₃)					0.232	0.249	0.266	0.286	0.322	0.359
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					24	32	39	45	54	61
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					42.1	57.7	68.8	80.3	96.2	109.0
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} x ARF _T)					42.1	57.7	68.8	80.3	96.2	109.0
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					12	17	22	28	37	47

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 5						
Calculated by				Wian Lombard			Date		2025-01-09	
Physical characteristics										
Size of the catchment (A)		2.85		km ²		Rainfall region				
Longest watercourse (L)		4.194		km		Area distribution factors				
10-85 Slope (S _{av})		0.16		m/m		Rural (α)		0.818		
Dolomite area (D _%)		0		%		Urban (β)		0.182		
Mean annual rainfall (MAP)		550.0		mm		Lakes (γ)		0.000		
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		13	0.01	0.001	Lawns					
Flat areas (3-10%)		20	0.06	0.012	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		53	0.12	0.063	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		14	0.22	0.031	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.107	Heavy soil, steep (>7%)		99	0.3	0.30	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		0.6	0.4	0.00	
Permeable (SCS Type B Soil)		15	0.06	0.009	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		6	0.12	0.008	Industry					
Impermeable (SCS Type D Soil)		79	0.21	0.166	Light industry		0.0	0.65	0	
Total (C _p)		100		0.182	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		4	0.03	0.001	City centre			0.825	0	
Light bush and farmlands		52	0.07	0.036	Suburban			0.6	0	
Grasslands		45	0.17	0.076	Streets		0.0	0.825	0	
No vegetation		0	0.26	0.001	Maximum flood			1	0	
Total (C _v)		100	-	0.114	Total (C ₂)		100		0.3006	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 1.63 hours			T _c = 0.40 hours		ARF (%) = 100.00					
					r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.403	0.403	0.403	0.403	0.403	0.403
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (D _{factor} x C _S %))					0.403	0.403	0.403	0.403	0.403	0.403
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.252	0.272	0.292	0.317	0.359	0.403
Combined run-off coefficient C _i (= αC _{1T} + βC ₂ + γC ₃)					0.261	0.277	0.294	0.314	0.348	0.385
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					21	28	34	39	47	53
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					50.7	69.5	82.9	96.7	115.9	131.2
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} x ARF _T)					50.7	69.5	82.9	96.7	115.9	131.2
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					10	15	19	24	32	40

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 6						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		3.44	km ²				Rainfall region			
Longest watercourse (L)		4.111	km				Area distribution factors			
10-85 Slope (S _{av})		0.12	m/m							
Dolomite area (D _%)		0	%							
Mean annual rainfall (MAP)		550.0	mm							
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		15	0.01	0.001	Lawns					
Flat areas (3-10%)		26	0.06	0.016	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		46	0.12	0.055	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		13	0.22	0.029	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.101	Heavy soil,steep (>7%)		96	0.3	0.29	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		4.4	0.4	0.02	
Permeable (SCS Type B Soil)		24	0.06	0.015	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		11	0.12	0.013	Industry					
Impermeable (SCS Type D Soil)		64	0.21	0.135	Light industry		0.0	0.65	0	
Total (C _p)		100		0.163	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		2	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		55	0.07	0.038	Suburban			0.6	0	
Grasslands		42	0.17	0.071	Streets		0.0	0.825	0	
No vegetation		2	0.26	0.005	Maximum flood			1	0	
Total (C _v)		100	-	0.115	Total (C ₂)		100		0.3044	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.73		hours		ARF (%) = 100.00			
			0.45		hours		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (=C _s + C _p + C _v)					0.380	0.380	0.380	0.380	0.380	0.380
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.380	0.380	0.380	0.380	0.380	0.380
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.237	0.256	0.275	0.298	0.338	0.380
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.253	0.267	0.282	0.300	0.330	0.362
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					21	29	35	41	49	56
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					48.0	65.8	78.5	91.6	109.8	124.3
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					48.0	65.8	78.5	91.6	109.8	124.3
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					12	17	21	26	35	43

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 7						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		0.65	km ²					Rainfall region		
Longest watercourse (L)		2.267	km					Area distribution factors		
10-85 Slope (S _{av})		0.06	m/m					Rural (α)		0.274
Dolomite area (D _%)		0	%					Urban (β)		0.726
Mean annual rainfall (MAP)		550.0	mm					Lakes (γ)		0.000
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		45	0.01	0.005	Lawns					
Flat areas (3-10%)		33	0.06	0.020	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		17	0.12	0.020	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		5	0.22	0.011	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.055	Heavy soil,steep (>7%)		100	0.3	0.30	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		0.3	0.4	0.00	
Permeable (SCS Type B Soil)		45	0.06	0.027	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		29	0.12	0.034	Industry					
Impermeable (SCS Type D Soil)		27	0.21	0.056	Light industry		0.0	0.65	0	
Total (C _p)		100		0.117	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		1	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		68	0.07	0.048	Suburban			0.6	0	
Grasslands		30	0.17	0.050	Streets		0.0	0.825	0	
No vegetation		1	0.26	0.002	Maximum flood			1	0	
Total (C _v)		100	-	0.101	Total (C ₂)		100		0.3003	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.53	hours	ARF (%) = 100.00					
			0.37	hours	r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (=C _s + C _p + C _v)					0.273	0.273	0.273	0.273	0.273	0.273
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.273	0.273	0.273	0.273	0.273	0.273
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.171	0.185	0.198	0.215	0.243	0.273
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.265	0.269	0.272	0.277	0.285	0.293
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					20	27	32	37	45	51
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					53.7	73.6	87.9	102.5	122.9	139.2
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					53.7	73.6	87.9	102.5	122.9	139.2
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m³/s) $Q_T = \frac{C_T I_T A}{3.6}$					3	4	4	5	6	7

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RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 9						
Calculated by				Wian Lombard			Date		2025-01-09	
Physical characteristics										
Size of the catchment (A)		0.83		km ²				Rainfall region		
Longest watercourse (L)		2.072		km				Area distribution factors		
10-85 Slope (S _{av})		0.10		m/m						
Dolomite area (D _%)		0		%						
Mean annual rainfall (MAP)		550.0		mm						
Rural					Urban					
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		33	0.01	0.003	Lawns					
Flat areas (3-10%)		16	0.06	0.010	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		38	0.12	0.045	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		13	0.22	0.029	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.088	Heavy soil, steep (>7%)		99	0.3	0.30	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		1.1	0.4	0.00	
Permeable (SCS Type B Soil)		35	0.06	0.021	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		14	0.12	0.017	Industry					
Impermeable (SCS Type D Soil)		51	0.21	0.108	Light industry		0.0	0.65	0	
Total (C _p)		100		0.145	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		37	0.07	0.026	Suburban			0.6	0	
Grasslands		63	0.17	0.107	Streets		0.0	0.825	0	
No vegetation		0	0.26	0.001	Maximum flood			1	0	
Total (C _v)		100	-	0.133	Total (C ₂)		100		0.3011	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 1.30 hours			T _c = 0.28 hours		ARF (%) = 100.00					
					r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.366	0.366	0.366	0.366	0.366	0.366
Adjusted for dolomitic areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (D _{factor} x C _{S%}))					0.366	0.366	0.366	0.366	0.366	0.366
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.229	0.247	0.266	0.288	0.326	0.366
Combined run-off coefficient C _i (= αC _{1T} + βC ₂ + γC ₃)					0.265	0.274	0.283	0.294	0.314	0.334
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					18	24	29	34	40	46
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					63.7	87.3	104.2	121.5	145.6	164.9
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} x ARF _T)					63.7	87.3	104.2	121.5	145.6	164.9
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					4	6	7	8	11	13

RURAL METHOD									
Description of the catchment				Rural					
River details				Monametsi Tributary 10					
Calculated by				Wian Lombard			Date		2025-01-09
Physical characteristics									
Size of the catchment (A)		2.90		km ²				Rainfall region	
Longest watercourse (L)		3.501		km				Area distribution factors	
10-85 Slope (S _{av})		0.13		m/m				Rural (α)	
Dolomite area (D _%)		0		%				Urban (β)	
Mean annual rainfall (MAP)		550.0		mm				Lakes (γ)	
Rural				Urban					
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂
Vleis and pans (0-3%)		18	0.01	0.002	Lawns				
Flat areas (3-10%)		18	0.06	0.011	Sandy, flat (<2%)			0.075	0
Hilly (10-30%)		49	0.12	0.059	Sandy, steep (>7%)			0.175	0
Steep areas (>30%)		15	0.22	0.033	Heavy soil, flat (<2%)			0.15	0
Total (C _s)		100		0.104	Heavy soil,steep (>7%)		87	0.3	0.26
Permeability		%	Factor	C _p	Residential area				
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		13.4	0.4	0.05
Permeable (SCS Type B Soil)		19	0.06	0.011	Flats			0.6	0
Semi-permeable (SCS Type C Soil)		5	0.12	0.006	Industry				
Impermeable (SCS Type D Soil)		76	0.21	0.160	Light industry		0.0	0.65	0
Total (C _p)		100		0.177	Heavy industry		0.0	0.75	0
Vegetation		%	Factor	C _v	Business				
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0
Light bush and farmlands		64	0.07	0.045	Suburban			0.6	0
Grasslands		25	0.17	0.043	Streets		0.0	0.825	0
No vegetation		10	0.26	0.026	Maximum flood			1	0
Total (C _v)		100	-	0.114	Total (C ₂)		100		0.3134
Time of concentration (T _c)					Notes				
Overland flow			Defined watercourse						
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$						
Tc =			1.57	hours	Tc =	0.38	hours		
Run-off coefficient									
Return period (years), T					2	5	10	20	50
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.396	0.396	0.396	0.396	0.396
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} X C _{S%})))					0.396	0.396	0.396	0.396	0.396
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.247	0.267	0.287	0.311	0.352
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.253	0.271	0.289	0.311	0.349
Rainfall									
Return period (years), T					2	5	10	20	50
Point rainfall (mm), P _T					20	27	33	38	46
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					52.4	71.9	85.8	100.0	119.9
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					52.4	71.9	85.8	100.0	119.9
Peak flow									
Return period (years), T					2	5	10	20	50
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					11	16	20	25	34

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 11						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		0.48	km ²				Rainfall region			
Longest watercourse (L)		2.613	km				Area distribution factors			
10-85 Slope (S _{av})		0.03	m/m				Rural (α)		0.516	
Dolomite area (D _%)		0	%				Urban (β)		0.484	
Mean annual rainfall (MAP)		550.0	mm				Lakes (γ)		0.000	
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		97	0.01	0.010	Lawns					
Flat areas (3-10%)		3	0.06	0.002	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		0	0.12	0.000	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		0	0.22	0.000	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.012	Heavy soil,steep (>7%)		94	0.3	0.28	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		4.0	0.4	0.02	
Permeable (SCS Type B Soil)		90	0.06	0.054	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		10	0.12	0.012	Industry					
Impermeable (SCS Type D Soil)		0	0.21	0.000	Light industry		0.0	0.65	0	
Total (C _p)		100		0.066	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		40	0.07	0.028	Suburban			0.6	0	
Grasslands		10	0.17	0.017	Streets		1.7	0.825	0.0142981	
No vegetation		50	0.26	0.129	Maximum flood			1	0	
Total (C _v)		100	-	0.174	Total (C ₂)		100		0.3131	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.98	hours	ARF (%)		=	100.00		
			T _c =	0.56	hours	r		Thick grass cover = 0.80		
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (=C _s + C _p + C _v)					0.252	0.252	0.252	0.252	0.252	0.252
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.252	0.252	0.252	0.252	0.252	0.252
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.157	0.170	0.182	0.198	0.224	0.252
Combined run-off coefficient C _t (= αC _{1T} + β _{C2} + γ _{C3})					0.233	0.239	0.246	0.253	0.267	0.281
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					24	32	39	45	54	61
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					42.1	57.8	68.9	80.4	96.3	109.1
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					42.1	57.8	68.9	80.4	96.3	109.1
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m³/s) $Q_T = \frac{C_T I_T A}{3.6}$					1	2	2	3	3	4

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 12						
Calculated by				Wian Lombard			Date		2025-01-09	
Physical characteristics										
Size of the catchment (A)		2.80		km ²				Rainfall region		
Longest watercourse (L)		3.378		km				Area distribution factors		
10-85 Slope (S _{av})		0.15		m/m						
Dolomite area (D _%)		0		%						
Mean annual rainfall (MAP)		550.0		mm						Rural (α)
								Urban (β)		0.276
								Lakes (γ)		0.000
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		29	0.01	0.003	Lawns					
Flat areas (3-10%)		27	0.06	0.016	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		33	0.12	0.040	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		11	0.22	0.025	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.084	Heavy soil, steep (>7%)		89	0.3	0.27	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		10.9	0.4	0.04	
Permeable (SCS Type B Soil)		38	0.06	0.023	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		5	0.12	0.006	Industry					
Impermeable (SCS Type D Soil)		57	0.21	0.120	Light industry		0.0	0.65	0	
Total (C _p)		100		0.149	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		1	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		49	0.07	0.034	Suburban			0.6	0	
Grasslands		38	0.17	0.064	Streets		0.0	0.825	0	
No vegetation		13	0.26	0.034	Maximum flood			1	0	
Total (C _v)		100	-	0.132	Total (C ₂)		100		0.3109	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 1.50 hours			T _c = 0.35 hours		ARF (%) = 100.00					
					r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.365	0.365	0.365	0.365	0.365	0.365
Adjusted for dolomitic areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (D _{factor} x C _{S%}))					0.365	0.365	0.365	0.365	0.365	0.365
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.228	0.246	0.264	0.286	0.324	0.365
Combined run-off coefficient C _i (= αC _{1T} + βC ₂ + γC ₃)					0.251	0.264	0.277	0.293	0.321	0.350
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					19	27	32	37	44	50
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					54.9	75.2	89.8	104.7	125.5	142.1
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					54.9	75.2	89.8	104.7	125.5	142.1
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					11	15	19	24	31	39

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 13						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		2.03	km ²		Rainfall region					
Longest watercourse (L)		3.645	km		Area distribution factors					
10-85 Slope (S _{av})		0.19	m/m		Rural (α)		0.866			
Dolomite area (D _%)		0	%		Urban (β)		0.134			
Mean annual rainfall (MAP)		550.0	mm		Lakes (γ)		0.000			
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		14	0.01	0.001	Lawns					
Flat areas (3-10%)		25	0.06	0.015	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		46	0.12	0.056	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		14	0.22	0.031	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.103	Heavy soil,steep (>7%)		89	0.3	0.27	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		11.0	0.4	0.04	
Permeable (SCS Type B Soil)		12	0.06	0.007	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		14	0.12	0.017	Industry					
Impermeable (SCS Type D Soil)		75	0.21	0.157	Light industry		0.0	0.65	0	
Total (C _p)		100		0.180	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		2	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		62	0.07	0.043	Suburban			0.6	0	
Grasslands		28	0.17	0.048	Streets		0.0	0.825	0	
No vegetation		8	0.26	0.022	Maximum flood			1	0	
Total (C _v)		100	-	0.114	Total (C ₂)		100		0.3110	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.46	hours	ARF (%)			=	100.00	
			T _c =	0.34	hours	r			Thick grass cover = 0.80	
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (=C _s + C _p + C _v)					0.397	0.397	0.397	0.397	0.397	0.397
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% /(Σ(D _{factor} x C _{S%})))					0.397	0.397	0.397	0.397	0.397	0.397
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.248	0.268	0.288	0.312	0.353	0.397
Combined run-off coefficient C _t (= αC _{1T} + β _{C2} + γ _{C3})					0.257	0.274	0.291	0.312	0.348	0.386
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					19	26	31	36	44	49
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					56.2	77.0	91.9	107.2	128.4	145.5
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					56.2	77.0	91.9	107.2	128.4	145.5
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m³/s) $Q_T = \frac{C_T I_T A}{3.6}$					8	12	15	19	25	32

B-32

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 15						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		0.42	km ²				Rainfall region			
Longest watercourse (L)		1.898	km				Area distribution factors			
10-85 Slope (S _{av})		0.21	m/m				Rural (α)		0.618	
Dolomite area (D _%)		0	%				Urban (β)		0.382	
Mean annual rainfall (MAP)		550.0	mm				Lakes (γ)		0.000	
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		31	0.01	0.003	Lawns					
Flat areas (3-10%)		14	0.06	0.008	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		40	0.12	0.048	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		15	0.22	0.033	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.093	Heavy soil,steep (>7%)		97	0.3	0.29	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		2.9	0.4	0.01	
Permeable (SCS Type B Soil)		47	0.06	0.028	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		0	0.12	0.000	Industry					
Impermeable (SCS Type D Soil)		53	0.21	0.112	Light industry		0.0	0.65	0	
Total (C _p)		100		0.140	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		75	0.07	0.053	Suburban			0.6	0	
Grasslands		23	0.17	0.040	Streets		0.0	0.825	0	
No vegetation		1	0.26	0.004	Maximum flood			1	0	
Total (C _v)		100	-	0.096	Total (C ₂)		100		0.3029	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.06		hours		ARF (%) = 100.00			
			T _c =		0.20		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (=C _s + C _p + C _v)					0.329	0.329	0.329	0.329	0.329	0.329
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.329	0.329	0.329	0.329	0.329	0.329
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.206	0.222	0.239	0.258	0.293	0.329
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.243	0.253	0.263	0.275	0.297	0.319
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					15	20	24	28	34	38
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					74.1	101.5	121.2	141.3	169.3	191.8
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					74.1	101.5	121.2	141.3	169.3	191.8
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m³/s) $Q_T = \frac{C_T I_T A}{3.6}$					2	3	4	5	6	7

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 16						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		0.88	km ²					Rainfall region		
Longest watercourse (L)		2.895	km					Area distribution factors		
10-85 Slope (S _{av})		0.15	m/m							
Dolomite area (D _%)		0	%							
Mean annual rainfall (MAP)		550.0	mm							
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		33	0.01	0.003	Lawns					
Flat areas (3-10%)		19	0.06	0.012	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		37	0.12	0.044	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		10	0.22	0.023	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.082	Heavy soil,steep (>7%)		98	0.3	0.29	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		2.5	0.4	0.01	
Permeable (SCS Type B Soil)		42	0.06	0.025	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		7	0.12	0.008	Industry					
Impermeable (SCS Type D Soil)		51	0.21	0.108	Light industry		0.0	0.65	0	
Total (C _p)		100		0.141	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		75	0.07	0.052	Suburban			0.6	0	
Grasslands		23	0.17	0.039	Streets		0.0	0.825	0	
No vegetation		2	0.26	0.006	Maximum flood			1	0	
Total (C _v)		100	-	0.097	Total (C ₂)		100		0.3025	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.38	hours	ARF (%) = 100.00					
			0.31	hours	r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (=C _s + C _p + C _v)					0.321	0.321	0.321	0.321	0.321	0.321
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.321	0.321	0.321	0.321	0.321	0.321
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.200	0.216	0.232	0.252	0.285	0.321
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.232	0.243	0.254	0.268	0.291	0.315
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					18	25	30	35	42	48
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					59.6	81.7	97.5	113.7	136.3	154.4
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					59.6	81.7	97.5	113.7	136.3	154.4
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m³/s) $Q_T = \frac{C_T I_T A}{3.6}$					3	5	6	7	10	12

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 17						
Calculated by				Wian Lombard			Date		2025-01-09	
Physical characteristics										
Size of the catchment (A)		0.45		km ²		Rainfall region				
Longest watercourse (L)		1.256		km		Area distribution factors				
10-85 Slope (S _{av})		0.03		m/m		Rural (α)		0.463		
Dolomite area (D _%)		0		%		Urban (β)		0.537		
Mean annual rainfall (MAP)		550.0		mm		Lakes (γ)		0.000		
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		65	0.01	0.006	Lawns					
Flat areas (3-10%)		16	0.06	0.009	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		13	0.12	0.016	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		6	0.22	0.014	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.046	Heavy soil, steep (>7%)		98	0.3	0.29	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		2.0	0.4	0.01	
Permeable (SCS Type B Soil)		62	0.06	0.037	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		17	0.12	0.020	Industry					
Impermeable (SCS Type D Soil)		21	0.21	0.045	Light industry		0.0	0.65	0	
Total (C _p)		100		0.102	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		1	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		69	0.07	0.049	Suburban			0.6	0	
Grasslands		20	0.17	0.034	Streets		0.0	0.825	0	
No vegetation		9	0.26	0.025	Maximum flood			1	0	
Total (C _v)		100	-	0.108	Total (C ₂)		100		0.3020	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 1.38 hours			T _c = 0.31 hours		ARF (%) = 100.00 Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.255	0.255	0.255	0.255	0.255	0.255
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (D _{factor} x C _{S%}))					0.255	0.255	0.255	0.255	0.255	0.255
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.160	0.172	0.185	0.201	0.227	0.255
Combined run-off coefficient C _i (= αC _{1T} + βC ₂ + γC ₃)					0.236	0.242	0.248	0.255	0.267	0.280
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					18	25	30	35	42	48
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					59.5	81.6	97.4	113.5	136.1	154.1
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} x ARF _T)					59.5	81.6	97.4	113.5	136.1	154.1
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					2	2	3	4	5	5

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 18						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		1.97	km ²				Rainfall region			
Longest watercourse (L)		3.289	km				Area distribution factors			
10-85 Slope (S _{av})		0.24	m/m							
Dolomite area (D _%)		0	%							
Mean annual rainfall (MAP)		550.0	mm							
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		13	0.01	0.001	Lawns					
Flat areas (3-10%)		21	0.06	0.012	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		52	0.12	0.063	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		14	0.22	0.031	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.107	Heavy soil,steep (>7%)		68	0.3	0.20	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		31.7	0.4	0.13	
Permeable (SCS Type B Soil)		4	0.06	0.002	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		17	0.12	0.020	Industry					
Impermeable (SCS Type D Soil)		79	0.21	0.166	Light industry		0.0	0.65	0	
Total (C _p)		100		0.189	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		1	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		65	0.07	0.045	Suburban			0.6	0	
Grasslands		33	0.17	0.056	Streets		0.0	0.825	0	
No vegetation		1	0.26	0.002	Maximum flood			1	0	
Total (C _v)		100	-	0.104	Total (C ₂)		100		0.3317	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.33	hours	T _c =		0.29	hours		
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (=C _s + C _p + C _v)					0.401	0.401	0.401	0.401	0.401	0.401
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.401	0.401	0.401	0.401	0.401	0.401
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.250	0.270	0.290	0.314	0.357	0.401
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.254	0.273	0.292	0.315	0.355	0.397
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					18	25	29	34	41	46
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					62.1	85.1	101.6	118.5	142.0	160.8
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					62.1	85.1	101.6	118.5	142.0	160.8
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m³/s) $Q_T = \frac{C_T I_T A}{3.6}$					9	13	16	20	28	35

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 19						
Calculated by				Wian Lombard			Date		2025-01-09	
Physical characteristics										
Size of the catchment (A)		0.91		km ²				Rainfall region		
Longest watercourse (L)		1.481		km				Area distribution factors		
10-85 Slope (S _{av})		0.09		m/m						
Dolomite area (D _%)		0		%						
Mean annual rainfall (MAP)		550.0		mm						
Rural					Urban					
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		54	0.01	0.005	Lawns					
Flat areas (3-10%)		11	0.06	0.006	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		27	0.12	0.032	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		9	0.22	0.019	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.063	Heavy soil, steep (>7%)		99	0.3	0.30	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		1.5	0.4	0.01	
Permeable (SCS Type B Soil)		30	0.06	0.018	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		16	0.12	0.019	Industry					
Impermeable (SCS Type D Soil)		55	0.21	0.115	Light industry		0.0	0.65	0	
Total (C _p)		100		0.151	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		65	0.07	0.046	Suburban			0.6	0	
Grasslands		30	0.17	0.050	Streets		0.0	0.825	0	
No vegetation		5	0.26	0.014	Maximum flood			1	0	
Total (C _v)		100	-	0.110	Total (C ₂)		100		0.3015	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 1.15 hours			T _c = 0.23 hours		ARF (%) = 100.00					
					r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.324	0.324	0.324	0.324	0.324	0.324
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (D _{factor} x C _S %))					0.324	0.324	0.324	0.324	0.324	0.324
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.202	0.218	0.235	0.254	0.288	0.324
Combined run-off coefficient C _i (= αC _{1T} + βC ₂ + γC ₃)					0.259	0.266	0.273	0.281	0.296	0.311
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					16	22	26	31	37	42
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					70.4	96.4	115.2	134.3	160.9	182.3
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} x ARF _T)					70.4	96.4	115.2	134.3	160.9	182.3
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					5	6	8	9	12	14

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 20						
Calculated by				Wian Lombard			Date		2025-01-09	
Physical characteristics										
Size of the catchment (A)		5.86		km ²				Rainfall region		
Longest watercourse (L)		5.681		km				Area distribution factors		
10-85 Slope (S _{av})		0.12		m/m						
Dolomite area (D _%)		0		%						
Mean annual rainfall (MAP)		550.0		mm						
Rural					Urban					
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		13	0.01	0.001	Lawns					
Flat areas (3-10%)		26	0.06	0.016	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		49	0.12	0.058	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		12	0.22	0.026	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.101	Heavy soil, steep (>7%)		55	0.3	0.17	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		44.9	0.4	0.18	
Permeable (SCS Type B Soil)		1	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		9	0.12	0.011	Industry					
Impermeable (SCS Type D Soil)		90	0.21	0.189	Light industry		0.0	0.65	0	
Total (C _p)		100		0.201	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		1	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		66	0.07	0.046	Suburban			0.6	0	
Grasslands		24	0.17	0.041	Streets		0.0	0.825	0	
No vegetation		8	0.26	0.022	Maximum flood			1	0	
Total (C _v)		100	-	0.110	Total (C ₂)		100		0.3449	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 2.00 hours			T _c = 0.57 hours		ARF (%) = 100.00					
					r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.412	0.412	0.412	0.412	0.412	0.412
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (D _{factor} x C _S %))					0.412	0.412	0.412	0.412	0.412	0.412
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.257	0.278	0.298	0.323	0.366	0.412
Combined run-off coefficient C _i (= αC _{1T} + βC ₂ + γC ₃)					0.258	0.278	0.299	0.323	0.366	0.411
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					24	32	39	45	54	61
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					41.9	57.4	68.5	79.9	95.8	108.5
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} x ARF _T)					41.9	57.4	68.5	79.9	95.8	108.5
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					18	26	33	42	57	73

RATIONAL METHOD																
Description of the catchment				Rural												
River details				Monametsi Tributary 21												
Calculated by				Wian Lombard			Date		2025-01-09							
Physical characteristics																
Size of the catchment (A)		0.12		km ²		Rainfall region										
Longest watercourse (L)		0.809		km		Area distribution factors										
10-85 Slope (S _{av})		0.02		m/m		Rural (α)		0.438								
Dolomite area (D _%)		0		%		Urban (β)		0.562								
Mean annual rainfall (MAP)		550.0		mm		Lakes (γ)		0.000								
Rural				Urban												
Surface slope		%		Factor		C _s		Description		%		Factor		C ₂		
Vleis and pans (0-3%)		100		0.01		0.010		Lawns								
Flat areas (3-10%)		0		0.06		0.000		Sandy, flat (<2%)				0.075		0		
Hilly (10-30%)		0		0.12		0.000		Sandy, steep (>7%)				0.175		0		
Steep areas (>30%)		0		0.22		0.000		Heavy soil, flat (<2%)				0.15		0		
Total (C _s)		100				0.010		Heavy soil, steep (>7%)		83		0.3		0.25		
Permeability		%		Factor		C _p		Residential area								
Very permeable (SCS Type A Soil)		0		0.03		0.000		Houses		17.4		0.4		0.07		
Permeable (SCS Type B Soil)		100		0.06		0.060		Flats				0.6		0		
Semi-permeable (SCS Type C Soil)		0		0.12		0.000		Industry								
Impermeable (SCS Type D Soil)		0		0.21		0.000		Light industry		0.0		0.65		0		
Total (C _p)		100				0.060		Heavy industry		0.0		0.75		0		
Vegetation		%		Factor		C _v		Business								
Thick bush & plantation		0		0.03		0.000		City centre				0.825		0		
Light bush and farmlands		0		0.07		0.000		Suburban				0.6		0		
Grasslands		5		0.17		0.009		Streets		0.0		0.825		0		
No vegetation		95		0.26		0.246		Maximum flood				1		0		
Total (C _v)		100				0.255		Total (C ₂)		100				0.3174		
Time of concentration (T _c)						Notes										
Overland flow			Defined watercourse													
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$													
T _c = 1.18 hours			T _c = 0.24 hours													
						ARF (%) = 100.00										
						Thick grass cover = 0.80										
Run-off coefficient																
Return period (years), T					2		5		10		20		50		100	
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.325		0.325		0.325		0.325		0.325		0.325	
Adjusted for dolomitic areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (D _{factor} x C _{S%}))					0.325		0.325		0.325		0.325		0.325		0.325	
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625		0.675		0.725		0.785		0.890		1.000	
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.203		0.219		0.236		0.255		0.289		0.325	
Combined run-off coefficient C _i (= αC _{1T} + βC ₂ + γC ₃)					0.267		0.275		0.282		0.290		0.305		0.321	
Rainfall																
Return period (years), T					2		5		10		20		50		100	
Point rainfall (mm), P _T					17		23		27		32		38		43	
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					69.4		95.1		113.6		132.4		158.7		179.7	
Area reduction factor (%), ARF _T					100.0		100.0		100.0		100.0		100.0		100.0	
Average intensity (mm/hour), I _T (= P _{IT} x ARF _T)					69.4		95.1		113.6		132.4		158.7		179.7	
Peak flow																
Return period (years), T					2		5		10		20		50		100	
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					1		1		1		1		2		2	

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Monametsi Tributary 23						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		1.35	km ²		Rainfall region					
Longest watercourse (L)		3.498	km		Area distribution factors					
10-85 Slope (S _{av})		0.06	m/m		Rural (α)		0.868			
Dolomite area (D _%)		0	%		Urban (β)		0.132			
Mean annual rainfall (MAP)		550.0	mm		Lakes (γ)		0.000			
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		58	0.01	0.006	Lawns					
Flat areas (3-10%)		23	0.06	0.014	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		15	0.12	0.018	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		5	0.22	0.010	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.047	Heavy soil,steep (>7%)		81	0.3	0.24	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		19.1	0.4	0.08	
Permeable (SCS Type B Soil)		20	0.06	0.012	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		22	0.12	0.027	Industry					
Impermeable (SCS Type D Soil)		57	0.21	0.120	Light industry		0.0	0.65	0	
Total (C _p)		100		0.159	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		40	0.07	0.028	Suburban			0.6	0	
Grasslands		13	0.17	0.021	Streets		0.0	0.825	0	
No vegetation		47	0.26	0.122	Maximum flood			1	0	
Total (C _v)		100	-	0.172	Total (C ₂)		100		0.3191	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.88	hours	ARF (%)		=	100.00		
			T _c =	0.51	hours	r		Thick grass cover = 0.80		
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (=C _s + C _p + C _v)					0.379	0.379	0.379	0.379	0.379	0.379
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.379	0.379	0.379	0.379	0.379	0.379
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.237	0.256	0.274	0.297	0.337	0.379
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.248	0.264	0.280	0.300	0.335	0.371
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					23	31	37	44	52	59
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					44.6	61.1	72.9	85.0	101.9	115.4
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					44.6	61.1	72.9	85.0	101.9	115.4
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m³/s) $Q_T = \frac{C_T I_T A}{3.6}$					4	6	8	10	13	16

RATIONAL METHOD											
Description of the catchment				Rural							
River details				Moopetsi Main							
Calculated by				Wian Lombard			Date	2025-01-09			
Physical characteristics											
Size of the catchment (A)	123.34	km ²					Rainfall region				
Longest watercourse (L)	28.929	km					Area distribution factors		Rural (α)		0.754
10-85 Slope (S _{av})	0.01	m/m							Urban (β)		0.237
Dolomite area (D _%)	0	%							Lakes (γ)		0.008
Mean annual rainfall (MAP)	578.4	mm									
Rural				Urban							
Surface slope	%	Factor	C _s	Description	%	Factor	C ₂				
Vleis and pans (0-3%)	44	0.01	0.004	Lawns							
Flat areas (3-10%)	24	0.06	0.014	Sandy, flat (<2%)		0.075	0				
Hilly (10-30%)	16	0.12	0.019	Sandy, steep (>7%)		0.175	0				
Steep areas (>30%)	16	0.22	0.036	Heavy soil, flat (<2%)		0.15	0				
Total (C _s)	100		0.074	Heavy soil,steep (>7%)	71	0.3	0.21				
Permeability	%	Factor	C _p	Residential area							
Very permeable (SCS Type A Soil)	0	0.03	0.000	Houses	6.8	0.4	0.03				
Permeable (SCS Type B Soil)	33	0.06	0.020	Flats		0.6	0				
Semi-permeable (SCS Type C Soil)	33	0.12	0.040	Industry							
Impermeable (SCS Type D Soil)	33	0.21	0.070	Light industry	0.1	0.65	0.0003684				
Total (C _p)	100		0.130	Heavy industry	21.6	0.75	0.1619711				
Vegetation	%	Factor	C _v	Business							
Thick bush & plantation	4	0.03	0.001	City centre		0.825	0				
Light bush and farmlands	48	0.07	0.034	Suburban		0.6	0				
Grasslands	33	0.17	0.055	Streets	0.3	0.825	0.0023608				
No vegetation	16	0.26	0.040	Maximum flood		1	0				
Total (C _v)	100	-	0.131	Total (C ₂)	100		0.4057				
Time of concentration (T _c)				Notes							
Overland flow		Defined watercourse									
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$		$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$									
T _c = 7.46 hours		T _c = 4.97 hours		ARF (%) = 93.43							
				r Thick grass cover = 0.80							
Run-off coefficient											
Return period (years), T	2	5	10	20	50	100					
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)	0.334	0.334	0.334	0.334	0.334	0.334					
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))	0.334	0.334	0.334	0.334	0.334	0.334					
Adjustment factor for initial saturation, F _t (Taken as average of two set of values provided in DM)	0.625	0.675	0.725	0.785	0.890	1.000					
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _t)	0.209	0.226	0.242	0.262	0.298	0.334					
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)	0.254	0.266	0.279	0.294	0.321	0.348					
Rainfall											
Return period (years), T	2	5	10	20	50	100					
Point rainfall (mm), P _T	46	63	76	88	106	121					
Point intensity (mm/hour), P _{IT} (= P _T / T _C)	9.2	12.7	15.2	17.8	21.4	24.2					
Area reduction factor (%), ARF _T	93.4	93.4	93.4	93.4	93.4	93.4					
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)	8.6	11.9	14.2	16.6	20.0	22.7					
Peak flow											
Return period (years), T	2	5	10	20	50	100					
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$	75.1	108.6	136.1	167.7	219.5	270.5					

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Motse Main						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		129.18	km ²				Rainfall region			
Longest watercourse (L)		30.097	km				Area distribution factors			
10-85 Slope (S _{av})		0.03	m/m				Rural (α)		0.914	
Dolomite area (D _%)		0	%				Urban (β)		0.086	
Mean annual rainfall (MAP)		578.4	mm				Lakes (γ)		0.000	
Rural				Urban						
Surface slope		%	Factor	C _s	Description	%	Factor	C ₂		
Vleis and pans (0-3%)		26	0.01	0.003	Lawns					
Flat areas (3-10%)		17	0.06	0.010	Sandy, flat (<2%)		0.075	0		
Hilly (10-30%)		26	0.12	0.031	Sandy, steep (>7%)		0.175	0		
Steep areas (>30%)		31	0.22	0.068	Heavy soil, flat (<2%)		0.15	0		
Total (C _s)		100		0.112	Heavy soil,steep (>7%)	85	0.3	0.25		
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses	6.7	0.4	0.03		
Permeable (SCS Type B Soil)		33	0.06	0.020	Flats		0.6	0		
Semi-permeable (SCS Type C Soil)		33	0.12	0.040	Industry					
Impermeable (SCS Type D Soil)		33	0.21	0.070	Light industry	0.2	0.65	0.0016149		
Total (C _p)		100		0.130	Heavy industry	7.0	0.75	0.0523383		
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		2	0.03	0.001	City centre		0.825	0		
Light bush and farmlands		49	0.07	0.035	Suburban		0.6	0		
Grasslands		46	0.17	0.078	Streets	1.5	0.825	0.0125996		
No vegetation		3	0.26	0.007	Maximum flood		1	0		
Total (C _v)		100	-	0.120	Total (C ₂)	100		0.3470		
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			6.02		hours		ARF (%) = 91.61			
T _c =			3.49		hours		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.362	0.362	0.362	0.362	0.362	0.362
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.362	0.362	0.362	0.362	0.362	0.362
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.226	0.244	0.262	0.284	0.322	0.362
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.236	0.253	0.269	0.289	0.324	0.360
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					43	59	70	82	99	112
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					12.2	16.9	20.2	23.6	28.3	32.1
Area reduction factor (%), ARF _T					91.6	91.6	91.6	91.6	91.6	91.6
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					11.2	15.4	18.5	21.6	25.9	29.4
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					95.1	140.1	178.6	224.1	301.4	380.3

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Motse Main Tributary 1.1						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		63.32	km ²				Rainfall region			
Longest watercourse (L)		18.624	km				Area distribution factors			
10-85 Slope (S _{av})		0.01	m/m				Rural (α)		0.864	
Dolomite area (D _%)		0	%				Urban (β)		0.135	
Mean annual rainfall (MAP)		578.4	mm				Lakes (γ)		0.000	
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		30	0.01	0.003	Lawns					
Flat areas (3-10%)		24	0.06	0.015	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		22	0.12	0.026	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		24	0.22	0.053	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.097	Heavy soil,steep (>7%)		85	0.3	0.25	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		6.3	0.4	0.03	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		2	0.12	0.002	Industry					
Impermeable (SCS Type D Soil)		98	0.21	0.206	Light industry		0.4	0.65	0.0026058	
Total (C _p)		100		0.208	Heavy industry		8.0	0.75	0.0600976	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		4	0.03	0.001	City centre			0.825	0	
Light bush and farmlands		74	0.07	0.052	Suburban			0.6	0	
Grasslands		17	0.17	0.029	Streets		0.3	0.825	0.0023346	
No vegetation		5	0.26	0.012	Maximum flood			1	0	
Total (C _v)		100	-	0.094	Total (C ₂)		100		0.3453	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			6.15		hours		ARF (%) = 95.78			
T _c =			3.62		hours		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.399	0.399	0.399	0.399	0.399	0.399
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.399	0.399	0.399	0.399	0.399	0.399
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.250	0.270	0.290	0.313	0.355	0.399
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.263	0.280	0.297	0.318	0.354	0.392
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					43	59	71	83	100	113
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					11.9	16.4	19.6	22.9	27.5	31.2
Area reduction factor (%), ARF _T					95.8	95.8	95.8	95.8	95.8	95.8
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					11.4	15.7	18.8	22.0	26.4	29.9
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					52.7	77.3	98.2	122.8	164.3	206.3

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Motse Main Tributary 1.2						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		40.79	km ²				Rainfall region			
Longest watercourse (L)		10.777	km				Area distribution factors			
10-85 Slope (S _{av})		0.06	m/m				Rural (α)		0.903	
Dolomite area (D _%)		0	%				Urban (β)		0.097	
Mean annual rainfall (MAP)		578.4	mm				Lakes (γ)		0.000	
Rural				Urban						
Surface slope		%	Factor	C _s	Description	%	Factor	C ₂		
Vleis and pans (0-3%)		25	0.01	0.003	Lawns					
Flat areas (3-10%)		26	0.06	0.015	Sandy, flat (<2%)		0.075	0		
Hilly (10-30%)		23	0.12	0.027	Sandy, steep (>7%)		0.175	0		
Steep areas (>30%)		27	0.22	0.058	Heavy soil, flat (<2%)		0.15	0		
Total (C _s)		100		0.104	Heavy soil,steep (>7%)	66	0.3	0.20		
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses	9.1	0.4	0.04		
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats		0.6	0		
Semi-permeable (SCS Type C Soil)		2	0.12	0.003	Industry					
Impermeable (SCS Type D Soil)		98	0.21	0.205	Light industry	0.0	0.65	0		
Total (C _p)		100		0.208	Heavy industry	24.7	0.75	0.1851136		
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		2	0.03	0.000	City centre		0.825	0		
Light bush and farmlands		75	0.07	0.052	Suburban		0.6	0		
Grasslands		20	0.17	0.033	Streets	0.3	0.825	0.00225		
No vegetation		4	0.26	0.010	Maximum flood		1	0		
Total (C _v)		100	-	0.096	Total (C ₂)	100		0.4216		
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			3.22		hours		ARF (%) = 93.67			
T _c =			1.24		hours		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.408	0.408	0.408	0.408	0.408	0.408
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.408	0.408	0.408	0.408	0.408	0.408
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.255	0.275	0.296	0.320	0.363	0.408
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.271	0.289	0.308	0.330	0.369	0.409
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					32	44	52	61	74	83
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					25.6	35.3	42.2	49.3	59.2	67.2
Area reduction factor (%), ARF _T					93.7	93.7	93.7	93.7	93.7	93.7
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					24.0	33.0	39.5	46.2	55.5	62.9
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					73.7	108.4	137.9	172.8	231.7	291.8

RATIONAL METHOD									
Description of the catchment				Rural					
River details				Motse Main Tributary 1.3					
Calculated by				Wian Lombard			Date		2025-01-09
Physical characteristics									
Size of the catchment (A)		3.20		km ²				Rainfall region	
Longest watercourse (L)		3.081		km				Area distribution factors	
10-85 Slope (S _{av})		0.03		m/m				Rural (α)	
Dolomite area (D _%)		0		%				Urban (β)	
Mean annual rainfall (MAP)		578.4		mm				Lakes (γ)	
Rural				Urban					
Surface slope		%		Factor		C _s		Description	
Vleis and pans (0-3%)		15		0.01		0.001		Lawns	
Flat areas (3-10%)		49		0.06		0.030		Sandy, flat (<2%)	
Hilly (10-30%)		25		0.12		0.031		Sandy, steep (>7%)	
Steep areas (>30%)		10		0.22		0.022		Heavy soil, flat (<2%)	
Total (C _s)		100				0.084		Heavy soil,steep (>7%)	
Permeability		%		Factor		C _p		Residential area	
Very permeable (SCS Type A Soil)		0		0.03		0.000		Houses	
Permeable (SCS Type B Soil)		2		0.06		0.001		Flats	
Semi-permeable (SCS Type C Soil)		1		0.12		0.001		Industry	
Impermeable (SCS Type D Soil)		98		0.21		0.205		Light industry	
Total (C _p)		100				0.207		Heavy industry	
Vegetation		%		Factor		C _v		Business	
Thick bush & plantation		0		0.03		0.000		City centre	
Light bush and farmlands		64		0.07		0.045		Suburban	
Grasslands		34		0.17		0.058		Streets	
No vegetation		2		0.26		0.005		Maximum flood	
Total (C _v)		100				0.108		Total (C ₂)	
								100	
								0.3431	
Time of concentration (T _c)						Notes			
Overland flow			Defined watercourse						
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$						
T _c =			2.16			hours			T _c =
			0.64			hours			
Run-off coefficient									
Return period (years), T					2	5	10	20	50
Run-off coefficient C ₁					0.399	0.399	0.399	0.399	0.399
(C ₁ = C _s + C _p + C _v)									
Adjusted for dolomite areas, C _{1D}					0.399	0.399	0.399	0.399	0.399
(=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))									
Adjustment factor for initial saturation, F _t					0.625	0.675	0.725	0.785	0.890
(Taken as average of two set of values provided in DM)									
Adjusted run-off coefficient, C _{1T}					0.249	0.269	0.289	0.313	0.355
(= C _{1D} x F _t)									
Combined run-off coefficient C _t					0.271	0.286	0.302	0.320	0.352
(= αC _{1T} + βC ₂ + γC ₃)									
Rainfall									
Return period (years), T					2	5	10	20	50
Point rainfall (mm), P _T					25	34	40	47	57
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					38.2	52.6	62.9	73.5	88.3
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					38.2	52.6	62.9	73.5	88.3
Peak flow									
Return period (years), T					2	5	10	20	50
Peak flow (m ³ /s)					9.2	13.4	16.9	20.9	27.6
$Q_T = \frac{C_T I_T A}{3.6}$									

RATIONAL METHOD									
Description of the catchment				Rural					
River details				Motse Tributary 1					
Calculated by				Wian Lombard			Date		2025-01-09
Physical characteristics									
Size of the catchment (A)		1.00		km ²				Rainfall region	
Longest watercourse (L)		2.792		km				Area distribution factors	
10-85 Slope (S _{av})		0.02		m/m				Rural (α)	
Dolomite area (D _%)		0		%				Urban (β)	
Mean annual rainfall (MAP)		578.4		mm				Lakes (γ)	
Rural				Urban					
Surface slope		%		Factor		C _s		Description	
Vleis and pans (0-3%)		35		0.01		0.003		Lawns	
Flat areas (3-10%)		24		0.06		0.014		Sandy, flat (<2%)	
Hilly (10-30%)		19		0.12		0.023		Sandy, steep (>7%)	
Steep areas (>30%)		22		0.22		0.049		Heavy soil, flat (<2%)	
Total (C _s)		100				0.090		Heavy soil,steep (>7%)	
Permeability		%		Factor		C _p		Residential area	
Very permeable (SCS Type A Soil)		0		0.03		0.000		Houses	
Permeable (SCS Type B Soil)		0		0.06		0.000		Flats	
Semi-permeable (SCS Type C Soil)		2		0.12		0.003		Industry	
Impermeable (SCS Type D Soil)		98		0.21		0.205		Light industry	
Total (C _p)		100				0.208		Heavy industry	
Vegetation		%		Factor		C _v		Business	
Thick bush & plantation		0		0.03		0.000		City centre	
Light bush and farmlands		61		0.07		0.043		Suburban	
Grasslands		37		0.17		0.062		Streets	
No vegetation		2		0.26		0.005		Maximum flood	
Total (C _v)		100				0.110		Total (C ₂)	
								100	
								0.6579	
Time of concentration (T _c)						Notes			
Overland flow			Defined watercourse						
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$						
T _c =			2.24			hours			
T _c =			0.69			hours			
Run-off coefficient									
Return period (years), T						2		5	
Run-off coefficient C ₁						0.408		0.408	
(C ₁ = C _s + C _p + C _v)						0.408		0.408	
Adjusted for dolomite areas, C _{1D}						0.408		0.408	
(=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))						0.408		0.408	
Adjustment factor for initial saturation, F _t						0.625		0.675	
(Taken as average of two set of values provided in DM)						0.725		0.785	
Adjusted run-off coefficient, C _{1T}						0.255		0.275	
(= C _{1D} x F _t)						0.296		0.320	
Combined run-off coefficient C _t						0.320		0.337	
(= αC _{1T} + βC ₂ + γC ₃)						0.354		0.375	
Rainfall									
Return period (years), T						2		5	
Point rainfall (mm), P _T						25		35	
Point intensity (mm/hour), P _{IT} (= P _T / T _C)						36.8		50.6	
Area reduction factor (%), ARF _T						100.0		100.0	
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)						36.8		50.6	
Peak flow									
Return period (years), T						2		5	
Peak flow (m ³ /s)						3.3		4.7	
$Q_T = \frac{C_T I_T A}{3.6}$						5.9		7.3	
						9.7		12.0	

RATIONAL METHOD									
Description of the catchment				Rural					
River details				Motse Tributary 2					
Calculated by				Wian Lombard			Date		2025-01-09
Physical characteristics									
Size of the catchment (A)		0.99		km ²				Rainfall region	
Longest watercourse (L)		2.594		km				Area distribution factors	
10-85 Slope (S _{av})		0.01		m/m				Rural (α)	
Dolomite area (D _%)		0		%				Urban (β)	
Mean annual rainfall (MAP)		578.4		mm				Lakes (γ)	
Rural				Urban					
Surface slope		%		Factor		C _s		Description	
Vleis and pans (0-3%)		83		0.01		0.008		Lawns	
Flat areas (3-10%)		14		0.06		0.009		Sandy, flat (<2%)	
Hilly (10-30%)		2		0.12		0.003		Sandy, steep (>7%)	
Steep areas (>30%)		1		0.22		0.001		Heavy soil, flat (<2%)	
Total (C _s)		100				0.021		Heavy soil,steep (>7%)	
Permeability		%		Factor		C _p		Residential area	
Very permeable (SCS Type A Soil)		0		0.03		0.000		Houses	
Permeable (SCS Type B Soil)		0		0.06		0.000		Flats	
Semi-permeable (SCS Type C Soil)		0		0.12		0.000		Industry	
Impermeable (SCS Type D Soil)		100		0.21		0.210		Light industry	
Total (C _p)		100				0.210		Heavy industry	
Vegetation		%		Factor		C _v		Business	
Thick bush & plantation		0		0.03		0.000		City centre	
Light bush and farmlands		94		0.07		0.066		Suburban	
Grasslands		3		0.17		0.005		Streets	
No vegetation		3		0.26		0.008		Maximum flood	
Total (C _v)		100				0.079		Total (C ₂)	
								100	
								0.7286	
Time of concentration (T _c)						Notes			
Overland flow			Defined watercourse						
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$						
T _c =			2.35			hours			
T _c =			0.74			hours			
Run-off coefficient									
Return period (years), T					2		5		10
Run-off coefficient C ₁					0.310		0.310		0.310
(C ₁ = C _s + C _p + C _v)					0.310		0.310		0.310
Adjusted for dolomite areas, C _{1D}					0.310		0.310		0.310
(=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))					0.310		0.310		0.310
Adjustment factor for initial saturation, F _t					0.625		0.675		0.725
(Taken as average of two set of values provided in DM)					0.625		0.675		0.725
Adjusted run-off coefficient, C _{1T}					0.194		0.209		0.225
(= C _{1D} x F _t)					0.194		0.209		0.225
Combined run-off coefficient C _t					0.209		0.224		0.239
(= αC _{1T} + βC ₂ + γC ₃)					0.209		0.224		0.239
Rainfall									
Return period (years), T					2		5		10
Point rainfall (mm), P _T					26		36		43
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					35.2		48.4		57.9
Area reduction factor (%), ARF _T					100.0		100.0		100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					35.2		48.4		57.9
Peak flow									
Return period (years), T					2		5		10
Peak flow (m ³ /s)					2.0		3.0		3.8
$Q_T = \frac{C_T I_T A}{3.6}$					2.0		3.0		3.8

RATIONAL METHOD															
Description of the catchment				Rural											
River details				Motse Tributary 3											
Calculated by				Wian Lombard			Date		2025-01-09						
Physical characteristics															
Size of the catchment (A)		4.96		km ²				Rainfall region							
Longest watercourse (L)		4.495		km				Area distribution factors							
10-85 Slope (S _{av})		0.17		m/m				Rural (α)		0.888					
Dolomite area (D _%)		0		%				Urban (β)		0.112					
Mean annual rainfall (MAP)		578.4		mm				Lakes (γ)		0.000					
Rural				Urban											
Surface slope		%		Factor		C _s		Description		%		Factor		C ₂	
Vleis and pans (0-3%)		5		0.01		0.000		Lawns							
Flat areas (3-10%)		13		0.06		0.008		Sandy, flat (<2%)				0.075		0	
Hilly (10-30%)		33		0.12		0.039		Sandy, steep (>7%)				0.175		0	
Steep areas (>30%)		49		0.22		0.107		Heavy soil, flat (<2%)				0.15		0	
Total (C _s)		100				0.155		Heavy soil,steep (>7%)		92		0.3		0.28	
Permeability		%		Factor		C _p		Residential area							
Very permeable (SCS Type A Soil)		0		0.03		0.000		Houses		7.3		0.4		0.03	
Permeable (SCS Type B Soil)		0		0.06		0.000		Flats				0.6		0	
Semi-permeable (SCS Type C Soil)		2		0.12		0.002		Industry							
Impermeable (SCS Type D Soil)		98		0.21		0.206		Light industry		0.0		0.65		0	
Total (C _p)		100				0.208		Heavy industry		0.0		0.75		0	
Vegetation		%		Factor		C _v		Business							
Thick bush & plantation		11		0.03		0.003		City centre				0.825		0	
Light bush and farmlands		61		0.07		0.042		Suburban				0.6		0	
Grasslands		24		0.17		0.041		Streets		0.9		0.825		0.0071895	
No vegetation		4		0.26		0.012		Maximum flood				1		0	
Total (C _v)		100				0.098		Total (C ₂)		100				0.3118	
Time of concentration (T _c)						Notes									
Overland flow			Defined watercourse												
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$												
T _c = 1.66 hours			T _c = 0.42 hours												
Run-off coefficient															
Return period (years), T						2	5	10	20	50	100				
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)						0.461	0.461	0.461	0.461	0.461	0.461				
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))						0.461	0.461	0.461	0.461	0.461	0.461				
Adjustment factor for initial saturation, F _t (Taken as average of two set of values provided in DM)						0.625	0.675	0.725	0.785	0.890	1.000				
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _t)						0.288	0.311	0.335	0.362	0.411	0.461				
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)						0.291	0.311	0.332	0.357	0.400	0.445				
Rainfall															
Return period (years), T						2	5	10	20	50	100				
Point rainfall (mm), P _T						21	28	34	40	48	54				
Point intensity (mm/hour), P _{IT} (= P _T / T _C)						49.3	67.9	81.2	94.9	114.0	129.3				
Area reduction factor (%), ARF _T						100.0	100.0	100.0	100.0	100.0	100.0				
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)						49.3	67.9	81.2	94.9	114.0	129.3				
Peak flow															
Return period (years), T						2	5	10	20	50	100				
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$						19.8	29.1	37.2	46.6	62.8	79.2				

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Motse Tributary 4						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		2.03	km ²		Rainfall region					
Longest watercourse (L)		3.473	km		Area distribution factors					
10-85 Slope (S _{av})		0.18	m/m		Rural (α)		0.515			
Dolomite area (D _%)		0	%		Urban (β)		0.485			
Mean annual rainfall (MAP)		578.4	mm		Lakes (γ)		0.000			
Rural				Urban						
Surface slope		%	Factor	C _s	Description	%	Factor	C ₂		
Vleis and pans (0-3%)		15	0.01	0.001	Lawns					
Flat areas (3-10%)		27	0.06	0.016	Sandy, flat (<2%)		0.075	0		
Hilly (10-30%)		18	0.12	0.022	Sandy, steep (>7%)		0.175	0		
Steep areas (>30%)		40	0.22	0.088	Heavy soil, flat (<2%)		0.15	0		
Total (C _s)		100		0.127	Heavy soil,steep (>7%)	97	0.3	0.29		
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses	3.0	0.4	0.01		
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats		0.6	0		
Semi-permeable (SCS Type C Soil)		0	0.12	0.000	Industry					
Impermeable (SCS Type D Soil)		100	0.21	0.210	Light industry	0.0	0.65	0		
Total (C _p)		100		0.210	Heavy industry	0.0	0.75	0		
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		16	0.03	0.005	City centre		0.825	0		
Light bush and farmlands		74	0.07	0.052	Suburban		0.6	0		
Grasslands		10	0.17	0.016	Streets	0.0	0.825	0		
No vegetation		1	0.26	0.002	Maximum flood		1	0		
Total (C _v)		100	-	0.075	Total (C ₂)	100		0.3030		
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.46		hours	T _c =		0.34		
					hours					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.412	0.412	0.412	0.412	0.412	0.412
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.412	0.412	0.412	0.412	0.412	0.412
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.257	0.278	0.299	0.323	0.367	0.412
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.280	0.290	0.301	0.313	0.336	0.359
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					19	26	31	36	44	50
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					56.0	77.1	92.2	107.8	129.4	146.8
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					56.0	77.1	92.2	107.8	129.4	146.8
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					8.8	12.6	15.6	19.0	24.5	29.7

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Motse Tributary 5						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		0.81	km ²					Rainfall region		
Longest watercourse (L)		1.902	km					Area distribution factors		
10-85 Slope (S _{av})		0.02	m/m					Rural (α)		0.601
Dolomite area (D _%)		0	%					Urban (β)		0.399
Mean annual rainfall (MAP)		578.4	mm					Lakes (γ)		0.000
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		51	0.01	0.005	Lawns					
Flat areas (3-10%)		23	0.06	0.014	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		12	0.12	0.014	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		14	0.22	0.031	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.064	Heavy soil,steep (>7%)		94	0.3	0.28	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		5.7	0.4	0.02	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		0	0.12	0.000	Industry					
Impermeable (SCS Type D Soil)		100	0.21	0.210	Light industry		0.0	0.65	0	
Total (C _p)		100		0.210	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		3	0.03	0.001	City centre			0.825	0	
Light bush and farmlands		82	0.07	0.057	Suburban			0.6	0	
Grasslands		15	0.17	0.026	Streets		0.5	0.825	0.0041562	
No vegetation		1	0.26	0.002	Maximum flood			1	0	
Total (C _v)		100	-	0.086	Total (C ₂)		100		0.3083	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.93		hours		ARF (%) = 100.00			
T _c =			0.54		hours		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.360	0.360	0.360	0.360	0.360	0.360
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.360	0.360	0.360	0.360	0.360	0.360
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.225	0.243	0.261	0.282	0.320	0.360
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.258	0.269	0.280	0.293	0.315	0.339
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					23	32	38	44	53	60
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					42.7	58.8	70.4	82.2	98.7	112.0
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					42.7	58.8	70.4	82.2	98.7	112.0
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					2.5	3.5	4.4	5.4	7.0	8.5

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Motse Tributary 6						
Calculated by				Wian Lombard			Date		2025-01-09	
Physical characteristics										
Size of the catchment (A)		5.61		km ²		Rainfall region				
Longest watercourse (L)		5.320		km						
10-85 Slope (S _{av})		0.14		m/m						
Dolomite area (D _%)		0		%						
Mean annual rainfall (MAP)		578.4		mm						
						Area distribution factors				
						Rural (α)		0.988		
						Urban (β)		0.012		
						Lakes (γ)		0.000		
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		12	0.01	0.001	Lawns					
Flat areas (3-10%)		14	0.06	0.008	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		30	0.12	0.036	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		44	0.22	0.097	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.142	Heavy soil,steep (>7%)		80	0.3	0.24	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		13.0	0.4	0.05	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		2	0.12	0.003	Industry					
Impermeable (SCS Type D Soil)		98	0.21	0.205	Light industry		0.0	0.65	0	
Total (C _p)		100		0.208	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		12	0.03	0.004	City centre			0.825	0	
Light bush and farmlands		65	0.07	0.045	Suburban			0.6	0	
Grasslands		16	0.17	0.027	Streets		7.5	0.825	0.0614907	
No vegetation		7	0.26	0.019	Maximum flood			1	0	
Total (C _v)		100	-	0.095	Total (C ₂)		100		0.3522	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 1.88 hours			T _c = 0.51 hours							
					ARF (%) = 100.00					
					r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.445	0.445	0.445	0.445	0.445	0.445
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))					0.445	0.445	0.445	0.445	0.445	0.445
Adjustment factor for initial saturation, F _t (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _t)					0.278	0.300	0.322	0.349	0.396	0.445
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.279	0.301	0.323	0.349	0.395	0.444
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					23	31	37	43	52	59
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					44.1	60.7	72.6	84.8	101.9	115.6
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					44.1	60.7	72.6	84.8	101.9	115.6
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					19.1	28.4	36.5	46.1	62.7	79.8

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Motse Tributary 7						
Calculated by				Wian Lombard			Date		2025-01-09	
Physical characteristics										
Size of the catchment (A)		5.34		km ²				Rainfall region		
Longest watercourse (L)		3.962		km				Area distribution factors		
10-85 Slope (S _{av})		0.17		m/m				Rural (α)		
Dolomite area (D _%)		0		%				Urban (β)		
Mean annual rainfall (MAP)		578.4		mm				Lakes (γ)		
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		15	0.01	0.002	Lawns					
Flat areas (3-10%)		24	0.06	0.014	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		27	0.12	0.032	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		34	0.22	0.075	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.123	Heavy soil,steep (>7%)		93	0.3	0.28	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		6.4	0.4	0.03	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		4	0.12	0.004	Industry					
Impermeable (SCS Type D Soil)		96	0.21	0.202	Light industry		0.0	0.65	0	
Total (C _p)		100		0.207	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		4	0.03	0.001	City centre			0.825	0	
Light bush and farmlands		78	0.07	0.054	Suburban			0.6	0	
Grasslands		15	0.17	0.025	Streets		0.8	0.825	0.006403	
No vegetation		4	0.26	0.010	Maximum flood			1	0	
Total (C _v)		100	-	0.091	Total (C ₂)		100		0.3105	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 1.56 hours			T _c = 0.38 hours		ARF (%) = 99.68					
					r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.421	0.421	0.421	0.421	0.421	0.421
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))					0.421	0.421	0.421	0.421	0.421	0.421
Adjustment factor for initial saturation, F _t (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _t)					0.263	0.284	0.305	0.330	0.374	0.421
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.269	0.287	0.306	0.328	0.366	0.407
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					20	27	33	38	46	52
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					52.3	72.1	86.3	100.8	121.0	137.3
Area reduction factor (%), ARF _T					99.7	99.7	99.7	99.7	99.7	99.7
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					52.2	71.9	86.0	100.5	120.6	136.8
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					20.8	30.6	39.0	48.8	65.5	82.5

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Motse Tributary 8						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		0.45	km ²			Rainfall region				
Longest watercourse (L)		1.354	km			Area distribution factors				
10-85 Slope (S _{av})		0.07	m/m							
Dolomite area (D _%)		0	%							
Mean annual rainfall (MAP)		578.4	mm							
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		17	0.01	0.002	Lawns					
Flat areas (3-10%)		45	0.06	0.027	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		18	0.12	0.022	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		20	0.22	0.044	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.095	Heavy soil, steep (>7%)		87	0.3	0.26	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		13.3	0.4	0.05	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		0	0.12	0.000	Industry					
Impermeable (SCS Type D Soil)		100	0.21	0.210	Light industry		0.0	0.65	0	
Total (C _p)		100		0.210	Heavy industry		0.0	0.75	0	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		84	0.07	0.059	Suburban			0.6	0	
Grasslands		16	0.17	0.027	Streets		0.0	0.825	0	
No vegetation		0	0.26	0.001	Maximum flood			1	0	
Total (C _v)		100	-	0.086	Total (C ₂)		100		0.3133	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c = 1.15 hours			T _c = 0.23 hours		ARF (%) = 100.00					
					r Thick grass cover = 0.80					
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.391	0.391	0.391	0.391	0.391	0.391
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))					0.391	0.391	0.391	0.391	0.391	0.391
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.244	0.264	0.284	0.307	0.348	0.391
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.266	0.279	0.293	0.309	0.337	0.367
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					16	22	26	31	37	42
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					70.4	97.0	116.1	135.6	162.8	184.7
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					70.4	97.0	116.1	135.6	162.8	184.7
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					2.3	3.4	4.2	5.2	6.9	8.5

RATIONAL METHOD											
Description of the catchment				Rural							
River details				Matadi Main							
Calculated by				Wian Lombard			Date		2025-01-09		
Physical characteristics											
Size of the catchment (A)		70.88		km ²				Rainfall region			
Longest watercourse (L)		23.819		km				Area distribution factors			
10-85 Slope (S _{av})		0.02		m/m				Rural (α)		0.651	
Dolomite area (D _%)		0		%				Urban (β)		0.347	
Mean annual rainfall (MAP)		578.4		mm				Lakes (γ)		0.001	
Rural				Urban							
Surface slope		%	Factor	C _s		Description		%	Factor	C ₂	
Vleis and pans (0-3%)		37	0.01	0.004		Lawns					
Flat areas (3-10%)		25	0.06	0.015		Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		20	0.12	0.024		Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		18	0.22	0.039		Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.082		Heavy soil,steep (>7%)		87	0.3	0.26	
Permeability		%	Factor	C _p		Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000		Houses		6.3	0.4	0.03	
Permeable (SCS Type B Soil)		33	0.06	0.020		Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		33	0.12	0.040		Industry					
Impermeable (SCS Type D Soil)		33	0.21	0.070		Light industry		0.1	0.65	0.0004055	
Total (C _p)		100		0.130		Heavy industry		6.4	0.75	0.0476714	
Vegetation		%	Factor	C _v		Business					
Thick bush & plantation		2	0.03	0.001		City centre			0.825	0	
Light bush and farmlands		59	0.07	0.041		Suburban			0.6	0	
Grasslands		30	0.17	0.050		Streets		0.2	0.825	0.0016116	
No vegetation		10	0.26	0.025		Maximum flood			1	0	
Total (C _v)		100	-	0.117		Total (C ₂)		100		0.3362	
Time of concentration (T _c)						Notes					
Overland flow			Defined watercourse								
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$								
T _c = 6.27 hours			T _c = 3.73 hours			ARF (%) = 95.30					
						r Thick grass cover = 0.80					
Run-off coefficient											
Return period (years), T						2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)						0.330	0.330	0.330	0.330	0.330	0.330
Adjusted for dolomite areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{g%})))						0.330	0.330	0.330	0.330	0.330	0.330
Adjustment factor for initial saturation, F _t (Taken as average of two set of values provided in DM)						0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _t)						0.206	0.223	0.239	0.259	0.294	0.330
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)						0.251	0.262	0.272	0.285	0.308	0.332
Rainfall											
Return period (years), T						2	5	10	20	50	100
Point rainfall (mm), P _T						43	60	72	84	100	114
Point intensity (mm/hour), P _{IT} (= P _T / T _C)						11.6	16.0	19.2	22.4	26.9	30.5
Area reduction factor (%), ARF _T						95.3	95.3	95.3	95.3	95.3	95.3
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)						11.1	15.3	18.3	21.4	25.6	29.1
Peak flow											
Return period (years), T						2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$						54.8	78.7	98.1	120.0	155.5	189.9

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Matadi Tributary 1						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		2.32	km ²					Rainfall region		
Longest watercourse (L)		3.119	km					Area distribution factors		
10-85 Slope (S _{av})		0.04	m/m							
Dolomite area (D _%)		0	%							
Mean annual rainfall (MAP)		578.4	mm							
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		38	0.01	0.004	Lawns					
Flat areas (3-10%)		31	0.06	0.019	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		20	0.12	0.024	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		11	0.22	0.025	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.071	Heavy soil,steep (>7%)		77	0.3	0.23	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		1.7	0.4	0.01	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		3	0.12	0.003	Industry					
Impermeable (SCS Type D Soil)		97	0.21	0.205	Light industry		0.0	0.65	0	
Total (C _p)		100		0.208	Heavy industry		21.0	0.75	0.1578738	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		30	0.07	0.021	Suburban			0.6	0	
Grasslands		57	0.17	0.098	Streets		0.0	0.825	0.0002187	
No vegetation		13	0.26	0.033	Maximum flood			1	0	
Total (C _v)		100	-	0.152	Total (C ₂)		100		0.3966	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			1.98		hours		ARF (%) = 100.00			
T _c =			0.56		hours		r Thick grass cover = 0.80			
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.430	0.430	0.430	0.430	0.430	0.430
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.430	0.430	0.430	0.430	0.430	0.430
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.269	0.291	0.312	0.338	0.383	0.430
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.353	0.360	0.367	0.376	0.392	0.408
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					23	32	38	45	54	61
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					41.8	57.5	68.9	80.4	96.6	109.6
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					41.8	57.5	68.9	80.4	96.6	109.6
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					9.5	13.3	16.3	19.5	24.4	28.8

RATIONAL METHOD										
Description of the catchment				Rural						
River details				Matadi Tributary 2						
Calculated by				Wian Lombard			Date	2025-01-09		
Physical characteristics										
Size of the catchment (A)		5.83	km ²				Rainfall region			
Longest watercourse (L)		6.537	km				Area distribution factors			
10-85 Slope (S _{av})		0.03	m/m				Rural (α)		0.479	
Dolomite area (D _%)		0	%				Urban (β)		0.521	
Mean annual rainfall (MAP)		578.4	mm				Lakes (γ)		0.000	
Rural				Urban						
Surface slope		%	Factor	C _s	Description		%	Factor	C ₂	
Vleis and pans (0-3%)		39	0.01	0.004	Lawns					
Flat areas (3-10%)		26	0.06	0.016	Sandy, flat (<2%)			0.075	0	
Hilly (10-30%)		20	0.12	0.025	Sandy, steep (>7%)			0.175	0	
Steep areas (>30%)		14	0.22	0.031	Heavy soil, flat (<2%)			0.15	0	
Total (C _s)		100		0.075	Heavy soil,steep (>7%)		91	0.3	0.27	
Permeability		%	Factor	C _p	Residential area					
Very permeable (SCS Type A Soil)		0	0.03	0.000	Houses		4.3	0.4	0.02	
Permeable (SCS Type B Soil)		0	0.06	0.000	Flats			0.6	0	
Semi-permeable (SCS Type C Soil)		10	0.12	0.012	Industry					
Impermeable (SCS Type D Soil)		90	0.21	0.189	Light industry		0.0	0.65	0	
Total (C _p)		100		0.201	Heavy industry		4.5	0.75	0.0335134	
Vegetation		%	Factor	C _v	Business					
Thick bush & plantation		0	0.03	0.000	City centre			0.825	0	
Light bush and farmlands		25	0.07	0.017	Suburban			0.6	0	
Grasslands		52	0.17	0.088	Streets		0.0	0.825	0	
No vegetation		23	0.26	0.060	Maximum flood			1	0	
Total (C _v)		100	-	0.165	Total (C ₂)		100		0.3244	
Time of concentration (T _c)					Notes					
Overland flow			Defined watercourse							
$T_c = 0.604 \left(\frac{rL}{\sqrt{S_{av}}} \right)^{0.467}$			$T_c = \left(\frac{0.87L^2}{1000S_{av}} \right)^{0.385}$							
T _c =			3.05			hours				
T _c =			1.14			hours				
Run-off coefficient										
Return period (years), T					2	5	10	20	50	100
Run-off coefficient C ₁ (C ₁ = C _s + C _p + C _v)					0.442	0.442	0.442	0.442	0.442	0.442
Adjusted for dolomitec areas, C _{1D} (=C ₁ (1 - D _%) + C ₁ D _% (Σ(D _{factor} x C _{S%})))					0.442	0.442	0.442	0.442	0.442	0.442
Adjustment factor for initial saturation, F _i (Taken as average of two set of values provided in DM)					0.625	0.675	0.725	0.785	0.890	1.000
Adjusted run-off coefficient, C _{1T} (= C _{1D} x F _i)					0.276	0.298	0.320	0.347	0.393	0.442
Combined run-off coefficient C _t (= αC _{1T} + βC ₂ + γC ₃)					0.301	0.312	0.322	0.335	0.357	0.380
Rainfall										
Return period (years), T					2	5	10	20	50	100
Point rainfall (mm), P _T					31	42	51	59	71	81
Point intensity (mm/hour), P _{IT} (= P _T / T _C)					27.0	37.2	44.5	52.0	62.5	70.9
Area reduction factor (%), ARF _T					100.0	100.0	100.0	100.0	100.0	100.0
Average intensity (mm/hour), I _T (= P _{IT} xARF _T)					27.0	37.2	44.5	52.0	62.5	70.9
Peak flow										
Return period (years), T					2	5	10	20	50	100
Peak flow (m ³ /s) $Q_T = \frac{C_T I_T A}{3.6}$					13.2	18.8	23.2	28.2	36.1	43.6

Appendix C

UHM Calculation Sheets

FLOOD HYDROLOGY: UNIT HYDROGRAPH METHOD

Project No 1002569
Project Title Olifants flood line investigation
River Palangwe Catchment

Calculated by: Wian Lombard
Date: 02/12/2024

INPUT DATA: Catchment characteristics

Total catchment area	108.60	km ²				
Length of watercourse (L)	29.90	km	Location	Lat	<u>Deg</u>	<u>Min</u>
Watercourse average slope (10/85)	0.02	m/m		Long		<u>Sec</u>
					24	37
					30	8
						0
Watercourse Length from Centroid	12.73	km	Veldtype		8	

INPUT DATA: Rainfall

Mean Annual Precipitation (MAP) 550 mm

From Design rainfall extract /analysis

Recurrence interval	years AEP (%)	2yr 50%	5yr 20%	10yr 10%	20yr 5%	50yr 2%	100yr 1%	200yr 0.5%
1-day		53	73	87	101	122	138	155

CALCULATIONS: Catchment index and unit hydrograph peak discharge

Catchment Index $I_c = \frac{L \cdot L_c}{\sqrt{S_{av}}}$ where; I_c Catchment index 2,939
 L Length of watercourse 29.904 km
 L_c Watercourse Length from Centroid 12.725 km
 S_{av} Watercourse average slope (10/85) 0.017 m/m

Peak discharge from unit hydrograph $Q_p = \frac{K_u \cdot A}{T_L}$ where; Q_p Peak discharge from Unit Hydrograph 11.73 m³/s
 K_u Veld type Factor 0.367
 A Catchment Area 108.6 km²
 T_L Lag time 3.40 hours

CALCULATIONS: Effective rainfall

Select smallest storm duration 1: 1 hours Time Interval for S-Curve Determination 0.1 hours
Select return period 1: 100 years

Calculations for effective rainfall for range of storm durations

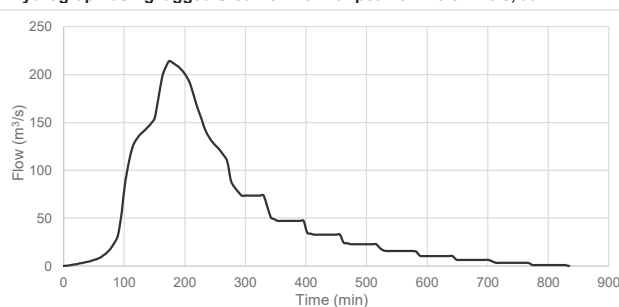
T_{SD}	Storm duration	1	2	4	8 hours
P_T	Point rainfall	78	103	117	134 mm
P_{IT}	Point intensity	78	51	29	17 mm/h
ARF_{IT}	Area reduction factor	91%	94%	97%	98% %
P_{AvgIT}	Average Rainfall	70.7	96.9	113.4	131.3 mm
f_{IT}	Flood run-off factor	19%	22%	25%	27% %
he_{IT}	Effective rain	13.3	21.7	27.9	35.2 mm

CALCULATIONS: Peak discharge

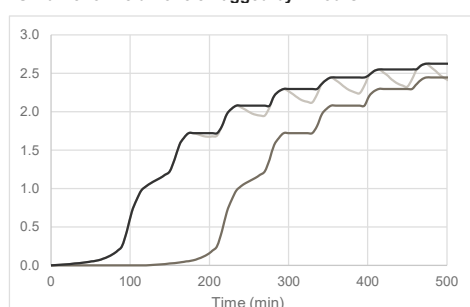
Results from lagged S-curve

Max interpolated S-curve	0.993			
$[(S_1 - S_{2T})/T_{SD}]_{Max}$	0.99	0.83	0.56	0.33
Q_{PIT} Unit Hydrograph peak	11.65	9.78	6.57	3.85 m ³ /s
Q_{IT} Peak discharge	155	212	183	135 m ³ /s
If $Q_{PIT}/Q_p < 1$,				
$Q_{IT} / [Interpolated\ S-curve]_{MAX}$	156	214	185	136 m ³ /s

Hydrograph using lagged S-curve info with peak of 213.82 m³/s, at 174 min



S-Curve for Veld Zone 8 Lagged by 2 hours



FLOOD HYDROLOGY: UNIT HYDROGRAPH METHOD

Project No 1002569
Project Title Olifants flood line investigation
River Moopetsi Main

Calculated by: Wian Lombard
Date: 02/12/2024

INPUT DATA: Catchment characteristics

Total catchment area **123.64** km²
 Length of watercourse (L) **28.93** km
 Watercourse average slope (10/85) **0.01** m/m
 Watercourse Length from Centroid **15.22** km

Location Lat **24** Deg **37** Min **0** Sec
 Long **30** 8 0
 Veldtype **8**

INPUT DATA: Rainfall

Mean Annual Precipitation (MAP) 578 mm

From Design rainfall extract /analysis

Recurrence interval	years AEP (%)	2yr 50%	5yr 20%	10yr 10%	20yr 5%	50yr 2%	100yr 1%	200yr 0.5%
1-day		52	72	86	101	121	137	154

CALCULATIONS: Catchment index and unit hydrograph peak discharge

Catchment Index $I_c = \frac{L \cdot L_c}{\sqrt{S_{av}}}$ where; Ic Catchment index **4,141**
 L Length of watercourse 28.929 km
 Lc Watercourse Length from Centroid 15.222 km
 Sav Watercourse average slope (10/85) 0.011 m/m

Peak discharge from unit hydrograph $Q_p = \frac{K_u \cdot A}{T_L}$ where; Qp Peak discharge from Unit Hydrograph **11.80** m³/s
 Ku Veld type Factor 0.367
 A Catchment Area 123.64 km²
 T_L Lag time 3.85 hours

CALCULATIONS: Effective rainfall

Select smallest storm duration 1: **1** hours Time Interval for S-Curve Determination **0.2** hours
Select return period 1: **100** years

Calculations for effective rainfall for range of storm durations

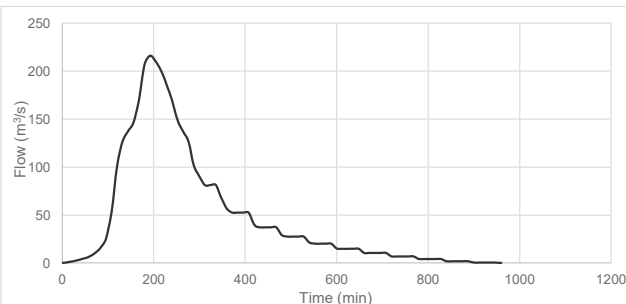
T _{SD}	Storm duration	1	2	4	8 hours
P _T	Point rainfall	77	101	116	133 mm
P _{IT}	Point intensity	77	51	29	17 mm/h
ARF _{IT}	Area reduction factor	90%	94%	96%	98% %
P _{AVGIT}	Average Rainfall	69.7	94.8	111.7	130.0 mm
f _{IT}	Flood run-off factor	19%	22%	24%	27% %
he _{IT}	Effective rain	13.0	21.0	27.2	34.6 mm

CALCULATIONS: Peak discharge

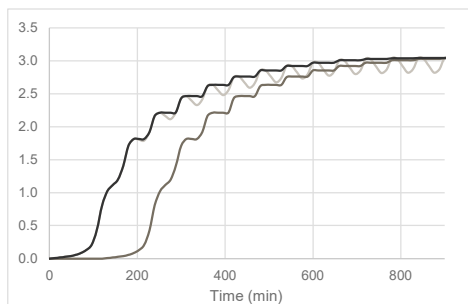
Results from lagged S-curve

Max interpolated S-curve	0.992			
$[(S_1 - S_{2T})/T_{SD}]_{MAX}$	0.99	0.87	0.60	0.36
Q _{PIT} Unit Hydrograph peak	11.71	10.21	7.02	4.23 m ³ /s
Q _{IT} Peak discharge	152	215	191	146 m ³ /s
If Q _{PIT} /Q _p < 1				
Q _{IT} /[Interpolated S-curve] MAX	153	216	193	148 m ³ /s

Hydrograph using lagged S-curve info with peak of 216.19 m³/s, at 192 min



S-Curve for Veld Zone 8 Lagged by 2 hours



FLOOD HYDROLOGY: UNIT HYDROGRAPH METHOD

Project No 1002569
Project Title Olifants flood line investigation
River Motse Main

Calculated by: Wian Lombard
Date: 02/12/2024

INPUT DATA: Catchment characteristics

Total catchment area **129.00** km²
 Length of watercourse (L) **30.10** km
 Watercourse average slope (10/85) **0.31** m/m
 Watercourse Length from Centroid **14.46** km

Location Lat **24** Deg **37** Min **0** Sec
 Long **30** Long **8** Sec **0**

Veldtype **8**

INPUT DATA: Rainfall

Mean Annual Precipitation (MAP) 578 mm

From Design rainfall extract /analysis

Recurrence interval	years AEP (%)	2yr 50%	5yr 20%	10yr 10%	20yr 5%	50yr 2%	100yr 1%	200yr 0.5%
1-day		52	72	86	101	121	137	154

CALCULATIONS: Catchment index and unit hydrograph peak discharge

Catchment Index

$$I_c = \frac{L \cdot L_c}{\sqrt{S_{av}}}$$

where; Ic Catchment index **787**
 L Length of watercourse 30.097 km
 Lc Watercourse Length from Centroid 14.462 km
 Sav Watercourse average slope (10/85) 0.306 m/m

Peak discharge from unit hydrograph

$$Q_p = \frac{K_u \cdot A}{T_L}$$

where; Qp Peak discharge from Unit Hydrograph **22.44** m³/s
 Ku Veld type Factor 0.367
 A Catchment Area 129 km²
 T_L Lag time 2.11 hours

CALCULATIONS: Effective rainfall

Select smallest storm duration 1: **1** hours
 Select return period 1: **100** years
 Time Interval for S-Curve Determination **0.1** hours

Calculations for effective rainfall for range of storm durations

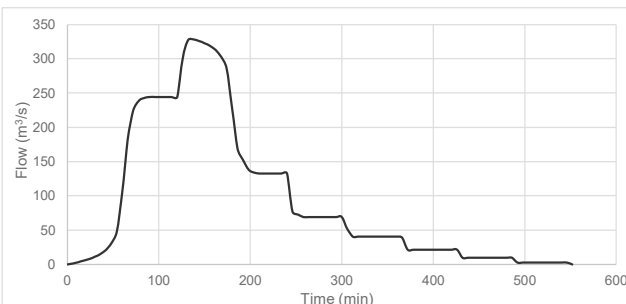
T _{SD}	Storm duration	1	2	4	8 hours
P _T	Point rainfall	77	101	116	133 mm
P _{IT}	Point intensity	77	51	29	17 mm/h
ARF _{IT}	Area reduction factor	90%	94%	96%	98% %
P _{AVGIT}	Average Rainfall	69.5	94.7	111.6	129.9 mm
f _{IT}	Flood run-off factor	19%	22%	24%	27% %
he _{IT}	Effective rain	12.9	21.0	27.2	34.6 mm

CALCULATIONS: Peak discharge

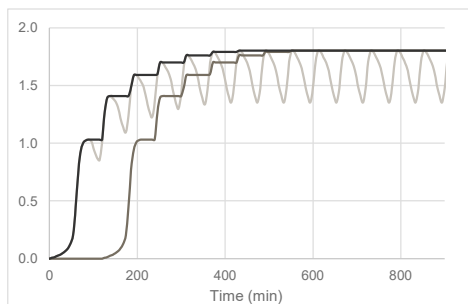
Results from lagged S-curve

Max interpolated S-curve	0.993			
[(S ₁ -S _{2T})/T _{SD}] _{Max}	0.99	0.69	0.42	0.23
Q _{PIT} Unit Hydrograph peak	22.29	15.55	9.47	5.06 m ³ /s
Q _{IT} Peak discharge	288	326	258	175 m ³ /s
If Q _{PIT} /Q _p < 1				
Q _{IT} /[Interpolated S-curve] _{MAX}	290	328	259	176 m ³ /s

Hydrograph using lagged S-curve info with peak of 328.16 m³/s, at 138 min



S-Curve for Veld Zone 8 Lagged by 2 hours



FLOOD HYDROLOGY: UNIT HYDROGRAPH METHOD

Project No 1002569
Project Title Olifants flood line investigation
River Motse Main Tributary 1.1

Calculated by: Wian Lombard
Date: 02/12/2024

INPUT DATA: Catchment characteristics

Total catchment area	63.00	km ²					
Length of watercourse (L)	18.62	km	Location	Lat	Deg	Min	Sec
Watercourse average slope (10/85)	0.01	m/m		Long	30	8	0
Watercourse Length from Centroid	10.39	km	Veldtype		8		

INPUT DATA: Rainfall

Mean Annual Precipitation (MAP) 578 mm

From Design rainfall extract /analysis

Recurrence interval	years AEP (%)	2yr 50%	5yr 20%	10yr 10%	20yr 5%	50yr 2%	100yr 1%	200yr 0.5%
1-day		52	72	86	101	121	137	154

CALCULATIONS: Catchment index and unit hydrograph peak discharge

Catchment Index $I_c = \frac{L \cdot L_c}{\sqrt{S_{av}}}$ where; I_c Catchment index 1,872
 L Length of watercourse 18.624 km
 L_c Watercourse Length from Centroid 10.395 km
 S_{av} Watercourse average slope (10/85) 0.011 m/m

Peak discharge from unit hydrograph $Q_p = \frac{K_u \cdot A}{T_L}$ where; Q_p Peak discharge from Unit Hydrograph 8.01 m³/s
 K_u Veld type Factor 0.367
 A Catchment Area 63 km²
 T_L Lag time 2.89 hours

CALCULATIONS: Effective rainfall

Select smallest storm duration 1: 1 hours Time Interval for S-Curve Determination 0.1 hours
Select return period 1: 100 years

Calculations for effective rainfall for range of storm durations

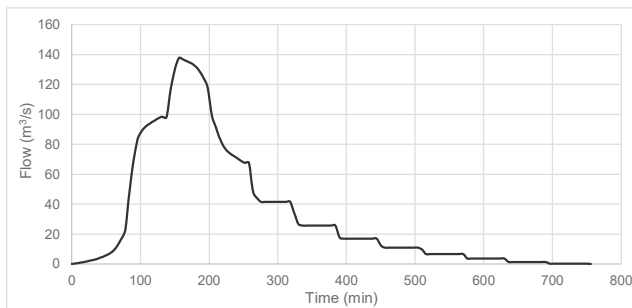
T _{SD}	Storm duration	1	2	4	8 hours
P _T	Point rainfall	77	101	116	133 mm
P _{IT}	Point intensity	77	51	29	17 mm/h
ARF _{IT}	Area reduction factor	94%	96%	98%	99% %
P _{AVGIT}	Average Rainfall	72.2	97.1	113.2	130.9 mm
f _{IT}	Flood run-off factor	19%	22%	25%	27% %
he _{IT}	Effective rain	13.7	21.8	27.8	35.0 mm

CALCULATIONS: Peak discharge

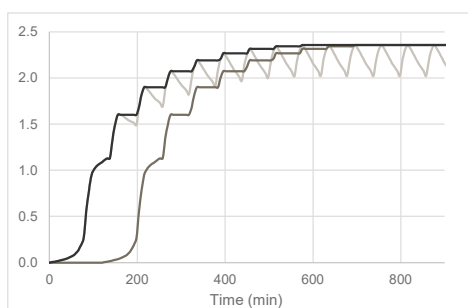
Results from lagged S-curve

Max interpolated S-curve	0.994			
$[(S_1 - S_{2T})/T_{SD}]_{MAX}$	0.99	0.78	0.51	0.29
Q _{PIT} Unit Hydrograph peak	7.96	6.27	4.08	2.32 m ³ /s
Q _{IT} Peak discharge	109	137	113	81 m ³ /s
If Q _{PIT} /Q _p < 1,				
Q _{IT} /[Interpolated S-curve] MAX	110	138	114	82 m ³ /s

Hydrograph using lagged S-curve info with peak of 137.57 m³/s, at 156 min



S-Curve for Veld Zone 8 Lagged by 2 hours



FLOOD HYDROLOGY: UNIT HYDROGRAPH METHOD

Project No 1002569
Project Title Olifants flood line investigation
River Motse Main Tributary 1.2

Calculated by: Wian Lombard
Date: 02/12/2024

INPUT DATA: Catchment characteristics

Total catchment area	40.28	km ²				
Length of watercourse (L)	10.78	km	Location Lat	Deg	Min	Sec
Watercourse average slope (10/85)	0.06	m/m	Long	30	8	0
Watercourse Length from Centroid	5.91	km	Veldtype	8		

INPUT DATA: Rainfall

Mean Annual Precipitation (MAP) 578 mm

From Design rainfall extract /analysis

Recurrence interval	years AEP (%)	2yr 50%	5yr 20%	10yr 10%	20yr 5%	50yr 2%	100yr 1%	200yr 0.5%
1-day		52	72	86	101	121	137	154

CALCULATIONS: Catchment index and unit hydrograph peak discharge

Catchment Index $I_c = \frac{L \cdot L_c}{\sqrt{S_{av}}}$ where;
 Ic Catchment index 266
 L Length of watercourse 10.776 km
 Lc Watercourse Length from Centroid 5.911 km
 Sav Watercourse average slope (10/85) 0.057 m/m

Peak discharge from unit hydrograph $Q_p = \frac{K_u \cdot A}{T_L}$ where;
 Qp Peak discharge from Unit Hydrograph 10.38 m³/s
 Ku Veld type Factor 0.367
 A Catchment Area 40.275 km²
 T_L Lag time 1.42 hours

CALCULATIONS: Effective rainfall

Select smallest storm duration 0.1 hours
Select return period 1: 100 years
 Time Interval for S-Curve Determination 0.025 hours

Calculations for effective rainfall for range of storm durations

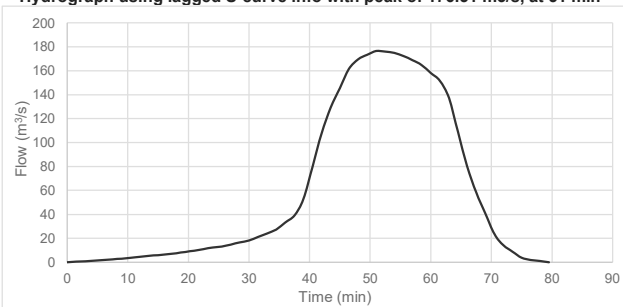
T _{SD}	Storm duration	0.1	0.2	0.4	0.8 hours
P _T	Point rainfall	25	39	53	70 mm
P _{IT}	Point intensity	253	194	133	88 mm/h
ARF _{IT}	Area reduction factor	86%	89%	92%	95% %
P _{Avgt}	Average Rainfall	21.7	34.4	48.9	66.8 mm
f _{IT}	Flood run-off factor	9%	13%	16%	18% %
he _{IT}	Effective rain	2.0	4.4	7.6	12.2 mm

CALCULATIONS: Peak discharge

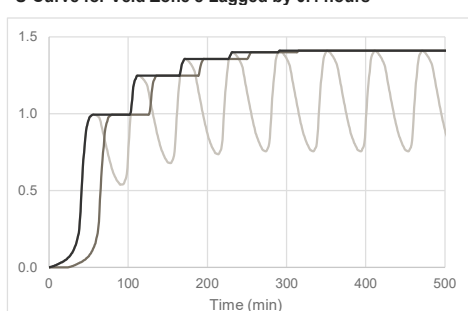
Results from lagged S-curve

Max interpolated S-curve	0.994			
$[(S_1 - S_{2T})/T_{SD}]_{Max}$	4.91	3.66	2.24	1.23
Q _{PIT} Unit Hydrograph peak	50.92	37.99	23.26	12.74 m ³ /s
Q _{IT} Peak discharge	103	167	177	155 m ³ /s
If Q _{PIT} /Q _p < 1				
Q _{IT} /[Interpolated S-curve] MAX	103	167	177	155 m ³ /s

Hydrograph using lagged S-curve info with peak of 176.51 m³/s, at 51 min



S-Curve for Veld Zone 8 Lagged by 0.4 hours



FLOOD HYDROLOGY: UNIT HYDROGRAPH METHOD

Project No 1002569
Project Title Olifants flood line investigation
River Matadi Main

Calculated by: Wian Lombard
Date: 02/12/2024

INPUT DATA: Catchment characteristics

Total catchment area	70.88 km ²	Location Lat	24	Min	37	Sec	0
Length of watercourse (L)	23.82 km	Long	30		8		0
Watercourse average slope (10/85)	0.02 m/m						
Watercourse Length from Centroid	16.06 km	Veldtype	8				

INPUT DATA: Rainfall

Mean Annual Precipitation (MAP) 578 mm

From Design rainfall extract /analysis

Recurrence interval	years AEP (%)	2yr 50%	5yr 20%	10yr 10%	20yr 5%	50yr 2%	100yr 1%	200yr 0.5%
1-day		52	72	86	101	121	137	154

CALCULATIONS: Catchment index and unit hydrograph peak discharge

Catchment Index

$$I_c = \frac{L \cdot L_c}{\sqrt{S_{av}}}$$

where; Lc Catchment index 3.011
L Length of watercourse 23.819 km
Lc Watercourse Length from Centroid 16.061 km
Sav Watercourse average slope (10/85) 0.016 m/m

Peak discharge from unit hydrograph

$$Q_p = \frac{K_u \cdot A}{T_L}$$

where; Qp Peak discharge from Unit Hydrograph 7.59 m³/s
Ku Veld type Factor 0.367
A Catchment Area 70.88 km²
T_L Lag time 3.43 hours

CALCULATIONS: Effective rainfall

Select smallest storm duration 1 hours
Select return period 1: 100 years
Time Interval for S-Curve Determination 0.1 hours

Calculations for effective rainfall for range of storm durations

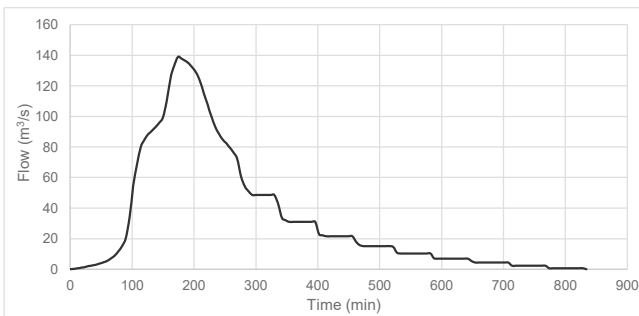
T _{SD}	Storm duration	1	2	3	4 hours
P _T	Point rainfall	77	101	109	116 mm
P _{IT}	Point intensity	77	51	36	29 mm/h
ARF _{IT}	Area reduction factor	93%	96%	97%	97% %
P _{Avgt}	Average Rainfall	71.9	96.8	105.1	113.0 mm
f _{IT}	Flood run-off factor	19%	22%	24%	25% %
he _{IT}	Effective rain	13.6	21.7	24.7	27.7 mm

CALCULATIONS: Peak discharge

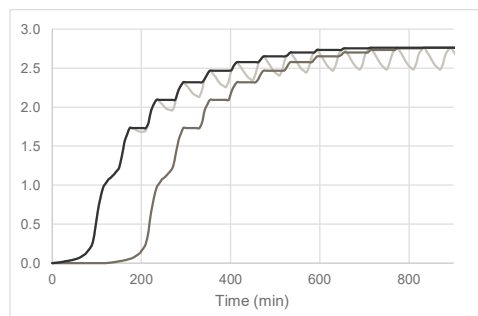
Results from lagged S-curve

Max interpolated S-curve	0.993			
[(S ₁ -S _{2T})/T _{SD}] _{Max}	0.99	0.84	0.68	0.57
Q _{PIT} Unit Hydrograph peak	7.53	6.35	5.16	4.29 m ³ /s
Q _{IT} Peak discharge	103	138	128	119 m ³ /s
If Q _{PIT} /Q _p < 1, Q _{IT} /[(Interpolated S-curve) _{MAX}]	103	139	129	120 m ³ /s

Hydrograph using lagged S-curve info with peak of 138.85 m³/s, at 174 min

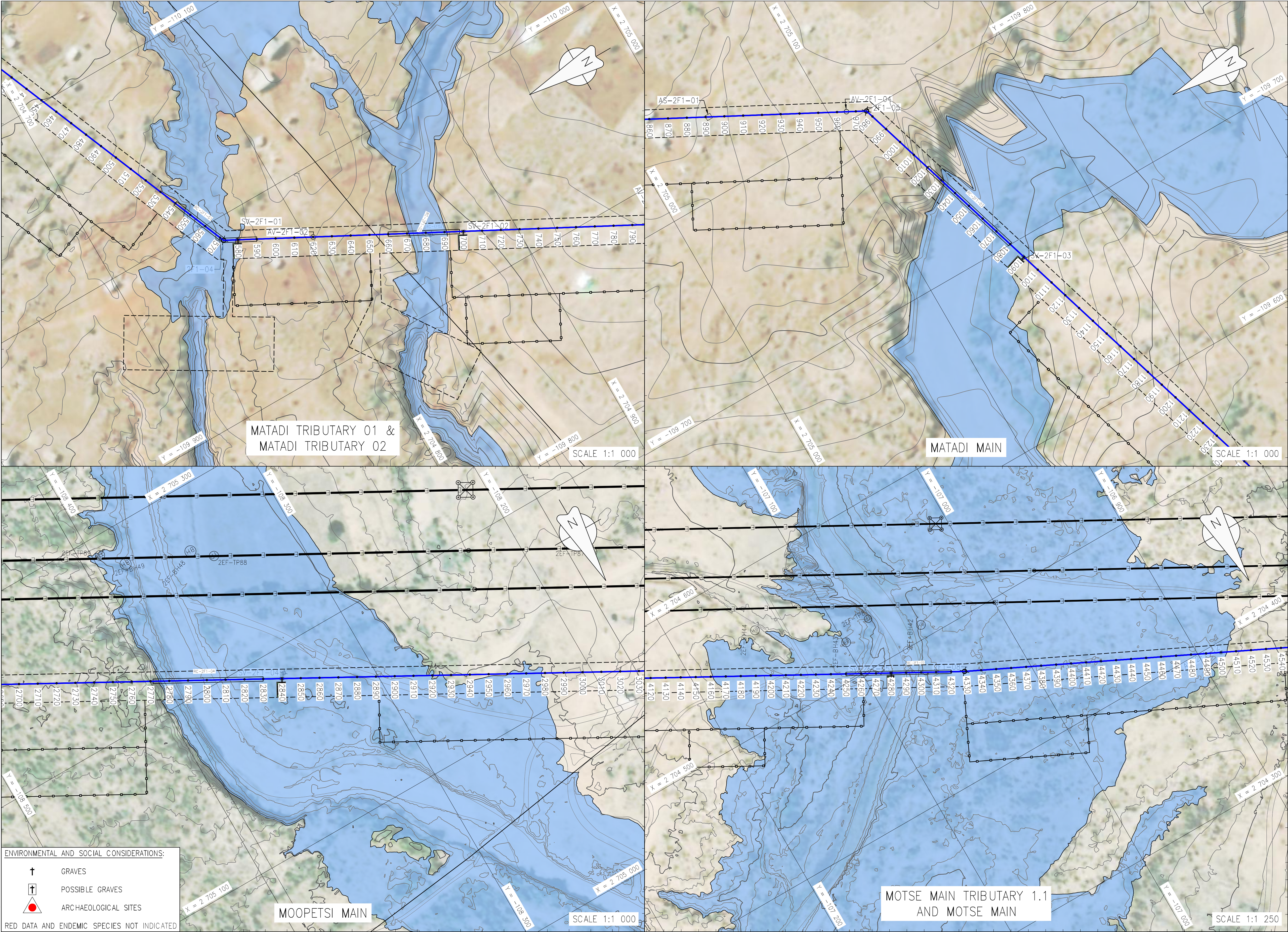


S-Curve for Veld Zone 8 Lagged by 2 hours



Appendix D

Floodline Layouts



CONSTRUCTION RESERVE

PERMANENT RESERVE

PIPELINE

PERMANENT RESERVE

NOTES:

1. REFER TO REPORT No. 1002569-2F-00-RP-YY-00001 FOR FLOODLINE DETERMINATION

2. FLOODLINES INUNDATION > 50 mm

LEGEND:

CHAINAGE MARKER (PLAN ONLY)

POINT OF INTERSECTION – HORIZONTAL BEND (2F1 XX)

NON RETURN VALVE

AIR VALVE

CONTROL VALVE

SCOUR VALVE

ISOLATING BALL VALVE

ROAD & STREAM/RIVER CROSSINGS

1:100 FLOODLINES

FARM TAKE OFF

SURVEY BEACON

PUMP SHAFT & ACCESS SHAFT

GEOTECHNICAL DATA: TP – TEST PIT
BH – BOREHOLE

WORKING AREA BOUNDARY

PIPE SERVITUDE

OVERHEAD POWERLINE

OVERHEAD TELEPHONE LINE

FENCES

EXISTING FARM BOUNDARIES

BUILDING

INUNDATED AREA

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS:

GRAVES

POSSIBLE GRAVES

ARCHAEOLOGICAL SITES

RED DATA AND ENDEMIC SPECIES NOT INDICATED

ZUTARI

NDODANA

JOINT VENTURE

Lebalele Association of Water Users

BUILDING A, FLOOR 2
4 DAVENTRY STREET
LYNNWOOD BRIDGE OFFICE
PARK
LYNNWOOD MANOR
PRETORIA

info@lebalele.co.za
Tel: (012) 348 4654

DISCLAIMER

REV

DATE

REVISION DETAILS

APPROVED

SCALE

SIZE

FOR APPROVAL
NOT FOR CONSTRUCTION

THE DRAWINGS
HAVE BEEN
APPROVED BY
ZNUV AND LWUA.
IT REMAINS THE
RESPONSIBILITY
OF THE
APPOINTED
CONTRACTOR TO
ENSURE THAT
THE DESIGN IS
CORRECT

A

05.05.25

FOR INTERNAL REVIEW

I.J.

AS SHOWN

A1

B

14.05.25

FOR APPROVAL

I.J.

DRAWN

DESIGNED

REVIEWED

E. ERASMUS

W. LOMBARD

I. JENKINS

APPROVED

DATE

I. JENKINS

PROJECT

TITLE

LWUA No.

ZNUV No.

PROGRAMME No.

PROJECT

PHASE

WBS

DOC TYPE

DISC

NUMBER

REV

###

1002569

2F

29

DR

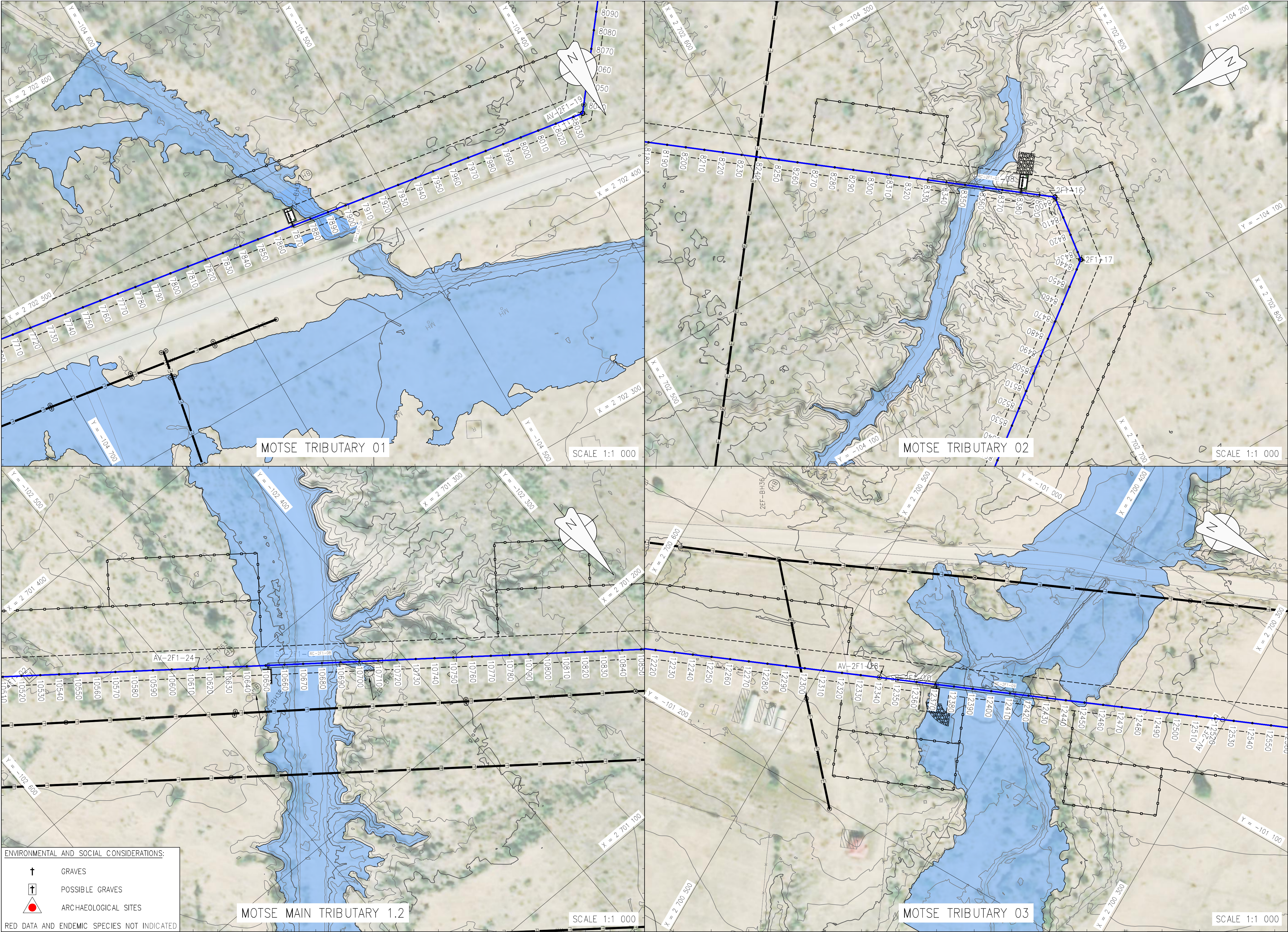
CC

00035

B

OMM PROGRAMME BULK RAW WATER STUDY PHASE

HAVERCROFT JUNCTION TO KLIPFONTEIN BALANCING DAM - 2F1
100 YEAR FLOODLINES SHEET 1 OF 4



CONSTRUCTION RESERVE

PERMANENT RESERVE

PIPELINE

PERMANENT RESERVE

NOTES:

1. REFER TO REPORT No. 1002569-2F-00-RP-YY-00001 FOR FLOODLINE DETERMINATION

2. FLOODLINES INUNDATION > 50 mm

LEGEND:

CHAINAGE MARKER (PLAN ONLY)

POINT OF INTERSECTION – HORIZONTAL BEND (2F1 XX)

NON RETURN VALVE

AIR VALVE

CONTROL VALVE

SCOUR VALVE

ISOLATING BALL VALVE

ROAD & STREAM/RIVER CROSSINGS

1:100 FLOODLINES

FARM TAKE OFF

SURVEY BEACON

PUMP SHAFT & ACCESS SHAFT

GEOTECHNICAL DATA: TP – TEST PIT
BH – BOREHOLE

WORKING AREA BOUNDARY

PIPE SERVITUDE

OVERHEAD POWERLINE

OVERHEAD TELEPHONE LINE

FENCES

EXISTING FARM BOUNDARIES

BUILDING

INUNDATED AREA

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS:

† GRAVES

† POSSIBLE GRAVES

▲ ARCHAEOLOGICAL SITES

RED DATA AND ENDEMIC SPECIES NOT INDICATED

CLIENT

BUILDING A, FLOOR 2
4 DAVENTRY STREET
LYNNWOOD BRIDGE OFFICE
PARK
LYNNWOOD MANOR
PRETORIA

DISCLAIMER

THE DRAWINGS HAVE BEEN APPROVED BY ZNVJ AND LWUA. IT REMAINS THE RESPONSIBILITY OF THE APPOINTED CONTRACTOR TO ENSURE THAT THE DESIGN IS CORRECT

REV	DATE	REVISION DETAILS
A	05.05.25	FOR INTERNAL REVIEW
B	14.05.25	FOR APPROVAL

APPROVED

I.J.

I.J.

SCALE	SIZE
AS SHOWN	A1

DRAWN E. ERASMUS

DESIGNED W. LOMBARD

REVIEWED I. JENKINS

FOR APPROVAL NOT FOR CONSTRUCTION

APPROVED

I. JENKINS

PROJECT

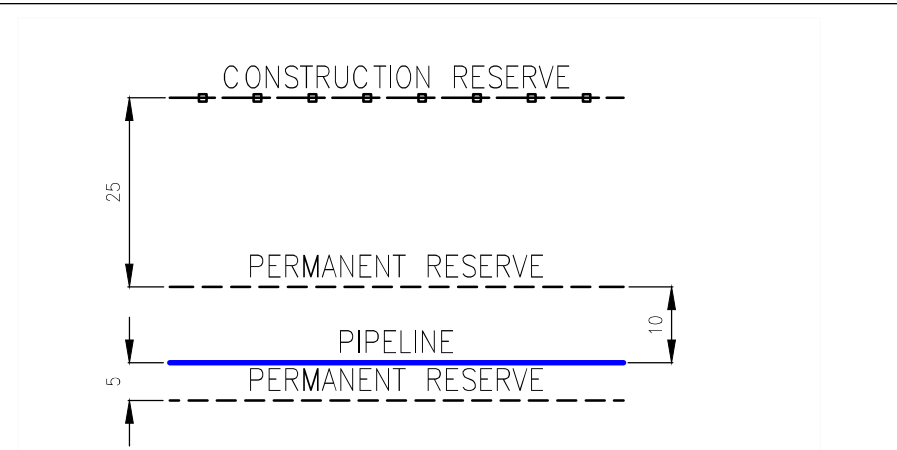
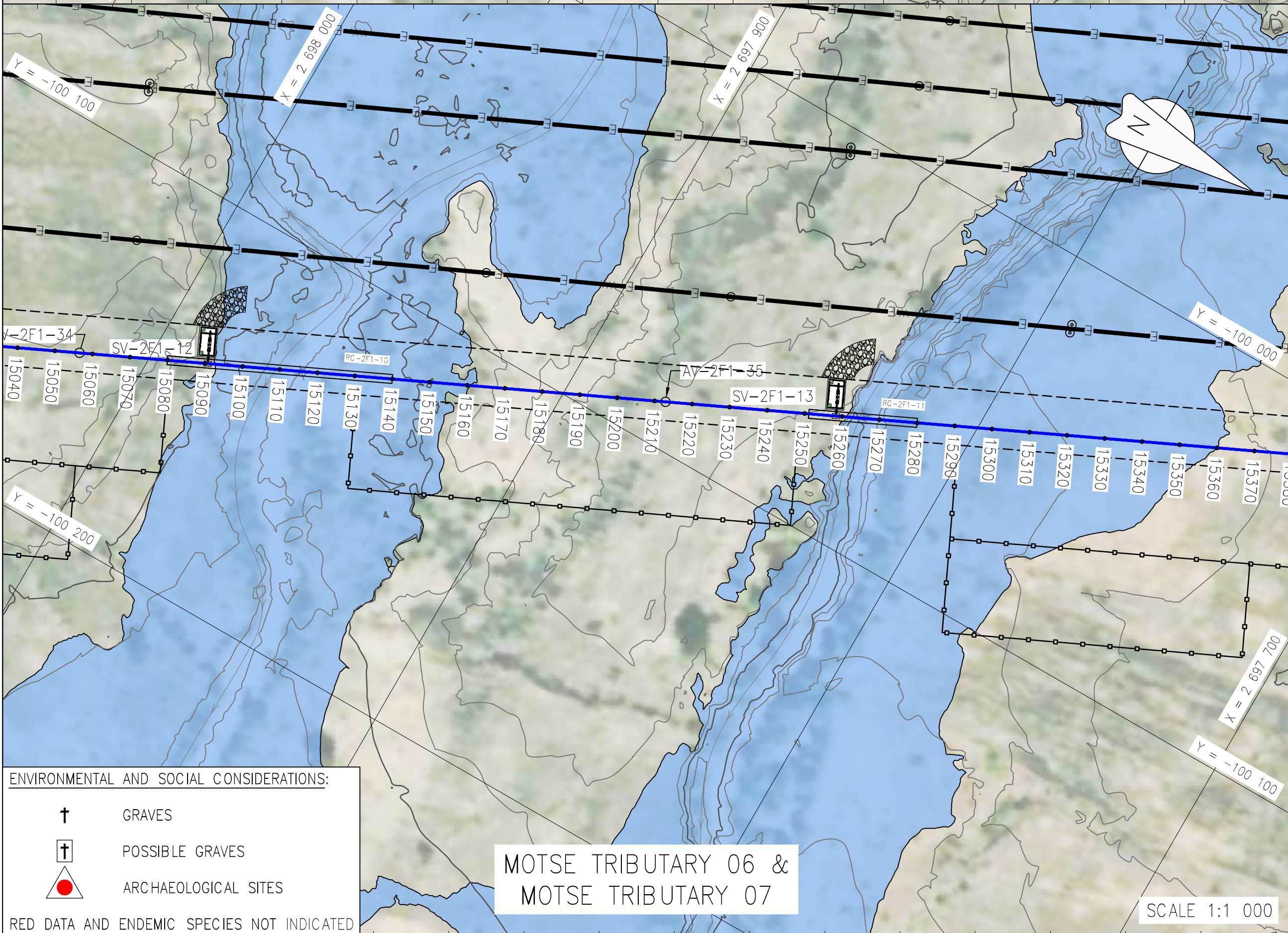
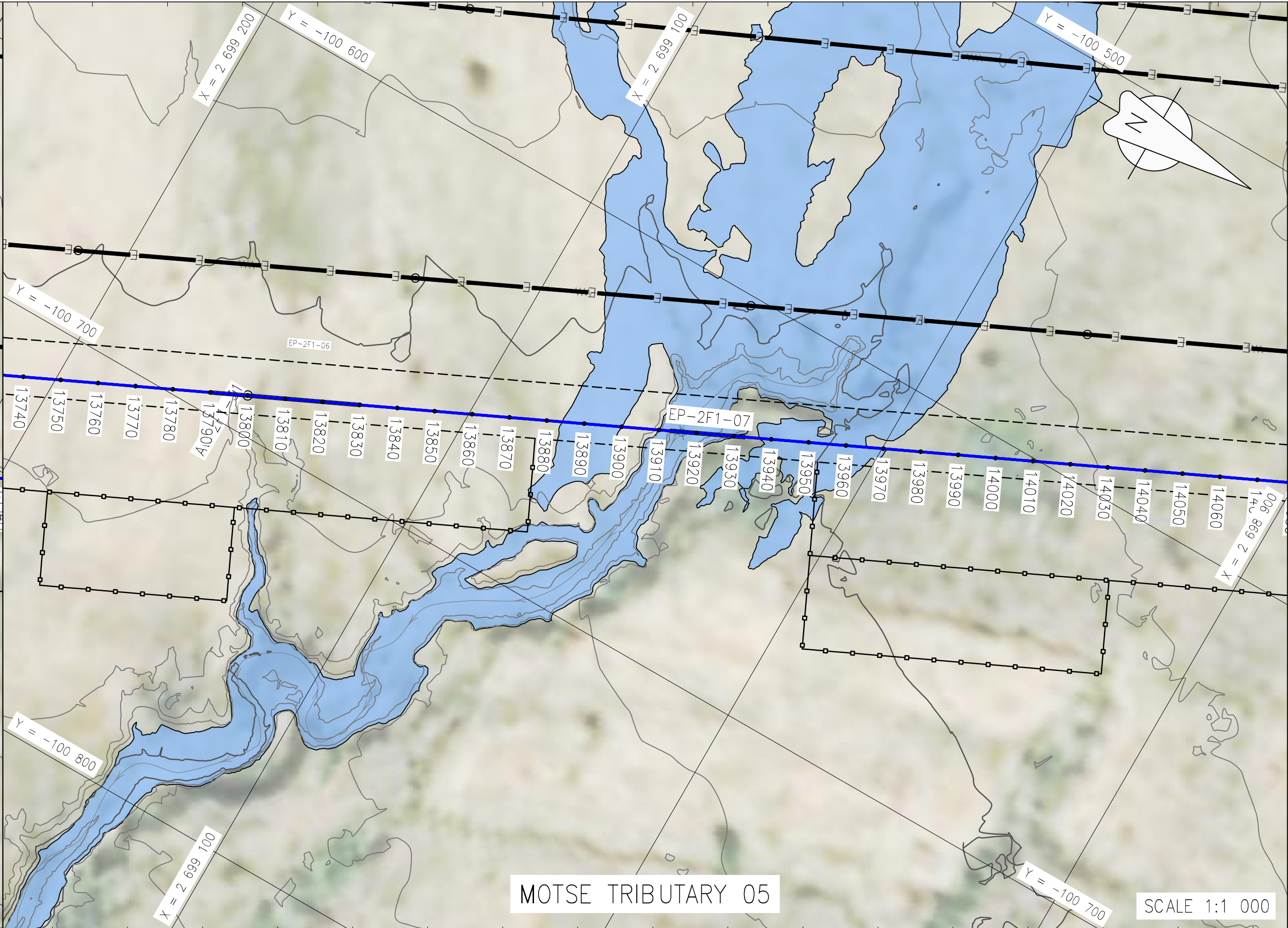
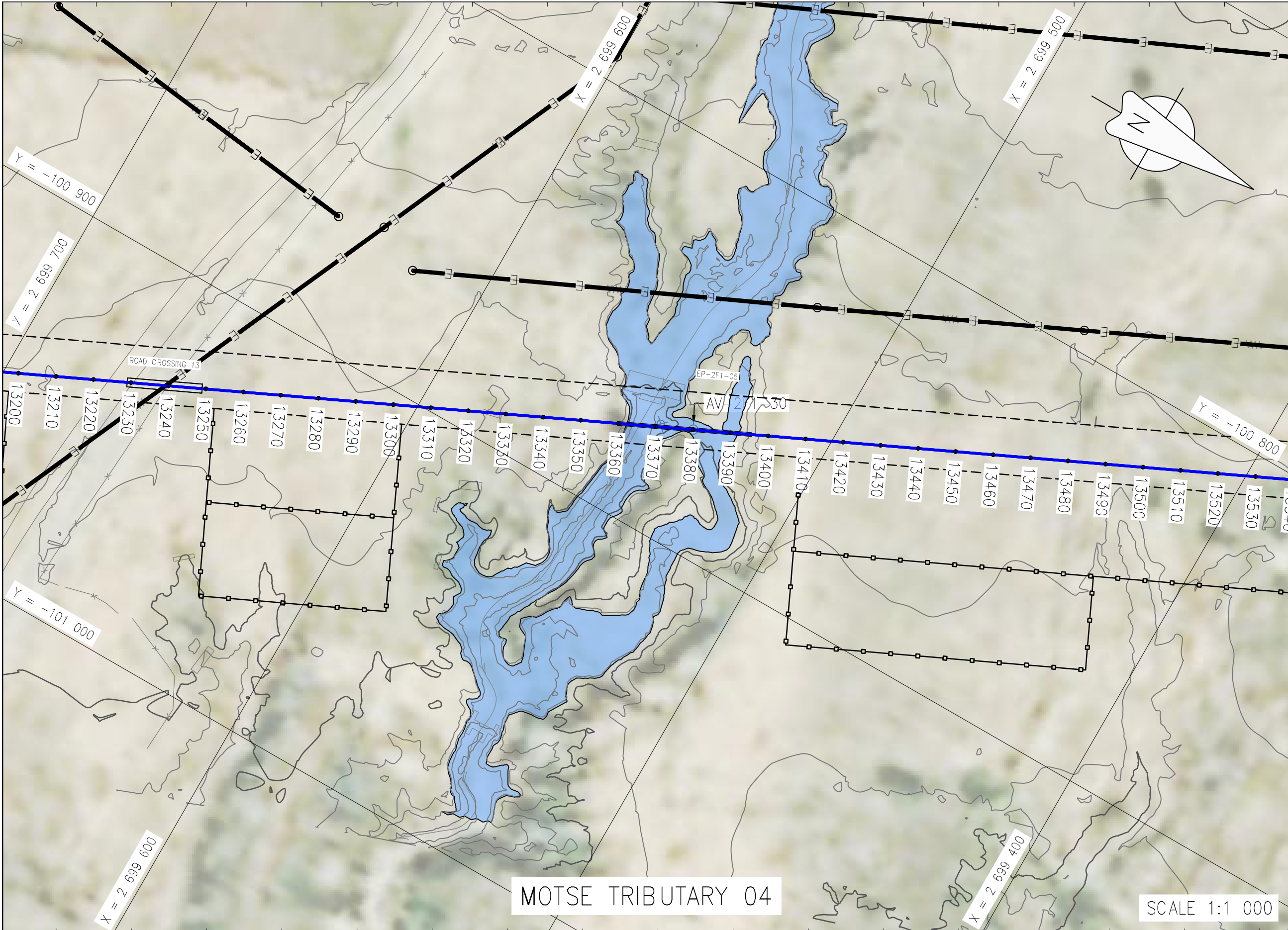
TITLE

LWUA No. PROGRAMME No. PROJECT PHASE DOC.TYPE DISC NUMBER REV

ZNVJ No. 1002569 - 2F - 29 - DR - CC - 00036 - B

OMM PROGRAMME BULK RAW WATER STUDY PHASE

HAVERCROFT JUNCTION TO KLIPFONTEIN BALANCING DAM - 2F1 100 YEAR FLOODLINES SHEET 2 OF 4



- NOTES:
- REFER TO REPORT No. 1002569-2F-00-RP-YY-00001 FOR FLOODLINE DETERMINATION
 - FLOODLINES INUNDATION > 50 mm

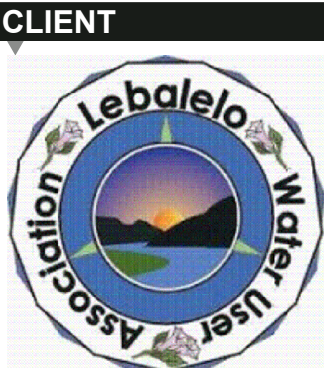
- LEGEND:
- CHAINAGE MARKER (PLAN ONLY)
 - POINT OF INTERSECTION - HORIZONTAL BEND (2F1 XX)
 - NON RETURN VALVE
 - AIR VALVE
 - CONTROL VALVE
 - SCOUR VALVE
 - ISOLATING BALL VALVE
 - ROAD & STREAM/RIVER CROSSINGS
 - 1:100 FLOODLINES
 - FARM TAKE OFF
 - SURVEY BEACON
 - PUMP SHAFT & ACCESS SHAFT
 - GEOTECHNICAL DATA: TP - TEST PIT, BH - BOREHOLE
 - WORKING AREA BOUNDARY
 - PIPE SERVITUDE
 - OVERHEAD POWERLINE
 - OVERHEAD TELEPHONE LINE
 - FENCES
 - EXISTING FARM BOUNDARIES
 - BUILDING
 - INUNDATED AREA

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS:

- GRAVES
- POSSIBLE GRAVES
- ARCHAEOLOGICAL SITES

RED DATA AND ENDEMIC SPECIES NOT INDICATED

ZUTARI **NDODANA**
JOINT VENTURE



BUILDING A, FLOOR 2
4 DAVENTRY STREET
LYNNWOOD BRIDGE OFFICE
PARK
LYNNWOOD MANOR
PRETORIA

info@lebalale.co.za
Tel: (012) 348 4654

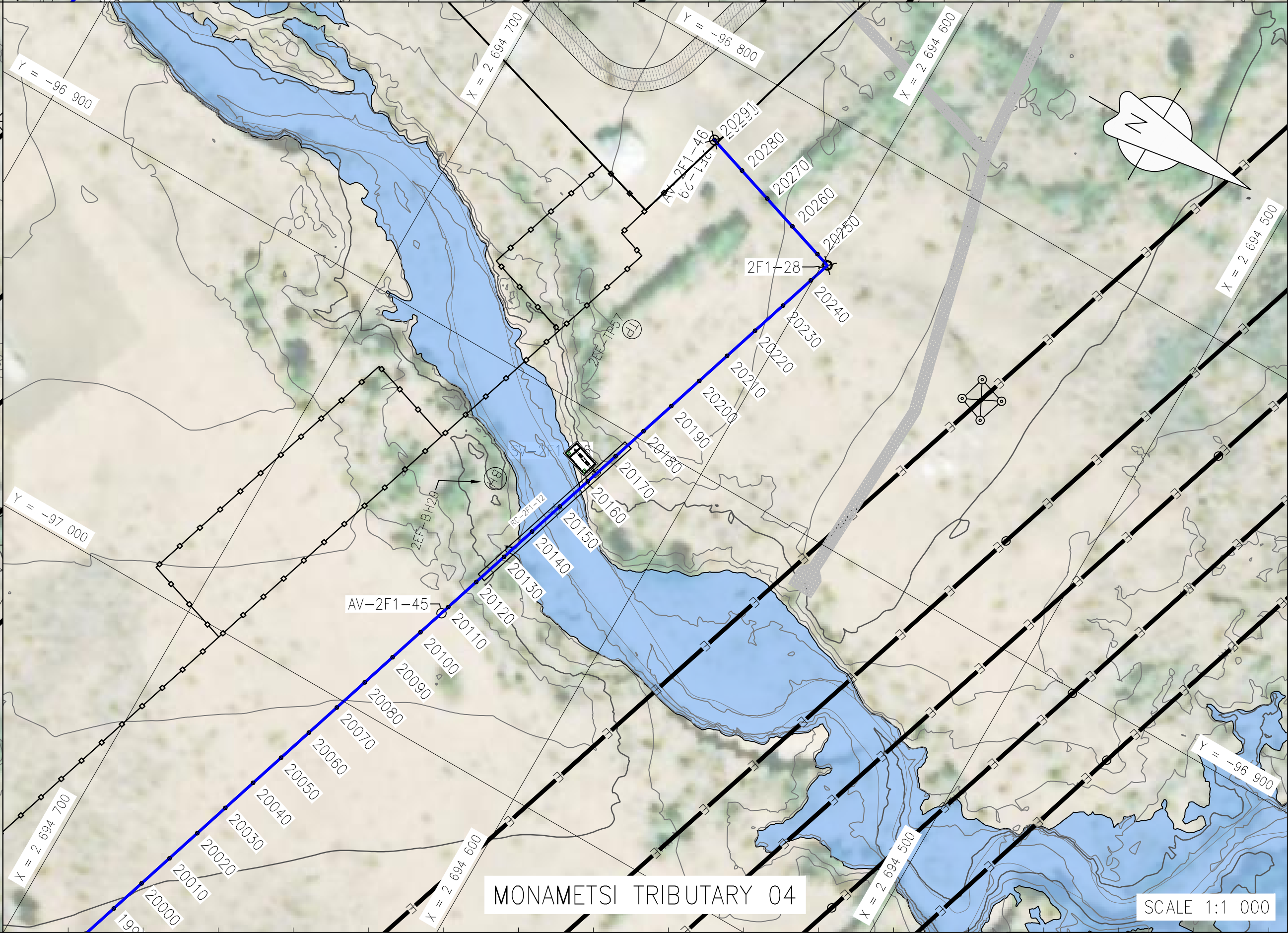
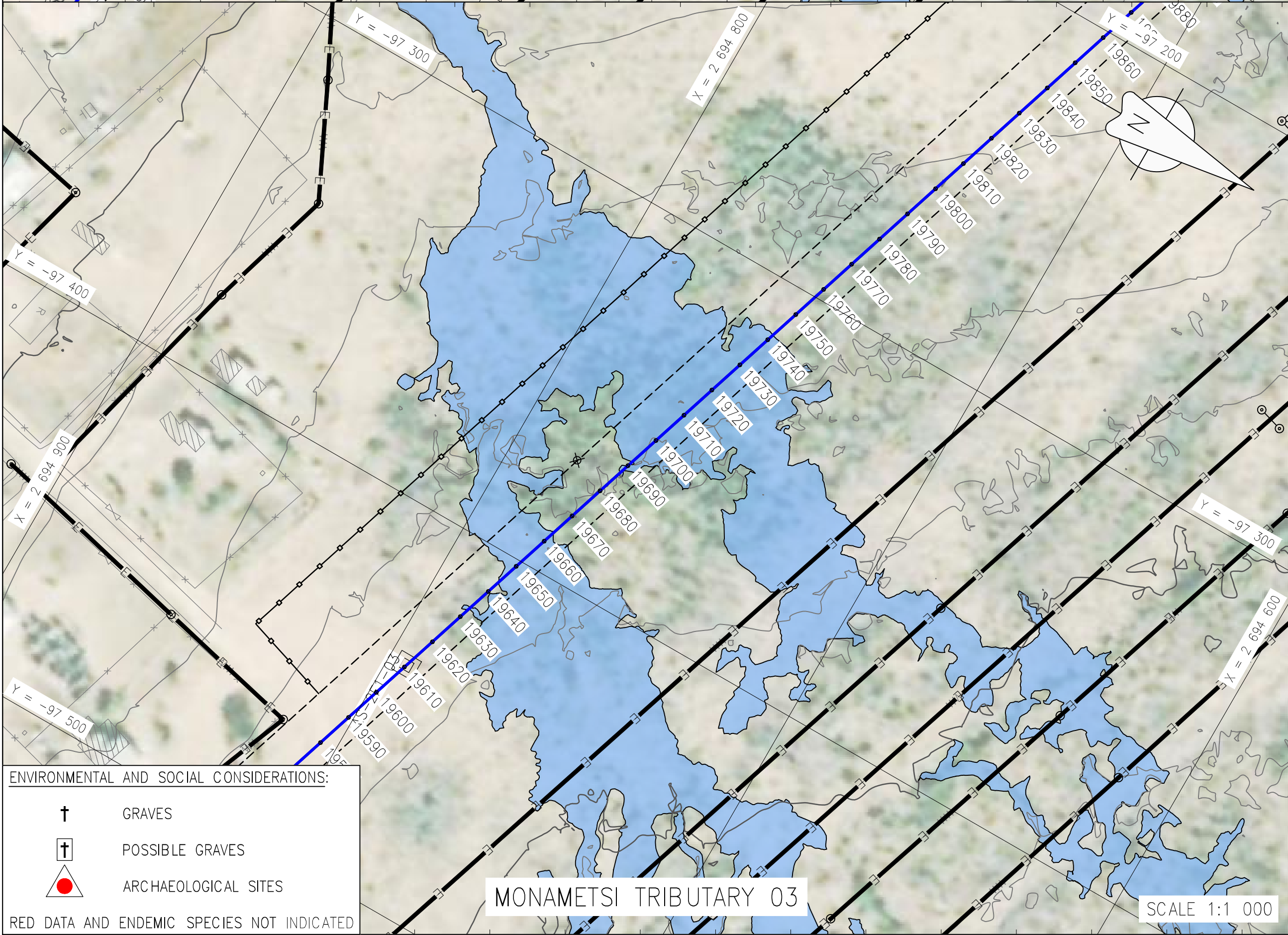
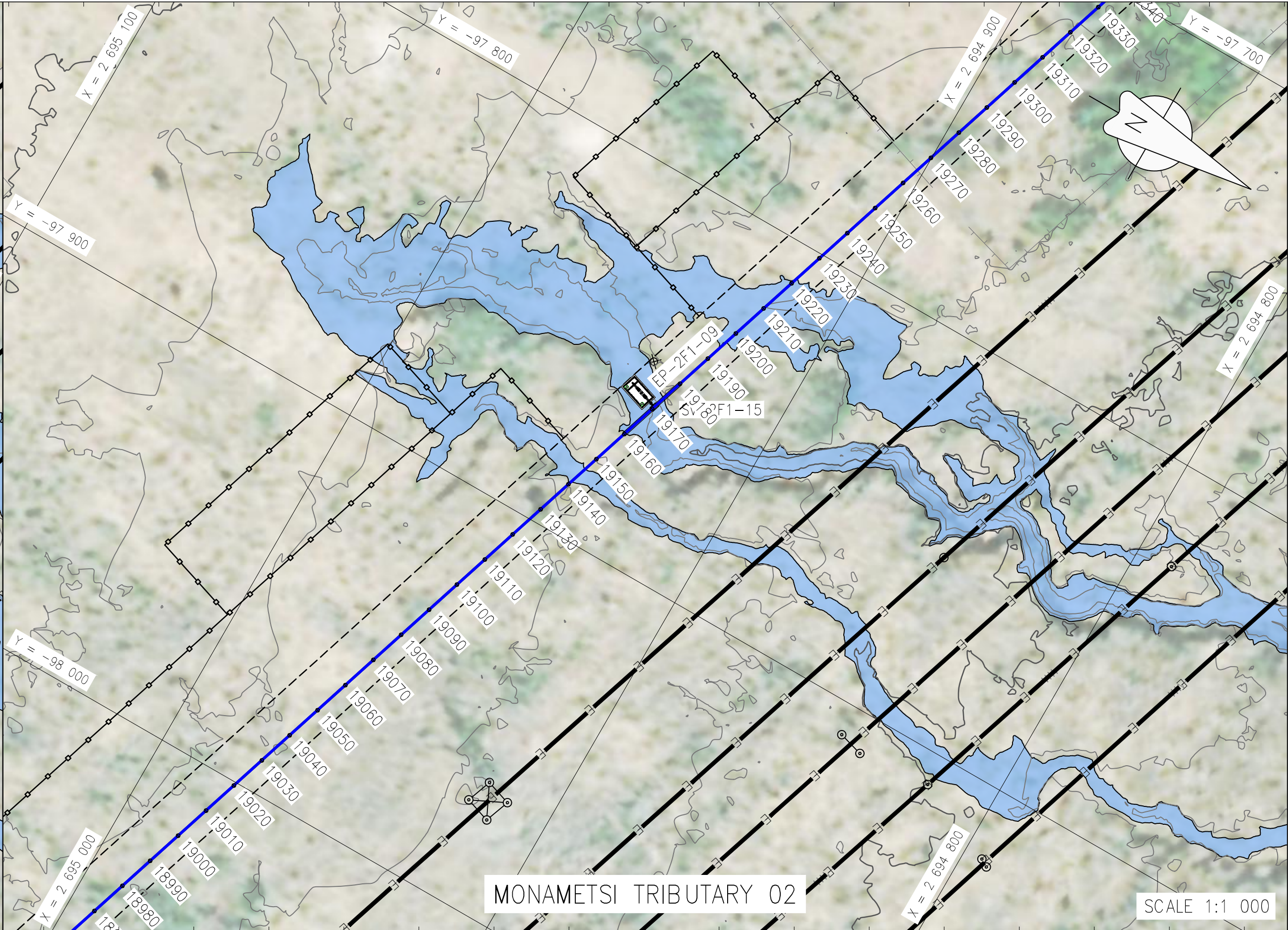
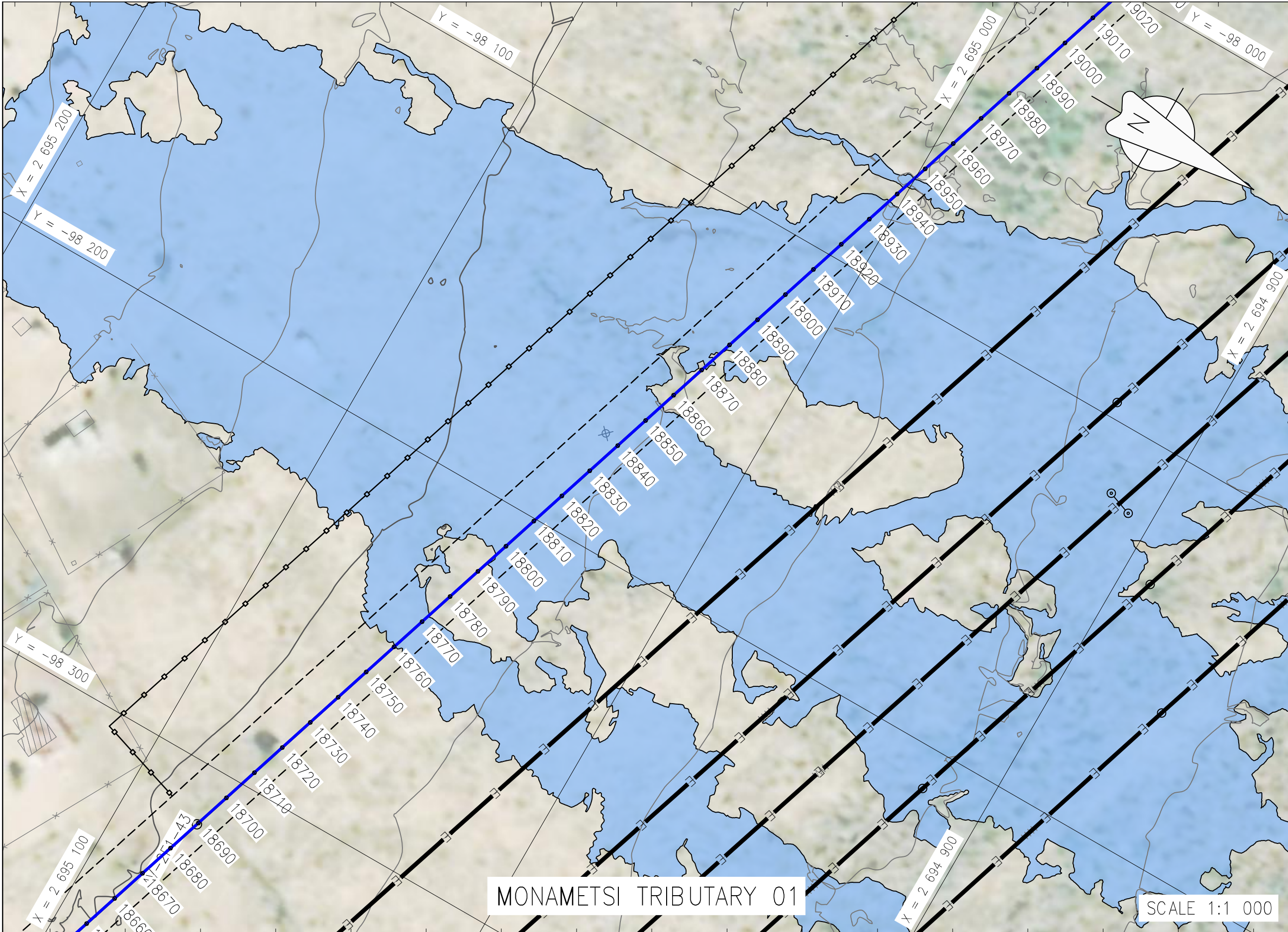
DISCLAIMER
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REV	DATE	REVISION DETAILS	APPROVED
A	05.05.25	FOR INTERNAL REVIEW	I.J.
B	14.05.25	FOR APPROVAL	I.J.

SCALE	SIZE
AS SHOWN	A1
DRAWN	E. ERASMUS
DESIGNED	W. LOMBARD
REVIEWED	I. JENKINS

FOR APPROVAL	DATE
NOT FOR CONSTRUCTION	
APPROVED	
I. JENKINS	

PROJECT	OMM PROGRAMME BULK RAW WATER STUDY PHASE
TITLE	HAVERCROFT JUNCTION TO KLIPFONTEIN BALANCING DAM - 2F1 100 YEAR FLOODLINES SHEET 3 OF 4
LWUA No.	PROGRAMME No. ###
ZNVJ No.	1002569
PHASE	2F
WBS	29
DOC TYPE	DR
DISC	CC
NUMBER	00037
REV	B



CONSTRUCTION RESERVE

PERMANENT RESERVE

PIPELINE

PERMANENT RESERVE

NOTES:

1. REFER TO REPORT No. 1002569-2F-00-RP-YY-00001 FOR FLOODLINE DETERMINATION

2. FLOODLINES INUNDATION > 50 mm

LEGEND:

CHAINAGE MARKER (PLAN ONLY)

POINT OF INTERSECTION – HORIZONTAL BEND (2F1 XX)

NON RETURN VALVE

AIR VALVE

CONTROL VALVE

SCOUR VALVE

ISOLATING BALL VALVE

ROAD & STREAM/RIVER CROSSINGS

1:100 FLOODLINES

FARM TAKE OFF

SURVEY BEACON

PUMP SHAFT & ACCESS SHAFT

GEOTECHNICAL DATA: TP – TEST PIT
BH – BOREHOLE

WORKING AREA BOUNDARY

PIPE SERVITUDE

OVERHEAD POWERLINE

OVERHEAD TELEPHONE LINE

FENCES

EXISTING FARM BOUNDARIES

BUILDING

INUNDATED AREA

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS:

GRAVES

POSSIBLE GRAVES

ARCHAEOLOGICAL SITES

RED DATA AND ENDEMIC SPECIES NOT INDICATED

JOINT VENTURE

CLIENT

BUILDING A, FLOOR 2
4 DAVENTRY STREET
LYNNWOOD BRIDGE OFFICE
PARK
LYNNWOOD MANOR
PRETORIA

DISCLAIMER

THE DRAWINGS
HAVE BEEN
APPROVED BY
ZNJV AND LWUA.
IT REMAINS THE
RESPONSIBILITY
OF THE
APPOINTED
CONTRACTOR TO
ENSURE THAT
THE DESIGN IS
CORRECT

REV

DATE

REVISION DETAILS

APPROVED

SCALE

SIZE

FOR APPROVAL

NOT FOR CONSTRUCTION

DRAWN

DESIGNED

REVIEWED

DATE

APPROVED

PROJECT

OMM PROGRAMME BULK RAW WATER STUDY PHASE

TITLE

HAVERCROFT JUNCTION TO KLIPFONTEIN BALANCING DAM - 2F1
100 YEAR FLOODLINES SHEET 4 OF 4

LWUA No.

PROGRAMME No.

PROJECT

PHASE

DOC.TYPE

DISC

NUMBER

REV

ZNJV No.

ZONE

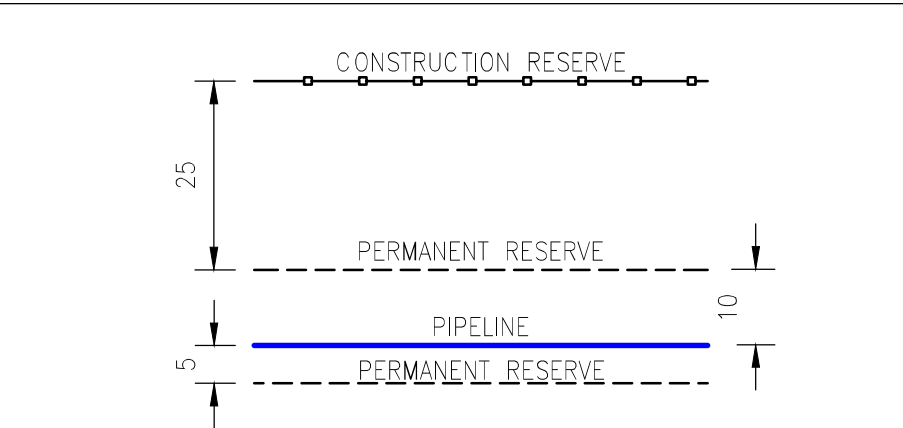
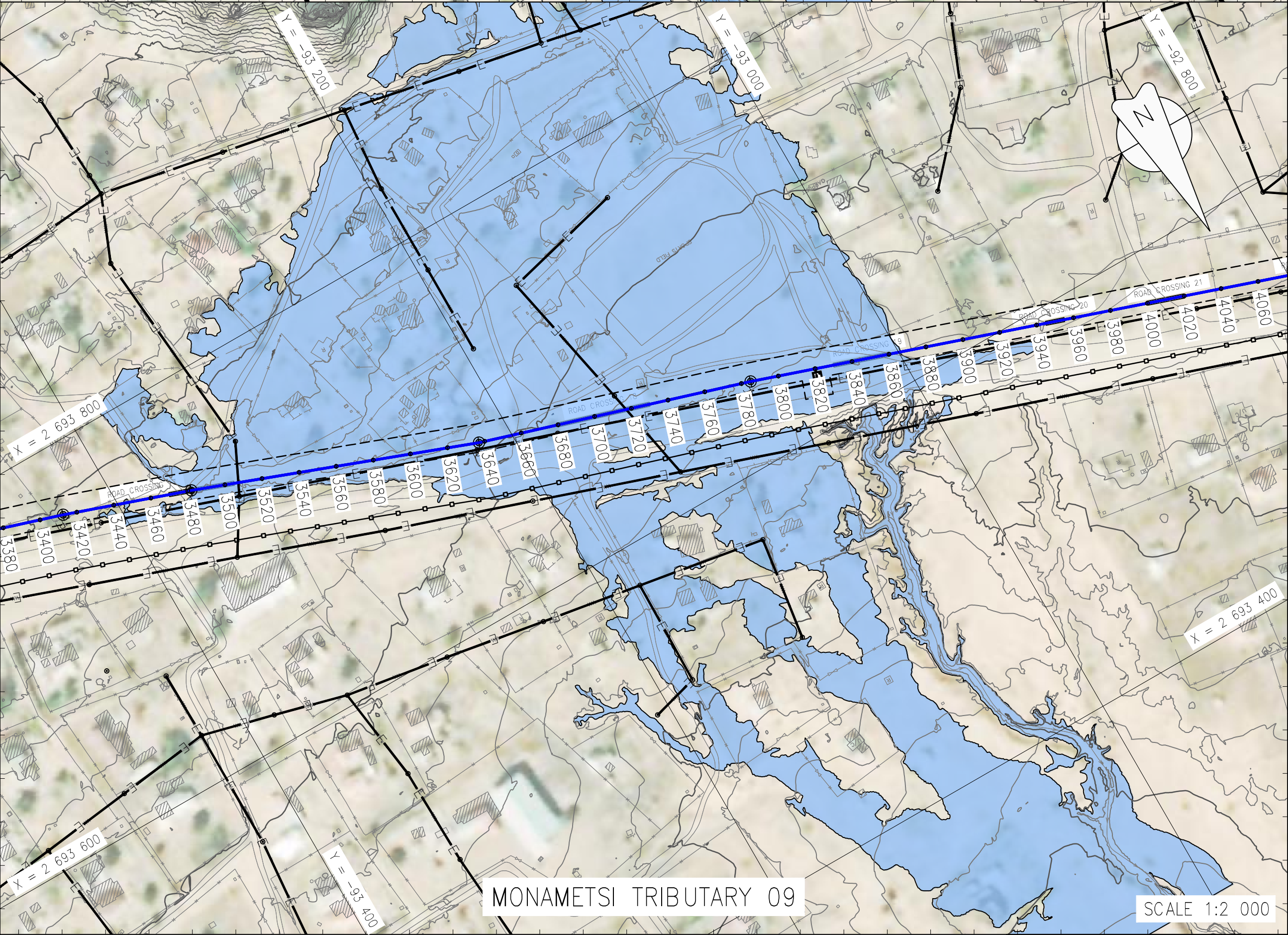
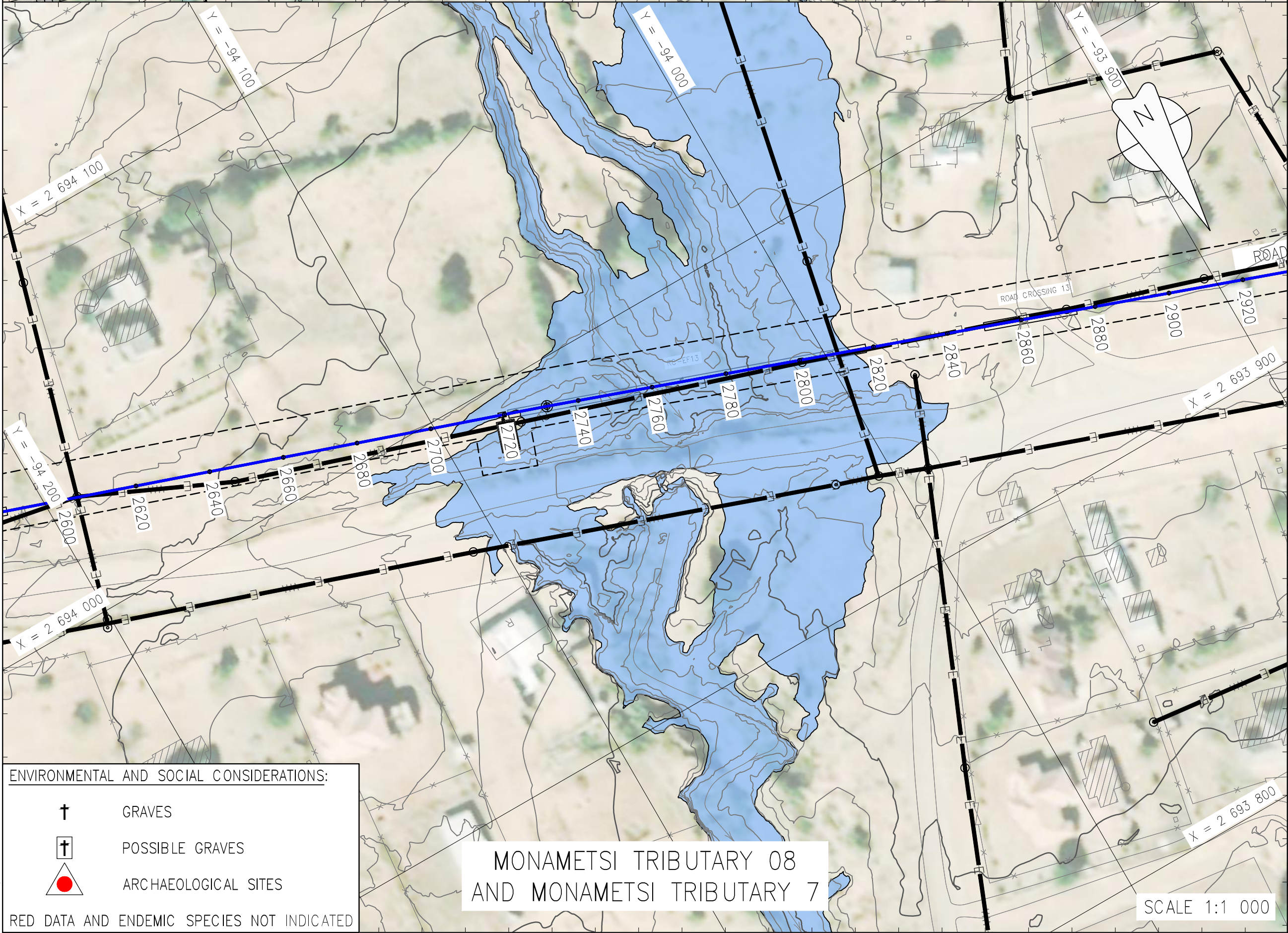
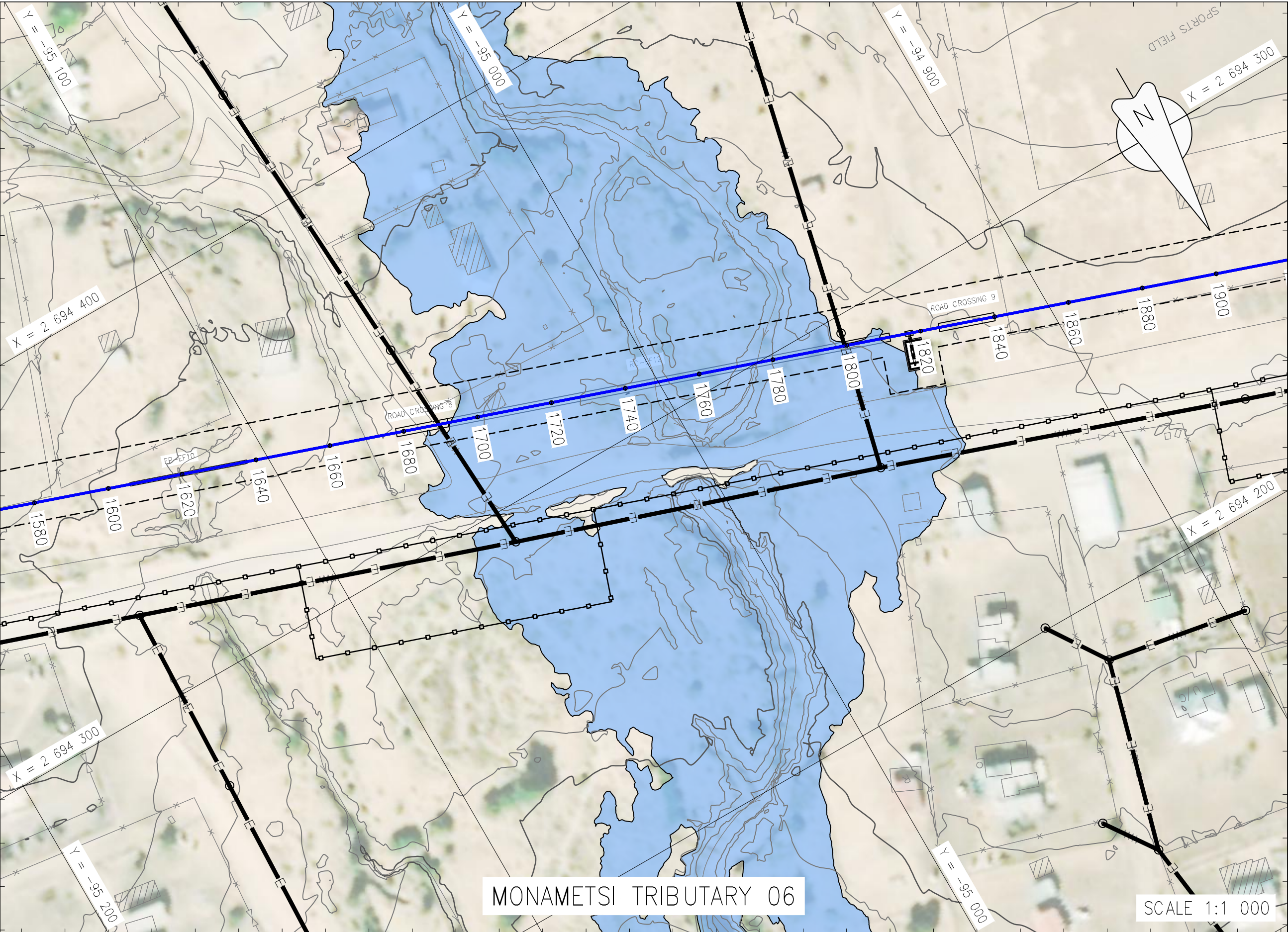
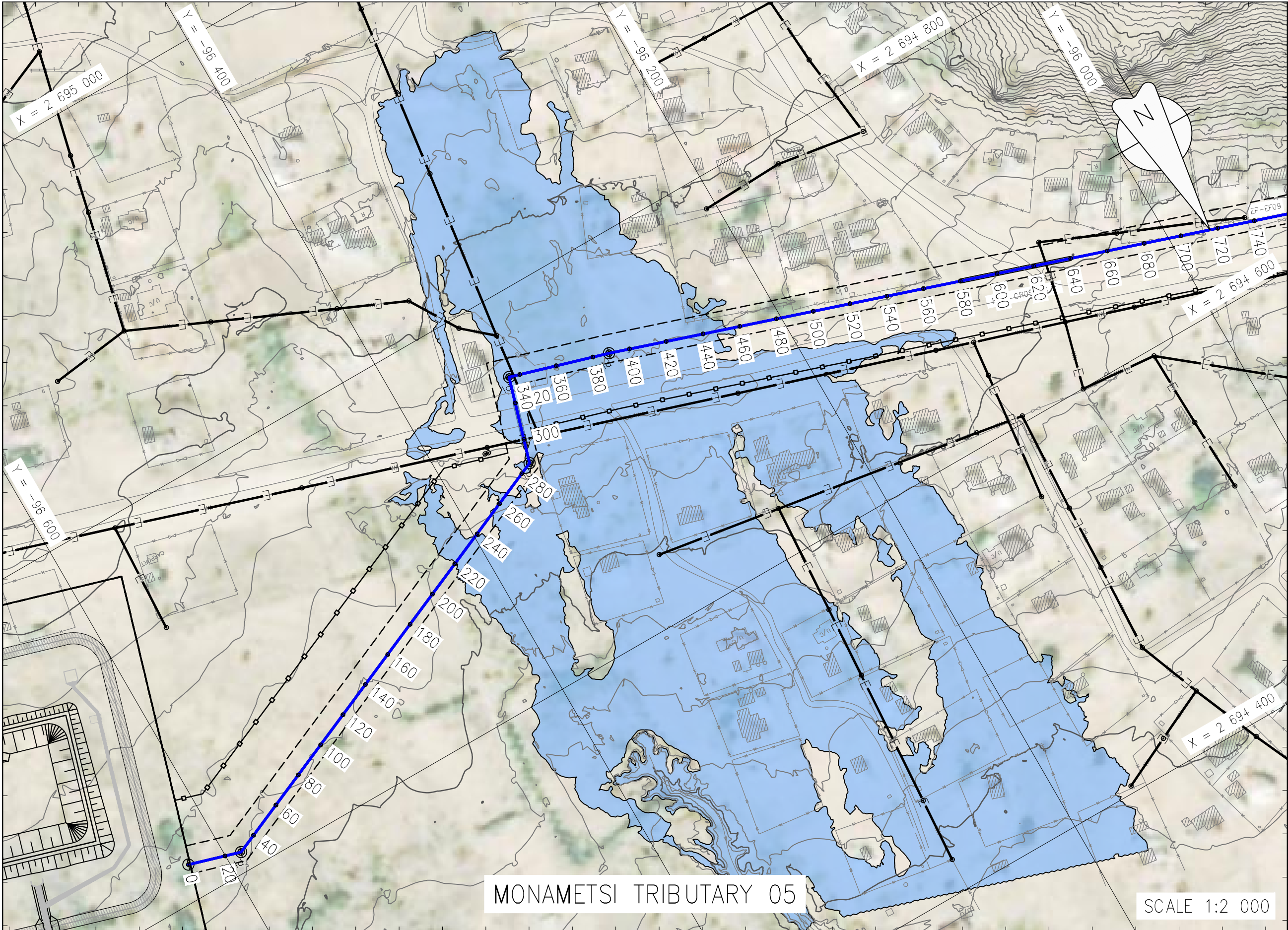
WBS

DOC.TYPE

DISC

NUMBER

REV



- NOTES:
1. REFER TO REPORT No. 1002569-2F-00-RP-YY-00001 FOR FLOODLINE DETERMINATION
 2. FLOODLINES INUNDATION > 50 mm
 3. INDICATIVE FLOODLINES PROVIDED FOR OLIFANTS 8 TO 14. REFER TO REPORT 1002569-2F-00-RP-YY-00001

- LEGEND:
- CHAINAGE MARKER (PLAN ONLY)
 - POINT OF INTERSECTION - HORIZONTAL BEND (2F2 XX)
 - NON RETURN VALVE
 - AIR VALVE
 - CONTROL VALVE
 - SCOUR VALVE
 - ISOLATING BALL VALVE
 - ROAD & STREAM/RIVER CROSSINGS
 - 1:100 FLOODLINES
 - FARM TAKE OFF
 - SURVEY BEACON
 - PUMP SHAFT & ACCESS SHAFT
 - GEOTECHNICAL DATA: TP - TEST PIT, BH - BOREHOLE
 - WORKING AREA BOUNDARY
 - PIPE SERVITUDE
 - OVERHEAD POWERLINE
 - OVERHEAD TELEPHONE LINE
 - FENCES
 - EXISTING FARM BOUNDARIES
 - BUILDING
 - INUNDATED AREA

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS:

- † GRAVES
- † POSSIBLE GRAVES
- ▲ ARCHAEOLOGICAL SITES

RED DATA AND ENDEMIC SPECIES NOT INDICATED

JOINT VENTURE

CLIENT

BUILDING A, FLOOR 2
4 DAVENTRY STREET
LYNNWOOD BRIDGE OFFICE
PARK
LYNNWOOD MANOR
PRETORIA

info@lebalele.co.za
Tel: (012) 348 4654

DISCLAIMER

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REV	DATE	REVISION DETAILS	APPROVED
A	05.05.25	FOR INTERNAL REVIEW	I.J.
B	14.05.25	FOR APPROVAL	I.J.

SCALE

AS SHOWN

SIZE

A1

DRAWN

E. ERASMUS

DESIGNED

W. LOMBARD

REVIEWED

I. JENKINS

FOR APPROVAL

NOT FOR CONSTRUCTION

APPROVED

I. JENKINS

PROJECT

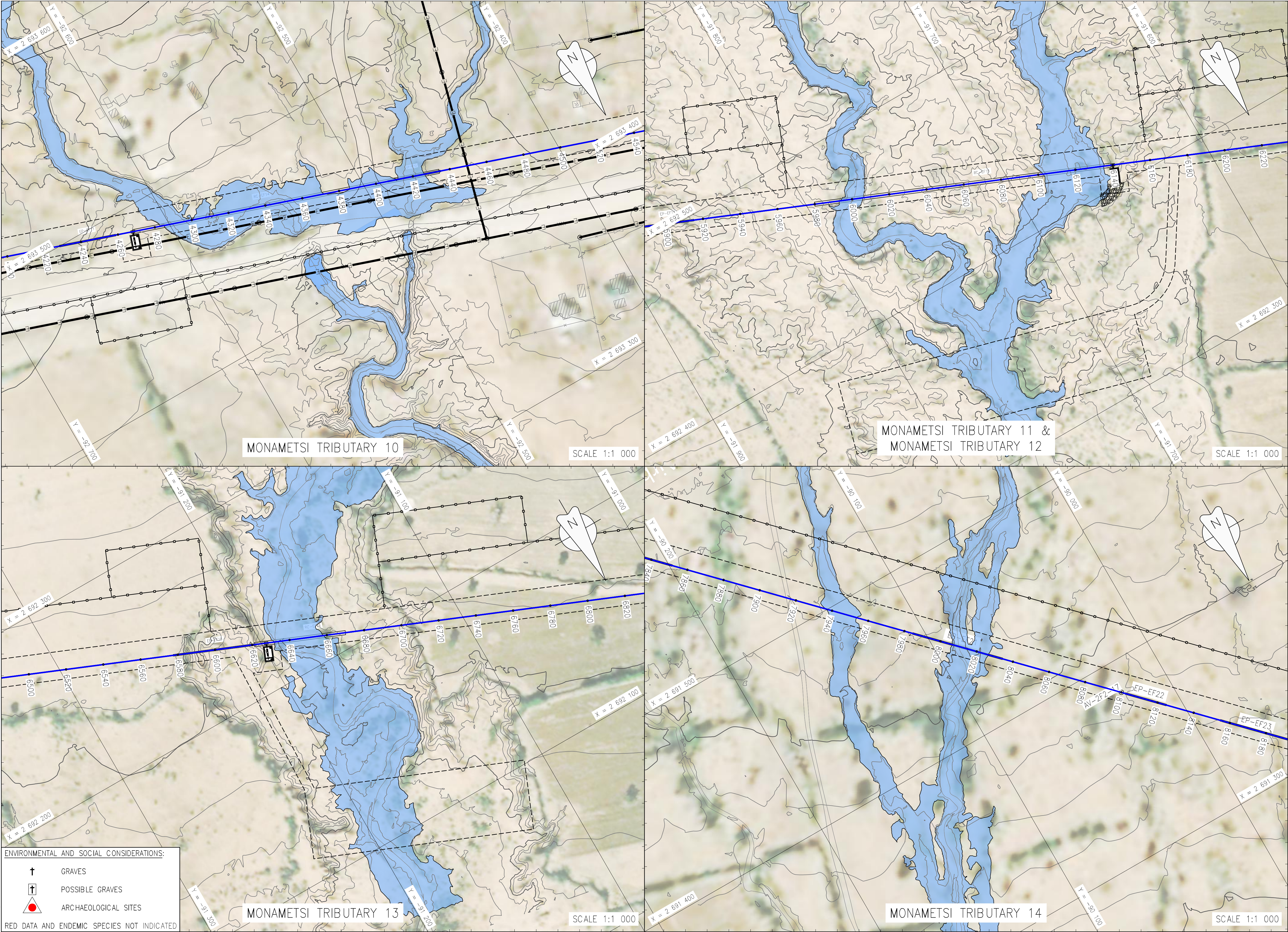
OLIFANTSPOORT WATER TREATMENT WORKS - 2F2

TITLE

100 YEAR FLOODLINES SHEET 1 OF 7

LWUA No.	PROGRAMME No.	PROJECT	PHASE	DOC TYPE	DISC	NUMBER	REV
###	###	###	###	###	###	###	#

ZNVJ No.	ZNVJ No.	ZONE	WBS	DOC TYPE	DISC	NUMBER	REV
1002569	2F	30	DR	CC	00045	B	



CONSTRUCTION RESERVE

PERMANENT RESERVE

PIPELINE

PERMANENT RESERVE

NOTES:

- REFER TO REPORT No. 1002569-2F-00-RP-YY-00001 FOR FLOODLINE DETERMINATION
- FLOODLINES INUNDATION > 50 mm
- INDICATIVE FLOODLINES PROVIDED FOR OLIFANTS 8 TO 14. REFER TO REPORT 1002569-2F-00-RP-YY-00001

LEGEND:

- CHAINAGE MARKER (PLAN ONLY)
- POINT OF INTERSECTION - HORIZONTAL BEND (2F2 XX)
- NON RETURN VALVE
- AIR VALVE
- CONTROL VALVE
- SCOUR VALVE
- ISOLATING BALL VALVE
- ROAD & STREAM/RIVER CROSSINGS
- 1:100 FLOODLINES
- FARM TAKE OFF
- SURVEY BEACON
- PUMP SHAFT & ACCESS SHAFT
- GEOTECHNICAL DATA: TP - TEST PIT, BH - BOREHOLE
- WORKING AREA BOUNDARY
- PIPE SERVITUDE
- OVERHEAD POWERLINE
- OVERHEAD TELEPHONE LINE
- FENCES
- EXISTING FARM BOUNDARIES
- BUILDING
- INUNDATED AREA

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS:

- GRAVES
- POSSIBLE GRAVES
- ARCHAEOLOGICAL SITES

RED DATA AND ENDEMIC SPECIES NOT INDICATED

JOINT VENTURE

CLIENT

BUILDING A, FLOOR 2
4 DAVENTRY STREET
LYNNWOOD BRIDGE OFFICE
PARK
LYNNWOOD MANOR
PRETORIA

info@lebalele.co.za
Tel: (012) 348 4654

DISCLAIMER

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REV	DATE	REVISION DETAILS	APPROVED
A	05.05.25	FOR INTERNAL REVIEW	I.J.
B	14.05.25	FOR APPROVAL	I.J.

SCALE

AS SHOWN

SIZE A1

DRAWN E. ERASMUS

DESIGNED W. LOMBARD

REVIEWED I. JENKINS

FOR APPROVAL NOT FOR CONSTRUCTION

APPROVED

DATE

I. JENKINS

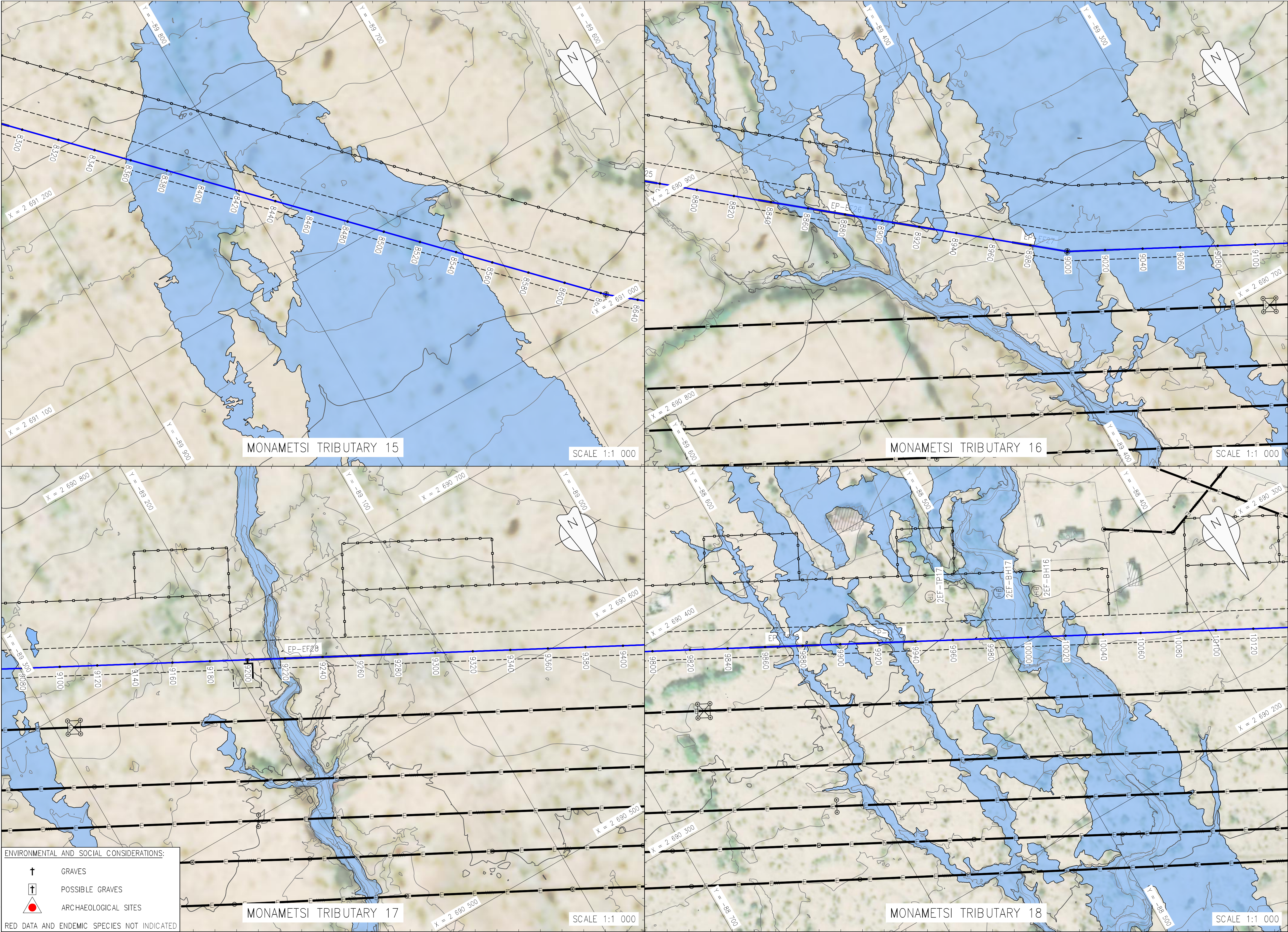
PROJECT

OLIFANTSPOORT WATER TREATMENT WORKS - 2F2

100 YEAR FLOODLINES SHEET 2 OF 7

PROGRAMME No.	PROJECT	PHASE	DOC TYPE	DISC	NUMBER	REV
###	###	###	###	###	###	#

LWUA No.	ZNJV No.	ZONE	WBS	DOC TYPE	DISC	NUMBER	REV
1002569	1002569	2F	30	DR	CC	00046	B



CONSTRUCTION RESERVE

PERMANENT RESERVE

PIPELINE

PERMANENT RESERVE

NOTES:

- REFER TO REPORT No. 1002569-2F-00-RP-YY-00001 FOR FLOODLINE DETERMINATION
- FLOODLINES INUNDATION > 50 mm
- INDICATIVE FLOODLINES PROVIDED FOR OLIFANTS 8 TO 14. REFER TO REPORT 1002569-2F-00-RP-YY-00001

LEGEND:

- CHAINAGE MARKER (PLAN ONLY)
- POINT OF INTERSECTION - HORIZONTAL BEND (2F2 XX)
- NON RETURN VALVE
- AIR VALVE
- CONTROL VALVE
- SCOUR VALVE
- ISOLATING BALL VALVE
- ROAD & STREAM/RIVER CROSSINGS
- 1:100 FLOODLINES
- FARM TAKE OFF
- SURVEY BEACON
- PUMP SHAFT & ACCESS SHAFT
- GEOTECHNICAL DATA: TP - TEST PIT, BH - BOREHOLE
- WORKING AREA BOUNDARY
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- OVERHEAD POWERLINE
- OVERHEAD TELEPHONE LINE
- FENCES
- EXISTING FARM BOUNDARIES
- BUILDING
- INUNDATED AREA

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS:

- GRAVES
- POSSIBLE GRAVES
- ARCHAEOLOGICAL SITES

RED DATA AND ENDEMIC SPECIES NOT INDICATED

JOINT VENTURE

CLIENT

BUILDING A, FLOOR 2
4. DAVENTRY STREET
LYNNWOOD BRIDGE OFFICE
PARK
LYNNWOOD MANOR
PRETORIA

DISCLAIMER

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REV	DATE	REVISION DETAILS
A	05.05.25	FOR INTERNAL REVIEW
B	14.05.25	FOR APPROVAL

APPROVED

I.J.

SCALE	SIZE
AS SHOWN	A1

FOR APPROVAL
NOT FOR CONSTRUCTION

APPROVED

I. JENKINS

PROJECT

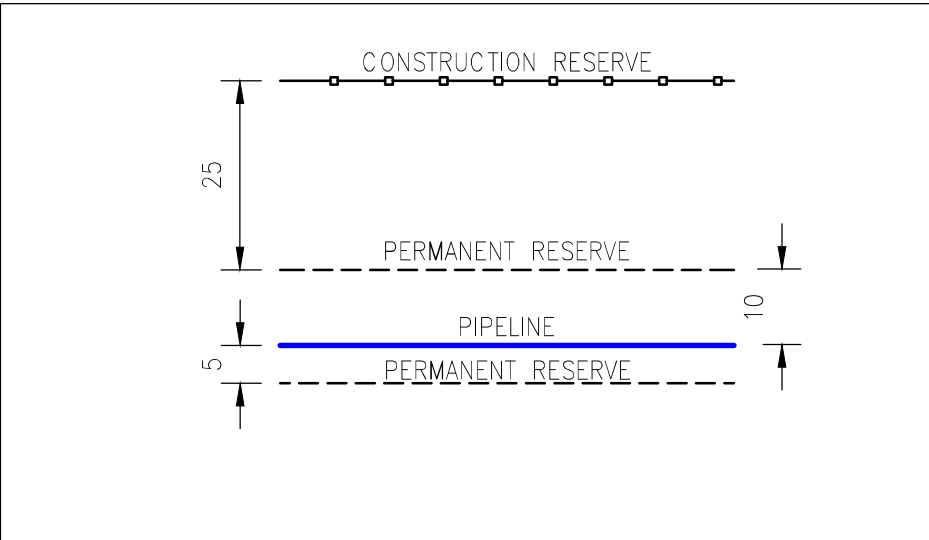
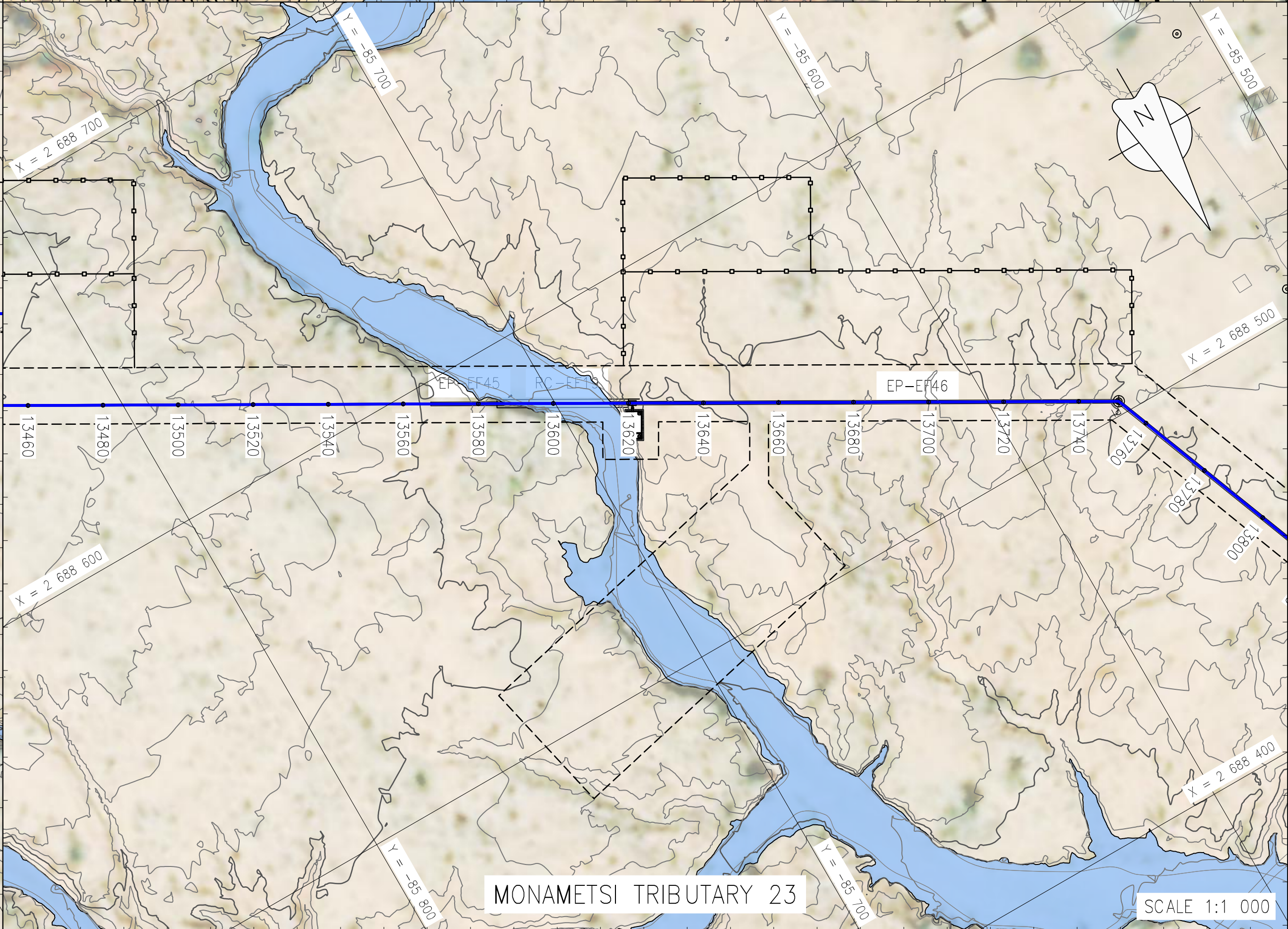
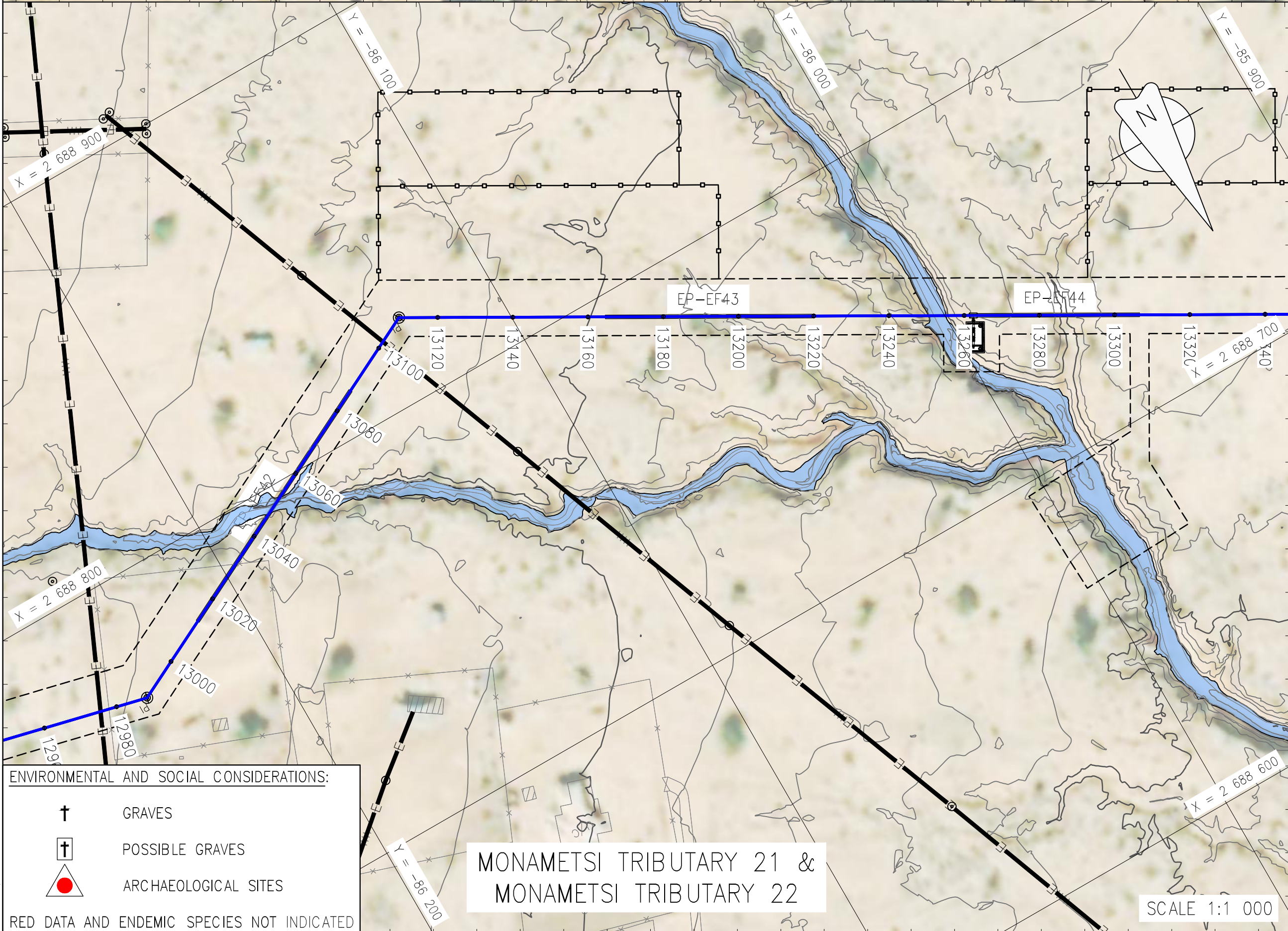
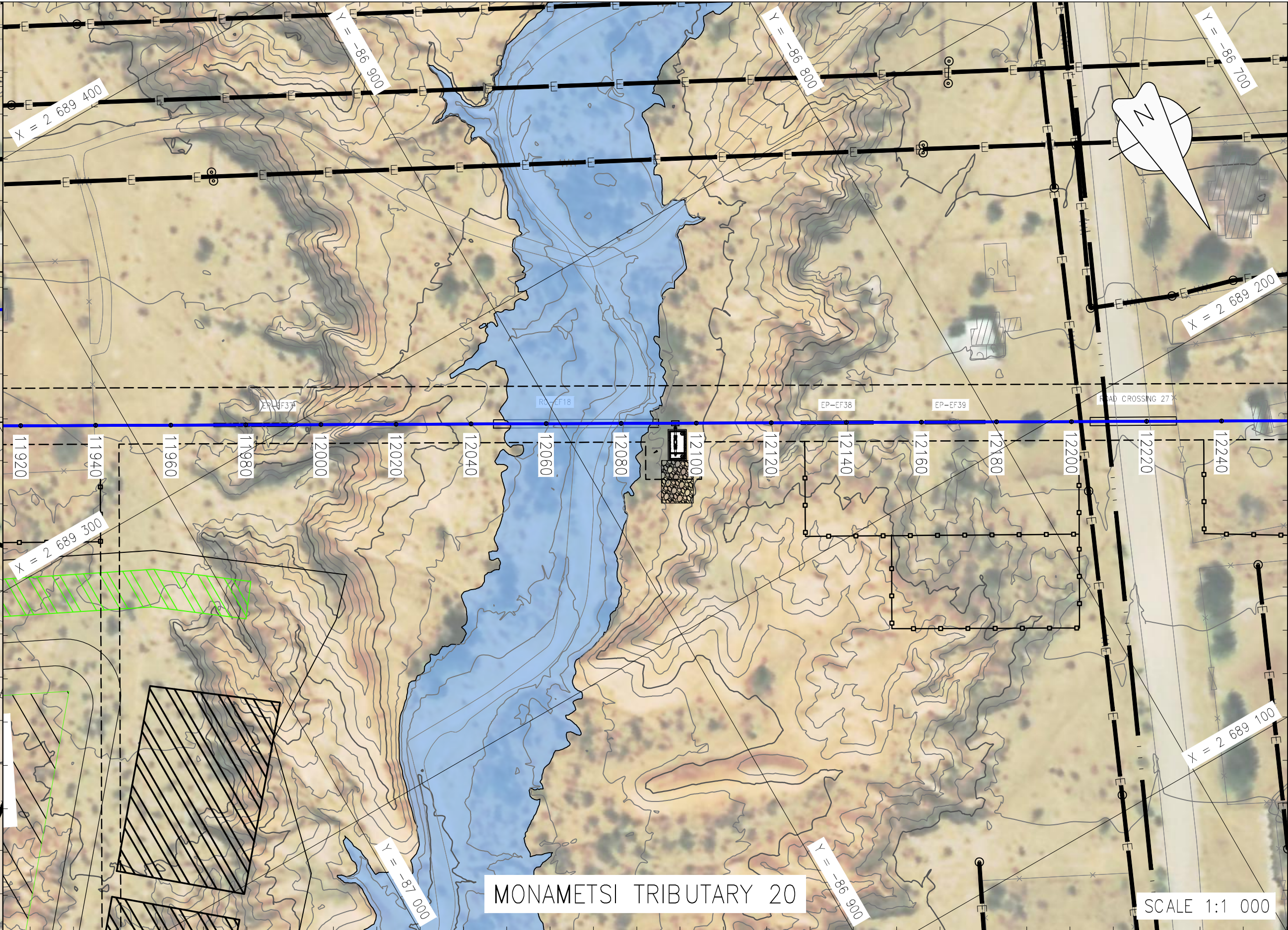
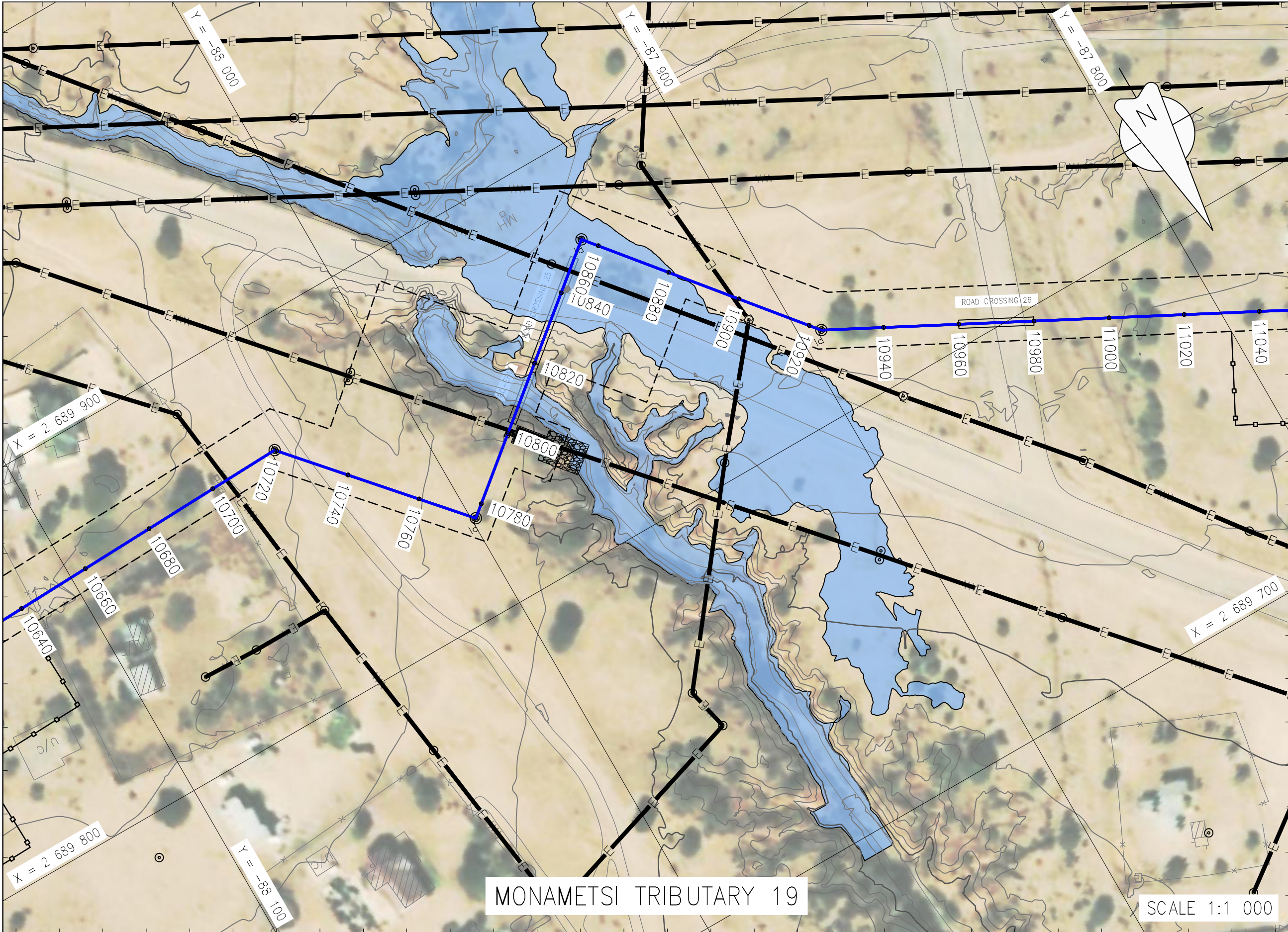
OLM PROGRAMME BULK RAW WATER STUDY PHASE

TITLE

KLIPFONTEIN BALANCING DAM TO OLIFANTSPOORT WATER TREATMENT WORKS - 2F2 100 YEAR FLOODLINES SHEET 3 OF 7

LWUA No.	PROGRAMME No.	PROJECT	PHASE	DOC. TYPE	DISC	NUMBER	REV
###	###	###	###	###	###	###	#

ZNUV No.	ZNUV No.	ZONE	WBS	DOC. TYPE	DISC	NUMBER	REV
1002569	2F	30	DR	CC	00047	B	



- NOTES:
1. REFER TO REPORT No. 1002569-2F-00-RP-YY-00001 FOR FLOODLINE DETERMINATION
 2. FLOODLINES INUNDATION > 50 mm
 3. INDICATIVE FLOODLINES PROVIDED FOR OLIFANTS 8 TO 14. REFER TO REPORT 1002569-2F-00-RP-YY-00001

- LEGEND:
- CHAINAGE MARKER (PLAN ONLY)
 - POINT OF INTERSECTION - HORIZONTAL BEND (2F2 XX)
 - NON RETURN VALVE
 - AIR VALVE
 - CONTROL VALVE
 - SCOUR VALVE
 - ISOLATING BALL VALVE
 - ROAD & STREAM/RIVER CROSSINGS
 - 1:100 FLOODLINES
 - FARM TAKE OFF
 - SURVEY BEACON
 - PUMP SHAFT & ACCESS SHAFT
 - GEOTECHNICAL DATA: TP - TEST PIT, BH - BOREHOLE
 - WORKING AREA BOUNDARY
 - PIPE SERVITUDE
 - OVERHEAD POWERLINE
 - OVERHEAD TELEPHONE LINE
 - FENCES
 - EXISTING FARM BOUNDARIES
 - BUILDING
 - INUNDATED AREA

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS:

- Graves
- Possible Graves
- Archaeological Sites

RED DATA AND ENDEMIC SPECIES NOT INDICATED

JOINT VENTURE

BUILDING A, FLOOR 2
4 DAVENTRY STREET
LYNNWOOD BRIDGE OFFICE
PARK
LYNNWOOD MANOR
PRETORIA

info@lebalele.co.za
Tel: (012) 348 4654

DISCLAIMER	REV	DATE	REVISION DETAILS	APPROVED	SCALE	SIZE	FOR APPROVAL
THE DRAWINGS HAVE BEEN APPROVED BY ZNVJ AND LWUA. IT REMAINS THE RESPONSIBILITY OF THE APPOINTED CONTRACTOR TO ENSURE THAT THE DESIGN IS CORRECT	A	05.05.25	FOR INTERNAL REVIEW	I.J.	AS SHOWN	A1	NOT FOR CONSTRUCTION
	B	14.05.25	FOR APPROVAL	I.J.	DRAWN	E. ERASMUS	APPROVED
					DESIGNED	W. LOMBARD	DATE
					REVIEWED	I. JENKINS	I. JENKINS

PROJECT

TITLE

LWUA No.

ZNVJ No.

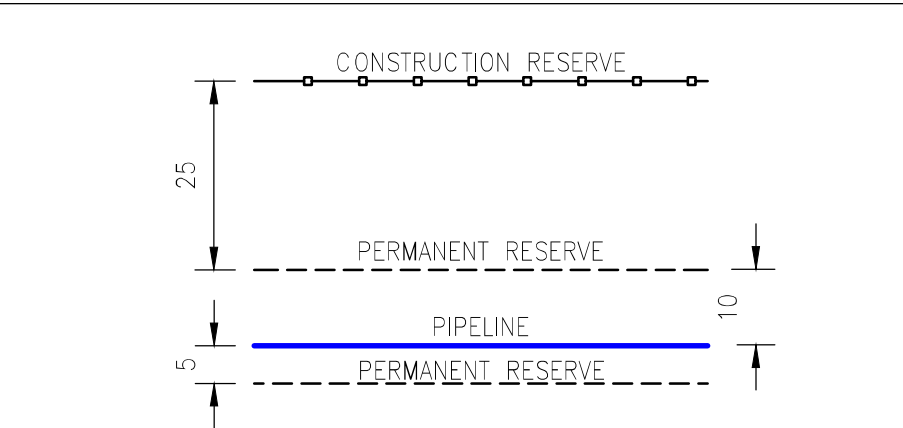
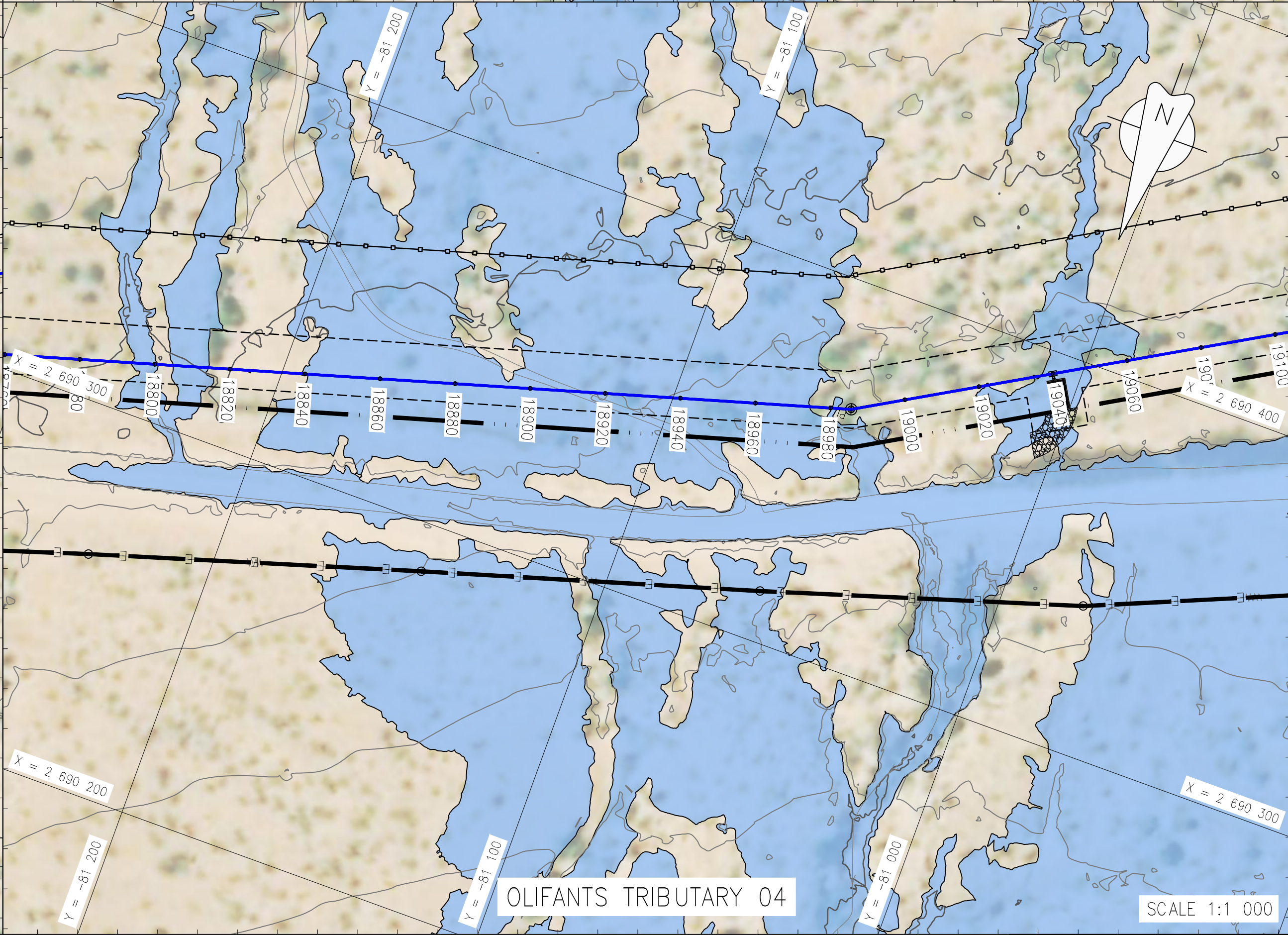
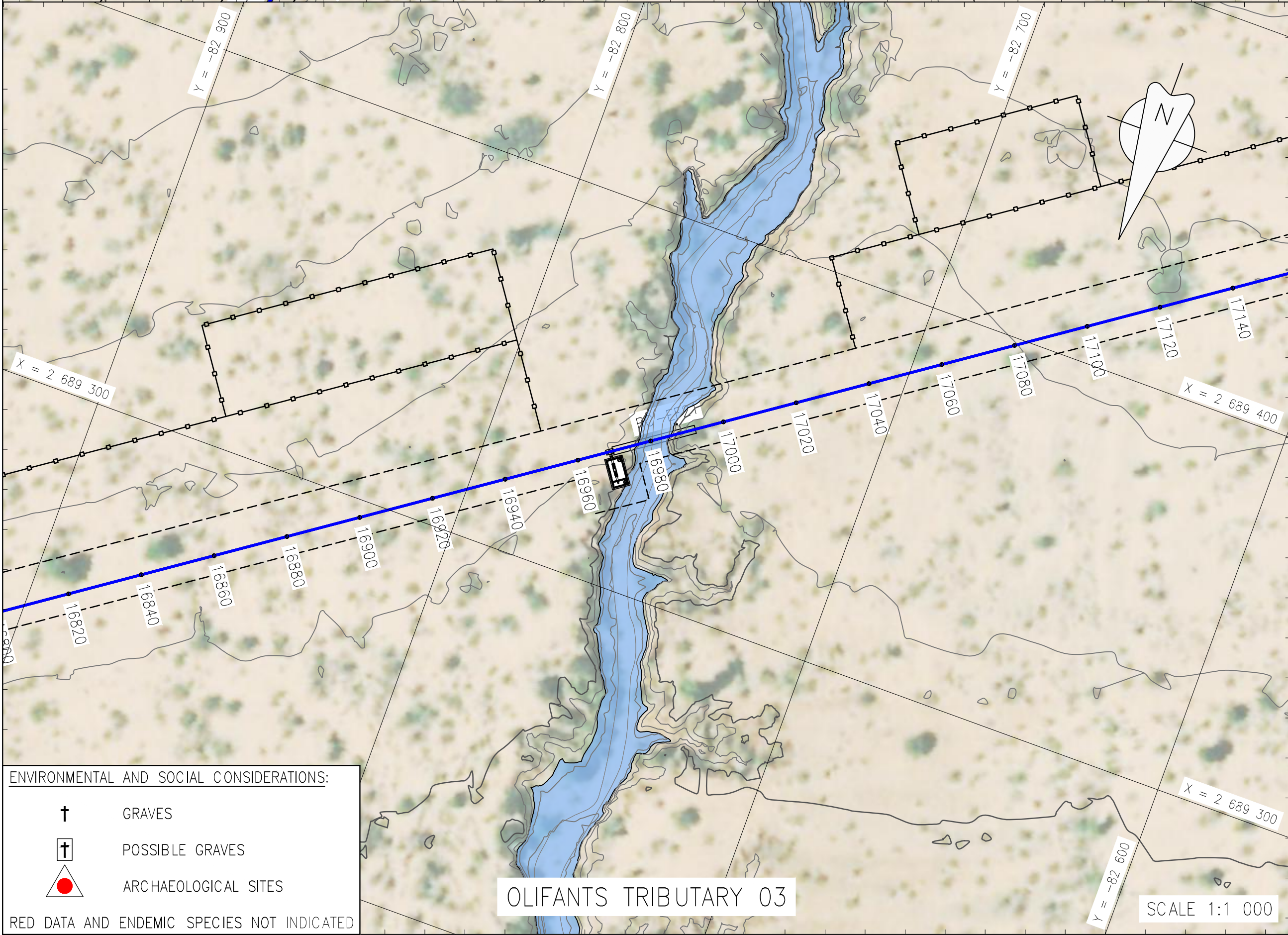
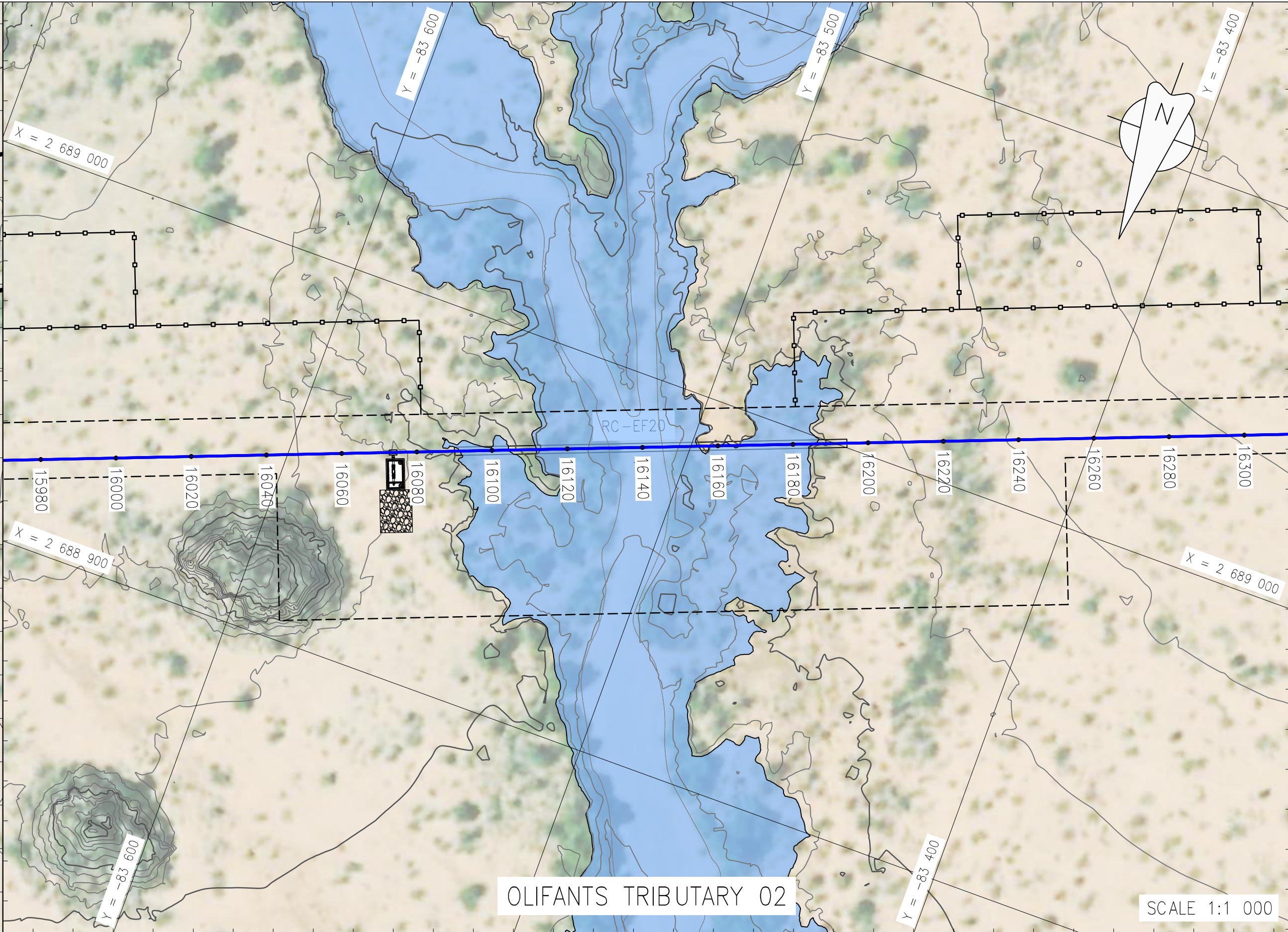
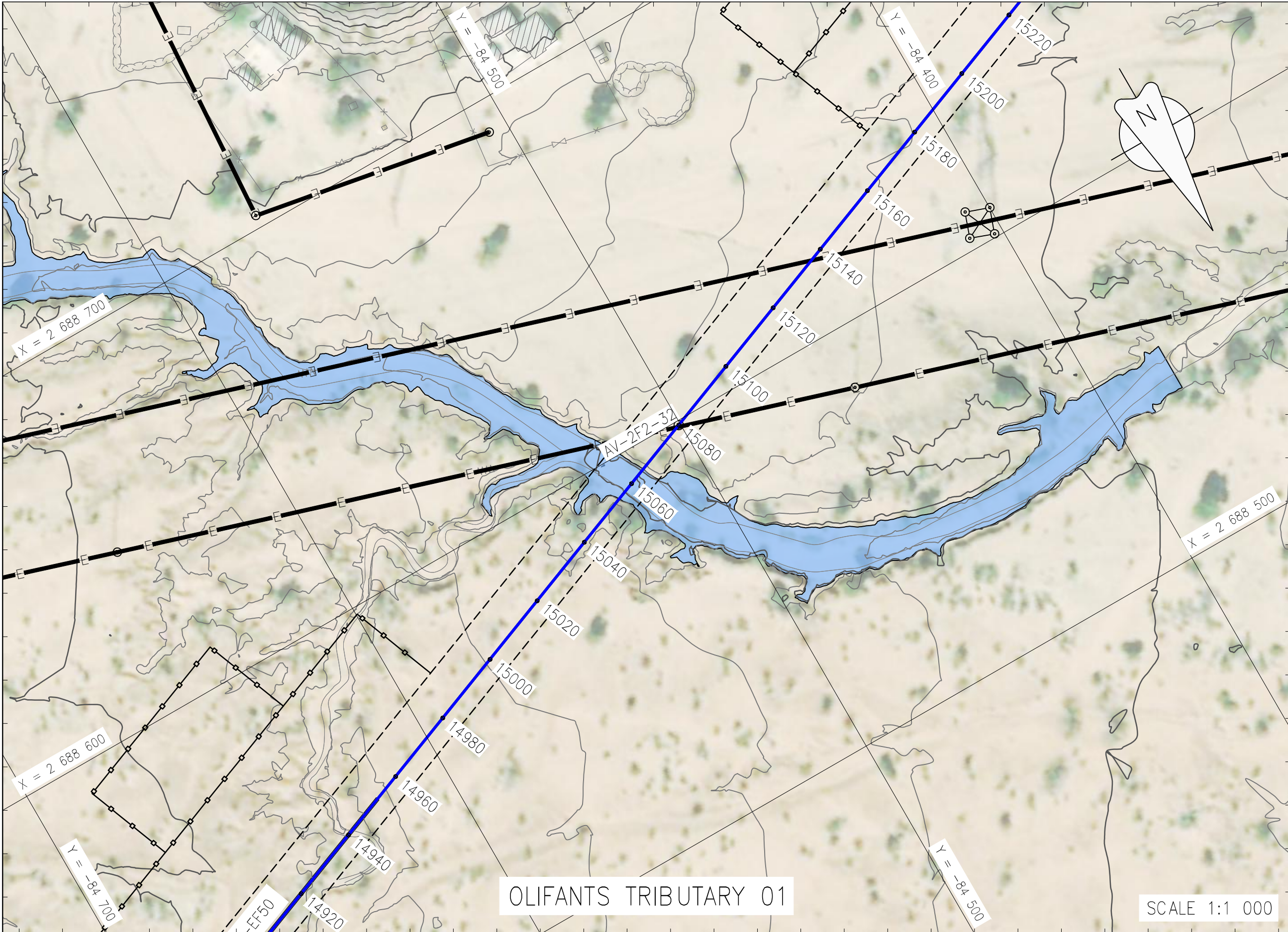
OMM PROGRAMME BULK RAW WATER STUDY PHASE

KLIPFONTEIN BALANCING DAM TO OLIFANTSPOORT WATER TREATMENT WORKS - 2F2

100 YEAR FLOODLINES SHEET 4 OF 7

PROGRAMME No.	PROJECT	PHASE	DOC TYPE	DISC	NUMBER	REV	
###	###	###	###	###	###	#	
ZNVJ No.	ZNVJ No.	ZONE	WBS	DOC TYPE	DISC	NUMBER	REV
1002569	2F	30	DR	CC	00048	B	

File Name: CPWP WORKING DRAWING 1002569-2F-2A-MC-00008 PIPELINE KLIPFONTEIN TO OLIFANTSPOORT - RIVER AND STREAM CROSSINGS.RC1.T07.DWG
Office: 240/01
Plot Date: 24/05/2025 3:17:42 pm



- NOTES:
1. REFER TO REPORT No. 1002569-2F-00-RP-YY-00001 FOR FLOODLINE DETERMINATION
 2. FLOODLINES INUNDATION > 50 mm
 3. INDICATIVE FLOODLINES PROVIDED FOR OLIFANTS 8 TO 14. REFER TO REPORT 1002569-2F-00-RP-YY-00001

- LEGEND:
- CHAINAGE MARKER (PLAN ONLY)
 - POINT OF INTERSECTION - HORIZONTAL BEND (2F2 XX)
 - NON RETURN VALVE
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 - CONTROL VALVE
 - SCOUR VALVE
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 - ROAD & STREAM/RIVER CROSSINGS
 - 1:100 FLOODLINES
 - FARM TAKE OFF
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 - PUMP SHAFT & ACCESS SHAFT
 - GEOTECHNICAL DATA: TP - TEST PIT, BH - BOREHOLE
 - WORKING AREA BOUNDARY
 - PIPE SERVITUDE
 - OVERHEAD POWERLINE
 - OVERHEAD TELEPHONE LINE
 - FENCES
 - EXISTING FARM BOUNDARIES
 - BUILDING
 - INUNDATED AREA

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS:

- Graves
- Possible Graves
- Archaeological Sites

RED DATA AND ENDEMIC SPECIES NOT INDICATED

JOINT VENTURE

CLIENT

BUILDING A, FLOOR 2
4 DAVENTRY STREET
LYNNWOOD BRIDGE OFFICE
PARK
LYNNWOOD MANOR
PRETORIA

info@lebalele.co.za
Tel: (012) 348 4654

DISCLAIMER

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REV	DATE	REVISION DETAILS	APPROVED
A	05.05.25	FOR INTERNAL REVIEW	I.J.
B	14.05.25	FOR APPROVAL	I.J.

SCALE

AS SHOWN

SIZE

A1

FOR APPROVAL

NOT FOR CONSTRUCTION

DATE

APPROVED

I. JENKINS

PROJECT

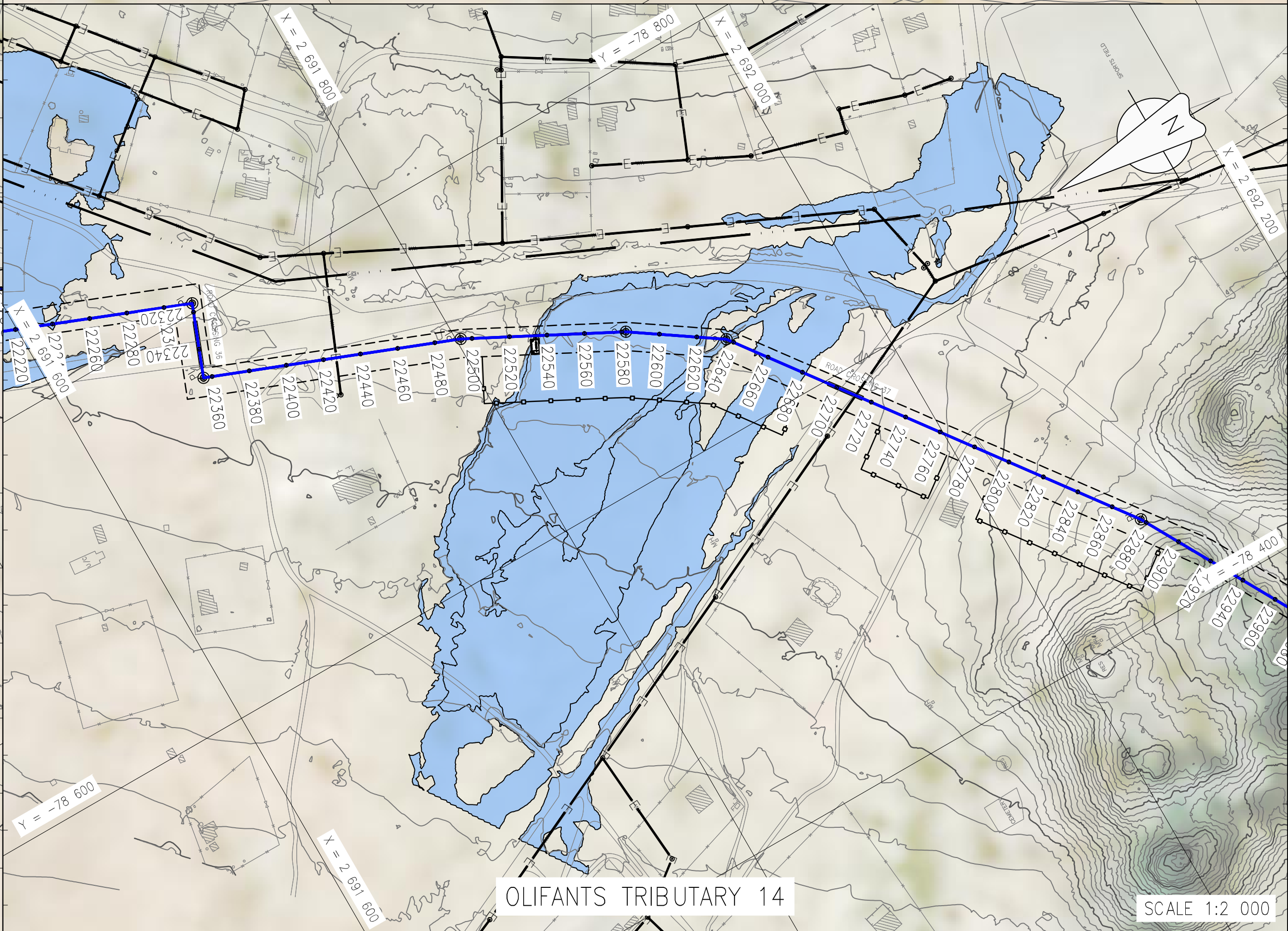
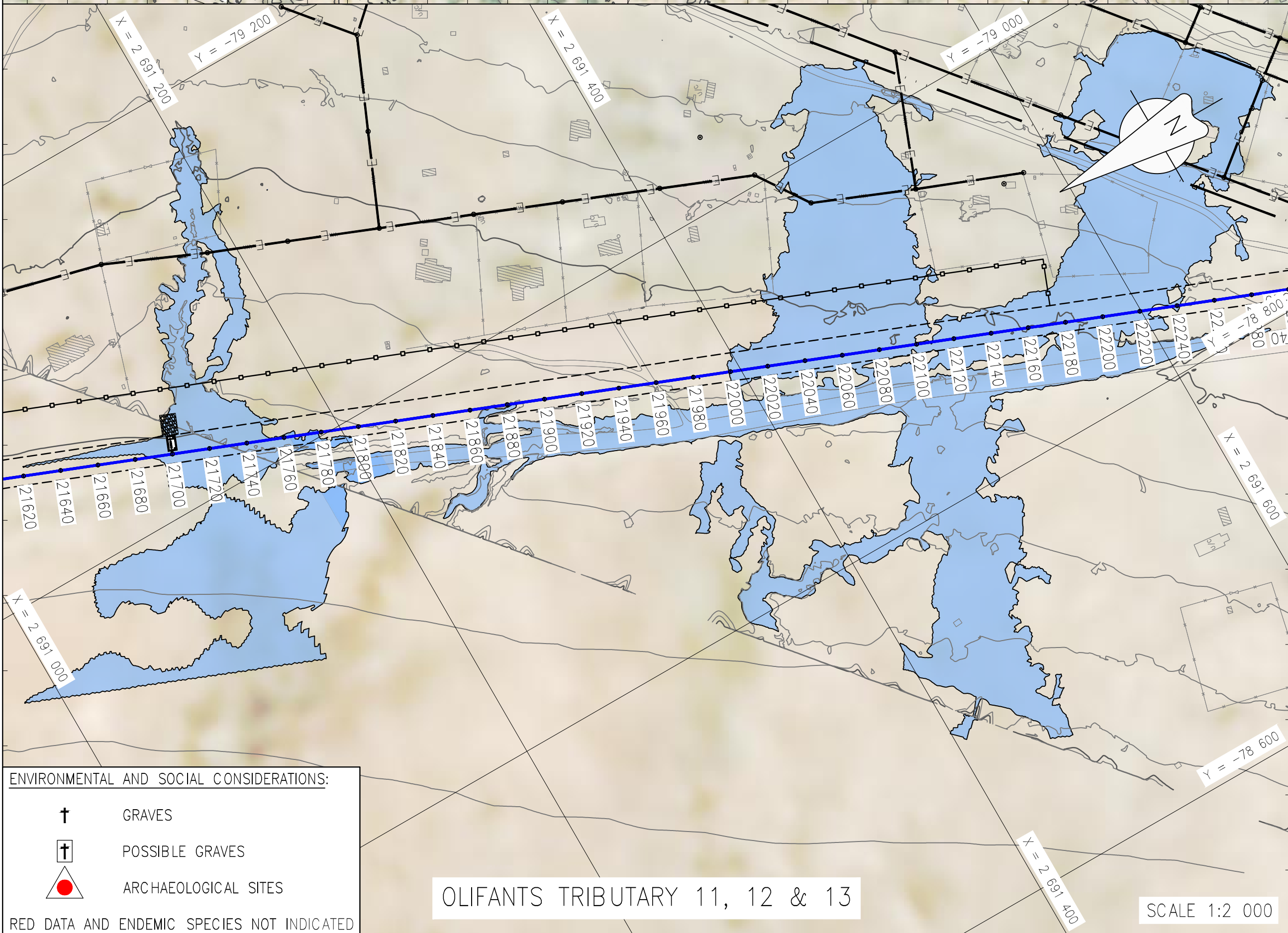
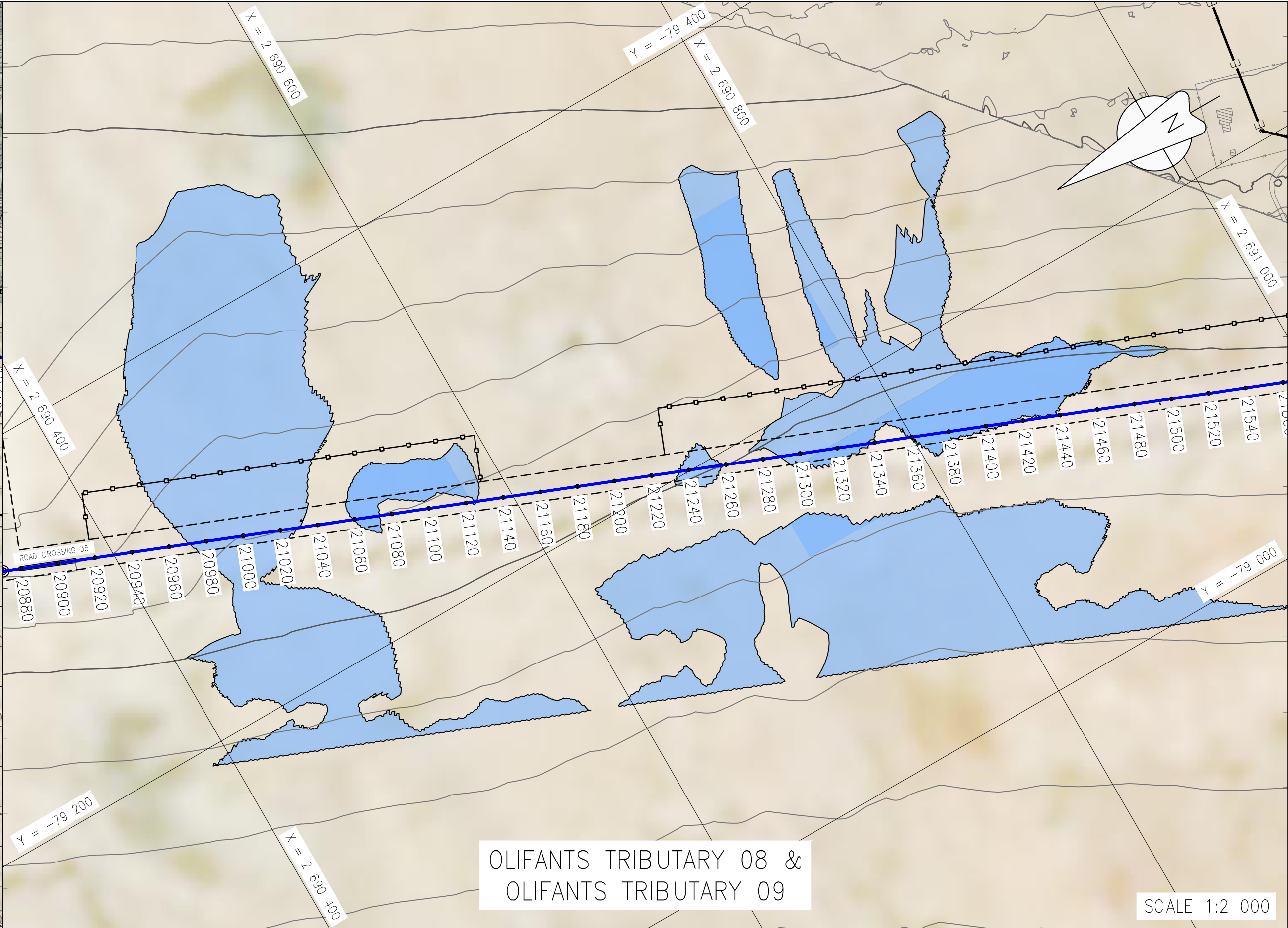
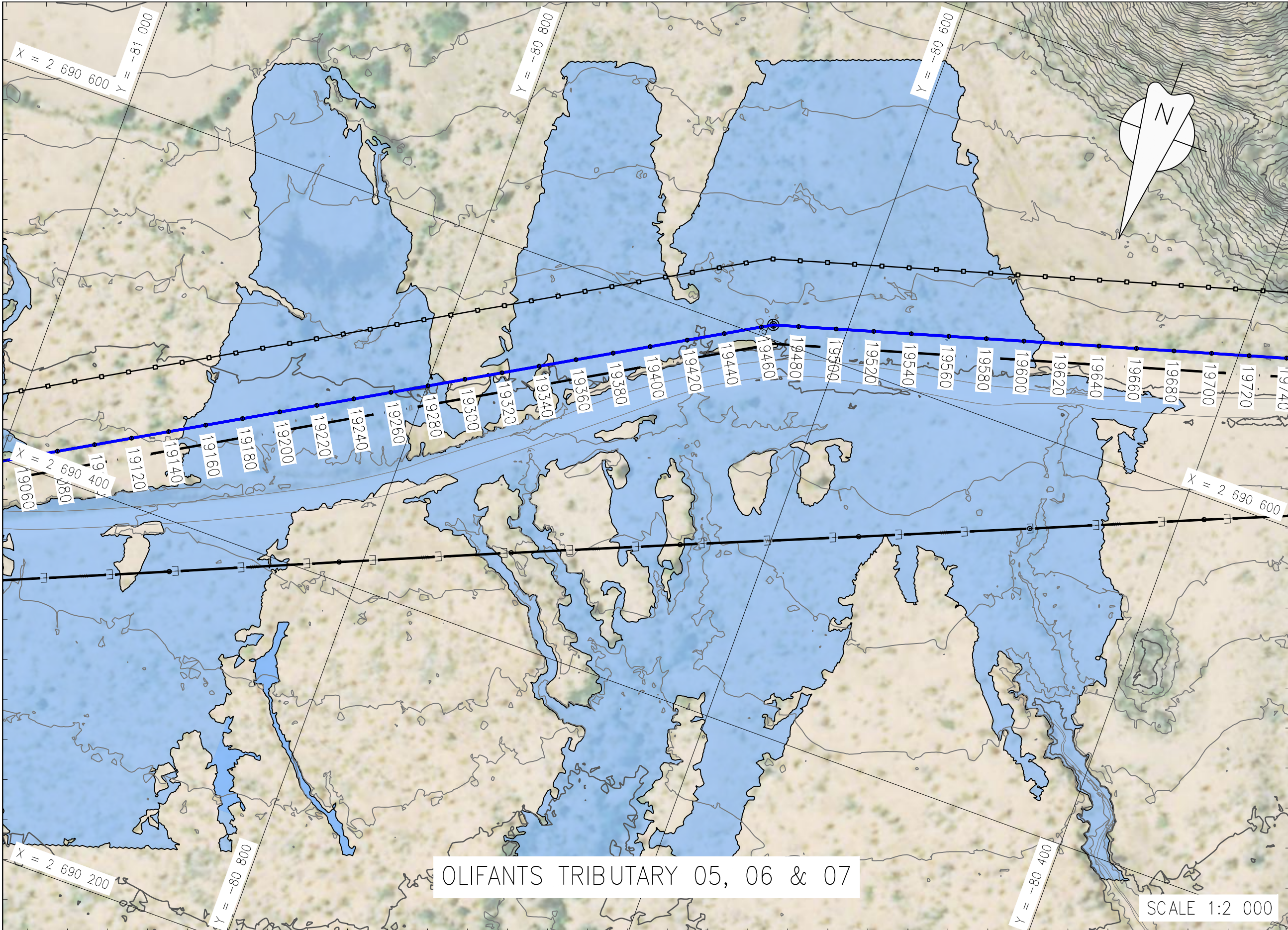
OLM PROGRAMME BULK RAW WATER STUDY PHASE

TITLE

KLIPFONTEIN BALANCING DAM TO OLIFANTSPOORT WATER TREATMENT WORKS - 2F2 100 YEAR FLOODLINES SHEET 5 OF 7

LWUA No.	PROGRAMME No.	PROJECT	PHASE	DOC TYPE	DISC	NUMBER	REV
	###	###	###	###	###	###	#

ZNVJ No.	ZNVJ No.	ZONE	WBS	DOC TYPE	DISC	NUMBER	REV
	1002569	2F	30	DR	CC	00049	B



CONSTRUCTION RESERVE

PERMANENT RESERVE

PIPELINE

PERMANENT RESERVE

NOTES:

- REFER TO REPORT No. 1002569-2F-00-RP-YY-00001 FOR FLOODLINE DETERMINATION
- FLOODLINES INUNDATION > 50 mm
- INDICATIVE FLOODLINES PROVIDED FOR OLIFANTS 8 TO 14. REFER TO REPORT 1002569-2F-00-RP-YY-00001

LEGEND:

- CHAINAGE MARKER (PLAN ONLY)
- POINT OF INTERSECTION - HORIZONTAL BEND (2F2 XX)
- NON RETURN VALVE
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- GEOTECHNICAL DATA: TP - TEST PIT, BH - BOREHOLE
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- OVERHEAD POWERLINE
- OVERHEAD TELEPHONE LINE
- FENCES
- EXISTING FARM BOUNDARIES
- BUILDING
- INUNDATED AREA

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS:

- GRAVES
- POSSIBLE GRAVES
- ARCHAEOLOGICAL SITES

RED DATA AND ENDEMIC SPECIES NOT INDICATED

ZUTARI **NDODANA**

JOINT VENTURE

CLIENT

Lebalele Water User Association

BUILDING A, FLOOR 2
4 DAVENTRY STREET
LYNNWOOD BRIDGE OFFICE
PARK
LYNNWOOD MANOR
PRETORIA

info@lebalele.co.za
Tel: (012) 348 4654

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REV	DATE	REVISION DETAILS
A	05.05.25	FOR INTERNAL REVIEW
B	14.05.25	FOR APPROVAL

APPROVED

I.J.

I.J.

SCALE	SIZE
AS SHOWN	A1

FOR APPROVAL

NOT FOR CONSTRUCTION

APPROVED

I. JENKINS

PROJECT

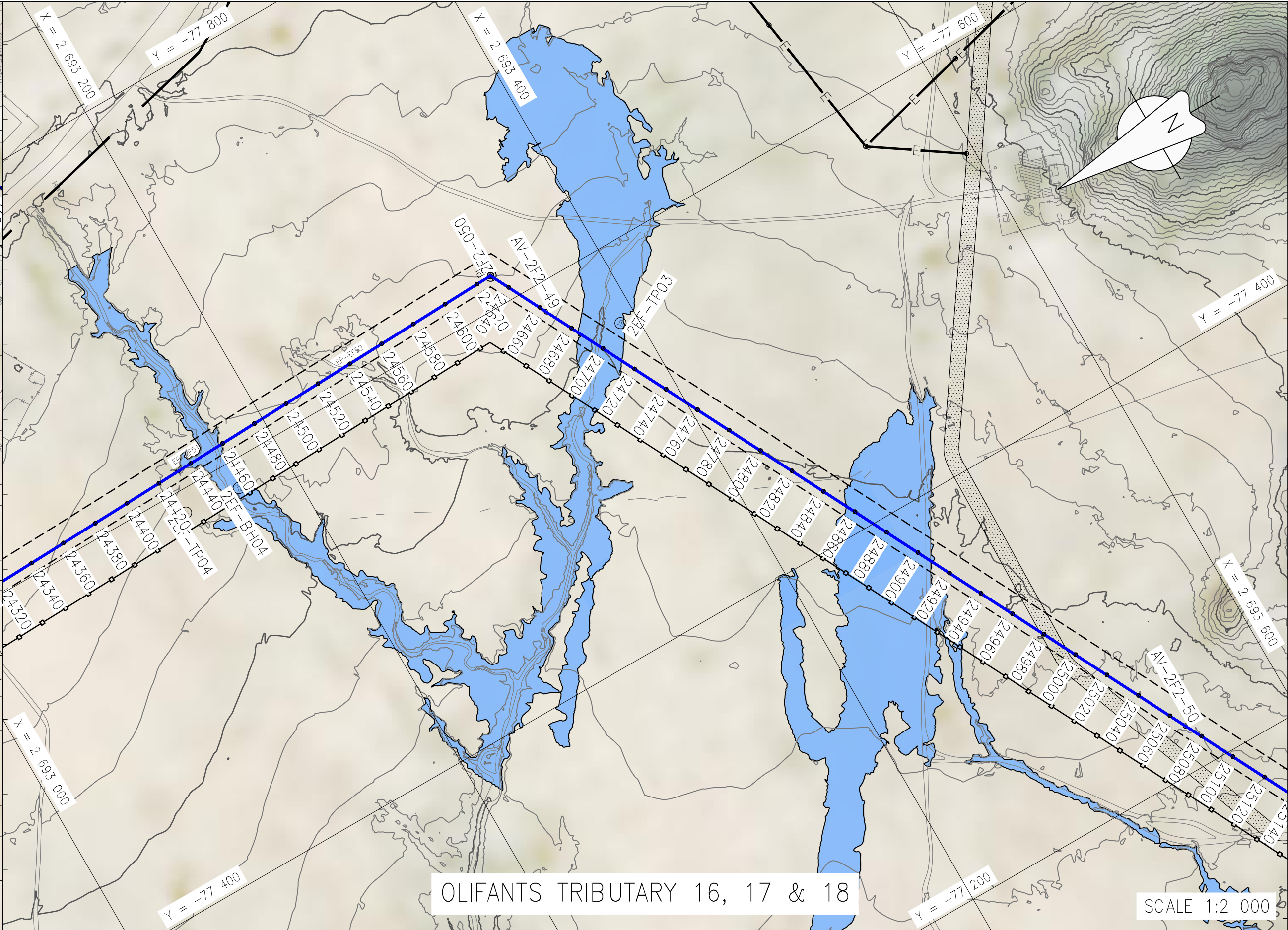
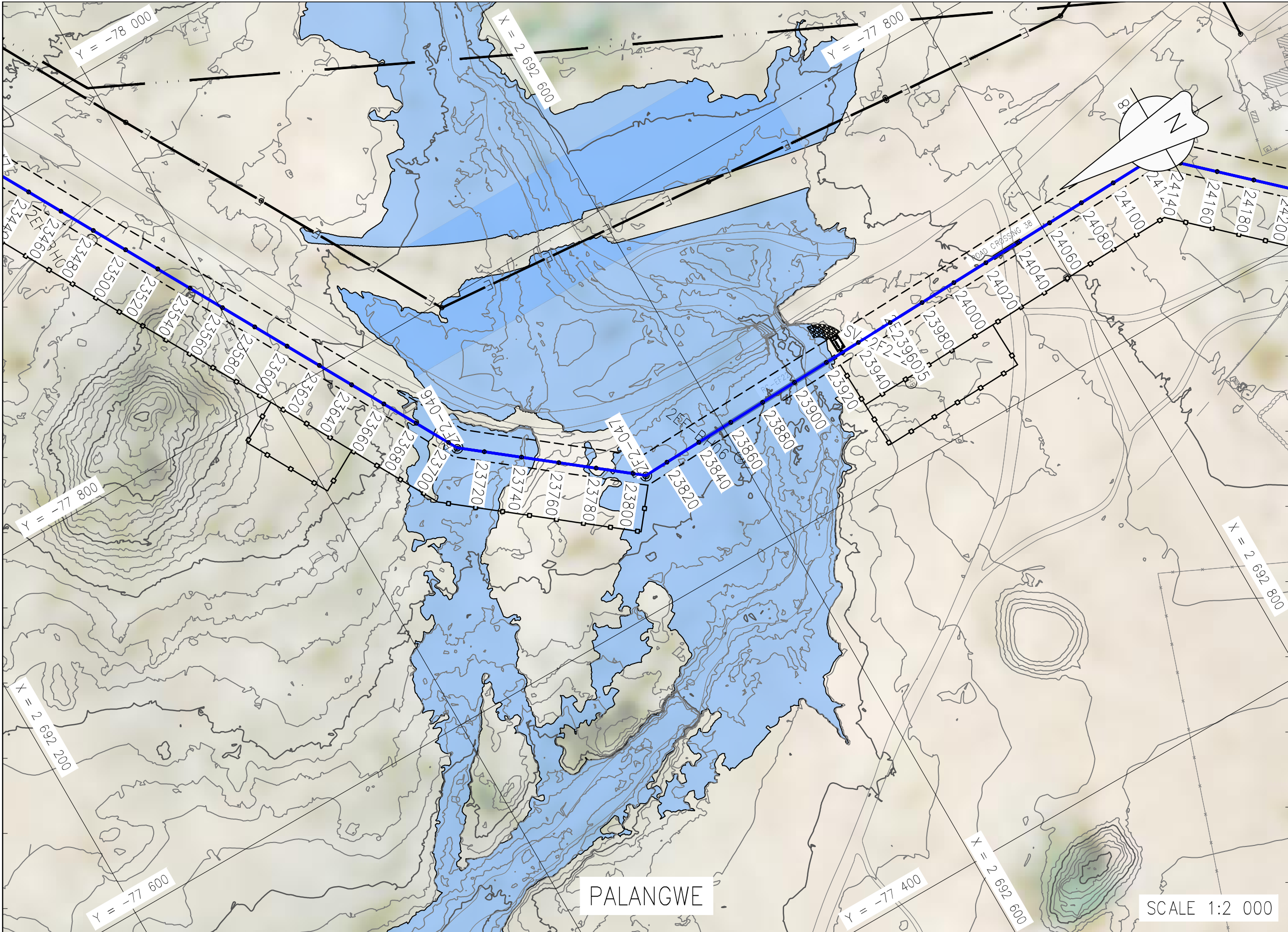
OLIFANTSPOORT WATER TREATMENT WORKS - 2F2

TITLE

100 YEAR FLOODLINES SHEET 6 OF 7

LWUA No.	PROGRAMME No.	PROJECT	PHASE	DOC TYPE	DISC	NUMBER	REV
###	###	###	###	###	###	###	#

ZNVJ No.	ZNVJ No.	ZONE	WBS	DOC TYPE	DISC	NUMBER	REV
1002569	2F	30	DR	CC	00050	B	



CONSTRUCTION RESERVE

PERMANENT RESERVE

PIPELINE

PERMANENT RESERVE

NOTES:

- REFER TO REPORT No. 1002569-2F-00-RP-YY-00001 FOR FLOODLINE DETERMINATION
- FLOODLINES INUNDATION > 50 mm
- INDICATIVE FLOODLINES PROVIDED FOR OLIFANTS 8 TO 14. REFER TO REPORT 1002569-2F-00-RP-YY-00001

LEGEND:

- CHAINAGE MARKER (PLAN ONLY)
- POINT OF INTERSECTION - HORIZONTAL BEND (2F2 XX)
- NON RETURN VALVE
- AIR VALVE
- CONTROL VALVE
- SCOUR VALVE
- ISOLATING BALL VALVE
- ROAD & STREAM/RIVER CROSSINGS
- 1:100 FLOODLINES
- FARM TAKE OFF
- SURVEY BEACON
- PUMP SHAFT & ACCESS SHAFT
- GEOTECHNICAL DATA: TP - TEST PIT, BH - BOREHOLE
- WORKING AREA BOUNDARY
- PIPE SERVITUDE
- OVERHEAD POWERLINE
- OVERHEAD TELEPHONE LINE
- FENCES
- EXISTING FARM BOUNDARIES
- BUILDING
- INUNDATED AREA

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS:

- GRAVES
- POSSIBLE GRAVES
- ARCHAEOLOGICAL SITES

RED DATA AND ENDEMIC SPECIES NOT INDICATED

JOINT VENTURE

CLIENT

BUILDING A, FLOOR 2
4 DAVENTRY STREET
LYNNWOOD BRIDGE OFFICE
PARK
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PRETORIA

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REV	DATE	REVISION DETAILS
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APPROVED

I.J.

SCALE

AS SHOWN

SIZE

A1

FOR APPROVAL

NOT FOR CONSTRUCTION

APPROVED

I. JENKINS

PROJECT

OLIFANTSPOORT WATER TREATMENT WORKS - 2F2

100 YEAR FLOODLINES SHEET 7 OF 7

LWUA No.	PROGRAMME No.	PROJECT	PHASE	DOC TYPE	DISC	NUMBER	REV
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ZNJV No.	ZNJV No.	ZONE	WBS	DOC TYPE	DISC	NUMBER	REV
1002569	---	2F	30	DR	CC	00051	B

Appendix E

Specialist Declaration



forestry, fisheries & the environment

Department:
Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

Private Bag X447, Pretoria, 0001, Environment House, 473 Steve Biko Road, Pretoria, 0002 Tel: +27 12 399 9000, Fax: +27 86 625 1042

SPECIALIST DECLARATION FORM – AUGUST 2023

Specialist Declaration form for assessments undertaken for application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

REPORT TITLE

OLIFANTS MANAGEMENT MODEL PROGRAMME BULK RAW WATER STUDY PHASE (OMMP-BRWSP): PROPOSED PHASE 2F PIPELINE AND ASSOCIATED INFRASTRUCTURE, IN THE FETAKGOMO TUBATSE AND LEPELLE NKUMPI LOCAL MUNICIPALITIES, WITHIN THE CAPRICORN AND GREATER SEKHUKHUNE DISTRICT MUNICIPALITIES, IN THE LIMPOPO PROVINCE.

Kindly note the following:

1. This form must always be used for assessment that are in support of applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting, where this Department is the Competent Authority.
2. This form is current as of August 2023. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at <https://www.dffe.gov.za/documents/forms>.
3. An electronic copy of the signed declaration form must be appended to all Draft and Final Reports submitted to the department for consideration.
4. The specialist must be aware of and comply with 'the Procedures for the assessment and minimum criteria for reporting on identified environmental themes in terms of sections 24(5)(a) and (h) and 44 of the act, when applying for environmental authorisation - GN 320/2020', where applicable.

1. SPECIALIST INFORMATION

Title of Specialist Assessment	Floodline Determination Report
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SPECIALIST DECLARATION FORM – AUGUST 2023

2. DECLARATION BY THE SPECIALIST

I, Ivan Jenkins declare that –

- I act as the independent specialist in this application;
- I am aware of the procedures and requirements for the assessment and minimum criteria for reporting on identified environmental themes in terms of sections 24(5)(a) and (h) and 44 of the National Environmental Management Act (NEMA), 1998, as amended, when applying for environmental authorisation which were promulgated in Government Notice No. 320 of 20 March 2020 (i.e. “the Protocols”) and in Government Notice No. 1150 of 30 October 2020.
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing –
 - any decision to be taken with respect to the application by the competent authority; and;
 - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 48 and is punishable in terms of section 24F of the NEMA Act.



Signature of the Specialist

Zutari

Name of Company:

18 Jun 2025

Date

SPECIALIST DECLARATION FORM – AUGUST 2023

3. UNDERTAKING UNDER OATH/ AFFIRMATION

I, Ivan Jenkins, swear under oath / affirm that all the information submitted or to be submitted for the purposes of this application is true and correct.



Signature of the Specialist

Zutari

Name of Company

18 June 2025

Date



Signature of the Commissioner of Oaths

18 JUNE 2025

Date

COMMISSIONER OF OATHS (RSA)

Fredah Nkuna

Designation: HR Professional | Reg Number: 9334

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Appendix F

Scour Modelling Report

**ORWRDP2 - SUBPHASE 2F - PIPELINE CROSSING OF THE
OLIFANTS RIVER AT THE OLIFANTSPOORT WTW**

Hydrodynamic modelling of scour



REPORT

July 2016

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1. INTRODUCTION

Prof Basson, ASP Technology (Pty) Ltd, was appointed on 20 June 2016, to carry out this study on the hydrodynamic modelling of scour at the proposed ORWRDP2-Subphase 2F pipeline crossing of the Olifants River at the Olifantspoort Water Treatment Works (WTW). The study area is shown in Figure 1-1.



Figure 1-1 **Satellite image of the Olifants River study reach and proposed pipeline crossing**

The aim of this study is to analyse the possible deepest bed scour of the alluvial river bed at the proposed pipe crossing on the Olifants River.

2. METHODOLOGY

The following tasks and methodology were identified and followed in this study:

- a) A fully hydrodynamic two dimensional hydrodynamic model was set up based on the survey and geotechnical data. A LiDAR survey along the pipe route is available over a 700 m reach length, but a more comprehensive LiDAR survey has been obtained which was done previously as part of the WTW upgrade design (Figure 2-1).
- b) Annual Recurrence Interval (ARI) flood peaks were determined in this study based on observed flood records of the Department of Water and Sanitation (DWS). Flood hydrographs determined in this study were routed through the river reach to determine the deepest river bed scour at the proposed pipe crossing site.

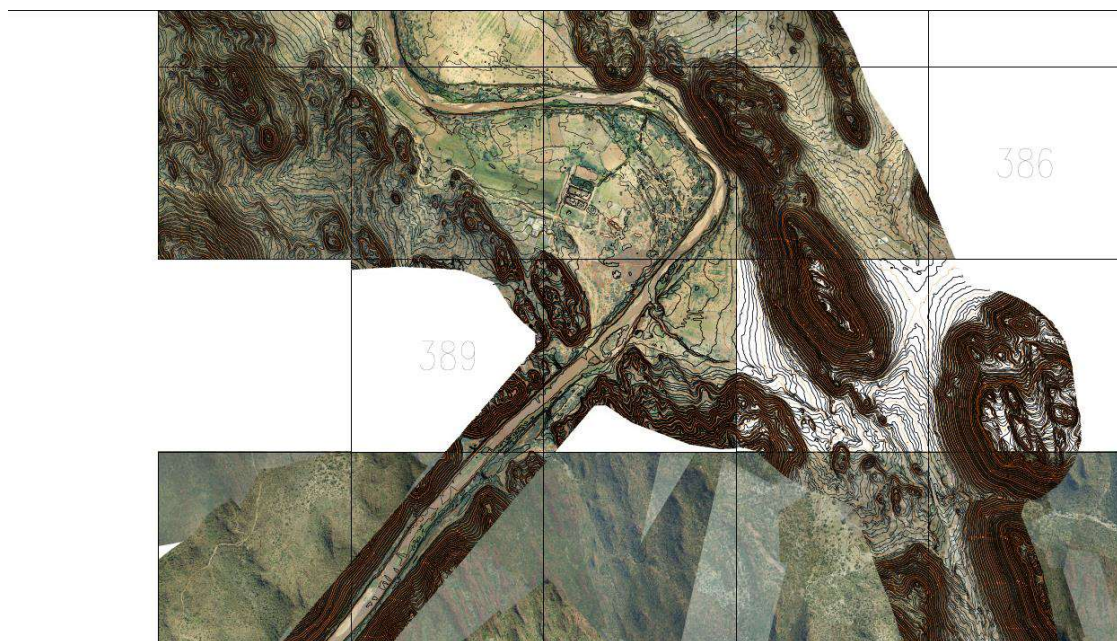


Figure 2-1 Available LiDAR survey zone (where contours are plotted)

3. FLOOD HYDROLOGY

The Department of Water and Sanitation (DWS) has a flow gauging station B5H002 about 15 km downstream of the proposed site of the river crossing. At the gauging station the total catchment area is 31416 km² and the flow record at the gauging station covers the period 1948/49 to 1979/80.

The flow records of gauging stations B7H007 (46583 km²) and B7H015 (49826 km²), were used to extend the flow record of B5H002, and also to fill gaps and extend the discharge rating at B5H002. The final annual maximum flood record used in the probabilistic analysis is

for the period 1948/49 to 2014/15. An additional historical large flood which occurred in year 1908 was also added in the analysis and is estimated at about 3800 m³/s at B5H002 (TR137, 1988). The second largest and a more recent observed flood occurred during 2011/12 and peaked at an estimated 3300 m³/s. Figure 3-1 shows the probabilistic flood analysis graphically. The log Pearson type III distribution fitted the data best. The probabilistic ARI flood peaks were adjusted for uncertainties in the flow measurement accuracy by increasing the discharge by 30 % (3rd column in Table 3.1).

A regional empirical method was also used based on the Regional Maximum Flood (RMF) methodology of TR137 (1988). At gauging station B5H002 the RMF is estimated at 7912 m³/s. ARI floods were scaled from the RMF based on ratios provided in TR137 and are indicated in Table 3.1 (2nd column). The RMF derived floods are usually seen as conservatively high and slightly overestimated for the 50 and 100 year floods. The probabilistic method has a relatively long record and it is proposed that the floods for this study are based on this method, but with further adjustments for climate change (+10 %) and land degradation (+10 %) with the final proposed ARI flood peaks indicated in the last column in Table 3.1. The ARI floods calculated at gauging station B5H002 were assumed to be the same at this study site to be conservative. The climate change impacts on flood peaks were obtained from the DEA (2015) study for year 2060 and are based on the analysis of 5 climate models.

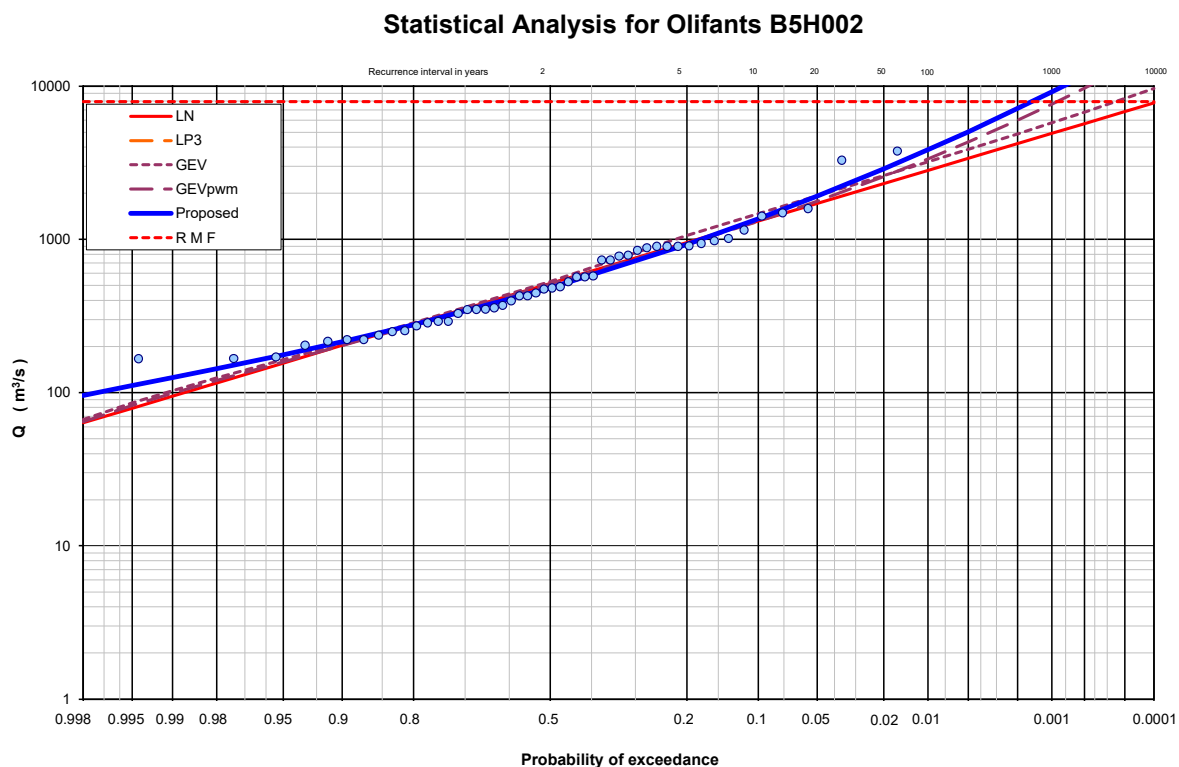
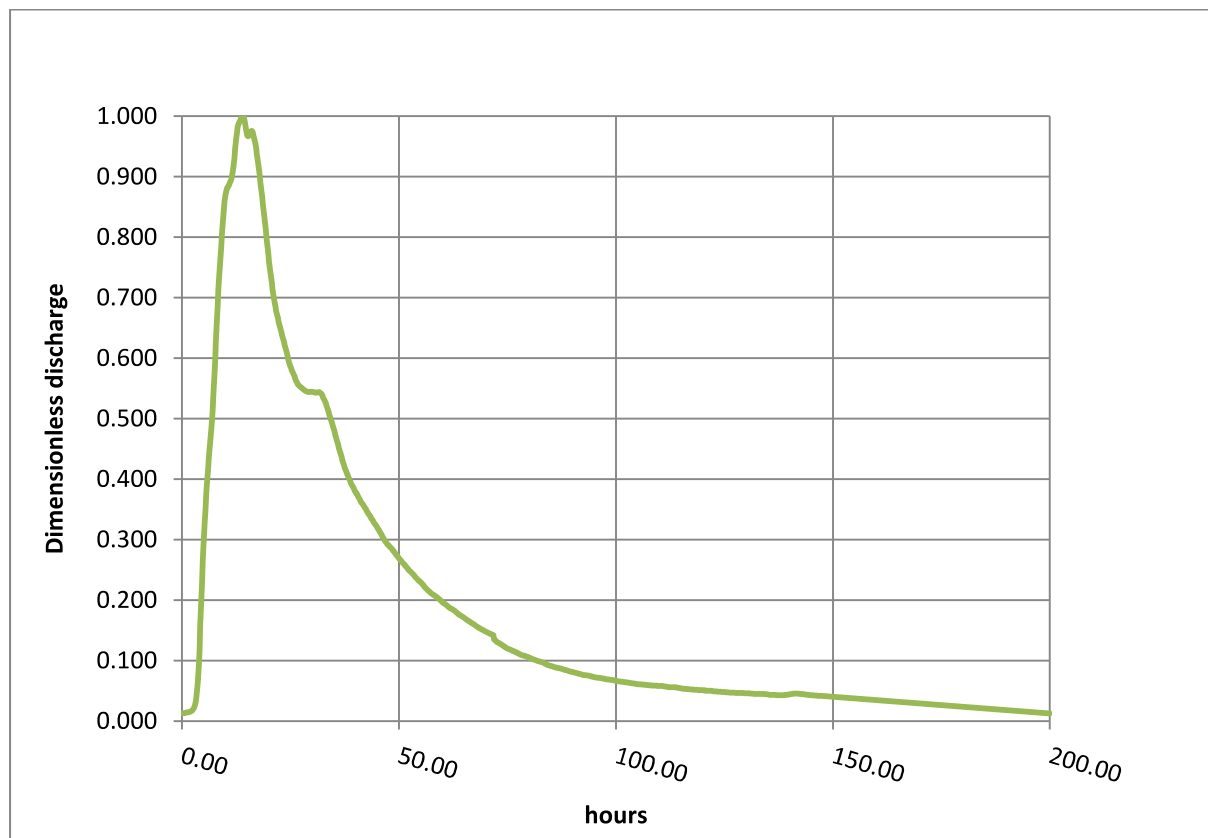


Figure 3-1 Probabilistic flood analysis at B5H002

Table 3.1 ARI floods used in this study at the proposed pipeline crossing

ARI flood (yr)	Empirical method (TR137, 1988)	Probabilistic flood peak, adjusted for measurement inaccuracy	Proposed ARI flood peaks based on probabilistic method adjusted for flow inaccuracy, future land degradation and climate change by 2060 (m³/s)
10	-	1770	2200
50	4352	3745	4500
100	5301	4993	6000
200	5934	6567	8000

Flood hydrographs were scaled from observed flood records. Figure 3-2 shows the dimensionless flood hydrograph used in the hydrodynamic modelling of this study.

**Figure 3-2 Dimensionless ARI flood hydrograph**

4. SITE INSPECTION

During a site inspection of the Olifants River in the past the photographs of Figures 4-1 to 4-4 were obtained. The sandy river bed has deep alluvial material and the banks have dense vegetation.



Figure 4-1 Pipe crossing site of the main channel viewed from the left bank



Figure 4-2 View from left bank looking downstream at the pipe crossing site



Figure 4-3 View looking downstream towards the pipe crossing site (located around the bend) from the temporary road crossing (rocks in foreground not natural of the river bed)



Figure 4-4 View from the Olifantspoort weir looking upstream

5. RIVER BED SEDIMENT GRADING

A bed grab sample collected from pipe crossing site has a grading as shown in Figure 5-1 and Table 5.1. A median sediment size of 0.17 mm was selected for the hydrodynamic modelling.

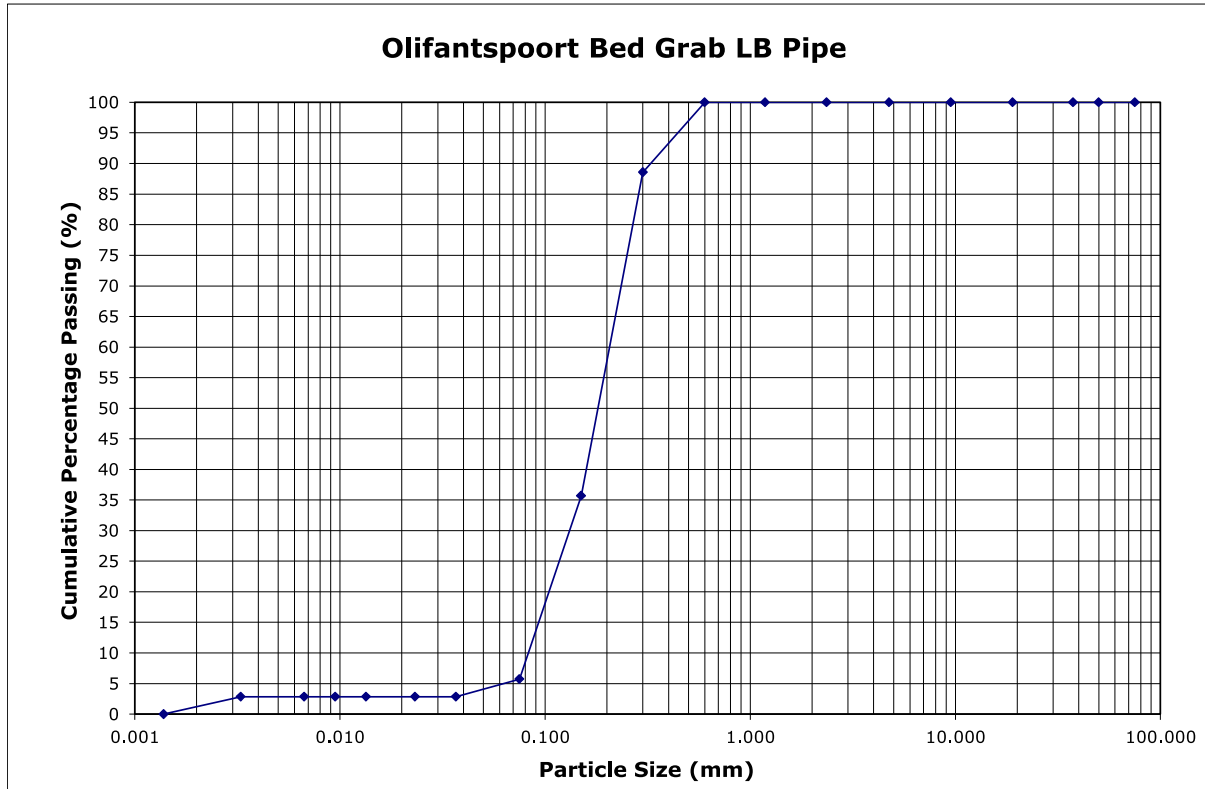


Figure 5-1 Bed sediment grading analysis

Table 5.1 Bed sediment grading analysis at the pipe crossing site based on sieve and hydrometer analysis

Unit	% Passing	Diameter (mm)
mm	100.00	0.6
mm	88.57	0.3
mm	35.71	0.15
mm	5.71	0.075
mm	2.86	0.0367
mm	2.86	0.0232
mm	2.86	0.0134
mm	2.86	0.0095
mm	2.86	0.0067
mm	2.86	0.0033
mm	0.00	0.0014

6. HYDRODYNAMIC MODELLING OF RIVER BED SCOUR AT THE PROPOSED RIVER CROSSING

A two dimensional hydrodynamic model developed for alluvial rivers were set up based on the available LiDAR data. The LiDAR survey data was obtained as 2 m x 2 m grid data. The model bathymetry is shown in Figure 6-1.

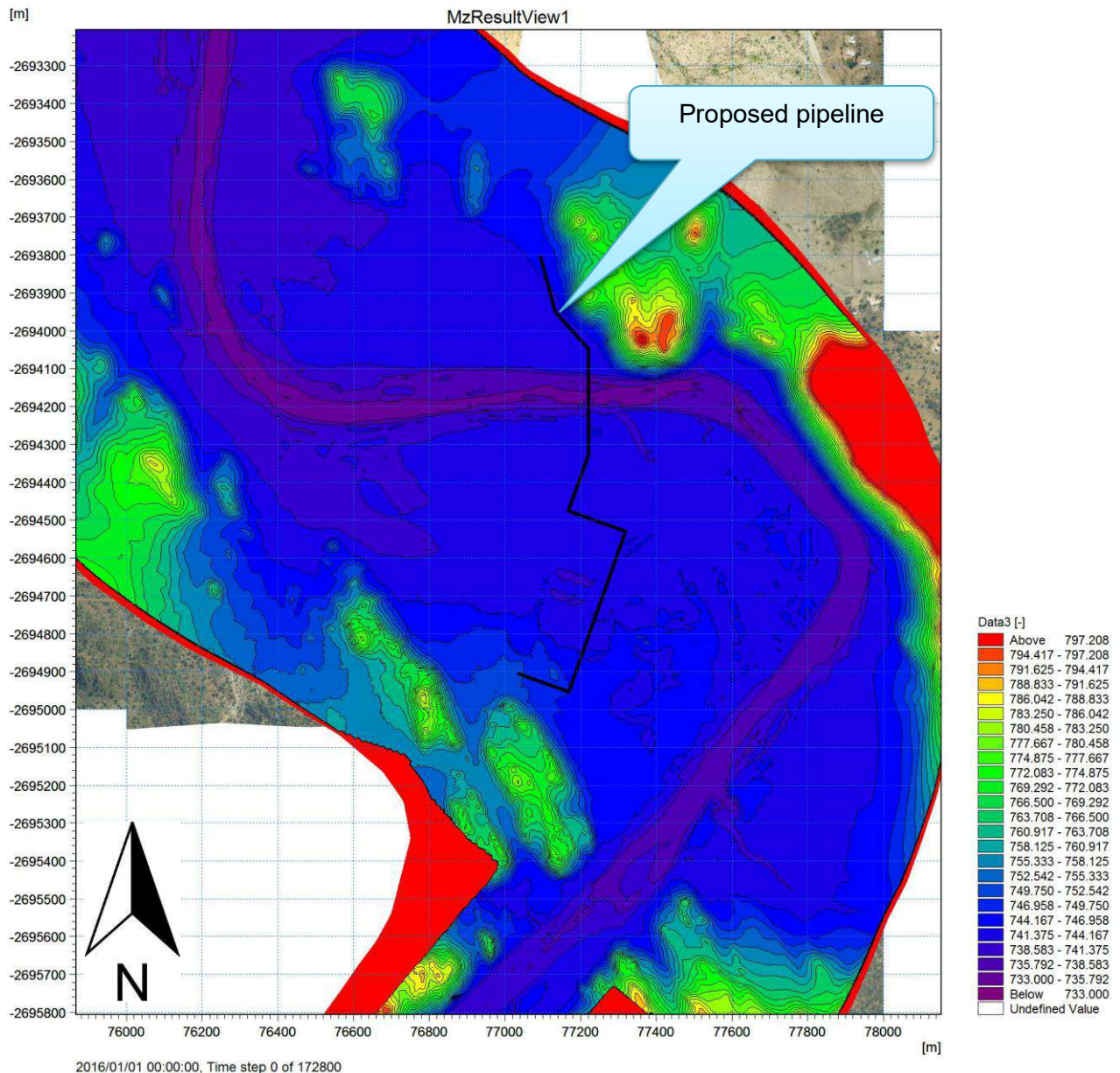


Figure 6-1 Model bathymetry based on the LiDAR survey data (masl)

At the upstream boundary the ARI flood hydrographs were specified and routed through the river reach. At the downstream boundary a time series of water levels were calculated for each flood, based on uniform flow conditions considering the river bed slope and hydraulic roughness. The following hydraulic roughness values were used: main channel Manning $n =$

0.045, river banks with riparian vegetation $n = 0.060$ and more open floodplain zones $n = 0.055$. These are typical values calibrated in the past for similar large alluvial rivers.

The simulated flow depths and flow velocities at the peaks of the ARI floods are indicated in **Appendix A**. The simulated flow depths and flow velocities for the 100 year flood are shown below in Figures 6-2 and 6-3. At the location of the proposed pipe crossing of the main channel the flow velocities are high and scour of the bed is expected. The flow velocities on the floodplains are however significantly smaller than in the main channel.

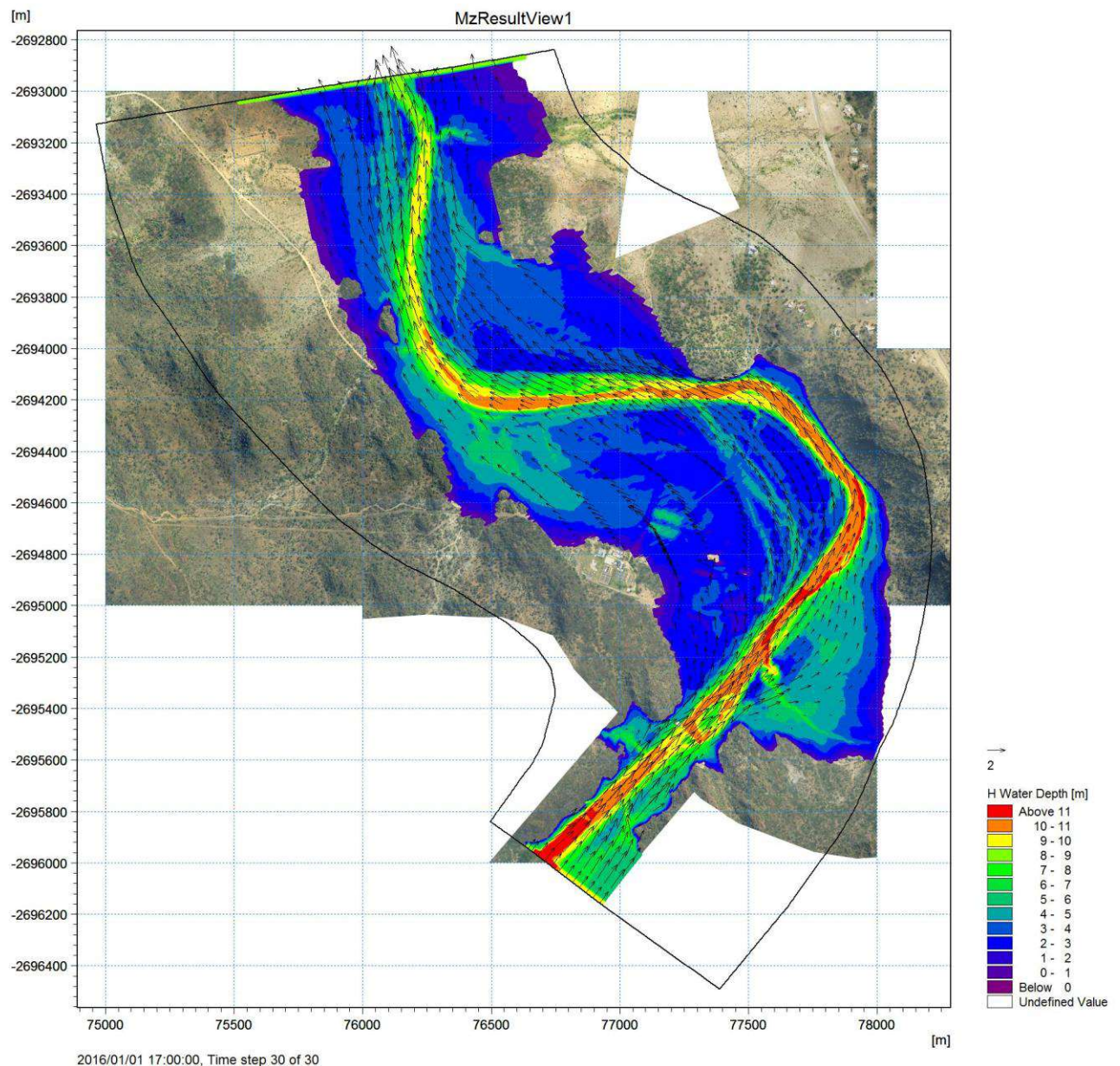


Figure 6-2 Simulated flow depths at the peak of the 100 year flood

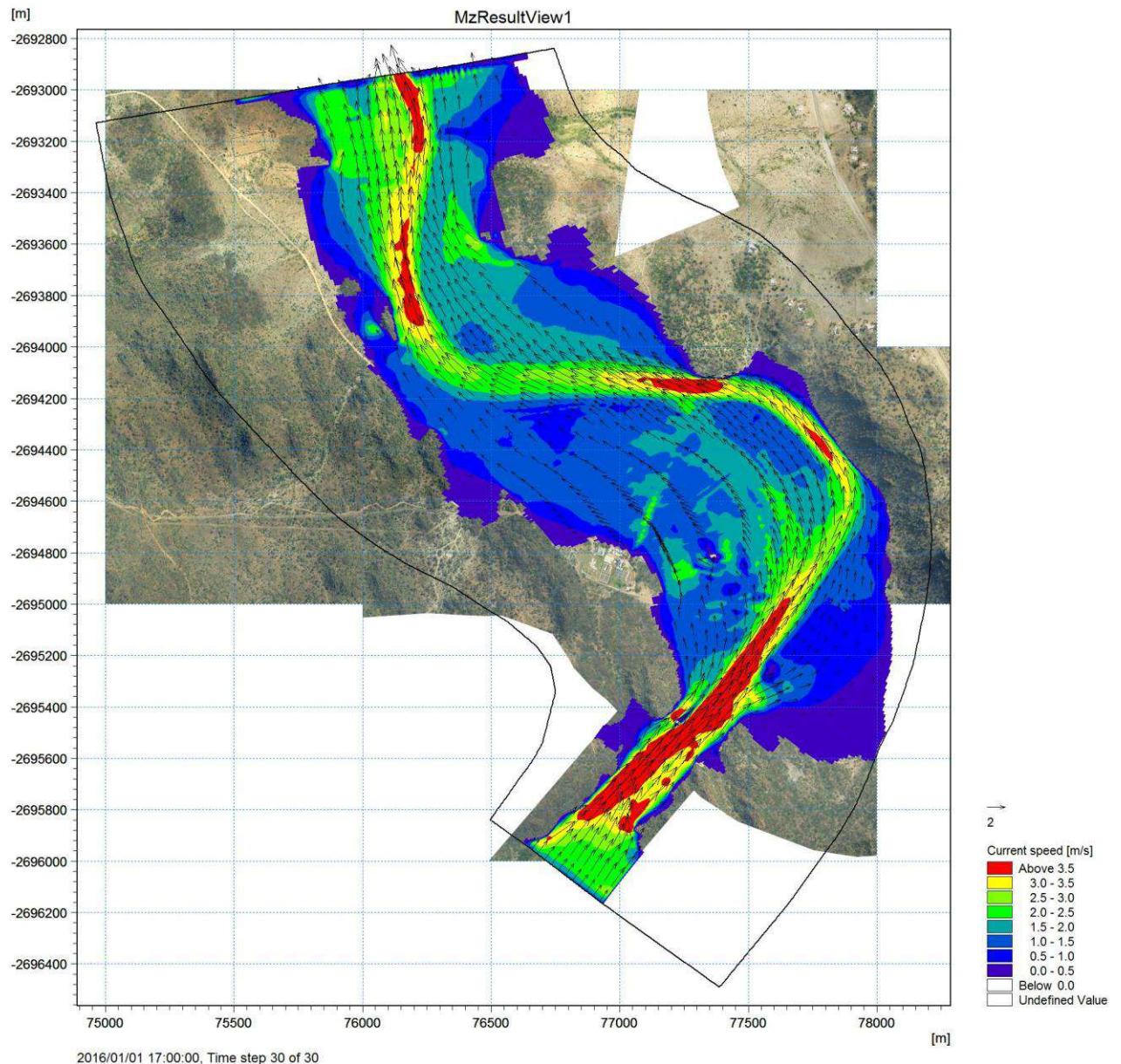


Figure 6-3 Simulated flow velocities at the peak of the 100 year flood

Simulation of sediment transport and scour was carried out by the hydrodynamic model and the model output for the flood hydrographs are enclosed in **Appendix B**. The scour patterns simulated during the 100 year flood are indicated in Figure 6-4. The right bank flow upstream of the pipe crossing is constricted by the hill and the river bend causes scour of the main channel which also widens during the large flood. In general it seems that the proposed pipe crossing site is a good site where the scoured main channel is relatively narrow compared to the rest of the river.

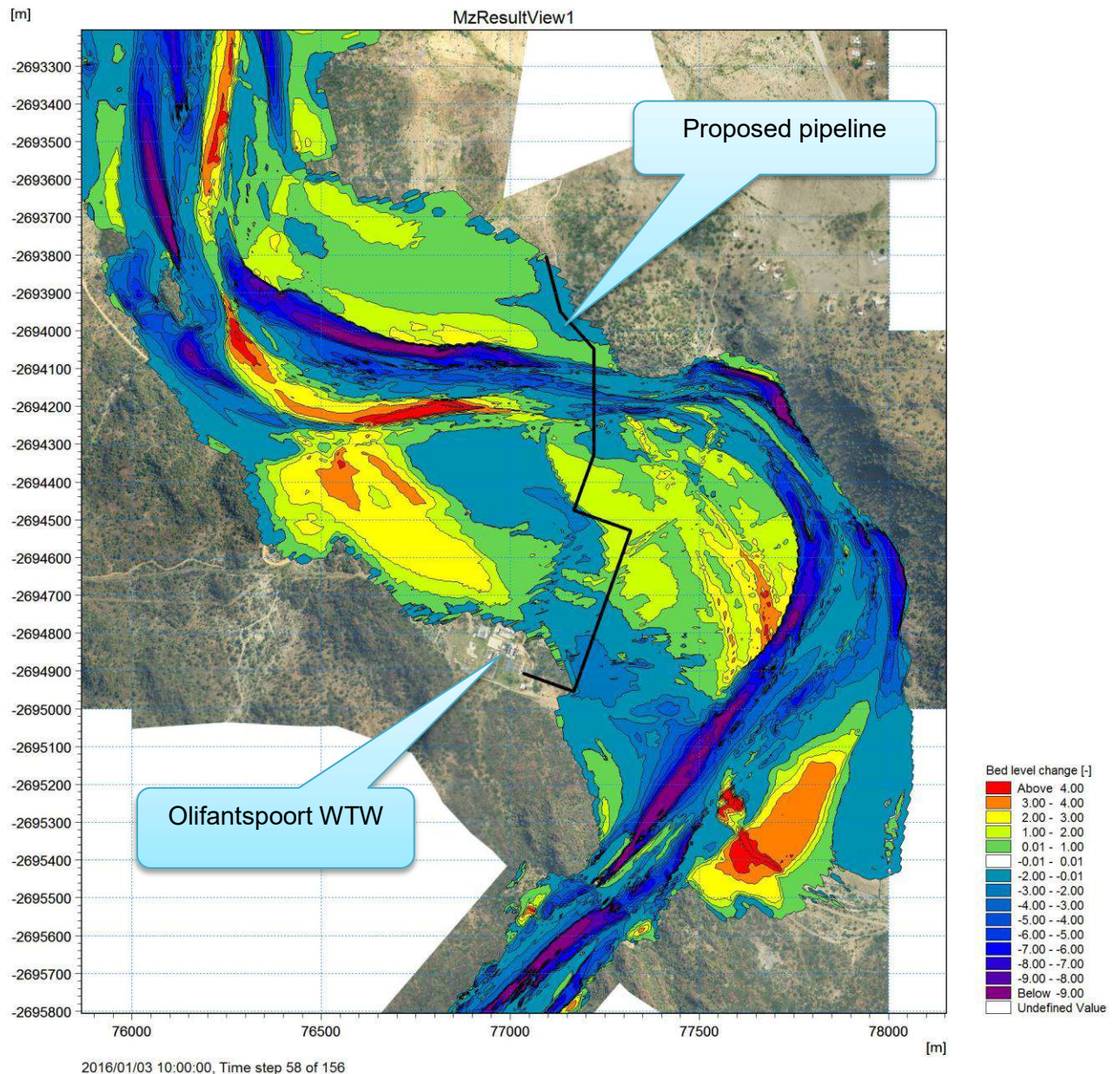


Figure 6-4 Simulated bed level change showing deepest scour during the 100 year flood hydrograph (m)

Figure 6-5 shows the simulated deepest scour along the pipe route as viewed from upstream. The locations of two boreholes are also indicated on the cross section with only borehole BH02 hitting hard rock at 7 m which is slightly deeper than the local bed scour indicated by the model. Borehole BH01 did not find hard rock down to 15 m deep, which is also deeper than the maximum scour simulated. The main channel moved laterally during different floods and the left bank floodplain scour is significant during the 200 year flood. The deepest scoured bed occurs during the 10 year flood at elevation 730.9 masl and scours the current main channel bed about 4.5 m deep. The formation of moving bed dunes however also needs consideration.

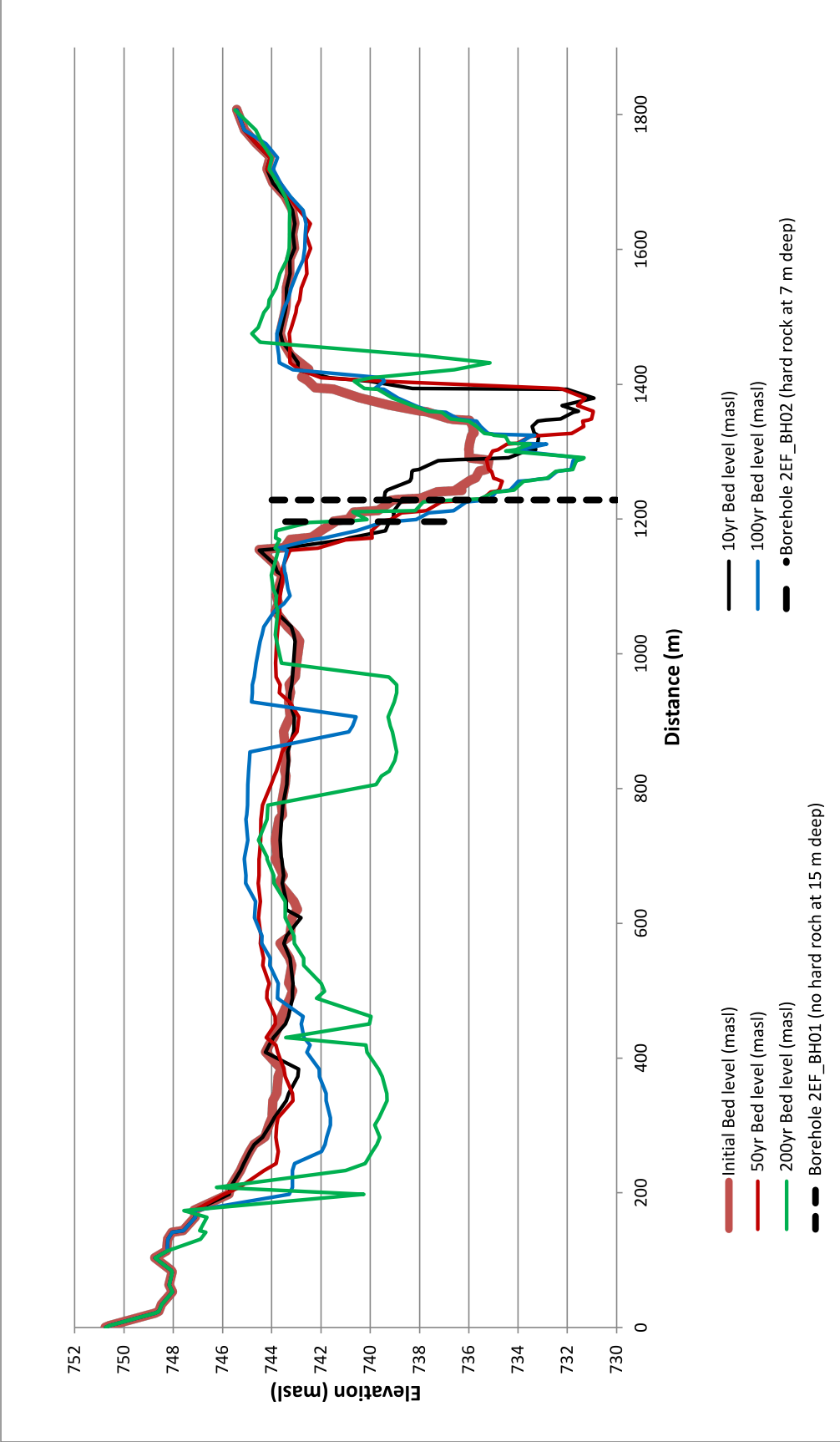


Figure 6-5 Simulated deepest general scour along the pipe route as viewed from upstream

The simulated flood levels at the main channel are as indicated in Table 6.1. The maximum bed dune height is estimated at 1/6 of the flow depth. If the dune height is subtracted from the simulated lowest bed level, the bed level for the pipe design is obtained (Table 6.1). The pipe should be encased in concrete and the top of the concrete on top of the pipe should be 1.5 m below the lowest bed level (as safety factor), for the pipe design indicated in the last column in Table 6.1. At the main channel of the river the concrete casing on top of the pipeline should therefore be below 727.1 masl, based on the last column in Table 6.1.

Table 6.1 Simulated flood levels and bed scour at the pipe route on the main channel of the Olifants River

ARI flood (yr)	Simulated water level (masl)	Simulated lowest scoured bed level (masl)	Deepest flow depth D = Water level – scoured bed level (m)	Max. bed dune height D/6 (m)	Lowest design invert level for the concrete casing of the pipeline = Lowest scoured bed level minus the bed dune height – 1.5 m (masl)
10	743.46	730.92	12.54	2.09	727.33
50	744.96	730.95	14.01	2.34	727.12
100	745.72	731.42	14.3	2.38	727.54
200	746.61	731.31	15.3	2.55	727.26

Based on the data in the table above it is proposed that the pipeline is constructed deep enough below the river bed and floodplains as shown in Figure 6-6. The data for the proposed top elevation of the concrete casing of the pipeline (dotted line), is enclosed in **Appendix C**. The maximum required depth of the top of the concrete casing below the current bed level is 13.5 m and is located at the right bank of the main channel.

Concrete casing of the pipeline is proposed where the pipeline is in the 100 year floodlines, but the 200 year floodlines may also be considered in the design. The floodlines for the ARI floods are enclosed in **Appendix D** and are available as AUTOCAD drawings.

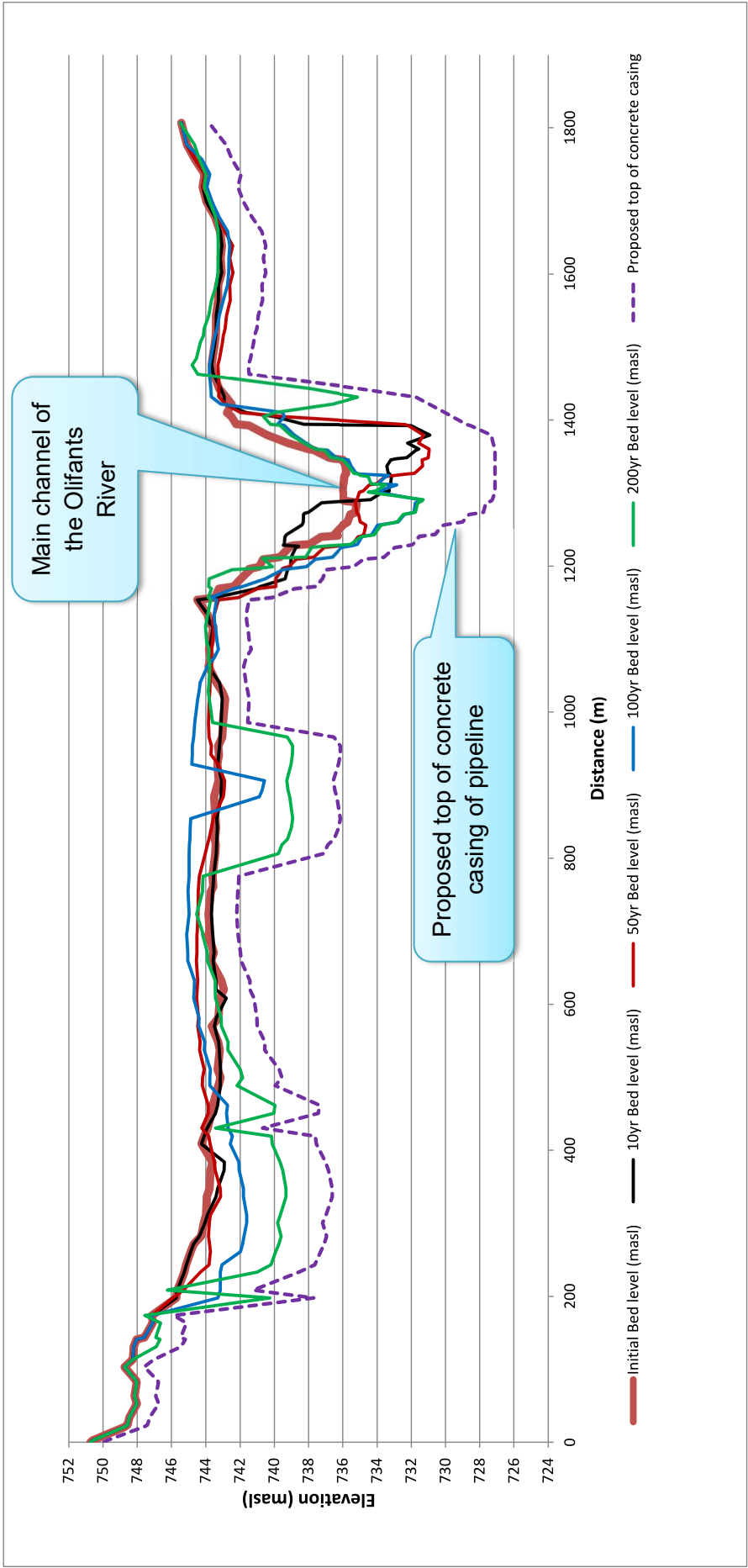


Figure 6-6 Proposed highest invert levels on top of the concrete casing of the pipeline to prevent scour of the pipeline river crossing (viewed looking downstream)

7. CONCLUSIONS AND RECOMMENDATIONS

The annual recurrence interval flood peaks were determined by using a probabilistic methodology based on DWS flow gauging station B5H002 located relatively close to the site. The data of the flow gauging station was improved and extended by correlation with two other DWS gauging stations further downstream to create a long record. A large historical flood of year 1908 was also included in the analysis. The log Pearson type 3 distribution fitted the data best and ARI floods were compared with the empirical Regional Maximum Flood methodology floods. The two methods gave similar results after adjustments were made to the probabilistic floods to compensate for flood flow measurement inaccuracy. The recommended ARI floods used in this study were further adjusted for climate change by 2060 and future land degradation impacts. The 100 year flood peak used in this study is 6000 m³/s. Due to the importance to design a sustainable pipe crossing of the river a range of ARI floods were considered: 10 year, 50 year, 100 year and 200 year floods. A typical flood hydrograph was derived from observed data.

A two dimensional hydrodynamic model was set up based on LiDAR data which was supplied in a 2 m x 2 m grid. Hydraulic roughness was spatially specified in the model with typical values for the main sand bed alluvial river previously calibrated on similar rivers. The downstream boundary of the model is a water level time series boundary based on uniform flow calculations. The bed sediment particle size was obtained from a grading analysis of a river bed sample.

The hydrodynamic model simulations of the flood hydrographs indicated relatively high flood flow velocities at the main channel of the river on the pipe route (**Appendix A**). The simulated deepest scour occurs at the right bank of the main channel, but the main channel also widens on the left bank side. The maximum scour depth for the 10 year flood is similar to that of larger floods but the locations of deepest scour differ: for the 10 and 50 year floods deepest scour is near the right bank of the main channel, while in larger floods the location of deepest scour shifts to the left bank. In general it seems that the proposed pipe crossing site is a good site where the scoured main channel is relatively narrow compared to the rest of the river. On the left bank floodplain scour along the pipe route was also simulated several meters deep during the 100 and 200 year floods (Figure 6-5 and **Appendix B**).

It is proposed that the pipeline is constructed deep enough below the river bed and floodplains as shown in Figure 6-6. The proposed top of the concrete casing of the pipeline was calculated by taking the lowest scoured bed level at a specific chainage along the pipe route for all 4 floods simulated, then the bed dune height was subtracted and a further 1.5 m was subtracted as safety factor. The maximum required depth of the top of the concrete casing below the current bed level is 13.5 m and is located at the right bank of the main channel. The recommended top of concrete casing below the current bed at the location of the borehole 2EF_BH02 is shallower than the hard rock level. The data for the proposed top elevation of the concrete casing of the pipeline is enclosed in **Appendix C**.

Concrete casing of the pipeline is proposed where the pipeline is inside the 100 year floodlines, but the 200 year floodlines may also be considered in the design due to the

importance of the pipe crossing in the scheme. The floodlines for the ARI floods are enclosed in **Appendix D** and are available as AUTOCAD drawings.

8. REFERENCES

DEA. (2015). Climate Change Adaptation: Perspectives for Disaster Risk Reduction and Management in South Africa *Provisional modelling of drought, flood and sea level rise impacts and a description of adaptation responses* REPORT No 3 FOR THE LONG TERM ADAPTATION SCENARIOS RESEARCH FLAGSHIP PROGRAM (LTAS). Department of Environmental Affairs.

TR137. (1988). Regional Maximum Flood Peaks in South Africa, Technical report TR137 Department of Water Affairs, Hydrology.

APPENDIX A SIMULATED FLOW DEPTHS AND FLOW VELOCITIES AT THE PEAK OF THE ARI FLOODS

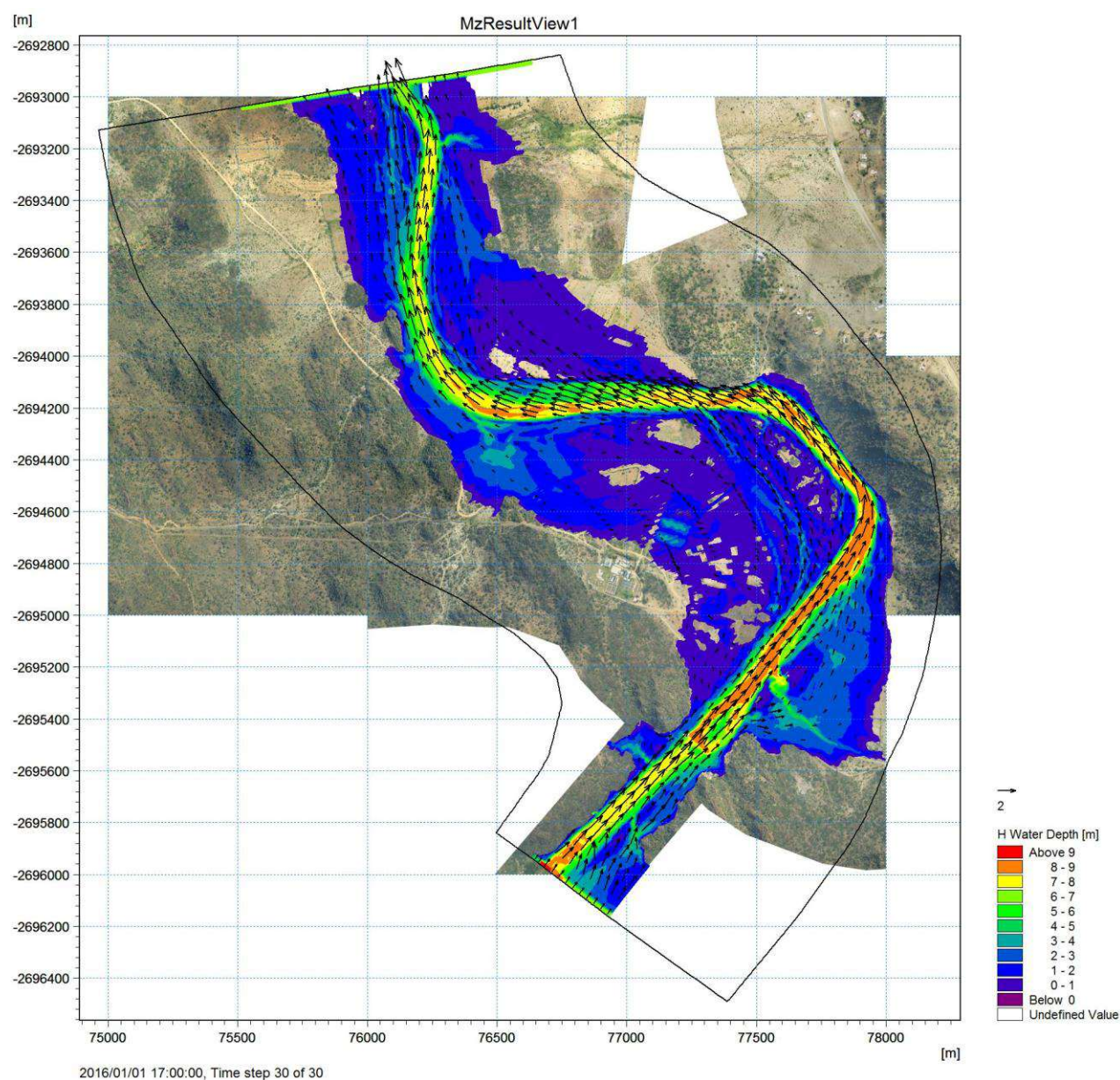


Figure A-1 Simulated flow depths at the peak of the 10 year flood

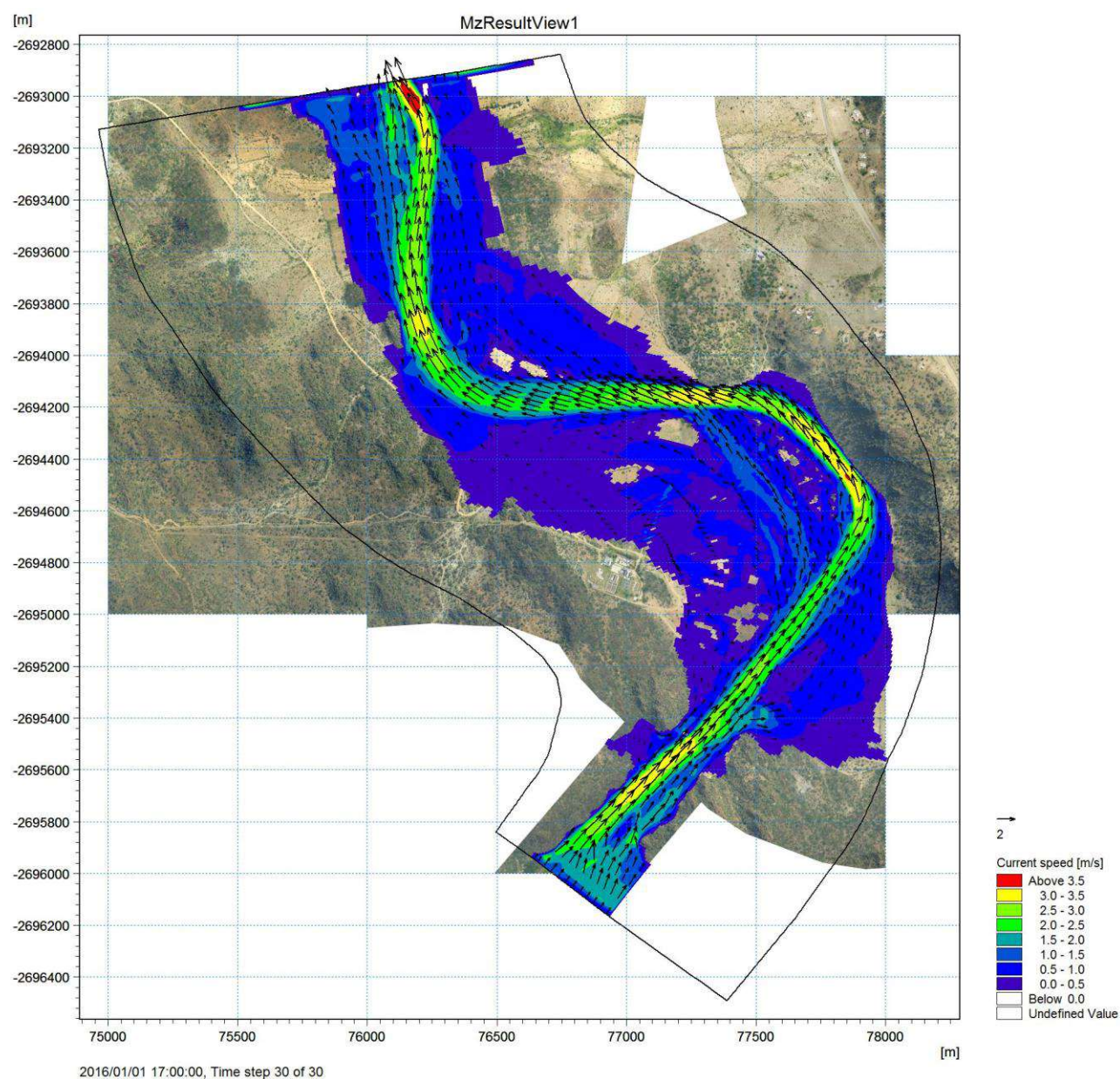


Figure A-2 Simulated flow velocities at the peak of the 10 year flood

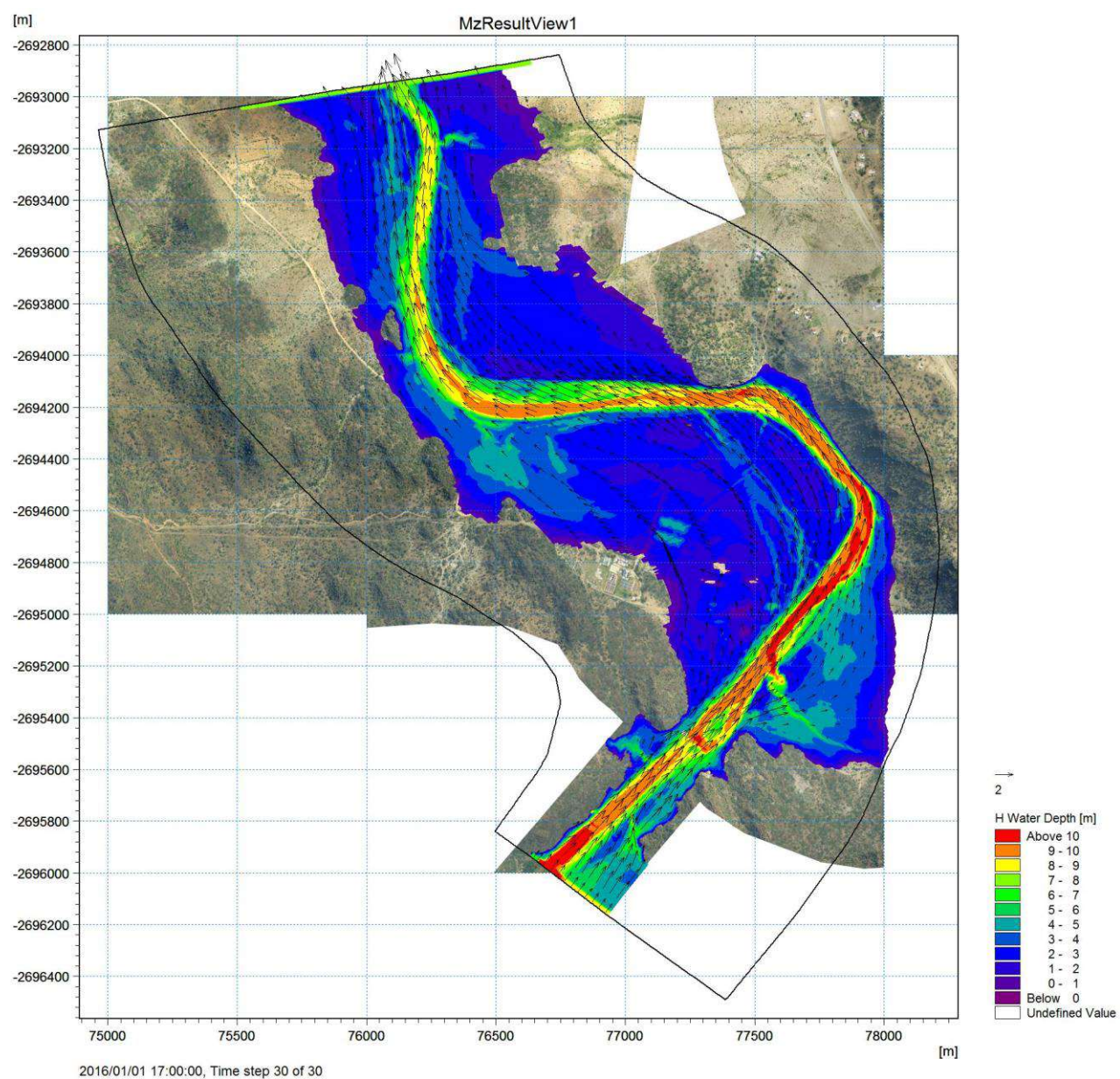


Figure A-3 Simulated flow depths at the peak of the 50 year flood

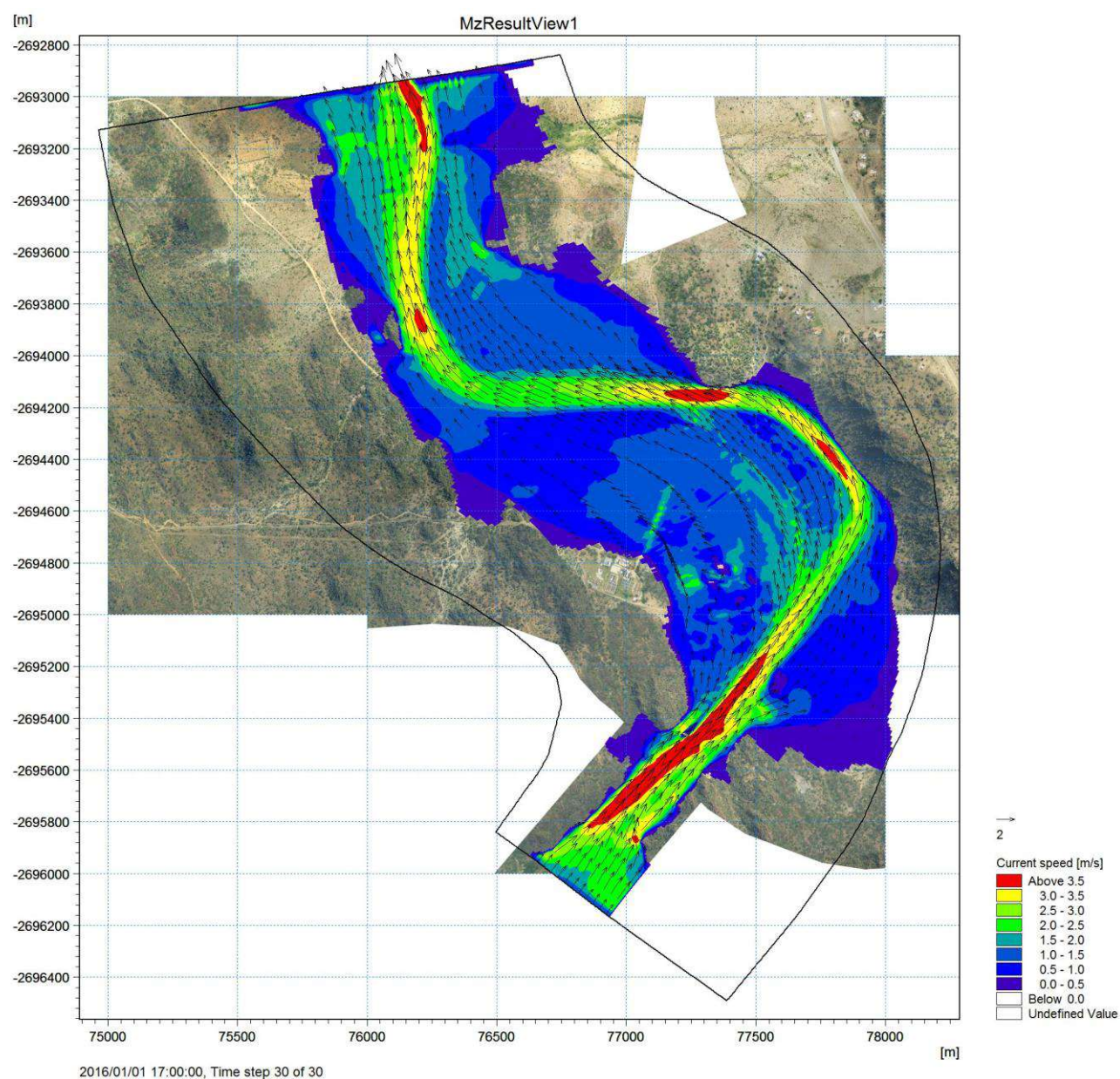


Figure A-4 Simulated flow velocities at the peak of the 50 year flood

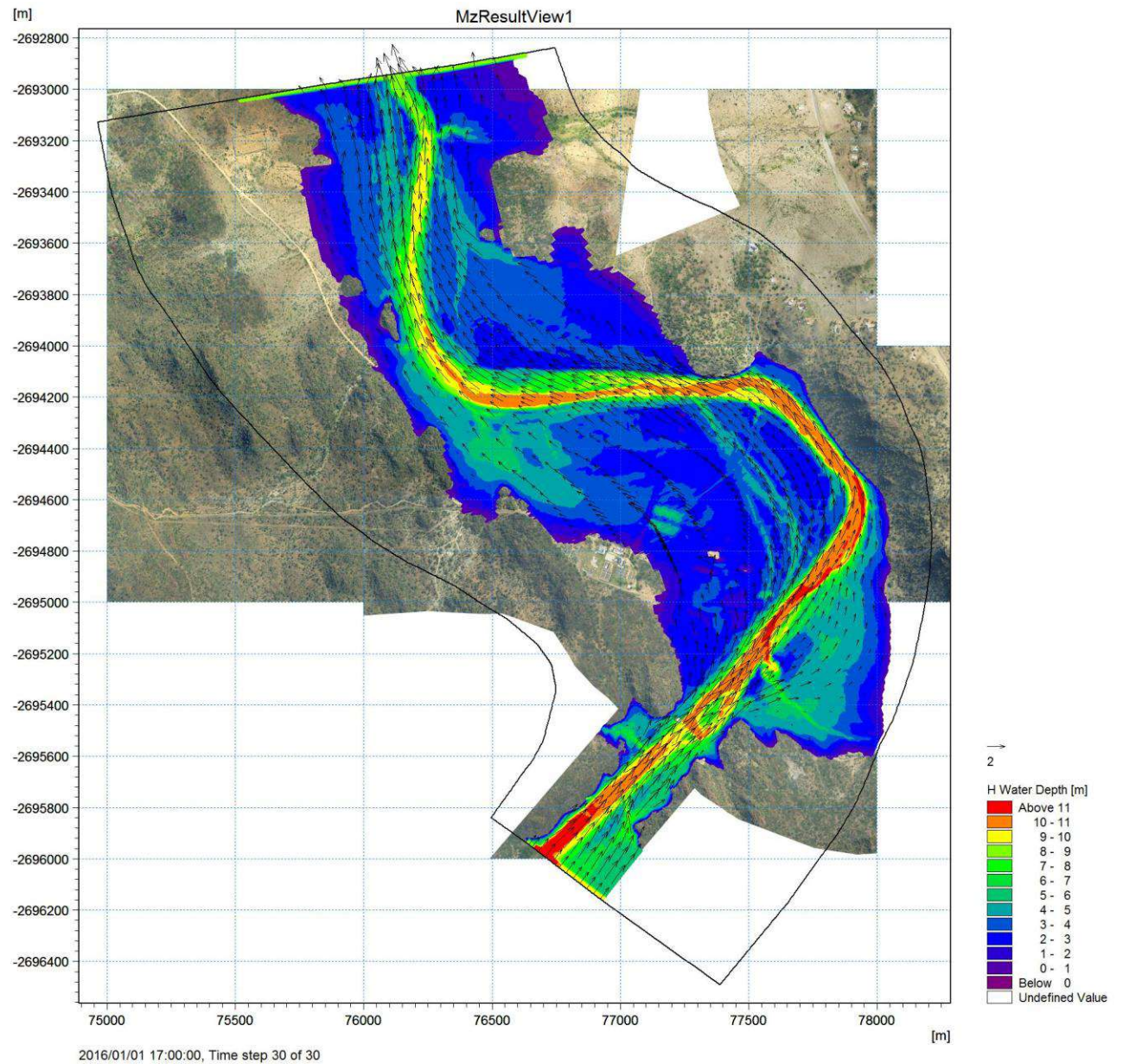


Figure A-5 Simulated flow depths at the peak of the 100 year flood

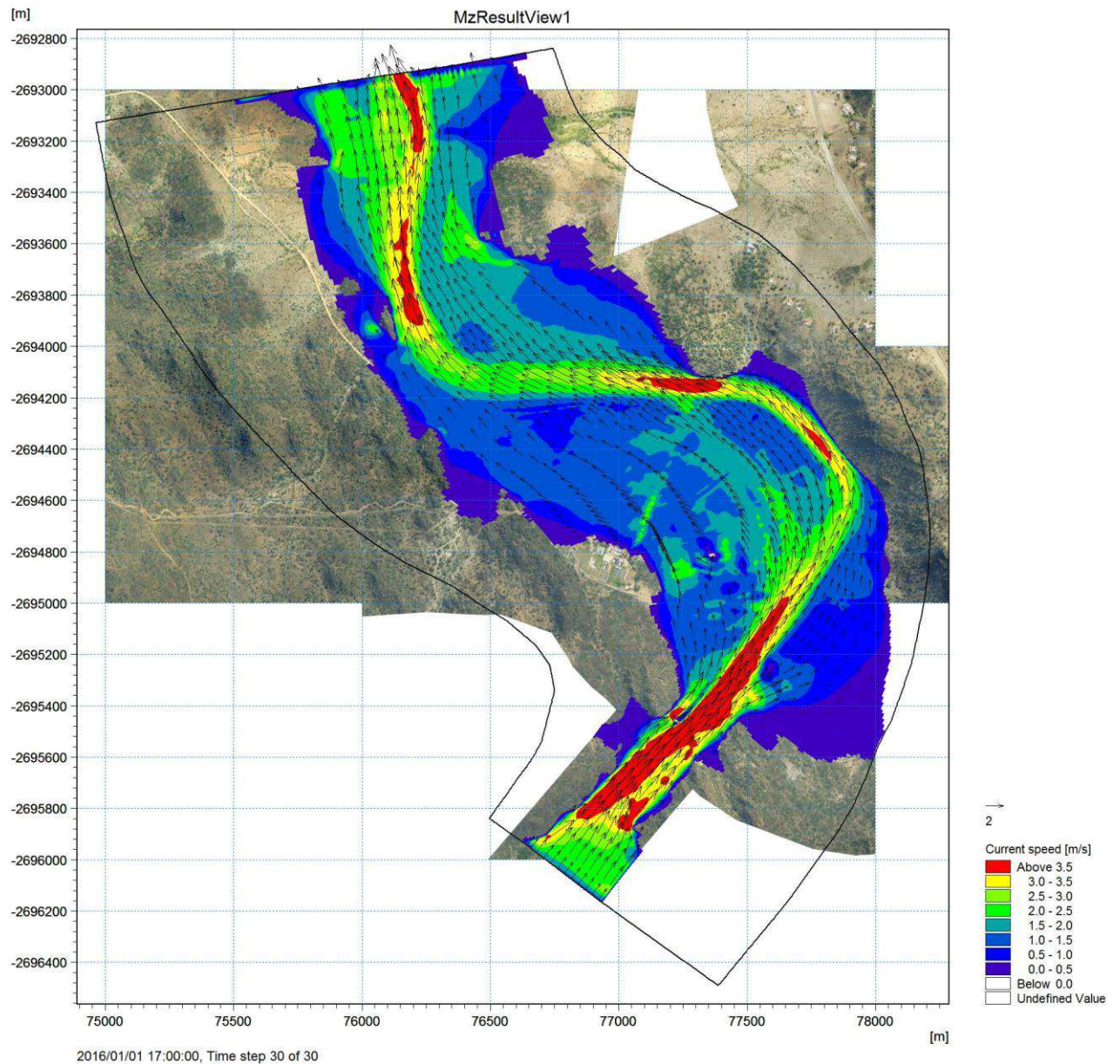


Figure A-6 Simulated flow velocities at the peak of the 100 year flood

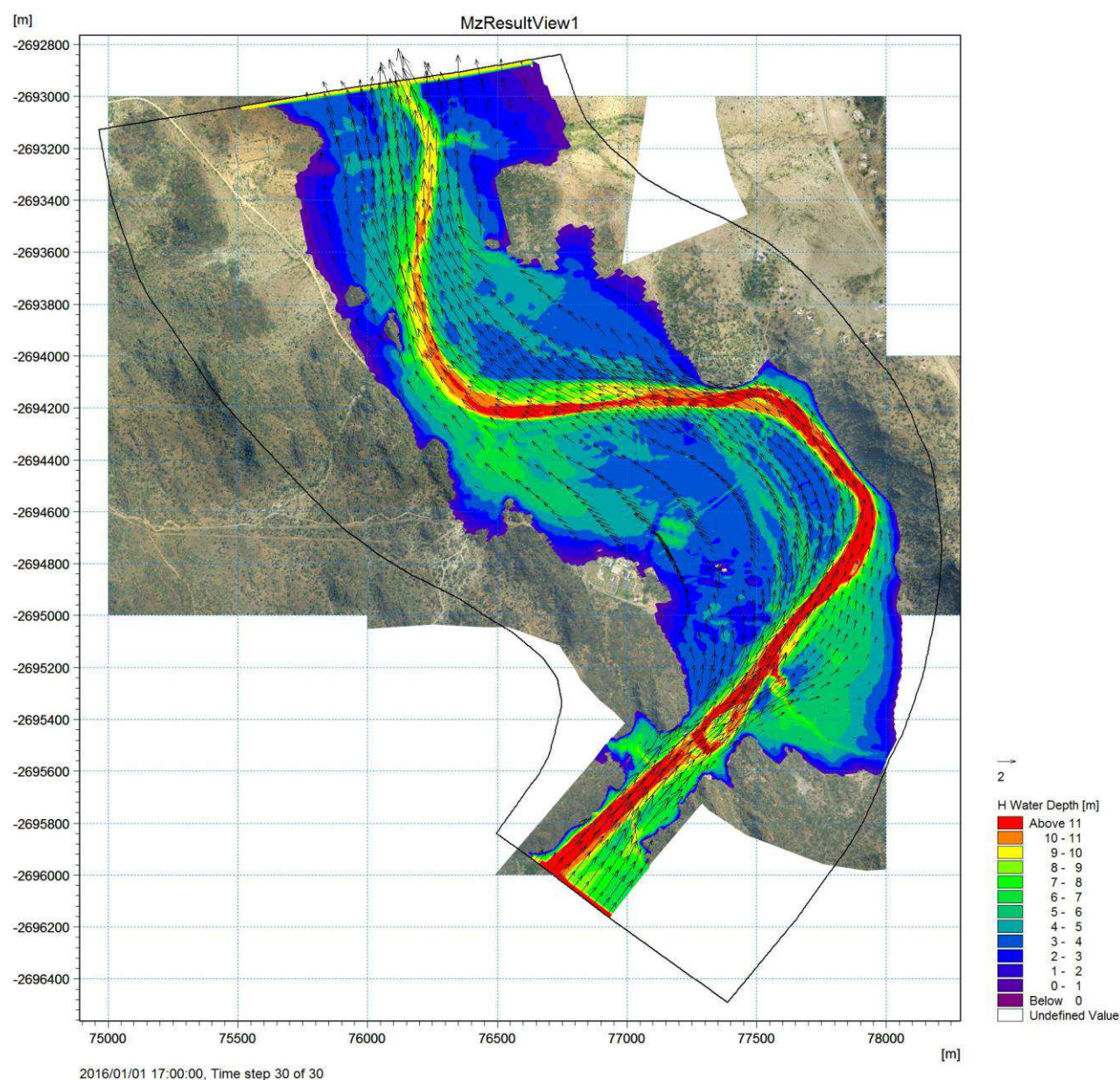


Figure A-7 Simulated flow depths at the peak of the 200 year flood

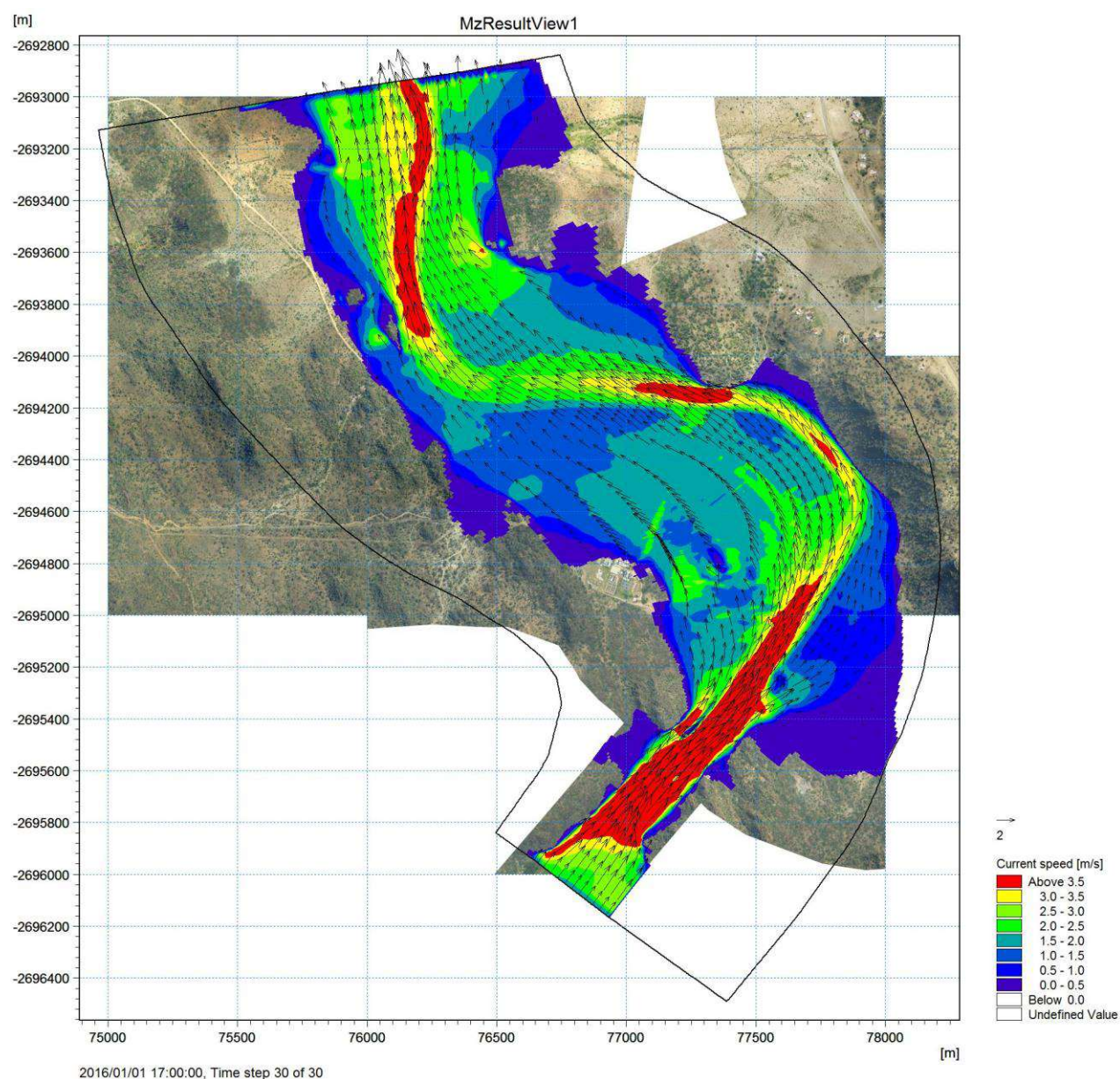


Figure A-8 Simulated flow velocities at the peak of the 200 year flood

**APPENDIX B SIMULATED BED LEVEL CHANGE DURING ARI
FLOODS (NEGATIVE VALUES INDICATE BED SCOUR (M); BLACK
LINE INDICATES PROPOSED PIPE ROUTE)**

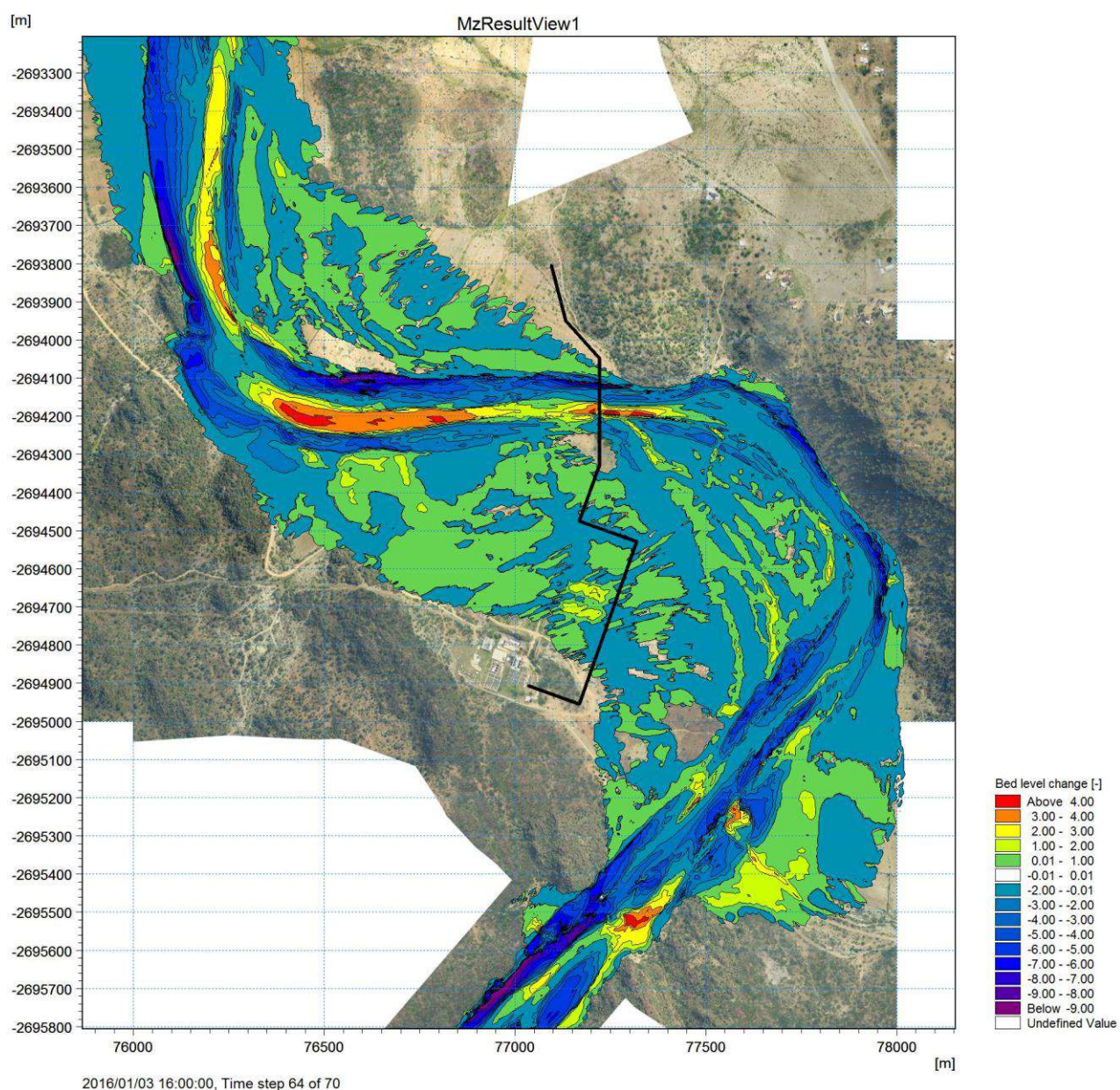


Figure B-1 Simulated bed level change showing deepest scour during the 10 year flood hydrograph (m) (Blue = erosion; green, yellow, orange and red = deposition)

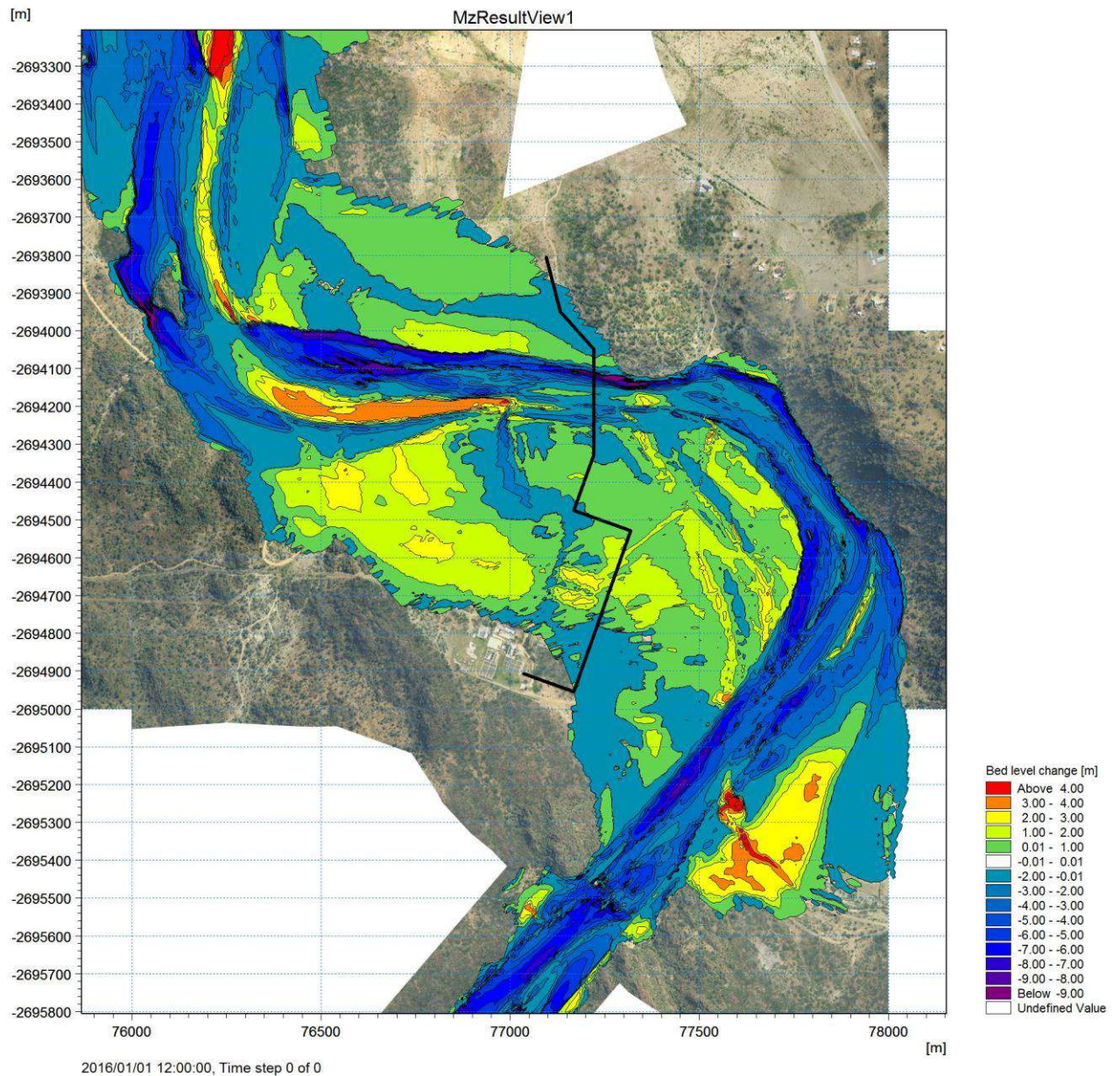


Figure B-2 Simulated bed level change showing deepest scour during the 50 year flood hydrograph (m)

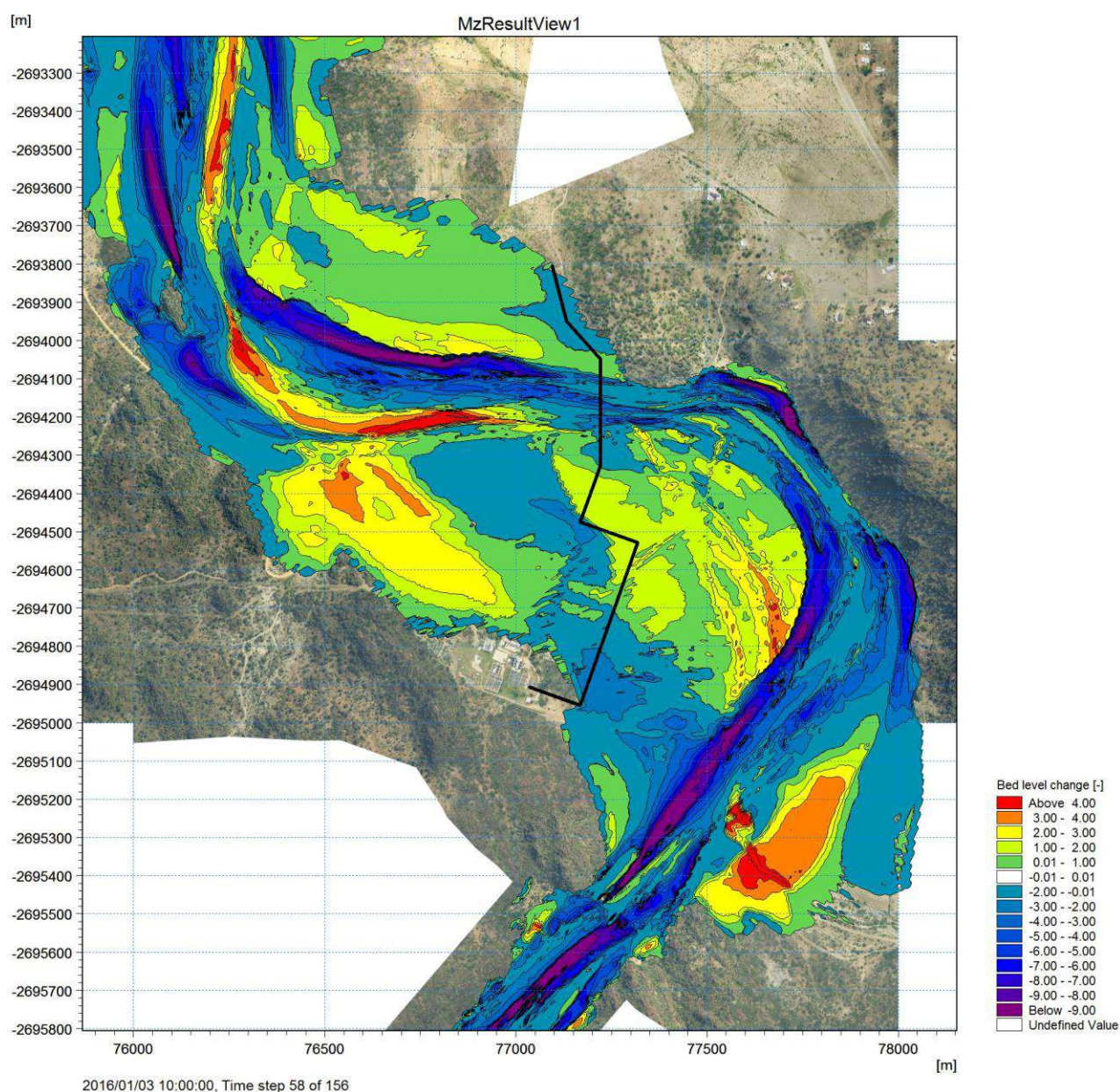


Figure B-3 Simulated bed level change showing deepest scour during the 100 year flood hydrograph (m)

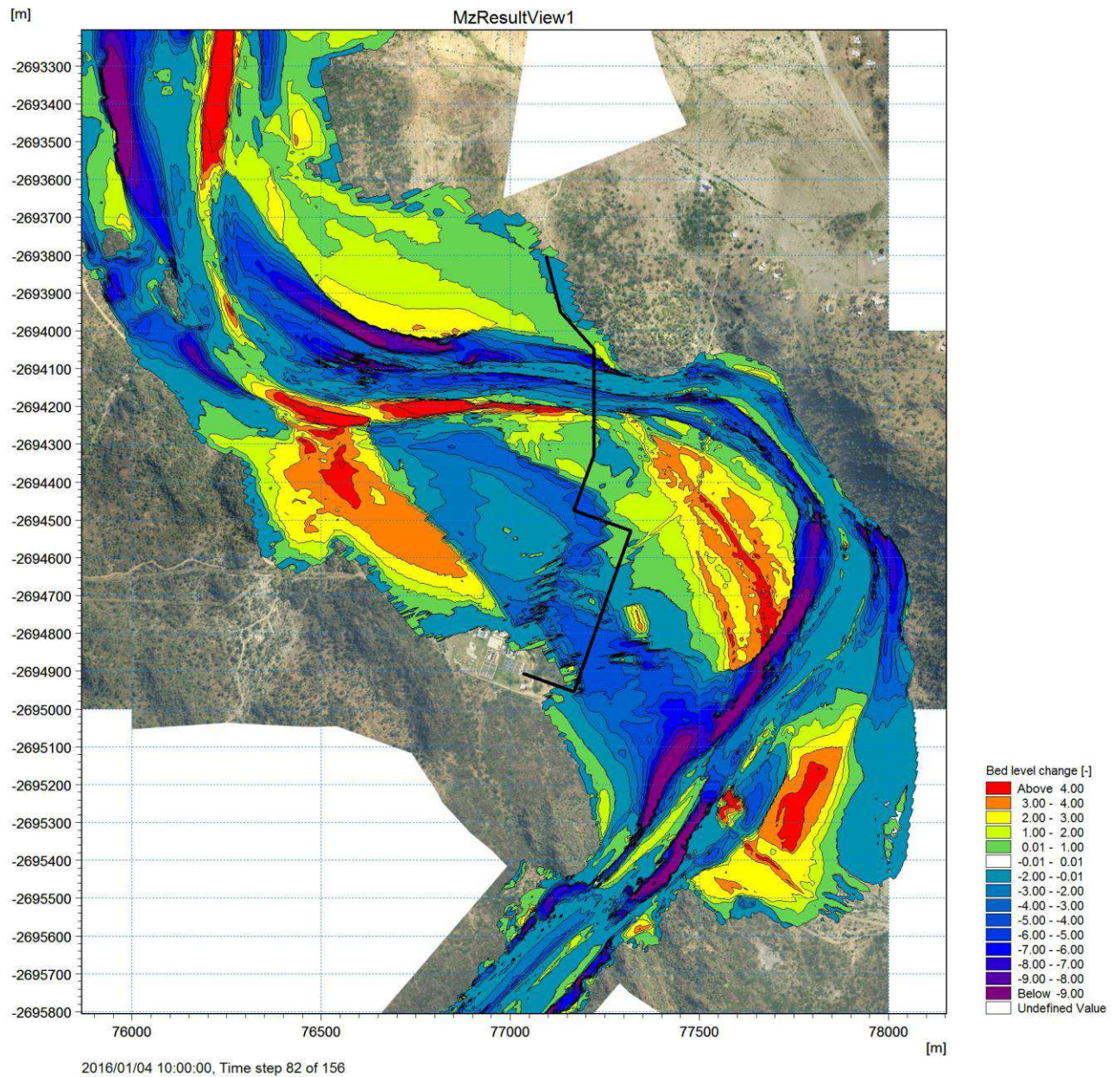


Figure B-4 Simulated bed level change showing deepest scour during the 200 year flood hydrograph (m)

**APPENDIX C PROPOSED TOP OF CONCRETE CASING
ELEVATION DATA ALONG THE PIPE CROSSING OF THE
OLIFANTS RIVER (3RD LAST COLUMN)**

X	Y	Chainage (m)	Initial survey ed Bed level (masl)	Simulated 10yr flood Bed level (masl)	Simulated 50yr flood Bed level (masl)	Simulated 100yr flood Bed level (masl)	Simulated 200yr flood Bed level (masl)	Proposed max elevation of top of concrete casing of pipe	Min. depth to top concrete below current bed level (m)	Comments
77048	-2694910	0	750.74	750.74	750.74	750.74	750.74	749.9	0.81	
77050	-2694910	3	750.59	750.59	750.59	750.59	750.59	749.8	0.84	
77069	-2694910	21	748.72	748.72	748.72	748.72	748.72	747.6	1.15	
77072	-2694910	24	748.58	748.58	748.58	748.58	748.58	747.4	1.17	
77074	-2694920	34	748.47	748.47	748.47	748.47	748.47	747.3	1.19	
77093	-2694920	53	748.02	748.02	748.02	748.02	748.03	746.8	1.26	
77096	-2694930	63	748.16	748.16	748.16	748.16	748.16	746.9	1.24	
77114	-2694930	82	748.03	748.03	748.03	748.03	748.03	746.8	1.26	
77117	-2694930	84	748.07	748.07	748.07	748.07	748.07	746.8	1.26	
77136	-2694930	103	748.74	748.74	748.74	748.74	748.74	747.6	1.15	
77138	-2694940	114	748.25	748.25	748.25	748.25	748.25	747.0	1.23	
77156	-2694940	131	748.21	748.21	748.21	748.21	746.89	745.4	2.77	
77157	-2694950	141	748.04	748.04	748.04	748.04	746.68	745.2	2.85	
77159	-2694950	144	747.59	747.59	747.59	747.59	746.92	745.5	2.12	
77177	-2694960	164	747.10	747.10	747.10	747.10	746.63	745.1	1.96	
77174	-2694950	174	747.14	747.14	747.14	747.14	747.57	745.9	1.26	
77188	-2694930	198	745.73	745.73	745.93	743.29	740.26	737.7	8.03	
77185	-2694920	208	745.67	745.67	745.31	743.16	746.23	741.2	4.43	
77199	-2694900	233	745.26	745.26	744.31	743.16	740.99	738.6	6.70	
77196	-2694890	243	745.14	745.14	743.82	743.07	740.20	737.6	7.50	
77210	-2694880	261	744.89	744.89	743.74	741.97	739.91	737.3	7.59	
77207	-2694870	272	744.71	744.71	743.79	741.84	739.73	737.1	7.63	
77204	-2694860	282	744.27	744.37	743.84	741.77	739.61	736.9	7.32	
77219	-2694850	301	744.11	744.06	743.80	741.62	739.81	737.2	6.93	
77216	-2694840	311	743.99	743.90	743.74	741.61	739.64	737.0	7.01	
77232	-2694820	336	743.95	743.41	743.14	741.80	739.32	736.6	7.34	
77228	-2694810	347	743.78	743.31	743.16	741.80	739.32	736.6	7.17	
77243	-2694790	372	743.73	742.93	743.45	742.06	739.51	736.8	6.90	
77238	-2694780	384	743.62	742.91	743.50	742.07	739.67	737.0	6.61	
77253	-2694760	409	744.25	744.25	743.75	742.57	740.13	737.5	6.70	
77250	-2694750	419	744.10	744.10	743.83	742.44	740.18	737.6	6.49	
77245	-2694740	430	743.90	743.92	744.23	742.69	743.43	740.7	3.22	
77262	-2694730	451	743.67	743.44	743.85	742.80	740.03	737.4	6.24	
77258	-2694720	462	743.59	743.32	743.87	742.73	739.97	737.4	6.23	
77276	-2694700	489	743.26	743.16	744.21	743.77	742.18	739.9	3.31	
77272	-2694690	499	743.15	743.16	744.19	743.75	741.86	739.6	3.58	
77267	-2694680	511	743.31	743.14	744.10	743.73	741.98	739.7	3.60	

77284	-2694660	537	743.18	743.22	744.36	744.08	742.71	740.6	2.62	
77280	-2694650	548	743.27	743.25	744.33	744.06	742.70	740.5	2.73	
77299	-2694640	570	743.65	743.50	744.46	744.41	743.09	741.0	2.65	
77294	-2694630	581	743.26	743.40	744.43	744.39	743.10	741.0	2.25	
77312	-2694610	608	743.17	742.81	744.54	744.70	743.45	741.2	1.97	
77306	-2694600	620	742.96	743.41	744.50	744.68	743.45	741.4	1.53	
77299	-2694590	632	743.09	743.41	744.47	744.66	743.45	741.4	1.67	
77318	-2694570	659	743.70	743.57	744.54	745.06	743.90	742.0	1.75	
77312	-2694560	671	743.53	743.52	744.52	745.05	743.92	742.0	1.56	
77327	-2694540	695	743.86	743.59	744.51	745.11	744.18	742.1	1.75	
77324	-2694540	698	743.77	743.61	744.50	745.10	744.19	742.1	1.63	
77339	-2694520	723	743.85	743.66	744.45	744.97	744.53	742.2	1.65	
77309	-2694520	754	743.70	743.60	744.44	745.04	744.18	742.1	1.58	
77302	-2694520	761	743.56	743.58	744.42	745.02	744.18	742.1	1.45	
77291	-2694510	775	743.61	743.55	744.37	744.98	744.16	742.1	1.54	
77261	-2694510	806	743.45	743.38	744.02	744.97	739.76	737.1	6.33	
77253	-2694500	818	743.42	743.37	743.90	744.95	739.54	736.9	6.55	
77246	-2694500	826	743.47	743.36	743.81	744.94	739.24	736.5	6.96	
77234	-2694490	841	743.40	743.32	743.67	744.91	739.00	736.2	7.17	
77226	-2694480	854	743.44	743.35	743.59	744.89	738.93	736.1	7.29	
77196	-2694480	884	743.52	743.11	742.98	740.87	739.10	736.4	7.17	
77188	-2694480	893	743.42	743.10	742.94	740.71	739.19	736.5	6.97	
77179	-2694470	906	743.25	743.08	742.90	740.57	739.28	736.6	6.69	
77189	-2694450	929	743.31	743.28	743.28	744.81	739.02	736.3	7.06	
77198	-2694440	942	743.23	743.25	743.70	744.79	738.93	736.2	7.07	
77192	-2694430	954	743.28	743.19	743.66	744.78	738.93	736.1	7.13	
77198	-2694420	966	743.04	743.16	743.81	744.72	739.24	736.5	6.52	
77202	-2694400	986	742.99	743.11	743.84	744.64	743.60	741.6	1.44	
77214	-2694370	1018	742.87	743.05	743.80	744.47	743.80	741.5	1.39	
77213	-2694360	1028	743.03	743.11	743.78	744.40	743.86	741.5	1.49	
77220	-2694350	1040	743.37	743.20	743.74	744.32	743.82	741.7	1.71	
77230	-2694330	1063	743.85	743.85	743.67	743.90	743.76	741.8	2.07	
77225	-2694320	1074	743.72	743.72	743.69	743.51	743.83	741.6	2.08	
77231	-2694310	1086	743.82	743.82	743.66	743.26	743.80	741.4	2.46	
77228	-2694300	1096	743.72	743.72	743.61	743.35	743.94	741.5	2.27	
77224	-2694280	1117	743.56	743.56	743.54	743.43	744.02	741.5	2.01	
77229	-2694280	1121	743.78	743.78	743.60	743.47	743.98	741.6	2.18	
77223	-2694270	1133	743.88	743.88	743.51	743.51	743.88	741.6	2.24	
77229	-2694250	1154	744.50	744.50	743.26	743.37	743.73	741.5	3.03	
77232	-2694250	1157	743.49	743.49	742.12	743.75	743.86	740.1	3.34	
77225	-2694240	1169	743.25	741.10	741.00	742.38	743.68	738.8	4.41	
77228	-2694240	1172	742.38	740.83	739.92	741.87	743.84	737.6	4.79	
77230	-2694230	1182	741.98	739.38	739.94	740.55	743.82	737.2	4.77	
77223	-2694220	1195	741.43	739.24	739.58	739.53	742.47	737.0	4.43	

77225	-2694220	1196	741.49	739.14	739.55	739.09	741.53	736.5	5.00	Hard rock 7 m deep
77226	-2694220	1198	741.11	739.10	739.42	738.62	740.59	735.9	5.17	
77227	-2694220	1199	740.88	739.07	739.16	738.14	740.13	735.4	5.51	
77229	-2694210	1209	740.67	739.04	738.74	737.62	740.64	734.8	5.90	
77230	-2694210	1211	740.17	739.08	738.20	737.10	740.70	734.2	6.01	
77232	-2694210	1212	739.68	739.03	737.72	736.62	738.19	733.6	6.08	
77223	-2694200	1226	739.14	738.77	737.11	736.09	737.84	733.0	6.16	
77225	-2694200	1227	739.16	738.59	736.41	735.64	737.23	732.5	6.70	
77226	-2694200	1228	738.92	739.49	735.86	735.37	736.37	732.1	6.77	Hard rock deeper than 15 m
77227	-2694200	1230	737.97	739.43	735.43	735.14	735.54	731.9	6.10	
77229	-2694190	1240	737.29	739.39	735.10	734.89	734.95	731.5	5.78	
77230	-2694190	1242	736.29	739.35	734.88	734.64	734.52	731.0	5.28	
77232	-2694190	1243	736.53	739.31	734.78	734.33	734.16	730.6	5.94	
77223	-2694180	1256	735.99	738.40	734.64	733.98	733.78	730.1	5.85	
77225	-2694180	1257	735.89	738.38	734.74	733.58	733.47	729.8	6.11	
77226	-2694180	1259	735.82	738.35	734.86	733.14	733.16	729.4	6.40	
77228	-2694180	1260	735.72	738.32	734.98	732.76	732.82	729.0	6.70	
77229	-2694170	1271	735.57	738.31	735.08	732.42	732.47	728.6	6.96	
77230	-2694170	1272	735.40	738.25	735.15	732.11	732.11	728.2	7.21	
77232	-2694170	1273	735.26	738.03	735.19	731.85	731.77	727.8	7.46	
77223	-2694160	1287	735.19	737.25	735.27	731.76	731.63	727.6	7.56	
77225	-2694160	1288	735.48	736.42	735.28	731.58	731.47	727.4	8.04	
77226	-2694160	1290	735.93	735.36	735.25	731.42	731.37	727.3	8.61	
77228	-2694160	1291	736.00	734.38	735.17	731.53	731.31	727.3	8.73	
77229	-2694150	1301	735.99	733.68	735.03	733.98	734.50	727.1	8.88	all made same as ch1359 m
77231	-2694150	1303	736.01	733.28	734.81	733.91	734.09	727.1	8.89	all made same as ch1359 m
77222	-2694150	1311	735.98	733.32	734.45	732.84	733.51	727.1	8.87	all made same as ch1359 m
77224	-2694150	1313	735.96	733.20	734.02	733.96	734.36	727.1	8.85	all made same as ch1359 m
77225	-2694140	1323	735.91	733.16	733.52	733.49	734.52	727.1	8.79	all made same as ch1359 m
77227	-2694140	1324	735.87	733.19	732.95	733.32	734.97	727.1	8.76	all made same as ch1359 m
77228	-2694140	1326	735.84	733.25	732.32	734.97	735.07	727.1	8.73	all made same as ch1359 m
77230	-2694140	1327	735.79	733.34	731.81	735.21	735.37	727.1	8.68	all made same as ch1359 m
77231	-2694130	1337	735.84	733.42	731.33	735.52	735.67	727.1	8.72	all made same as ch1359 m
77223	-2694130	1346	735.98	733.19	731.37	735.68	736.01	727.1	8.86	all made

										same as ch1359 m
77224	-2694130	1347	736.61	732.87	731.15	736.10	736.32	727.1	9.49	all made same as ch1359 m
77226	-2694130	1348	736.85	732.28	731.01	736.43	736.73	727.1	9.73	all made same as ch1359 m
77227	-2694120	1359	737.71	731.76	730.95	736.92	737.09	727.1	10.60	
77229	-2694120	1360	738.05	731.55	730.95	737.62	737.65	727.1	10.94	
77220	-2694120	1368	739.24	732.21	731.58	738.19	738.30	727.2	12.02	interpolated
77232	-2694120	1379	740.45	730.92	731.28	738.87	739.08	727.3	13.12	
77223	-2694110	1392	741.50	732.01	732.18	739.45	739.69	728.5	12.95	
77225	-2694110	1394	742.24	738.28	732.36	739.82	740.24	728.8	13.48	
77228	-2694100	1404	742.52	740.01	739.46	739.43	740.65	729.6	12.93	interpolated
77223	-2694100	1410	742.77	741.65	741.99	739.52	739.96	730.0	12.76	interpolated
77229	-2694090	1421	742.50	742.96	742.87	743.13	736.59	730.9	11.57	interpolated
77227	-2694080	1432	742.84	742.93	743.26	743.68	735.14	731.7	11.11	
77223	-2694070	1442	743.22	743.14	743.27	743.71	737.87	734.9	8.31	
77226	-2694050	1463	743.56	743.56	743.27	743.79	744.47	741.5	2.07	
77234	-2694040	1475	743.65	743.65	743.29	743.78	744.80	741.5	2.14	
77225	-2694040	1484	743.60	743.60	743.20	743.72	744.55	741.4	2.20	
77215	-2694020	1506	743.46	743.46	743.03	743.55	744.31	741.2	2.26	
77206	-2694020	1515	743.42	743.42	742.99	743.47	744.14	741.2	2.26	
77206	-2694010	1525	743.40	743.40	742.86	743.35	744.11	741.0	2.39	
77188	-2694010	1543	743.40	743.40	742.80	743.22	743.83	740.9	2.46	
77181	-2693990	1564	743.27	743.27	742.58	742.99	743.66	740.7	2.59	
77176	-2693970	1585	743.27	743.27	742.61	742.72	743.39	740.7	2.55	
77159	-2693970	1602	743.08	743.08	742.42	742.66	743.29	740.5	2.58	
77155	-2693950	1622	743.14	743.14	742.61	742.65	743.28	740.6	2.51	
77139	-2693950	1638	743.06	743.06	742.43	742.60	743.28	740.5	2.56	
77136	-2693930	1658	743.16	743.16	742.89	742.73	743.27	740.7	2.44	
77136	-2693910	1678	743.46	743.46	743.31	743.23	743.45	741.3	2.14	
77136	-2693890	1698	743.95	743.95	743.64	743.63	743.76	741.8	2.17	
77130	-2693870	1719	744.19	744.19	744.19	743.94	744.10	742.1	2.05	
77116	-2693860	1737	744.06	744.06	744.06	743.77	743.99	741.9	2.11	
77119	-2693840	1757	744.63	744.63	744.63	744.23	744.38	742.5	2.15	
77117	-2693820	1777	745.11	745.11	745.11	745.11	744.65	742.8	2.29	
77116	-2693790	1807	745.42	745.42	745.42	745.42	745.49	743.8	1.62	

APPENDIX D FLOODLINES OF ARI FLOODS SIMULATED BY 2D HYDRODYNAMIC MODEL

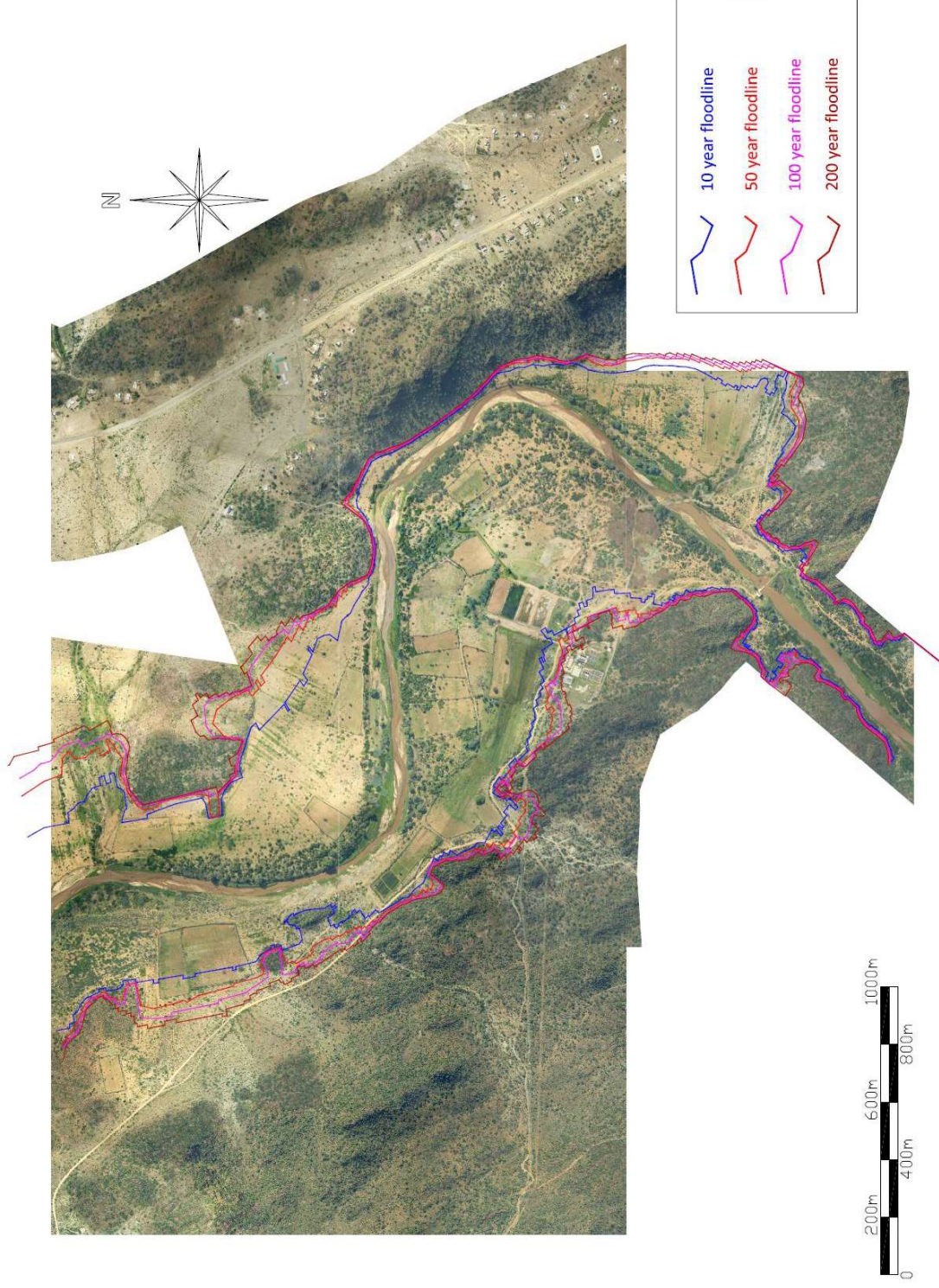


Figure D-1 ARI floodlines of the Olifants River at the Olifantspoort WTW

In diversity there is beauty and
there is strength.

MAYA ANGELOU

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