SMEC South Africa
Member of the Surbana Jurong Group

SMEC INTERNAL REF. JH0049

Draft Report

Tetra4 Gas Hydrological Assessment

Prepared for EIMS (Pty) Ltd
14 November 2022

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Declaration of Independence:

I, Rendani Thovhakale and Neil Meyer, representing SMEC South Africa (PTY) Ltd., hereby declare that I am an independent consultant appointed to provide specialist input for the hydrological component of an Environmental Impact Assessment (EIA) study for the proposed Gas Cluster 2 project. I confirm that I have no personal financial interest other than the remuneration of the EIA study itself, neither I nor SMEC South Africa (Pty) Ltd will benefit in any other away from the outcomes of the Gas Cluster 2 project. I further declare that opinions expressed in this report have been formulated in an objective manner without interference from any third party.

Rendani Thovhakale	
Name	Signature
Neil Meyer	
Name	Signature
27-July-2022	
Date	

Summary of Expertise:

Rendani Thovhakale

Rendani is a registered ECSA Candidate Civil Engineer with 6 years of experience in undertaking Hydrological impact assessments. He has specialist skills in hydrological analysis and hydraulic modelling. Rendani has worked on similar hydrological projects based in 6 different countries including Lesotho, Mauritius, South Africa, Eswatini, Guinea and Mali. He has undertaken Environmental Impact Assessment (EIA) studies in the hydrology specialist area with adherence to relevant legislation and guidelines including the National Water Act, Act 36 of 1998 (NWA) aimed at the protection of water resources.

Neil Meyer

Neil is a registered ECSA professional Civil Engineer with 20 year of experience in the design and project management of various projects both in South Africa and internationally, plus design and project management of bulk and municipal water, sanitation and drainage infrastructure including water and wastewater treatment projects. He has completed his MSc. Eng at the University of Stellenbosch from 2000 to 2001 and his MSc. Eng HEM/DIC at the University of London, United Kingdom from 2001 to 2002.

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List of Abbreviations

Abbreviation	Description
EIA	Environmental Impact Assessment
EA	Environmental Authorisation
EMPr	Environmental Management Programme
km^2	Square kilometres
m	meters
m^3/s	cubic meters per second
m/s	meters per second
Ml	megaliters
SWMP	Storm Water Management Plan
WUL	Water Use Licence

1 Introduction

SMEC South Africa (Pty) Ltd. was appointed by EIMS to undertake a Hydrological Study for the proposed Tetra4 Gas Cluster 2 located in the Free State, South Africa. Tetra4 (Pty) Ltd aims to extend its natural gas operations inside the project area indicated in Figure 1-1. The purpose of this hydrological study is to serve as a component of the Environmental Impact Assessment (EIA) study. The objectives of this EIA phase are to determine the overall impacts and potential mitigation measures, on the hydrological environment, in order to ensure environmental legal compliance and efficient, cost-effective surface water management. The project area is situated approximately 10 kilometres (km) south of Welkom, as shown in Figure 1-1, below. The approximate geographical coordinates of the centre of project area are:

- Latitude - 28°10'00"S
- Longitude - 26°44'00"E

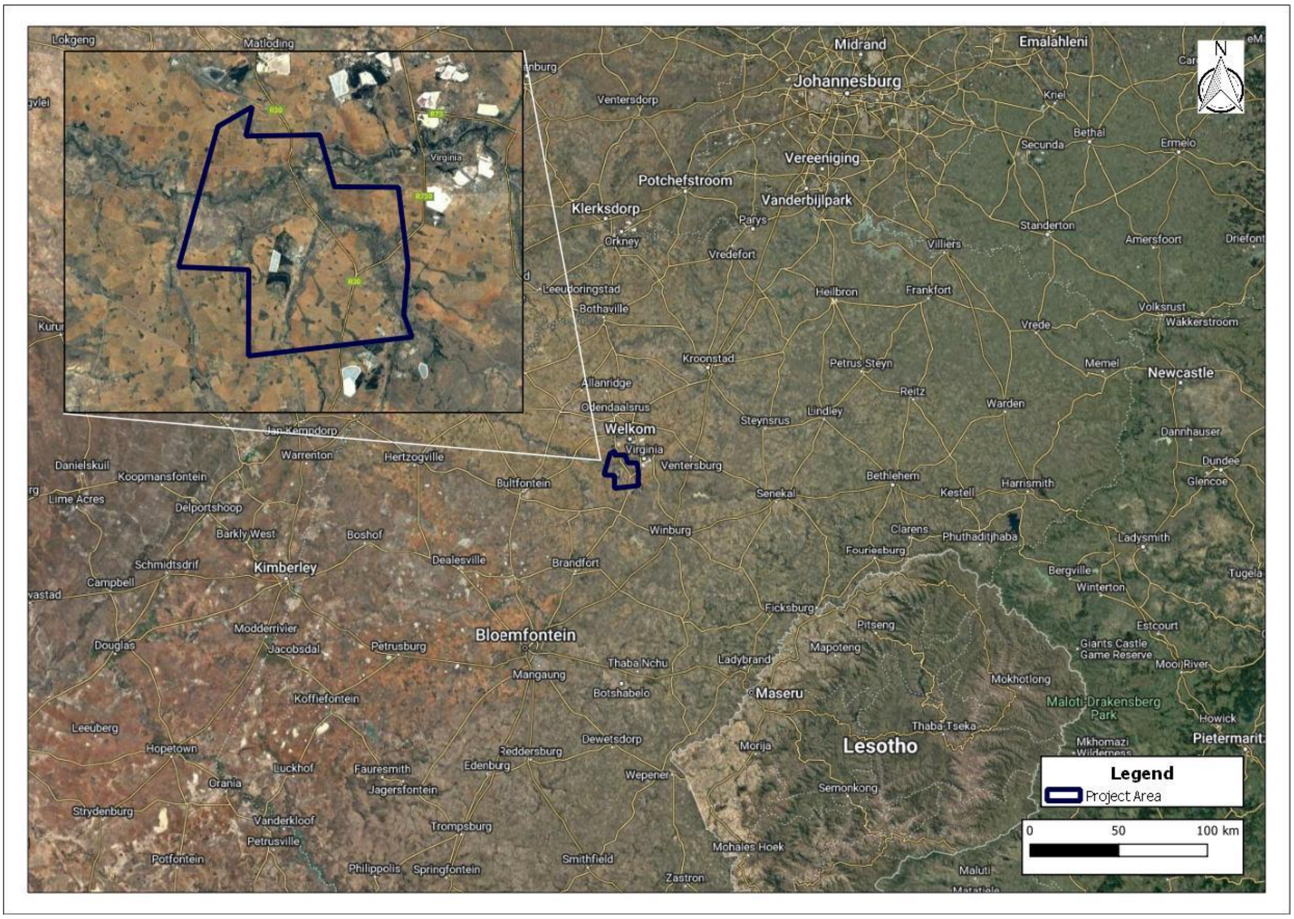

Figure 1-1: Project area location

The extent of the Project area boundary is shown below. The area of the site is approximately 27 500 Hectares.

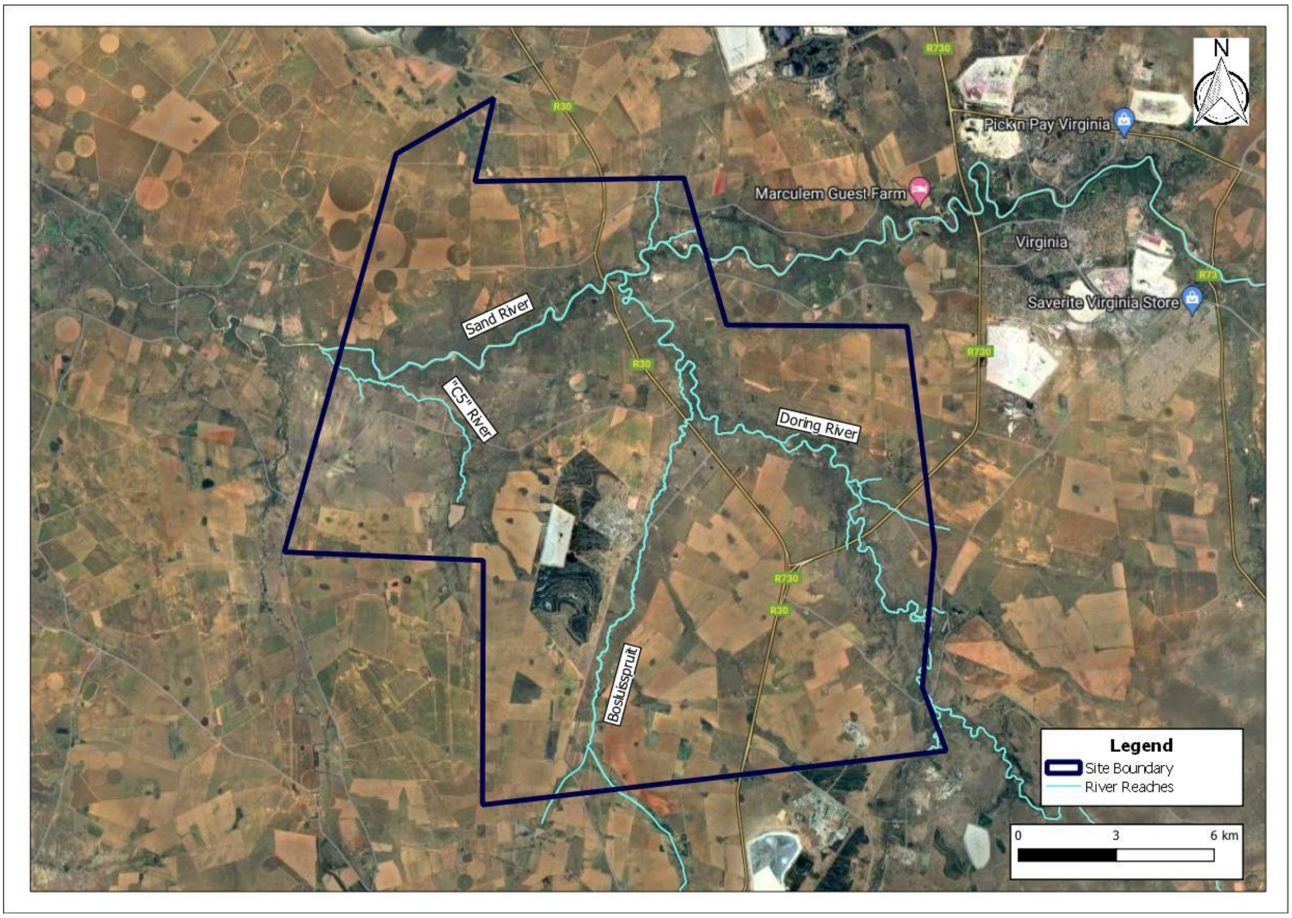

Figure 1-2: Project area Boundary

2 Scope of Work

The Scope of Work for the Hydrological Impact Assessment can be summarised as follows:

1. Desktop Assessment:
   - A description of the hydrological baseline receiving environment was prepared based on publicly available data;
   - Identification and description of surface water drainage systems that occur in the study area, and the manner in which these may be affected by the proposed activities were undertaken.
2. Site Visit:
   - A site visit was conducted on 12th and 13th of April 2022 to measure the hydraulic structure located within the rivers crossing the site and to verify findings of the desktop assessment.
3. Hydrology:
   - The catchment size was assessed, and run-off factors and catchment characteristics were determined.
   - Historical daily rainfall records for the area were sourced.
   - Time of concentration was calculated for each catchment along its longest watercourse, using methods and formulae appropriate to the hydrological method selected.
   - 1:100-year flood peaks were calculated using the most appropriate hydrological methods for each catchment.
4. Hydraulic Modelling:
   - A 1D river hydraulic model was compiled for each of the identified rivers using GeoHEC-RAS river modelling software.
   - Appropriate boundary conditions were selected based on the likely hydraulic regime.
   - The model geometry was based on topographic survey data to be provided by the Client.
   - Roughness factors were determined through an assessment of site and aerial photos.
5. Floodlines:
   - Delineate the floodlines on a map, with respect to any known locations of pipe routes, well locations and plant areas.
6. Risk Assessment:
   - A description of all surface water impacts and proposed mitigation measures, using EIMS' standard EIA Risk and Mitigation methodology.
   - Site sensitivities and relevant potential surface water constraints to the project were identified.
7. Reporting:
   - Recommendations on required hydrological management and mitigation measures will be provided

3 Legal Framework

The EIA study was conducted by EIMS to comply with relevant legislation and policies. The direct applicable guiding legislation is the following:

- **National Water Act (Act 36 of 1998)**

  The National Water Act, 1998 (Act No. 36 of 1998) (NWA) is the principal legal instrument relating to water resource management in South Africa. As guardian and trustee of the nation's water resources, the Government (specifically the Department of Water and Sanitation) must ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner for the benefit of all persons and in accordance with its constitutional mandate.

  In accordance with GN509 of 2016 as it relates to the National Water Act, 1998 (Act No. 36 of 1998), a regulated area of a watercourse in terms of water uses as listed in Section 21c and 21i is defined as:

  - 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;
  - 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: or
  - A 500m radius from the delineated boundary (extent) of any wetland or pan in terms of this regulation.

- **National Environmental Management Act (Act 107 of 1998)**

  The National Environmental Management Act, 1998 (Act No. 107 of 1998) and the associated Regulations as amended in 2017, states that prior to any development taking place within a wetland or riparian area, an environmental authorisation process needs to be followed. This could follow either the Basic Assessment Report (BAR) process or the Environmental Impact Assessment (EIA) process depending on the scale of the impact. Provincial regulations must also be considered.

- **The Constitution of South Africa, 1996**

  The environment and the health and well-being of people are safeguarded under the Constitution of the Republic of South Africa, 1996 by way of section 24. Section 24(a) guarantees a right to an environment that is not harmful to human health or well-being and to environmental protection for the benefit of present and future generations. Section 24(b) directs the state to take reasonable legislative and other measures to prevent pollution, promote conservation, and secure the ecologically sustainable development and use of natural resources (including water and mineral resources) while promoting justifiable economic and social development. Section 27 guarantees every person the right of access to sufficient water, and the state is obliged to take reasonable legislative and other measures within its available resources to achieve the progressive normalization of this right. Section 27 is defined as a socio-economic right and not an environmental right. However, read with section 24 it requires of the state to ensure that water is conserved and protected and that sufficient access to the resource is provided. Water regulation in South Africa places a great emphasis on protecting the resource and on providing access to water for everyone.

4 Hydrological Characteristics

The project area is located within the 42K, 42L and 43K quaternary catchment areas as defined by Water resources of South Africa, 2005 study (WR 2005). The main drainage features traversing the project area include the Bosluisspruit River, Doring River and the Sand River, of which the Sand River is the major system originating in the area of east and draining south-west past Welkom and the Project site.

Based on the observations made from Google Earth Pro satellite imagery (Google Earth, 2022) and the site visit that was conducted on the 13th of April 2022, the project area comprises mostly of farmlands with some bush areas in-between. In general, based on the available topographic survey data, the project area is generally flat (<10% slope). According to the "SANRAL Drainage Manual, 6th Edition", the soils in the project area have a moderately low to moderately high internal drainage capacity and generalised SCS soil grouping classification for South Africa. Soils that are well drained produce a lower stormflow response than poorly drained soils.

The delineation of catchment areas draining to the above-mentioned rivers was undertaken using the topography of the area defined by SRTM DEM data. A catchment area is generally defined as that area from which all rainfall will drain into a drainage system through surface flow, to a common point.

The focus of the reporting on this section is on the major points of the major rivers, however, the project area has multiple small tributaries that drain into the major rivers at multiple points along the major rivers; these were individually considered as flow change locations in the river modelling so that the peak flow at the downstream end of a river doesn't represent the entire river. The catchment areas are shown below:

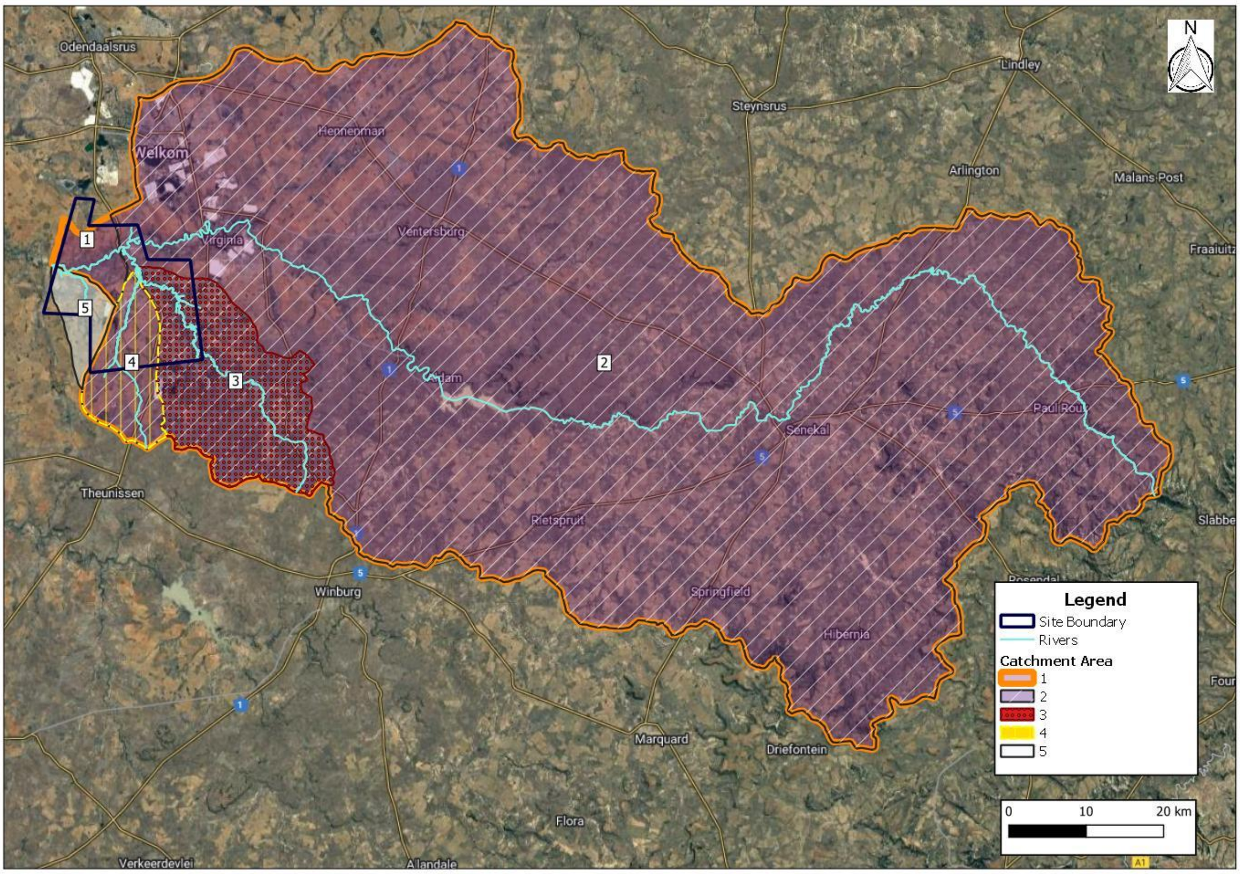

Figure 4-1: Catchment Areas

The physical properties of the various catchment areas shown in Figure 4-1 are summarized in Table 4-1.

Table 4-1: Catchment Area Physical Properties

Description	Unit	1	2	3	4	5
Size of Catchment Area	km^2	7118	7054	442	155	68
Hydraulic length of Catchment	km	251	217	58	29	20
Average Stream Slope	m/m	0.0013	0.0012	0.0032	0.0055	0.0079

5 Hydrological Analysis

5.1 Methodology

The following methodology was used in the hydrological analysis to determine flood peaks:

- Five flood estimation methods were selected as being relevant to the catchment areas under consideration, being the Standard Design Flood Method (SDF), Rational Method (RM), Alternative Rational Method (ARM), Unit Hydrograph Method (UHM) and the Empirical Method developed by Midgley and Pitman.
- Input data for these three methods was developed as follows:
  - Design rainfall depths were obtained from Water Research Commission Project Number K5/1060 (2002) for Welkom/Sandvet Station (South African Weather Bureau (SAWB) Number 0328308A) for the majority of small catchment areas inside the project area. For the larger catchment areas (1 and 2) that fall within multiple rainfall stations, an average of the MAPs was considered. The considered rainfall stations are:
    (i) Paul Roux (SAWB No. 0330797W) with MAP of 614mm;
    (ii) Senekal (SAWB No. 0553762 W) with MAP of 625mm;
    (iii) Ventersberg (SAWB No. 0329215W) with MAP of 546mm; and the
    (iv) Welkom/Sandvet (SAWB No. 0328308A) with MAP of 496mm.
    (v) These stations have an average record of 80 years between them.
  - The catchment area was delineated using the 30 m SRTM DEM topographical data, using QGIS software.
  - The project area is located in SDF Basin number 7, Veld type zone 4 and Kovács region K4.
  - The design flood peaks for various return periods were then estimated both methods using the above inputs. The Utility Programs for Drainage Software (from University of Pretoria) was used to calculate the flood peaks. The program was developed specifically for South African rainfall conditions.

5.2 Topographical Data

The client provided a topographic survey of the project area. The water depth maps provided in this study are only as accurate as the quality of the topographical data provided, however SMEC took all the necessary steps to apply best engineering judgment to produce the flood maps as accurately as possible. The survey data that was provided for this project was 1 m contours data. The name of the data file used was “Tetra_Virginia_20211102_All Contours” and was received on the 1st of February 2022.

5.3 Climate Data

The climate of the study area is characterised by dry winters and wet summers. The warmest periods are usually noted between November and February and the coldest periods are usually seen between May and August. Average annual maximum temperature is approximately 28 ºC per annum, according to the National Centre for Environmental Information (NCEI). The main characteristics are shown in Table 5-1 below:

Table 5-1: Climate Data

Month	Max. Temp (ºC)	Min. Temp (ºC)
Jan	32	17
Feb	32	17
Mar	30	15
Apr	27	11
May	24	6
Jun	20	3

Month	Max. Temp (°C)	Min. Temp (°C)
Jul	20	2
Aug	24	5
Sep	28	9
Oct	30	13
Nov	31	14
Dec	32	16
Average	**28**	**11**

The Witbank/Sandvet rainfall station is located approximately 8 km north from the centre of the project area. The Mean Annual Precipitation (MAP) for the project area is 496 mm based on the Witbank/Sandvet rainfall station data. This station has a 60 year record. This station was applied to peak flow calculations involving the smaller catchment areas (3, 4 and 5) nearest to the station. Catchment areas 1 and 2 fall within multiple rainfall stations, therefore an average MAP (580 mm) and rainfall depth was applied between all the relevant stations (See Section 5.1). The 24-hour storm rainfall depths for various return periods at the stations are presented in Table 5-2.

Table 5-2: Design Rainfall – 24-hour Rainfall Depths at Rainfall Stations within the Project Area (mm)

Rainfall Station	Return Period (years)					
	2	5	10	20	50	100
Paul Roux	52	69	81	93	100	123
Senekal	48	64	76	87	103	115
Ventersberg	48	64	76	88	104	117
Welkom/Sandvet	51	69	82	94	111	124
Average	**50**	**67**	**79**	**91**	**105**	**120**

5.4 Peak Flow Volumes

The peak flows used for floodline determination were calculated using 5 standard methods applied in South Africa shown in Table 5-3. Based on the legislation adopted for this study, peak flows resulting from the 1:100-year event were used in floodline modelling. A summary of the calculated peak flows, for the various catchment areas are presented below and are based on the calculations and inputs indicated in Section 5.1. The peak flow volumes are indicated in Table 5-3.

Table 5-3: 1:100-year peak flow rates (m^3/s)

Flood Estimation Method	Catchment Areas (km^2)				
	1	2	3	4	5
Standard Design Flood (SDF)	**3045**	**3022**	**745**	**502**	**325**
Rational Method (RM)	1493	1000	285	188	112
Alternative Rational Method (ARM)	1397	933	242	185	139
Unit Hydrograph Method (UHM)	1267	1258	424	229	134
Midgley and Pitman Empirical Method (EM)	2111	2086	356	213	134

The calculated SDF method flows are generally higher than the other methods. The SDF method was chosen to represent the 1:100-year flood peak at the site. The SDF method resulted in the highest peak flows being estimated for most catchment areas, making its application a conservative approach. The SDF method is designed for South African conditions and is one of the most widely used and accepted methods in South Africa (SANRAL, 2013). The method can also be used accurately for catchment areas of any size.

6 Floodline Modelling

The river hydraulics were modelled using the GeoHEC-RAS software suite, developed by CivilGEO Engineering Software. The software utilises the widely used one-dimensional HEC-RAS river hydraulics engine, developed by the US Army Corps of Engineers. The floodlines are based on static flow conditions and do not reflect any additional water rise, due to possible dam break events, in the upstream catchment area. Flood modelling was undertaken for the sections of the above-mentioned rivers that lie within project area boundary.

6.1 Channel Roughness

Channel roughness values are physical parameters describing the unevenness of the surface within a particular stream/river that impacts the water depth, velocity and therefore energy and momentum of water moving from upstream to a downstream location.

Manning's Roughness coefficient/values (n) were estimated using a visual assessment of Google Earth aerial photograph maps and site photographs. They were based on the description obtained from the SANRAL Drainage manual, 6th Edition as well as the following equation developed by Cowan (1956), to estimate the Manning's Roughness Coefficient/values (n) for the channel.

$$n = (nb + n1 + n2 + n3 + n4) \times m$$

Where:

- **nb** = a base value of n for a straight, uniform, smooth channel in natural materials
- **n1** = a correction factor for the effect of surface irregularities
- **n2** = a value for variations in shape and size of the channel cross section
- **n3** = a value for obstructions
- **n4** = a value for vegetation and flow conditions
- **m** = a correction factor for meandering of the channel

Table 6-1: Manning's Roughness Coefficient/values

Parameter	Left Bank	Channel	Right Bank
Sand River	0.111	0.036	0.079
Doring River	0.101	0.040	0.084
Bosluisspruit River	0.099	0.039	0.073
"Catchment 5" River	0.078	0.037	0.078

The values above represent the average Manning's roughness values across the rivers inside the project area. Generally, every section along a natural river has a different manning's roughness due to its irregular nature. The following figures indicate the channel characteristics at each of the rivers.

Figure 6-1: Sand River Channel Characteristic

Figure 6-2: Doring River Channel Characteristics

Figure 6-3: Bosluisspruit Channel Characteristics

Figure 6-4: "Catchment 5" River Channel Characteristics

6.2 River Hydraulic Model

A site visit of the culverts and bridges was conducted on the 12th and 13th of April 2022 by SMEC. During this site visit, the dimensions for bridges and culvert structures, considered/included in the model, were measured. Weir structures/ dams were not included in the analysis since they could not be measured. The model accuracy relies on this data and can be deemed fairly inaccurate on the near upstream side of any potential dams located within the rivers of the study area. Figure 6-5 indicates the hydraulic structures that were measured:

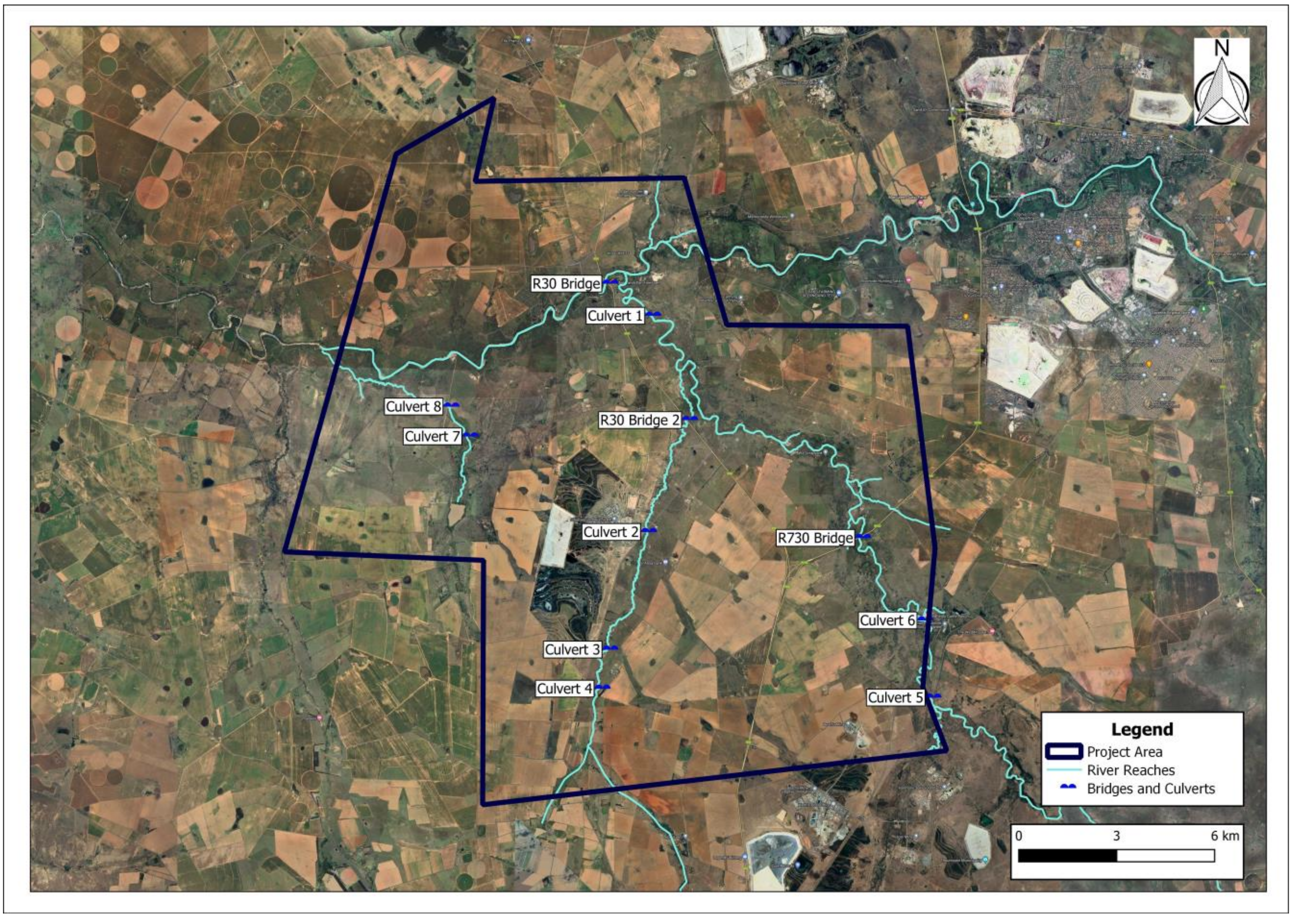

Figure 6-5: Bridges and Culverts Locations

6.2.1 Boundary Conditions

The normal depth condition was used as the downstream and upstream hydraulic controls / boundaries. In general, the boundary condition assumption had little to no effect on the flood depth, near the project area. It did however make a difference on the downstream boundary of the Sand River. Increasing or reducing the slope affects the position of floodlines. The average slope of the river was assumed as the downstream boundary. The downstream boundary slope used was the average slope of the river inside the project area.

6.3 Results

The peak flows estimated by the SDF method as presented in Section 5.4 were used to simulate the floodlines of the rivers running through the Tetra4 Gas project area. The floodlines are indicated in Figure 6-6, below.

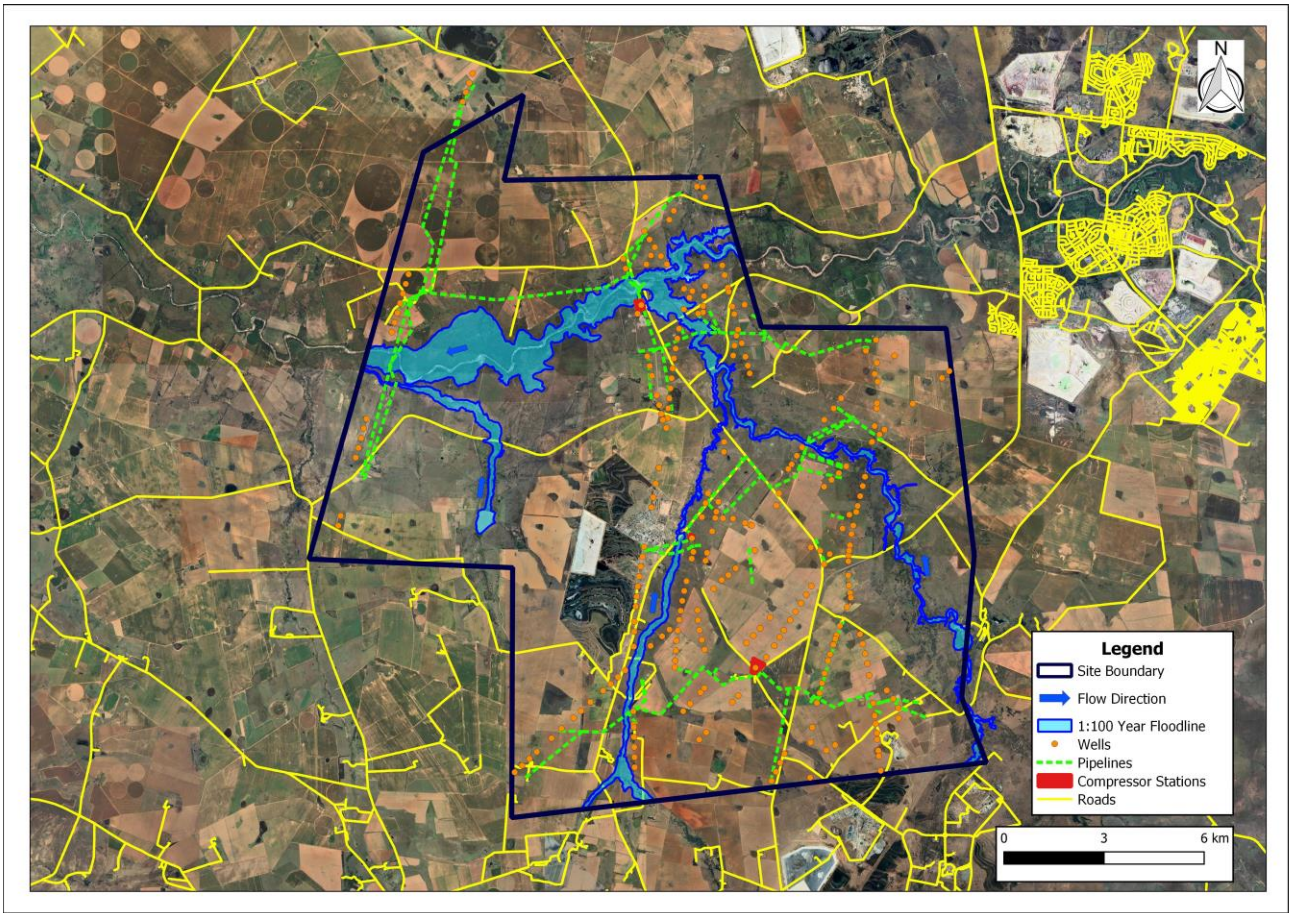

Figure 6-6: 100-year floodlines

7 Site Sensitivities

The sensitivities and constraints at the Tetra4 Cluster 2 Gas project site were assessed in accordance with the National Water Act Regulations (GN509, 2016) and the EIMS sensitivity assessment methodologies. Based on the National Water Act (GN509, 2016) described in Section 3, the area within the 1:100-year floodline is considered to be the regulated area of a watercourse. Any activities within the 1:100-year floodline will require the appropriate water use authorisation by the DWS. Figure 7-1 indicates a sensitivity map which was developed to assist in identifying sensitive features in relation to the 1:100-year flood within the project area.

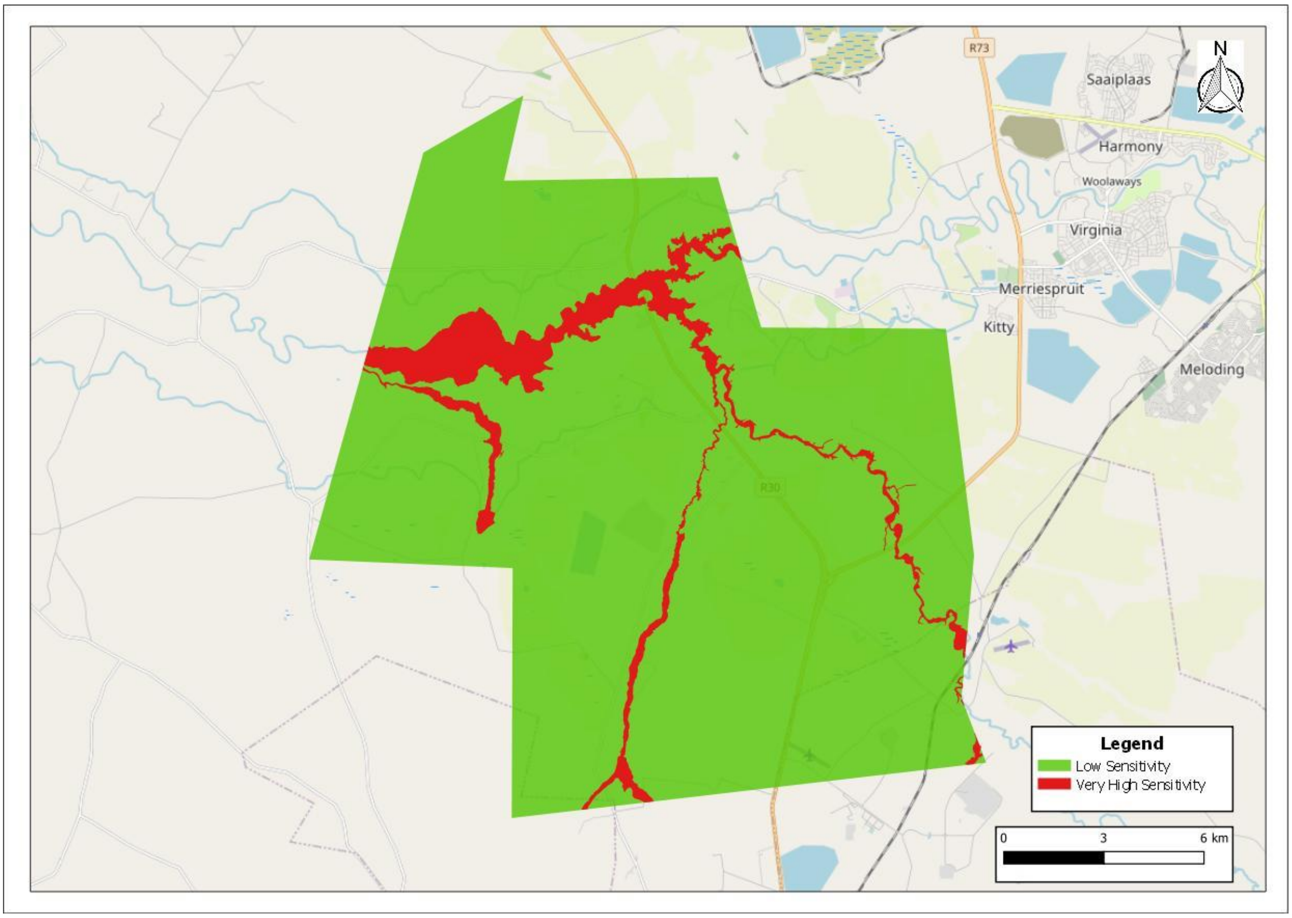

Figure 7-1: Hydrology Sensitivity Map

8 Potential Impacts and Mitigation

This section presents the flowing:

- Potential impacts on the ecology of the identified watercourses associated with the proposed development;
- Recommended mitigation measures needed to minimise the perceived impacts of the proposed development.

Most impacts are considered to be easily detectable and the considered mitigation measures are easily practicable therefore the risks associated with the development are considered to be low.

8.1 Construction Phase Impacts

During the construction phase, pipes connecting the new wells to the compressor stations and helium plant will be laid down. Construction work for laying of pipes across rivers or parallel to them may involve the excavation of riverbed material and restoring the river to a near-natural state thereafter. Horizontal Directional Drilling (HDD) will be the method generally used on site to lay pipes so that the impact is minimal/negligible.

Table 8-1: Construction Phase Impacts and Mitigation Measures

• Potential Impacts	Mitigation Measures
Exposure of soil, leading to increased runoff, and erosion, and thus increased sedimentation of the watercourses.	Ensure total footprint area is kept to a minimum.
	Traffic and movement of machinery should be minimised and restricted to certain paths.
	Progressive rehabilitation of disturbed land should be carried out.
Soil and stormwater contamination by oils and hydrocarbons spills, originating from construction vehicles	Construction waste must be collected and stored safely for disposal in accordance with the relevant waste regulations, protocols, and product specifications. Care must be taken not to leave any waste on project area that can lead to future contamination of the project area or the downstream area.
Increase in the number of alien and/or invasive vegetation as a result of disturbances.	Monitoring for the project area for alien and invasive vegetation species must be undertaken, specifically for access roads through or along the watercourses. Should alien and invasive plan species be identified, they must be removed and disposed of as per an alien and invasive species control plan and the area must be revegetated with suitable indigenous vegetation.
Alterations of the river banks and river bed due to movement near the drainage lines.	The reaches of all watercourses where no construction activities are planned to occur must be considered no-go areas.

8.2 Operational Phase Impacts

The activities expected during the operational phase involve the operation of the well pad, pipelines, compression station and LNG/LHe beneficiation plant, movement of trucks and other vehicles, general and hazardous waste management, gas processing as well as operation of Road tankers for gas distribution. The potential environmental impacts and mitigation measures during the operational phase are listed below.

Table 8-2: Operational Phase Impacts and Mitigation Measures

Potential Impacts	Mitigation Measures
Disturbance to soil and ongoing erosion as a result of periodic maintenance activities.	No movement of construction equipment through the watercourses may be permitted during standard operational activities or maintenance activities. Use must be made of the existing and/or approved watercourse crossings only.
	Regular conditional inspections of all stormwater infrastructure are required. Inspection data must be recorded and accumulated for tracking purposes. Regular reporting should be scheduled management task.
	Specific attention must be given to inspection during and after any rain and/or flood event to kerb any damage that may have occurred.
Altered water quality as a result of increased availability of pollutants.	Oil recovered from construction vehicles and machinery should be collected, stored and disposed of by accredited vendors for recycling.
Potential increase in the number of alien and/or invasive vegetation as a result of floods or people who visit the site.	Monitoring for the project area for alien and invasive vegetation species must be undertaken, specifically for access roads through or along the watercourses. Should alien and invasive plan species be identified, they must be removed and disposed of as per an alien and invasive species control plan and the area must be revegetated with suitable indigenous vegetation.

8.3 Decommissioning Phase Impacts

The decommissioning phase involves the removal of all berms, trenches and other storm water infrastructure, stationary infrastructure, pipeline infrastructure and wastes.

Potential Impacts	Mitigation Measures
Increased erosion due to construction vehicles movement.	Topsoil removed during construction must be stored on site for rehabilitation and re-vegetation. The soil must be stabilised using materials such as netting or geotextiles where necessary.
	The site shall be re-instated to its original condition as far as possible. No foreign material generated / deposited during construction shall remain on site.
	Rehabilitate disturbance areas as soon as construction in an area is completed.
Stormwater Contamination resulting from spillages of polluted groundwater from wells	All wells should be capped to prevent the spilling of contaminated groundwater.
Potential increase in the number of alien and/or invasive vegetation as a result of floods or people who visit the site.	Monitoring for the project area for alien and invasive vegetation species must be undertaken, specifically for access roads through or along the watercourses. Should alien and invasive plan species be identified, they must be removed and disposed of as per an alien and invasive species control plan and the area must be revegetated with suitable indigenous vegetation.

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Appendix A: Hydrological Calculations

Utility Programs for Drainage
Flood calculations

Project name: Tetra4 Gas Floodline
Analysed by: Rendani Thovhakale
Name of river: Reach 1
Description of site: Catchment 1
Filename: C:\Users\rt2704930\OneDrive - Surbana Jurong Private Limited\Desktop\Desktop\Manager\Tetra4 Gas\Hydrology\Downstream 1 (Catchment 1) .fld
Date: 10 February 2022

Flood frequency analysis : Standard Design Flood method

Project name	= Tetra4 Gas Floodline
Analysed by	= Rendani Thovhakale
Name of river	= Reach 1
Description of site	= Catchment 1
Date	= 2022/02/10
Catchment characteristics:	
Area of catchment	= 7118 km²
Length of longest watercourse	= 251 km
1085 height difference	= 251 m
Average slope	= 0.0013 m/m
Drainage basin characteristics:	
Drainage basin number	= 7
Mean annual daily max rain	= 49 mm
Days on which thunder was heard	= 39 days
Runoff coefficient C2	= 15 %
Runoff coefficient C100	= 60 %
Basin mean annual precipitation	= 510 mm
Basin mean annual evaporation	= 1700 mm
Basin evaporation index MAE/MAP	= 3.33

RAINFALL DATA

The rainfall data in the table below are derived from two sources. The daily rainfall is from the Department of Water Affair's publication TR102 for the representative site. The modified Hershfield equation is used for durations up to four hours. Linear interpolation is used for values between 4 hours and one day.

Weather Services station ex TR102 = 328726 @ OLIVINE
Point mean annual precipitation = 510 mm

Dur:	RP =2	5	10	20	50	100	200
.25 h	14	24	32	39	49	57	64
.50 h	19	32	41	51	64	74	84
1 h	23	39	51	63	79	91	103
2 h	27	46	61	75	94	108	122
4 h	32	54	70	87	109	125	142
1 day	49	68	82	96	118	137	157
2 days	62	87	107	128	158	184	213
3 days	68	94	115	136	167	193	221
7 days	84	118	144	172	211	243	279

Runoff coefficients C2 = 15 % C100 = 60 %

Return period (years)	Time of concentration (hours)	Point precipitation (mm)	ARF (%)	Catchment precipitation (mm)	Runoff coefficient (%)	Peak flow (m³/s)
1:2	59.75	48.8	79.8	39.0	15.0	193.56
1:5	59.75	82.4	79.8	65.7	31.2	679.70
1:10	59.75	107.7	79.8	86.0	39.7	1131.06
1:20	59.75	133.1	79.8	106.2	46.7	1642.05
1:50	59.75	166.6	79.8	133.0	54.6	2404.59
1:100	59.75	192.0	79.8	153.3	60.0	3045.14
1:200	59.75	217.4	79.8	173.5	64.8	3724.94

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Project name: Tetra4 Gas Floodlines
Analysed by: Rendani Thovhakale
Name of river:
Description of site: Catchment 2
Filename: C:\Users\rt2704930\OneDrive - Surbana Jurong Private Limited\Desktop\Desktop\Manager\Tetra4 Gas\Hydrology\R30 Bridge (Catchment 2).fld
Date: 10 February 2022

Flood frequency analysis : Standard Design Flood method

Project name	= Tetra4 Gas Floodlines
Analysed by	= Rendani Thovhakale
Name of river	=
Description of site	= Catchment 2
Date	= 2022/02/10
Catchment characteristics:	
Area of catchment	= 7054 km²
Length of longest watercourse	= 239 km
1085 height difference	= 217 m
Average slope	= 0.0012 m/m
Drainage basin characteristics:	
Drainage basin number	= 7
Mean annual daily max rain	= 49 mm
Days on which thunder was heard	= 39 days
Runoff coefficient C2	= 15 %
Runoff coefficient C100	= 60 %
Basin mean annual precipitation	= 510 mm
Basin mean annual evaporation	= 1700 mm
Basin evaporation index MAE/MAP	= 3.33

RAINFALL DATA
The rainfall data in the table below are derived from two sources. The daily rainfall is from the Department of Water Affair's publication TR102 for the representative site. The modified Hershfield equation is used for durations up to four hours. Linear interpolation is used for values between 4 hours and one day.

Weather Services station ex TR102 = 328726 @ OLIVINE
Point mean annual precipitation = 510 mm

Dur:	RP =2	5	10	20	50	100	200
.25 h	14	24	32	39	49	57	64
.50 h	19	32	41	51	64	74	84
1 h	23	39	51	63	79	91	103
2 h	27	46	61	75	94	108	122
4 h	32	54	70	87	109	125	142
1 day	49	68	82	96	118	137	157
2 days	62	87	107	128	158	184	213
3 days	68	94	115	136	167	193	221
7 days	84	118	144	172	211	243	279

Runoff coefficients C2 = 15 % C100 = 60 %

Return period (years)	Time of concentration (hours)	Point precipitation (mm)	ARF (%)	Catchment precipitation (mm)	Runoff coefficient (%)	Peak flow (m³/s)
1:2	59.72	48.8	79.9	39.0	15.0	192.06
1:5	59.72	82.4	79.9	65.8	31.2	674.43
1:10	59.72	107.7	79.9	86.0	39.7	1122.29
1:20	59.72	133.1	79.9	106.3	46.7	1629.31
1:50	59.72	166.6	79.9	133.1	54.6	2385.94
1:100	59.72	192.0	79.9	153.4	60.0	3021.53
1:200	59.72	217.4	79.9	173.6	64.8	3696.06

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Project name: Tetra4 Gas Floodlines
Analysed by: Rendani Thovhakale
Name of river:
Description of site: Catchment 3
Filename: C:\Users\rt2704930\OneDrive - Surbana Jurong Private Limited\Desktop\Desktop\Manager\Tetra4 Gas\Hydrology\Junction 1 (Catchment 3).fld
Date: 10 February 2022

Flood frequency analysis : Standard Design Flood method

```
Project name                              = Tetra4 Gas Floodlines
Analysed by                               = Rendani Thovhakale
Name of river                             =
Description of site                       = Catchment 3
Date                                      = 2022/02/10
Catchment characteristics:
Area of catchment                         = 442 km²
Length of longest watercourse             = 58 km
1085 height difference                    = 134 m
Average slope                             = 0.0031 m/m
Drainage basin characteristics:
Drainage basin number                     = 7
Mean annual daily max rain                = 49 mm
Days on which thunder was heard           = 39 days
Runoff coefficient C2                     = 15 %
Runoff coefficient C100                   = 60 %
Basin mean annual precipitation           = 510 mm
Basin mean annual evaporation             = 1700 mm
Basin evaporation index MAE/MAP           = 3.33
```

RAINFALL DATA
The rainfall data in the table below are derived from two sources. The daily rainfall is from the Department of Water Affair's publication TR102 for the representative site. The modified Hershfield equation is used for durations up to four hours. Linear interpolation is used for values between 4 hours and one day.

Weather Services station ex TR102 = 328726 @ OLIVINE
Point mean annual precipitation = 510 mm

Dur:	RP =2	5	10	20	50	100	200
.25 h	14	24	32	39	49	57	64
.50 h	19	32	41	51	64	74	84
1 h	23	39	51	63	79	91	103
2 h	27	46	61	75	94	108	122
4 h	32	54	70	87	109	125	142
1 day	49	68	82	96	118	137	157
2 days	62	87	107	128	158	184	213
3 days	68	94	115	136	167	193	221
7 days	84	118	144	172	211	243	279

Runoff coefficients C2 = 15 % C100 = 60 %

Return period (years)	Time of concentration (hours)	Point precipitation (mm)	ARF (%)	Catchment precipitation (mm)	Runoff coefficient (%)	Peak flow (m³/s)
1:2	14.01	39.7	90.6	36.0	15.0	47.36
1:5	14.01	67.0	90.6	60.7	31.2	166.31
1:10	14.01	87.6	90.6	79.4	39.7	276.75
1:20	14.01	108.3	90.6	98.1	46.7	401.78
1:50	14.01	135.6	90.6	122.9	54.6	588.36
1:100	14.01	156.2	90.6	141.6	60.0	745.09
1:200	14.01	176.8	90.6	160.3	64.8	911.43

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Project name: Tetra4 Gas Floodline
Analysed by: Rendani Thovhakale
Name of river:
Description of site: Catchment 4
Filename: C:\Users\rt2704930\OneDrive - Surbana Jurong Private Limited\Desktop\Desktop\Manager\Tetra4 Gas\Hydrology\Junction 2 (Catchment 4).fld
Date: 10 February 2022

Flood frequency analysis : Standard Design Flood method

Project name	= Tetra4 Gas Floodline
Analysed by	= Rendani Thovhakale
Name of river	=
Description of site	= Catchment 4
Date	= 2022/02/10
Catchment characteristics:	
Area of catchment	= 155 km²
Length of longest watercourse	= 29 km
1085 height difference	= 117 m
Average slope	= 0.0054 m/m
Drainage basin characteristics:	
Drainage basin number	= 7
Mean annual daily max rain	= 49 mm
Days on which thunder was heard	= 39 days
Runoff coefficient C2	= 15 %
Runoff coefficient C100	= 60 %
Basin mean annual precipitation	= 510 mm
Basin mean annual evaporation	= 1700 mm
Basin evaporation index MAE/MAP	= 3.33

RAINFALL DATA
The rainfall data in the table below are derived from two sources. The daily rainfall is from the Department of Water Affair's publication TR102 for the representative site. The modified Hershfield equation is used for durations up to four hours. Linear interpolation is used for values between 4 hours and one day.

Weather Services station ex TR102 = 328726 @ OLIVINE
Point mean annual precipitation = 510 mm

Dur:	RP =2	5	10	20	50	100	200
.25 h	14	24	32	39	49	57	64
.50 h	19	32	41	51	64	74	84
1 h	23	39	51	63	79	91	103
2 h	27	46	61	75	94	108	122
4 h	32	54	70	87	109	125	142
1 day	49	68	82	96	118	137	157
2 days	62	87	107	128	158	184	213
3 days	68	94	115	136	167	193	221
7 days	84	118	144	172	211	243	279

Runoff coefficients C2 = 15 % C100 = 60 %

Return period (years)	Time of concentration (hours)	Point precipitation (mm)	ARF (%)	Catchment precipitation (mm)	Runoff coefficient (%)	Peak flow (m³/s)
1:2	6.63	35.0	93.4	32.7	15.0	31.89
1:5	6.63	59.1	93.4	55.2	31.2	111.97
1:10	6.63	77.3	93.4	72.2	39.7	186.33
1:20	6.63	95.5	93.4	89.2	46.7	270.51
1:50	6.63	119.5	93.4	111.6	54.6	396.13
1:100	6.63	137.7	93.4	128.6	60.0	501.66
1:200	6.63	155.9	93.4	145.6	64.8	613.65

Calculated using Utility Programs for Drainage 1.1.0

Utility Programs for Drainage
Flood calculations

Project name: Tetra4 Gas Floodline
Analysed by:
Name of river:
Description of site: Catchment 5
Filename: C:\Users\rt2704930\OneDrive - Surbana Jurong Private Limited\Desktop\Desktop\Manager\Tetra4 Gas\Hydrology\Downstream 2 (Catchment 5).fld
Date: 10 February 2022

Flood frequency analysis : Standard Design Flood method

```
Project name                              = Tetra4 Gas Floodline
Analysed by                               =
Name of river                             =
Description of site                       = Catchment 5
Date                                      = 2022/02/10
Catchment characteristics:
Area of catchment                         = 68.2 km²
Length of longest watercourse             = 20.5 km
1085 height difference                    = 117 m
Average slope                             = 0.0076 m/m
Drainage basin characteristics:
Drainage basin number                     = 7
Mean annual daily max rain                = 49 mm
Days on which thunder was heard           = 39 days
Runoff coefficient C2                     = 15 %
Runoff coefficient C100                   = 60 %
Basin mean annual precipitation           = 510 mm
Basin mean annual evaporation             = 1700 mm
Basin evaporation index MAE/MAP           = 3.33
```

RAINFALL DATA

The rainfall data in the table below are derived from two sources. The daily rainfall is from the Department of Water Affair's publication TR102 for the representative site. The modified Hershfield equation is used for durations up to four hours. Linear interpolation is used for values between 4 hours and one day.

Weather Services station ex TR102 = 328726 @ OLIVINE
Point mean annual precipitation = 510 mm

Dur:	RP =2	5	10	20	50	100	200
.25 h	14	24	32	39	49	57	64
.50 h	19	32	41	51	64	74	84
1 h	23	39	51	63	79	91	103
2 h	27	46	61	75	94	108	122
4 h	32	54	70	87	109	125	142
1 day	49	68	82	96	118	137	157
2 days	62	87	107	128	158	184	213
3 days	68	94	115	136	167	193	221
7 days	84	118	144	172	211	243	279

Runoff coefficients C2 = 15 % C100 = 60 %

Return period (years)	Time of concentration (hours)	Point precipitation (mm)	ARF (%)	Catchment precipitation (mm)	Runoff coefficient (%)	Peak flow (m³/s)
1:2	4.44	32.5	96.2	31.3	15.0	20.03
1:5	4.44	54.8	96.2	52.8	31.2	70.35
1:10	4.44	71.7	96.2	69.0	39.7	117.06
1:20	4.44	88.6	96.2	85.3	46.7	169.94
1:50	4.44	110.9	96.2	106.8	54.6	248.86
1:100	4.44	127.8	96.2	123.0	60.0	315.16
1:200	4.44	144.7	96.2	139.3	64.8	385.51

Calculated using Utility Programs for Drainage 1.1.0

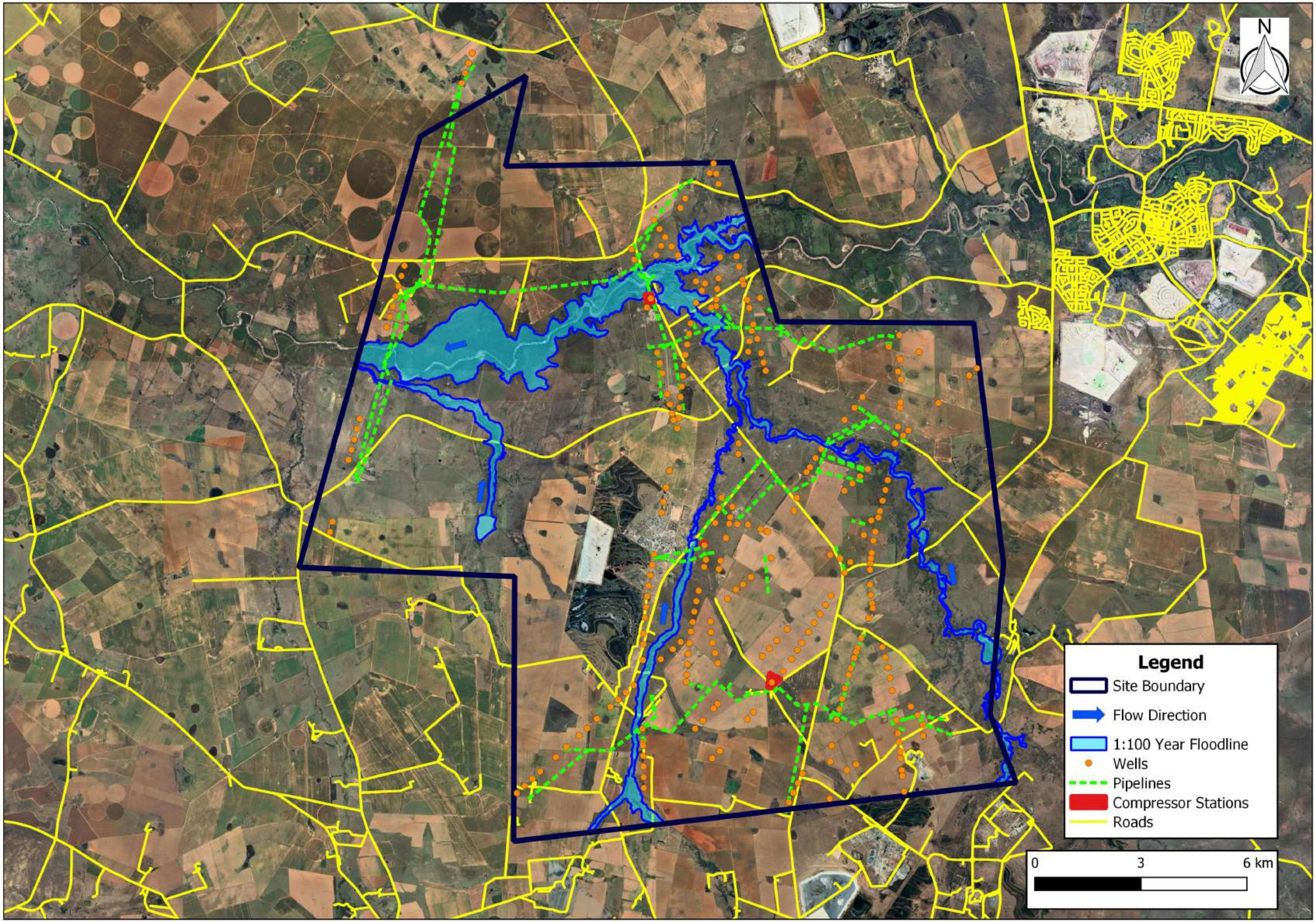
Appendix B: Impact Significance Ratings

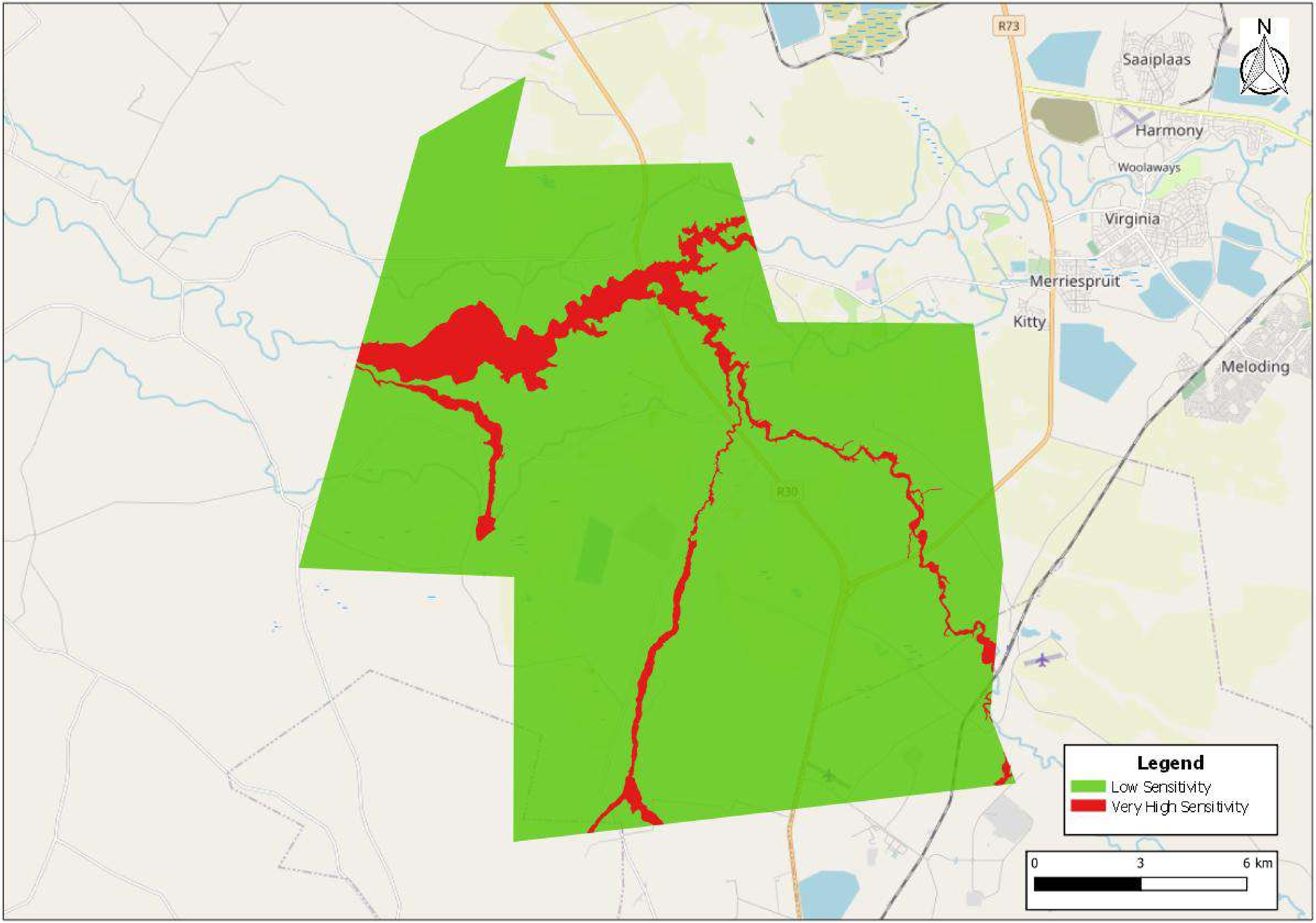
IMPACT DESCRIPTION			Pre-Mitigation						
Identifier	Impact	Phase	Nature	Extent	Duration	Magnitude	Reversibility	Probability	Pre-mitigation ER
10.1.1	Loss of watercourse vegetation	Construction	-1	2	1	1	2	2	-3
10.1.2	Erosion	Construction	-1	1	2	1	2	4	-6
10.1.3	Stormwater contamination	Construction	-1	1	2	2	2	4	-7
10.1.4	Alien and/or Invasive Vegetation	Construction	-1	3	4	3	3	2	-6.5
10.1.5	Alterations of the river banks and river bed	Construction	-1	2	2	2	3	3	-6.75
10.1.6	Erosion	Operation	-1	2	4	3	2	2	-5.5
10.1.7	Stormwater contamination	Operation	-1	3	3	3	3	3	-9
10.1.8	Alien and/or Invasive Vegetation	Operation	-1	3	4	3	3	3	-9.75
10.1.9	Erosion	Decommissioning	-1	2	3	3	2	2	-5
10.1.10	Stromwater contamination	Decommissioning	-1	3	3	3	3	3	-9
10.1.11	Alien and/or Invasive Vegetation	Decommissioning	-1	3	4	3	3	2	-6.5

IMPACT DESCRIPTION			Post Mitigation						
Identifier	Impact	Phase	Nature	Extent	Duration	Magnitude	Reversibility	Probability	Post-mitigation ER
10.1.1	Loss of watercourse vegetation	Construction	-1	2	1	1	2	1	-1.5
10.1.2	Erosion	Construction	-1	1	1	2	2	2	-3
10.1.3	Stormwater contamination	Construction	-1	1	1	2	2	2	-3
10.1.4	Alien and/or Invasive Vegetation	Construction	-1	2	2	1	2	1	-1.75
10.1.5	Alterations of the river banks and river bed	Construction	-1	2	2	1	2	2	-3.5
10.1.6	Erosion	Operation	-1	2	4	3	2	1	-2.75
10.1.7	Stormwater contamination	Operation	-1	2	2	1	2	2	-3.5
10.1.8	Alien and/or Invasive Vegetation	Operation	-1	2	2	1	3	2	-4
10.1.9	Erosion	Decommissioning	-1	2	3	3	2	1	-2.5
10.1.10	Stromwater contamination	Decommissioning	-1	2	2	1	2	2	-3.5
10.1.11	Alien and/or Invasive Vegetation	Decommissioning	-1	2	2	1	2	1	-1.75

IMPACT DESCRIPTION				Priority Factor Criteria			
Identifier	Impact	Phase	Confidence	Cumulative Impact	Irreplaceable loss	Priority Factor	Final score
10.1.1	Loss of watercourse vegetation	Construction	Low	2	1	1.13	-1.6875
10.1.2	Erosion	Construction	Low	2	1	1.13	-3.375
10.1.3	Stormwater contamination	Construction	Medium	2	1	1.13	-3.375
10.1.4	Alien and/or Invasive Vegetation	Construction	Low	2	1	1.13	-1.96875
10.1.5	Alterations of the river banks and river bed	Construction	Medium	2	2	1.25	-4.375
10.1.6	Erosion	Operation	Low	2	2	1.25	-3.4375
10.1.7	Stormwater contamination	Operation	Medium	2	2	1.25	-4.375
10.1.8	Alien and/or Invasive Vegetation	Operation	Medium	2	2	1.25	-5
10.1.9	Erosion	Decommissioning	Low	2	2	1.25	-3.125
10.1.10	Stromwater contamination	Decommissioning	Medium	2	2	1.25	-4.375
10.1.11	Alien and/or Invasive Vegetation	Decommissioning	Low	2	1	1.13	-1.96875

Appendix C: Maps


N
Legend
Site Boundary
Flow Direction
1:100 Year Floodline
Wells
Pipelines
Compressor Stations
Roads
0
3
6 km


N
Saaiplaas
Harmony
Woolaways
Virginia
Merriespruit
Kitty
Meloding
R73
R30
Legend
Low Sensitivity
Very High Sensitivity
0
3
6 km

Appendix D: NEMA Reporting Requirements Checklist

Reporting requirements as per NEMA Appendix 6 for specialist reports. Requirements of Appendix 6 – GN R326 EIA Regulations of 7 April 2017	Relevant section in report	Comment where not applicable
1.(1) (a) (i) Details of the specialist who prepared the report	Page i of Report – Contact details and company	-
(ii) The expertise of that person to compile a specialist report including a curriculum vita	Page iii – refer to Appendix E	-
(b) A declaration that the person is independent in a form as may be specified by the competent authority	Page ii of the report	-
(c) An indication of the scope of, and the purpose for which, the report was prepared	Section 1	-
(cA) An indication of the quality and age of base data used for the specialist report	Section 5.3	-
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 8	-
(d) The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 6.2	-
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 5 and 6	-
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Sections 7	-
(g) An identification of any areas to be avoided, including buffers	Section 7	-
(h) A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 6.3	-
(i) A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 6.2	-
(j) A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Sections 6.3, 7, 8	-
(k) Any mitigation measures for inclusion in the EMPr	Sections 8	-
(l) Any conditions for inclusion in the environmental authorisation	Sections 8	-
(m) Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Sections 8	-
(n)(i) A reasoned opinion as to whether the proposed activity, activities or portions thereof should be authorised and	Section 8	-
(n)(iA) A reasoned opinion regarding the acceptability of the proposed activity or activities; and		-
(n)(ii) If the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Sections 8	-
(o) A description of any consultation process that was undertaken during the course of carrying out the study	-	Not applicable. A public consultation process will be handled as part of the environmental process.
(p) A summary and copies if any comments that were received during any consultation process	-	Not applicable. To date no comments regarding

		Stormwater that require input from a specialist have been raised.
(q) Any other information requested by the competent authority.		Not applicable.
(2) Where a government notice by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	NEMA Appendix 6 and GN648 SAHRA guidelines.	

Appendix E: CVs

Neil Meyer

Technical Principal: Water Infrastructure

Personal information
- ID no.: 760810 5061 082
- South African

Years of Industry Experience
- 20+ years

Countries of Experience
- South Africa
- Rwanda
- Zambia
- Gabon
- Malawi
- Sierra Leone
- Saudi Arabia
- Lesotho

Qualifications and Memberships
- University of London, Imperial College for Science, Technology and Medicine UK, MSc HEM (Hydrology for Environmental Management), 01/11/2001
- Master of Science Engineering (cum laude) (Civil), University of Stellenbosch 08/12/2000
- Bachelor of Engineering (cum laude) (Civil), University of Stellenbosch, 02/12/1998
- Professional Engineer (Pr. Eng), Engineering Council of South Africa (ECSA), 20060199, 14/08/2006
- Member: South African Institution of Civil Engineering (SAICE), Member, 980108, 15/01/2010
- Professional: Institute of Municipal Engineering of South Africa (IMESA) No M3362 10/02/2010
- South African National Commission on Large Dams (SANCOLD)

Key Skills and Competencies
- Project Management
- Master Planning
- Hydraulic Design
- Hydrological Analysis
- Basic WTW Design
- Basic WWTW Design

Professional Overview

Neil joined SMEC South Africa in 2013.

He has 20 years' experience in the design and project management of various projects both in South Africa and internationally, plus the design and project management of bulk water, sanitation/wastewater and drainage/stormwater infrastructure including water and wastewater treatment projects.

Neil is proficient with the use of numerous software packages for the planning, design and implementation of water, wastewater and stormwater projects. Neil has also developed spreadsheet models used to simplify and optimize water, sanitation and stormwater/drainage calculations, master planning assessments and evaluations of various infrastructure and treatment related projects.

Neil completed his MSc. Eng at the University of Stellenbosch from 2000 to 2001 and his MSc. Eng HEM/DIC at the University of London, United Kingdom from 2001 to 2002.

Relevant Project Experience

C1859 | Temporary Works on High-Speed Rail Network 2 (HS2), United Kingdom | GBP +500 Billion

Client: Sub-consultant to Robert Bird Group (RBG), United Kingdom on behalf of Effage, Kier, Ferrovial Construction and BAM Nuttal (EKFB), United Kingdom

Client Contact Details: Lisa Rapson; Director, Robert Bird Group; Tel: +44 20 7633 2880; Email: lisa.rapson@robertbird.com

Description: The temporary works contractor, EKFB, was appointed to conduct Temporary Works along the future High Speed 2 Rail Network (HS2) between London and Birmingham. The temporary works consist of Civil, Structural and Road works. RBG appointed SMEC to assist with Civil designs for the temporary works. To date a total of ten (10) earthwork design packages have been delivered.

Role and Responsibilities: Design lead for stormwater design and innovative drainage solutions for various excavations for temporary works. Design involvement included stormwater collection, routing, attenuation, silt management and pumping of stormwater. Hydraulic modelling of attenuation structures prepared using EPASWMM.

C1881 - Ernest Robertson Dam Dam Safety Evaluation, Western Cape, South Africa | R 92,366 Fees

Client: Mossel Bay Local Municipality | **Dates:** April 2022 – June 2022

Client Contact Details: Catherine Koelman; Project Manager; +27 (0)44 606 5269

Description: The 5th dam Safety Evaluation (DSE) for the Ernest Robertson Dam was undertaken in 2013. The 6th DSE was due, as required by the Department of Water and Sanitation (DWS) in terms of Regulations 35 of the Regulations regarding safety of dams published in government notice R.139 dated February 2012. SMEC was tasked with undertaking the 6th DSE. The scope of services of the Dam Safety Evaluation were as follows:

- Dam Inspection: Undertake the dam safety inspection and state the condition of indicators including the dam wall, dam crest and spillway, outlet works, reservoir basin slopes and monitoring instruments.
- Evaluation and Reporting: Review dam monitoring data to identify any issues; confirm flood hydrology and spillway capacity values remain applicable; prepare and submit draft Dam Safety

Evaluation Report with recommendations and action plan; Update and submit final Dam Safety Evaluation Report following receipt of comments from the client.

Role: Technical Lead.

Responsibilities: Review of Flood hydrology calculations, spillway capacity calculations, and report.

JH0049 - Tetra4 Gas Floodlines, Free State, South Africa | R 348 000 Fees

Client: EIMS | **Dates:** January 2022 – Ongoing

Client Contact Details: Brian Whitfield; Project Manager; +27 (0)82 688 9850

Description: SMEC was engaged by EIMS to prepare a Hydrological Impact Assessment that will be required to assist with the application of a Water Use License and Environmental Authorization for the Tetra4 Gas Production Project located in Welkom, Free State province.

Several hydrological methods, including Rational Method, Alternative Rational Method and SDF method were considered to calculate peak flood discharges for various return periods.

River hydraulics were modelled using the GeoHECRAS software suite developed by CivilGEO Engineering Software. The geometric information for the model was obtained from local topographic survey and roughness coefficients estimated from site surveys, based on the HEC-RAS hydraulic reference manual descriptions.

A flood hazard map and hydrological study report was prepared as input to various regulatory approval applications.

Role: Technical Lead.

Responsibilities: Review of Hydrological Analysis, Hydraulic Analysis, and the Hydrological assessment report.

Jh0051 - Mogalakwena PV Hydrological Study, Limpopo, South Africa | R250 917 Fees

Client: EDF Renewables | **Involvement Period:** April 2022 – July 2022

Client Contact Details: Martin Zietsman; Project Manager; +27 (0)83 69 13701

Description: SMEC was engaged by EDF Renewables to prepare a Hydrological Impact Assessment for a PV plant located in the Limpopo province of South Africa. This Hydrological Impact Assessment deals with the following aspects:

- Hydrological Analysis.
- Hydraulic Modelling.
- Floodline Delineation; and
- Flood impacts on infrastructure and flood mitigation measures.

The project also involved the design of a conceptual stormwater management plan. The scope of work was the design of a drainage layout, the sizing of drainage channels and detention basins, and erosion protection measures.

Role: Project manager and Design Engineer.

Responsibilities: Review of Hydrological Analysis, Hydraulic Analysis, Hydrology report and the stormwater management plan.

JH0050 - UMSO PV Hydrological Study, Northern Cape, South Africa | R 276 766 Fees

Client: EDF Renewables | **Dates:** January 2022 - Ongoing

Client Contact Details: Bradley Rabbitte; Project Manager; +27 (0)72 855 3420

Description: SMEC was engaged by EDF Renewables to prepare a Hydrological Impact Assessment for 5 PV plants located in the Northern Cape province of South Africa. This Hydrological Impact Assessment deals with the following aspects:

- Hydrological Analysis.
- Hydraulic Modelling.
- Floodline Delineation; and
- Flood impacts on infrastructure and flood mitigation measures.

Role: Technical Lead.

Responsibilities: Review of Hydrological Analysis, Hydraulic Analysis, and the Hydrology report.

DM0226: Replacement of AC/Mains for eThekwini Water and Sanitation, Phase II, Durban, KwaZulu-Natal, South Africa | R200 million

Client: eThekwini Municipality | Date: 2022 – Ongoing

Client Contact Details: Devashan Govender; Project Manager; Contact details: devashan.govender@durban.gov.za

Description: Replacement project comprising 12 months of intense field work and analysis to identify and select critical reservoir zones based on multi parameter optimization algorithms using GIS tools as part of the EWS water master plan and asset replacement programme for 2015/2030. A total of 80km of water mains to be designed already identified under phase I of the project. Prepare specification and tender documents for 40km of water mains in eThekwini Water Supply area.

Role and Responsibilities: Project Engineer, Lead Design Engineer. Technical advisor to field and data analysis teams in developing strategies to prioritize critical reservoir zones based on key KPI's. Lead the design work, prepare tender documentation, specification and project coordination of 2 construction contracts.

XL0048: NEOM Trojena, Stages 3B,3C,3D - Saudi Arabia | R 25 million (fees)

Client: Surbana Jurong (SJ) | **Date**: March 2022 – Ongoing

Contact Details: Sybille Tildsley - sybille.tildsley@smec.com

Description: SMEC International signed a sub-consultant agreement with Surbana Jurong (Holding Company) for the design of a futuristic city and freshwater lake in the NEOM mountains of Saudi Arabia. The project comprises all disciplines of stormwater, water, foul water, irrigation, recycled water and all the associated treatment processes. The harsh terrain required the teams to develop innovative solutions to provide wet services while managing the water quality of an artificial lake with challenges of high evaporation, lake seepage through designed liners etc. The project comprised confirming the master planning, developing the concept design through detailed design to tender and construction supervision.

Role and Responsibilities: Water Design Expert. Responsible for design development of bulk water systems for lake filling, lake recirculation and lake water treatment. Coordinating technical input required from potable water, foul water, recycled water, and treated water systems to ensure Lake water levels and quality is ensured through the correct sizing and placement of associated wet utility services around the lake and within the site-wide mountain assets as planned. Responsible to coordinate the design of stormwater and stormwater treatment systems impacting the Lake Water Quality.

Ferreira Canal, ESwatini | USD 27,000 (fees)

Client: eSwatini Electricity Company | **Date**: January to March 2022

Client Contact Details: Charles Coleman, Power Stations Manager, +268 550 2611, charles.coleman@sec.co.sz

Description: The Edwaleni Hydropower Station receives water from the Little Usutu and the Great Usutu rivers via two canals; the Main Canal and the Ferreira Canal respectively. This project entails the design of improvements to the Ferreira Canal (approximately 7.2 km in length and predominantly unlined) to increase the flow capacity to 6m^3/s, by enlarging and lining.

Role and Responsibilities: Technical Hydraulic Design Support and Peer Review. Review hydraulic models, advise on sizing/position of sediment traps, junction boxes/stilling basins and inlet/outlet structures. High level input to quantities and cost to preliminary design levels, input with regards to constructability to the Preliminary Design Report.

C1847: Juba-Rumbek Road Upgrade – Hydrological Study Review, South Sudan | R 0.1 million (fees)

Client: SMEC International | **Date**: Jan 2021 – March 2021

Client Contact Details: Daniel Kamau Daniel.Kamau@smec.com +254 20 444 1541/2/3

Description: The upgrade of the 63 km road from Juba to Rumbek in South-Sudan has been prioritized by the Ministry of Roads and Transport to address severe flooding. The project comprises the upgrading of at least 5 large bridges and up to 60 culverts along the route for which flood modelling and hydraulic capacity calculations were reviewed.

Role and Responsibilities: Specialist Hydrologist / Hydraulic Engineer. Responsible for review of hydrological calculations of the 1:50 and 1:100-year events, including hydraulic capacity reviews of structures.

XL0022: Consulting Engineering Services for the Upgrading of the Mpiti to Sehlaba Thebe Road Project – Hydrological Study Review, Lesotho | R 0.1 million

Client: Ministry of Public Works & Transport, Lesotho| **Date**: Nov 2020 - 2021

Client Contact Details: SA Thamae: +266 22 324191

Description: Hydraulic capacity reviews of 20 key culverts along the 90 km length of road, including full hydrological modelling of mountain catchments using various flood estimation methods. Advising on culvert upgrades.

Role and Responsibilities: Specialist Hydrologist / Hydraulic Engineer. Responsible for review of hydrological calculations of the 1:20 and 1:50 year events including hydraulic capacity reviews of existing structures.

XL0048: Neom Mountain Lake and Village, Stage 3A - Saudi Arabia | R 13 million (fees)

Client: Bureu Proberts | **Date**: Oct 2020 – June 2021

Contact Details: skyer@bureauproberts.com.au

Description: SMEC International signed a Contract with an international architect (name undisclosed – under NDA) who won a design competition for the design of a Lake and Lake village located within mountain resort project. SMEC South Africa is required to provide input to the Feasibility and Concept Design for various Infrastructure, Dam, Geology, Hydrology, Power & Urban Infrastructure of the Lake and Village.

Role and Responsibilities: Water Engineer / Stormwater Engineer. Responsible for undertaking Lake water balances, determining bulk water requirements, lake filling times, lake management energy requirements and costs, lake catchment stormwater conceptual designs, flood calculations and development and sizing of stormwater treatment options. Conceptualizing and sizing and Desalination of Lake Water and management of brine.

XL0049: Consultancy Services for Freetown Water Supply and Sanitation Master Plan and Medium-Term Investment Project Proposal. GVWC, Freetown, Sierra Leone | R5.67 million (fees)

Client: Guma Valley Water Company – Sub-Consultant to COBA, Portugal| **Date**: 2020 - Ongoing

Client Contact Details: Francis H Lahai PE MSLIE, Contact Nr. +232 78781396, Contact Nr. ++232 30642872; Julio Arsenio (COBA); Contact Nr: +351 210 125 000

Description: The project addresses the water and sanitation master planning for Freetown with a population of 1.5 million people where dilapidated water and infrastructure forced authorities to plan ahead for the identification of short, medium- and long-term investment projects.

Role and Responsibilities: External Water & Sanitation Master Plan Reviewer. Responsible to direct and review inputs from a team with Sanitary Expert, Drainage Expert, Water Resources Expert, Financial Expert, Groundwater Expert and RAP/Environmental Expert. Directing master planning and design related philosophies, approaches and guidelines.

DM0020: Review of the Ndumo A Irrigation Scheme, Jozini, South Africa | R 0.5 million (fees)

Client: Department of Treasury, KwaZulu-Natal, South Africa | | **Date:** 2020

Client Contact Details: Nolwazi Maduma/ Rob Kempen, Project Managers, Contact Nr. +27 33 897 4496 / +27 82 651 3898; Nolwazi.Maduma@kzntreasury.gov.za / Rob.Kempen@kzntreasury.gov.za

Description: The project aimed to identify various alternative pumping main routes from the Pongola and other rivers to service the Ndumo A Irrigation Scheme more effectively and sustainability. The project concluded deficiencies in the original design and assisted the client to make informed discussion to rectify and approve the pumping system to ensure a sustainable overall scheme.

Role and Responsibilities: Hydraulic Modelling Expert. Responsible for the review of existing river abstraction works on the Pongola River and rising mains, storage reservoir hydraulic modelling as well as option development and hydraulic modelling for alternative irrigation bulk water supply options to the Ndumo A Irrigation Scheme. Development of review comments, reporting to the Project Manager.

XL0037: Master Plan of Proposed Airport City in Nkok, Gabonese Republic | R2.1 million

Client: DP Architects PTE LTD, Singapore | **Date:** 2018 - 2019

Client Contact Details: Djoko Prihanto, Project Manager, Contact Nr. + +65 6338 3988 & Dave Duke; +27 31 277 6600 dparchitects@dpa.com.sg

Description: Stormwater and flood modelling for Airport City with primary focus to confirm 1:50 and 1:100-year drainage lines to guide Town Planning process to ensure most suitable and efficient positioning of roads, stands and major infrastructure.

Role and Responsibilities: Hydrologist. Technical advisor on rainfall and runoff generation and stormwater/flood modelling using HEC-RAS 2D software. Services provided to SMEC South African team developing overall master plan for Airport City.

DH874: Investigations in the Improvements for Autumn Drive Dam, Umhlanga as Multipurpose Facility, KwaZulu-Natal, South Africa | R0.065 million

Client: Tongaat Hulett Developments | **Date:** 2016 - 2018

Client Contact Details: Lawrence Kirkman; PM; Contact Nr. +27 31 560 1900

Description: Hydrological & Hydraulic modelling of stormwater systems, dam and spillway to optimize re-use potential of dam considering both applications for retention and aesthetics.

Role and Responsibilities: Project Director. Liaise with client's representative, oversee modelling work in PCSWMM and review technical reports.

DT0001: Flood Calculations for Farm Dam SANRAL N1-17 at km 13.600, KwaZulu-Natal, South Africa

Client: SANRAL | **Date:** 2018

Client Contact Details: Zandile Nene; PM; Contact Nr. +27 33 392 8139

Description: Culvert hydraulics and river flood level modelling

Role and Responsibilities: Hydraulics Engineer. The Hydraulic Engineer undertook flood calculations for a river section at SANRAL's N1 Bridge at chainage 13.6km to ascertain a suitable flood outlet level for a farm dam downstream of the N1 Bridge to evaluate back-water effects on the N1 river bridge.

PE243: Heuningness Estuary, Western Cape Province, South Africa | R0.4 million

Client: Western Cape Nature Conservation | **Date:** 2016 - 2017

Client Contact Details: Pierre de Villiers; Programme Manager; Contact Nr. +27 21 866 8000 estuaries@capenature.co.za

Description: Undertake hydrological and hydrodynamic modelling to predict water (flood) levels under feasible system and mouth management scenarios for a big an area as possible of the Heuningnes Estuary and catchment. Provide recommendations and substantiated motivations for a mouth management regime/s that best balances ecological and human needs for the foreseeable future.

Role and Responsibilities: Project Manager. Project management and technical assistance to flood modelling, flood peak arrival

DH874: Investigations in the Improvements for Autumn Drive Dam, Umhlanga as Multipurpose Facility, Durban, KwaZulu-Natal, South Africa | R0.065 million

Client: Tongaat Hulett Developments | **Date:** 2016

Client Contact Details: Lawrence Kirkman; PM; Contact Nr. +27 31 560 1900

Description: Hydrological & Hydraulic modelling of stormwater systems, dam and spillway to optimize re-use potential of dam considering both applications of retention and aesthetics.

Role and Responsibilities: Project Director. Liaise with client's representative, oversee modelling work in PCSWMM and review technical reports.

DM0113: Cwaka Environmental Impact Assessment and Formalization, KwaZulu-Natal, South Africa | R1 million

Client: LDM Consulting | **Date:** 2016

Client Contact Details: Trivi Arjunan; PM; Contact Nr. +27 31 207 1340

Description: Floodline delineation and report.

Role and Responsibilities: Design Engineer, Hydraulic modelling Oversight. Hydraulic modelling and floodline delineation of 100-year floodlines for two major rivers in the Cwaka area using HEC-RAS software, drafting and reporting

DM0120: Rukwa Coal Project – Flood Analysis, Rukwa, Tanzania | R0.3 million

Client: Shangoni Management Services | **Date:** 2016

Client Contact Details: Dawie Maree, Contact Nr. +27 73 330 5815

Description: Hydrological flood modelling with UPFD software and hydraulic routing and mapping with HEC-RAS.

Role and Responsibilities: Project Manager. Oversee and project management of floodline and flood volume assessment for three major rivers for Rukwa Coal Mine.

PK270: Polokwane Wastewater Treatment Works Flood Line Analysis, Polokwane, South Africa | R 8 million

Client: Polokwane Municipality | **Date:** 2017

Client Contact Details: Vonani Mathebula, Director, Contact Nr. 072 153 3175

Description: Flood line delineation and report for the construction of a new wastewater treatment works.

Role and Responsibilities: Hydraulic Modelling Reviewer. Oversee hydrological study for two rivers' catchments (the Bloed River and the Sand Riviera) for the purposes of delineating the 1:20, 1:50 and 1:100-year floods. Review hydraulic modelling of the rivers for delineation of flood lines for the various storm events using HEC-RAS modelling software. The results were reported for the purposes of positioning the wastewater treatment works appropriately.

DD0081: Upgrade of KwaNqetho Inlet 300mm Ø Steel Pipe Watermain, Durban, KwaZulu-Natal, South Africa | R 10 million

Client: eThekwini Water and Sanitation | **Date:** 2016

Client Contact Details: Devashan Govender PM (Leisel Bowes); Contact Nr. +27 31 311 8796

Description: In the execution of eThekwini's water master plan and wider drive for asset renewal, the project considered the investigation and pipe replacement of a problematic section of water main in a challenging (steep topography) with a high historic frequency of bursts.

Role and Responsibilities: Lead Hydraulic Modeller, Design Review, Technical Advisor. Hydraulic modelling of existing water distribution system to determine cause of failure using Bentley WaterGEMS hydraulic modelling software, analysing pressure and flow data, modelling of proposed system with new connectivity to optimise break-pressure tank positions, design of proposed upgrade (diameters). Provide technical advice and design review to EWS on related matters such as valve selection, erosion protection and connectivity.

DD451 Developing a Stormwater Flood Risk Assessment Tool, Phoenix, KwaZulu-Natal, South Africa | R60k

Client: eThekwini Municipality, Coastal Stormwater & Catchment Management | **Date:** Jan 2015 – Feb 2015

Client Contact Details: Kiyash CherrSha, Contact Nr. 031 311 7323

Description: Pilot study to develop a storm water flood risk assessment tool. The assignment involved hydrological and hydraulic modelling (using PCSWMM software) of an urban catchment in Phoenix to the north-west of Durban comprising 479 sub-catchments, 18,400m of storm water pipes with diameters ranging from 225mm to 2,000mm.

Role and Responsibilities: Project Manager. Oversee and project management, Review of hydrological and hydraulic modelling. PCSWMM software.

DM0089: Pre-Feasibility Investigation, Water, Sewage & Effluent requirements, HEBEI Iron & Steel Industry, Richards Bay, KwaZulu-Natal, South Africa | R 1.3 billion

Client: Richards Bay Infrastructure Development Zone (IDZ) | **Date:** 2015

Client Contact Details: Brenda Mabaso; Research, Marketing Intelligence Manager; Contact Nr. +27 35 788 0571

Description: Feasibility studies, water & sewer services for planned Steel Smelter in Richards Bay.

Role and Responsibilities: Design Engineer / Support to Project Manager. Prepare high level feasibility studies on bulk water and sanitation supply for planned Steel Smelter in Richards Bay, analysis included various technical options and costs comparison's to ultimately inform decision makers on investment options and key timeframes.

DM0035: DUT Riverside and Indumiso Campus Storm Water Management Plan (Planning), Pietermaritzburg, KwaZulu-Natal Province, South Africa | R1.2 million

Client: Durban University of Technology | **Date:** Aug 2013 – Feb 2017

Client Contact Details: Tom McKune, Contact Nr. +27 (0)86 010 3194

Description: Civil and structural engineering services for the infrastructure upgrade at the Riverside campus of DUT in Pietermaritzburg. New engineering building, lecture halls, library and computer centre. Determination and delineation of 1:50 and 1:100 flood lines for the Msunduzi River at the Durban University of Technology (DUT) Riverside Campus.

Role and Responsibilities: Hydrological/Hydraulic Engineer. Hydrological calculations and Hydraulic Modelling of the Msunduzi River for delineation of 1:50 and 1:100-year flood lines including sensitivity analysis of building structures in the 1:100-year floodplain.

Rehabilitation of Centurion Lake, Pretoria, South Africa | R10 million

Client: City of Tshwane, Roads & Stormwater | **Date:** 2013

Client Contact Details: Gawie Janse van Vuuren; PM; Contact Nr. +27 21 358 9999

Description: Hydraulic capacity calculations.

Role and Responsibilities: Design Engineer. Project management and coordination of specialist river rehabilitation and flood hydrology studies. Hydraulic optimization of proposed drainage and diversion structures in support of the rehabilitation of the Centurion Lake suffering from toxic sedimentation pollution. Hydraulic investigations were undertaken for the Hennops River which included the SANRAL N1 road bridge section in Centurion. HEC-RAS software was used following hydrological inputs from XP-SWMM software.

Flood overtopping of N11 between Amersfoort and Ermelo, Mpumalanga, South Africa | part of R350 million project

Client: South African National Roads Agency | **Date:** 2008 - 2011

Client Contact Details: Willem van der Merwe, Contact Nr: +27 12 426 6200

Description: Hydraulic capacity calculations.

Role and Responsibilities: Hydraulics Engineer. The Hydraulic Engineer working for SCIP Engineering Group undertook flood calculations following flooding of a section of the N11 which involved hydrological calculations and culvert capacity assessments based on photo evidence and high-water levels observed during the flood event.

Professional History

- **2013 – Present | SMEC South Africa**
  2013 – Present | Technical Principal, Water Infrastructure
- **2003 – 2013 | SCIP Engineering Group (Pty) Ltd, Witbank**
  2003 – 2013 | Director
- **2001 – 2003 | Group 5 Roads & Earthworks (Pty) Ltd**
  2001 – 2003 | Site Agent
- **2000 – 2001 | Post graduate studies, University of London**
  2000 – 2001 | Student
- **1998 – 2000 | Post Graduate studies, Sigma Beta/Water Resources Commission, University of Stellenbosch**
  1998 – 2000 | Student

Courses and Conferences Attended

2020	IMESA	Site visit to 20 MLD Rosetta Water Treatment Works
2019	University of Cape Town	Permeable Pavements and Bio Retention Cells
2019	WISA	Getting Control Valves Right
2017	WISA	Energy recovery in pipelines – micro turbines
2016	WRC, University of Pretoria	Biofilm n water mains
2016	WISA	Water Institute South Africa – 2016 Conference
2015	University of Cape Town	Report Writing
2015	University of Cape Town	Sustainable Drainage Systems (SuDS)
2014	WISA	CFD & Pipe/Earth interaction
2014	Wolf Weidemann Pr Eng.	Finances for Built Environment Profession
2013	WISA Conference	Annual Conference
2013	University of Pretoria/SINOTECH	Conduit Hydropower
2013	Kaytech	Filtration & pipe material

Publications and Papers Presented

2000 MSc Thesis on Flood Measurement Techniques using Bridge Structures – University of Stellenbosch

2001 MSc HEM Thesis on Groundwater Recharge to Coastal Plains, Aden/Southern Yemen – University of London

Language Skills

Mother Tongue:	Afrikaans		
Languages	**Speak**	**Read**	**Write**
English	Excellent	Excellent	Excellent
Afrikaans	Excellent	Excellent	Excellent

Rendani Byven Thovhakale

Water Engineer

Years of Industry Experience

- 6 years

Personal Information

- Cell Number: +27 78 041 1701
- Email: rendanitb@yahoo.com
- Nationality: South African

Qualifications

- Bachelor of Engineering (Civil), University of Johannesburg, 2015

Key Skills and Competencies

- Hydrological analysis
- River hydraulics modelling
- Floodline delineation
- Surface Drainage
- Pipeline and Pump station design
- Erosion protection structures
- Energy dissipation structures
- Stormwater ponds
- AutoCAD Civil 3D
- AutoCAD
- GeoHEC-RAS
- QGIS
- Microsoft Excel

Professional History

- 2019 – Present | Engineer
- 2016 – 2019 | Graduate Engineer

Referees

Dawid van Coller, Senior Water Engineer, vancollerd@gmail.com, +44 7748 176 086

Roshuma Makhado, Classmate, roshumamakhado@gmailcom, +27 79 251 9246

Professional Overview

Rendani is a Water Engineer with 6 years of experience in the civil engineering industry, during which time he has developed varied technical expertise, primarily in the water sector. He is highly proficient in Hydrology and River hydraulic modelling and related studies having completed numerous hydrological and floodline studies on several international projects, most notably for the Lesotho Highlands Water project. Often the design of erosion protection measures or river rehabilitation work also form part of these projects. My expertise also extends to the detailed design of hydraulic components associated with river systems such as weirs, canals, and erosion protection structures.

Some of the projects he has been involved in include the feasibility design and planning of steel and concrete pipelines and pump stations.

Relevant Project Experience

Ernest Robertson Dam DSE, Western Cape, South Africa | US$ 5 621

Client: Mossel Bay Local Municipality | **Dates:** April 2022 – June 2022

Client Contact Details: Catherine Koelman; Project Manager; +27 (0)44 606 5269

Description: The 5^{th} dam Safety Evaluation (DSE) for the Ernest Robertson Dam was undertaken in 2013. The 6^{th} DSE was due, as required by the Department of Water and Sanitation (DWS) in terms of Regulations 35 of the Regulations regarding safety of dams published in government notice R.139 dated February 2012. SMEC was tasked with undertaking the 6^{th} DSE. The scope of services of the Dam Safety Evaluation were as follows:

Dam Inspection: Undertake the dam safety inspection and state the condition of indicators including the dam wall, dam crest and spillway, outlet works, reservoir basin slopes and monitoring instruments.

Evaluation and Reporting: Review dam monitoring data to identify any issues; confirm flood hydrology and spillway capacity values remain applicable; prepare and submit draft Dam Safety Evaluation Report with recommendations and action plan; Update and submit final Dam Safety Evaluation Report following receipt of comments from the client.

Role: Design Engineer.

Responsibilities: Flood hydrology calculations, checking of spillway capacity, and preparation of report.

Tetra4 Gas Floodlines, Free State, South Africa | US$ 21 178 Fees

Client: EIMS | **Dates:** January 2022 – Ongoing

Client Contact Details: Brian Whitfield; Project Manager; Ph +27 (0)82 688 9850

Description: SMEC was engaged by EIMS to prepare a Hydrological Impact Assessment that will be required to assist with the application of a Water Use License and Environmental Authorization for the Tetra4 Gas Production Project located in Welkom, Free State province.

Several hydrological methods, including Rational Method, Alternative Rational Method and SDF method were considered to calculate peak flood discharges for various return periods.

River hydraulics were modelled using the GeoHECRAS software suite developed by CivilGEO Engineering Software. The geometric information for the model was obtained from local topographic survey and roughness coefficients estimated from site surveys, based on the HEC-RAS hydraulic reference manual descriptions.

A flood hazard map and hydrological study report was prepared as input to various regulatory approval applications.

Role: Project manager and Design Engineer.

Responsibilities: Review of Hydrological Analysis, Review Hydraulic Analysis, Floodline delineation and preparing the Hydrological assessment report.

Mogalakwena PV Hydrological Study, Limpopo, South Africa | US$ 15 270

Client: EDF Renewables | **Involvement Period:** April 2022 – July 2022

Client Contact Details: Martin Zietsman; Project Manager; Ph +27 (0)83 691 3701

Description: SMEC was engaged by EDF Renewables to prepare a Hydrological Impact Assessment for a PV plant located in the Limpopo province of South Africa. This Hydrological Impact Assessment deals with the following aspects:

- Hydrological Analysis;
- Hydraulic Modelling;
- Floodline Delineation; and
- Flood impacts on infrastructure and flood mitigation measures.

The project also involved the design of a conceptual stormwater management plan. The scope of work was the design of a drainage layout, the sizing of drainage channels and detention basins, and erosion protection measures.

Role: Project manager and Design Engineer.

Responsibilities: Review of Hydrological Analysis, Hydraulic Analysis, Floodline delineation and preparing the Hydrology report. Design of stormwater management plan.

UMSO PV Hydrological Study, Northern Cape, South Africa | US$ 16 843 Fees

Client: EDF Renewables | **Dates:** January 2022 - Ongoing

Client Contact Details: Bradley Rabbitte; Project Manager; Ph +27 (0)72 855 3420

Description: SMEC was engaged by EDF Renewables to prepare a Hydrological Impact Assessment for 5 PV plants located in the Northern Cape province of South Africa. This Hydrological Impact Assessment deals with the following aspects:

- Hydrological Analysis;
- Hydraulic Modelling;
- Floodline Delineation; and
- Flood impacts on infrastructure and flood mitigation measures.

Role: Project manager and Design Engineer.

Responsibilities: Review of Hydrological Analysis, Hydraulic Analysis, Floodline delineation and preparing the Hydrology report.

Kaalspruit Climate Resilient Catchment Management Plan, Gauteng Province, South Africa | US$ 105 246 Fees

Client: Gauteng Department of Agriculture and Rural Development (GDARD) | **Dates:** August 2021 - Ongoing

Client Contact Details: Gerson Nethavhani; Project Manager; Ph +27 (0)11 240 3435

Description: The assignment entailed the development of a climate-resilient Catchment Management Plan (CMP) for the Kaalspruit catchment to the east of Johannesburg. The 1st step in developing the CMP was to identify the diverse stakeholders in the catchment and to prepare a Stakeholder Engagement Plan. This was followed by stakeholder engagement and literature review leading to a description of the catchment status quo in the form of a Situational Assessment Report. This step included development of a base case hydrological and hydraulic model using PCSWMM software. Planned future steps were identification of potential catchment interventions and testing of these in the model to assess physical benefits, further stakeholder engagement, and ultimately the development of the CMP.

Role: Project Manager and Design Engineer

Responsibility: Hydrological and Hydraulic analysis.

Calitzdorp Spa Dam, Northern Cape Province, South Africa | US$ 7647 Fees

Client: Calitzdorp Export Agri Hub | **Dates:** April 2021 - July 2021

Client Contact Details: Gerhard Meyer; Project Manager; Ph +27 (0)82 802 7138

Description: Execution of a Water Resource Study to investigate the feasibility of the proposed Calitzdorp Spa Dam. The primary purpose of the Study was to ascertain whether there is sufficient water available in the catchment over the long-term for the intended water use, at a sufficiently high assurance of supply. Four potential dam sites were assessed using the Water Resources Simulation Model (WRSM/Pitman), taking environmental water requirements into account. The Study had a positive outcome, and the following investigations were scoped for execution subject to funding availability.

Role: Design Engineer

Responsibility: Water resources modelling

Pandora Water Extraction, North West Province, South Africa | US$ 41 000 Fees

Client: Eastern Platinum Limited | **Dates:** November 2020- April 2021

Client Contact Details: Andre Laubscher; Project Manager; Ph +27 (0)82 228 7069

Description: To supplement water supply to the Marikana Platinum Mine, Sibanye Stillwater have secured an allocation from the Hartbeestpoort Dam Irrigation System. The project will entail the detail design of the following components: Extraction point from the West Canal Hartbeespoort Dam Irrigation System; gravity feed pipeline/canal from the offtake to a new holding dam with a transfer capacity of 10 million litres per day; 30 million litre (3 days) holding dam adjacent to the irrigation canal; and pump station fed from the holding dam and delivering into an existing 315mm diameter pipeline which is connected to the mine's water reticulation/distribution system.

Role: Design Engineer

Responsibility: Preliminary design of Pump Station and 5.3km HDPE pipeline

Mokopane Treated Wastewater Pipeline, Limpopo, South Africa | US$ 91 500

Client: Anglo American Platinum | Date: August 2020 - December 2020

Client Contact Details: Chiedza Mnguni; Project Manager; Chiedza.mnguni@angoamerican.com

Anglo American Platinum intends to improve the current 30km long, 250mm and 300mm diameter steel pipeline's capacity. The pipe is intended to deliver 6Ml/day which is an improvement over the 4.42Ml/day that it delivers currently in 2020. SMEC was assigned to investigate the possible options for improving the current pipe system. These options included analysing: various pipe sizes for pipe replacement; lining options for refurbishing the current pipe; required pump station capacity; and cost models for all options.

Role: Design Engineer

Analysed the capacity of the existing pump station and Pipeline; Designed options for improving the pipe system capacity; and prepared the feasibility study and cost models

Steynsrus Water Supply Scheme, Free State, South Africa | US$ 38 000

Client: MIB Infrastructure Development | Date: May 2020 - July 2020

Client Contact Details: Papi Wessie; Project Manager; Ph (+27) 12 942 4450

The existing Steynsrus Water Supply Scheme sources water from the Vals River and supplies the towns of Steynsrus and Matlwangtlwang. The scheme comprises an abstraction weir and pump station on the Vals River, which pumps raw water via a 400 mm diameter low pressure asbestos-cement (AC) pipeline into the off-channel Morgenzon Dam. Water is stored in the dam and pumped from there by a high lift pump station via a booster pump station and balancing reservoir to the water treatment works (WTW), from whence treated water is supplied to Steynsrus and Matlwangtlwang. These towns regularly suffer from water shortages. This feasibility study investigated options to augment the supply to the town. A raising of the dam in combination with an upgrade of the pump station was the recommended option.

Role: Design Engineer

Performed the Water Resource Study, Analysed the capacity of the existing pump station and Pipeline and prepared the feasibility study

Steenkoolspruit Hydrodynamic Modelling, Mpumalanga, South Africa | US$ 9 500 Fees

Client: Anglo American Coal South Africa | Date: April 2020 - May 2020

Client Contact Details: Marthinus van Wyk; Project Manager; Ph +27 (0)17 620 2714

SMEC was engaged by the Anglo American Coal South Africa to undertake a Hydrological and Flood Risk Assessment at the Isibonelo Colliery which is located 9 km to the north of Secunda, Mpumalanga Province. The objective of this study was to investigate the impacts of removing the Isibonelo Attenuation Dam on flood levels on the farmlands upstream, and on the mining area downstream. A 1D hydrodynamic HEC-RAS model was used to determine flood levels of various flood events in combination with a flood routing model to take into account the attenuation effects of the existing dam.

Role: Design Engineer

Review of Hydrological Analysis, Hydraulic Analysis, Floodline delineation and preparing the Hydrology report.

Polokwane Waste Water Treatment Works, Limpopo, South Africa | US$ 50 000 000m

Client: Mafumu Consulting (Pty) Ltd | Date: March 2020 - March 2021

Client Contact Details: Terrence Mathebula; Manager; Ph +27 72 153 3175

Development of the new Polokwane Regional Wastewater Treatment Works with an ultimate capacity of 40ML/day. The scope of SMEC's appointment entails design, documentation and procurement, construction monitoring and contract administration. The works are being implemented in two contracts, namely an earthworks contract and a main works contract.

Role: Design Engineer

Design of a 1m diameter and 100m long concrete pipe and the design of an energy dissipation structure. Design of stormwater drains. Site Supervision

Lesotho Highlands Water Project Delivery Tunnel North Maintenance Shutdown, Free State Province, South Africa | US$ 710 000

Client: Trans Caledon Tunnel Authority (TCTA) | **Date**: Oct 2019 – Feb 2020

Client Contact Details: David Keyser, Project Manager; Ph +27 12 683 1203

Description: The 4,6m diameter and 22km long Delivery Tunnel North which is part of the Lesotho Highlands Water Project was constructed in the 1990s to transfer water to the Gauteng Provence of South Africa. SMEC undertook a planned inspection of the tunnel during a 9week system outage to identify the repair and maintenance requirements. Other works that were undertaken during that period involved the inspection of the Ash River to assess erosion and deposition conditions along the river and to assess the status of existing structures along the river. SMEC procured a contractor and repairs and maintenance of tunnel lining and valves were executed, all within the outage period.

Role: Design Engineer and Inspector

Responsibilities: Inspection of the Ash River, Hydraulic modelling, preparing the Ash River Inspection report.

Isibonelo Dam Inspections, Mpumalanga Province, South Africa| US$ 6 700

Client: Anglo American Coal South Africa | **Date**: December 2019

Client Contact Details: Marthinus van Wyk, Project Manager; Ph +27 17 620 2714

Description: SMEC South Africa (SMEC) was appointed by Anglo American Coal South Africa (AACSA) to carry out an annual safety inspection for five dams at their Isibonelo Colliery including:

- Attenuation Dam (Category II 11.5m high earthfill embankment with Armco Culvert Spillway)
- Diversion Dam (Category II 10.5m high earthfill embankment with side channel and auxiliary culvert spillway)
- Farm Dam (Uncategorized approximately 5m high earthfill embankment with side channel spillway)
- Montedi Dam (Uncategorized approximately 5m high earthfill embankment with side channel spillway)
- Vaskop Dam (Category II 13.5m high earthfill embankment with side channel spillway)

The main purpose of the dam inspection was to assess the condition of each of the following indicators: Wall embankment; Inlet; Outlet; Spillway; Pump station; Leak detectors; and Safety and security.

Role: Dam Inspector

Responsibilities: Dam inspections and preparing the dam inspection reports.

Emalahleni Discard Dump Floodlines, Mpumalanga Province, South Africa| US$ 4 000

Client: Shangoni Management Services | **Date**: November 2019

Client Contact Details: Christiaan Schutte, Project Manager; Ph +27 82 784 2942

Description: SMEC was engaged by Shangoni Management Services to undertake a floodline study for the proposed discard dump in Emalahleni, Mpumalanga Province.
This study report documents the results of the floodline study which deals with the following aspects:

- Hydrological Analysis
- Hydraulic Modelling
- Flood routing
- Floodline Delineation; and

Several hydrological methods, including Rational Method, Alternative Rational Method and SDF method were considered to calculate peak flood discharges for various return periods.
River hydraulics were modelled using the GeoHECRAS software suite developed by CivilGEO Engineering Software. The geometric information for the model was obtained from local topographic survey and roughness coefficients estimated from site surveys, based on the HEC-RAS hydraulic reference manual descriptions.

A floodline map and hydrological study report was prepared as input to various regulatory approval applications.

R**ole:** Design Engineer

Responsibilities: Hydrological analysis, Hydraulic modelling, Floodline delineation and preparing the Hydrology report.

Greefspan 2 Solar Farm Hydrology, Northern Cape Province, South Africa | US$ 2 500

Client: Grupo Gransolar | **Date**: October 2019

Client Contact Details: Manuel Bolano, Project Manager; Ph +34 917 364 248

Description: SMEC was engaged by Gransolar to undertake a Hydrological and Flood Risk Assessment for the proposed Greefspan 2 Photovoltaic Solar plant in Northern Cape, South Africa. The objective of the hydrological study is to determine the external flows that will enter the site for various return periods.
Several hydrological methods, including Rational Method and SCS method were considered to calculate peak flood discharges for various return periods.
Whilst there are no defined watercourses traversing the site, local storm water will still need to be managed when the site infrastructure is developed. The input parameters generated in this hydrological study will be used to size any storm water drainage infrastructure using similar methods presented in this report.

Role: Design Engineer

Responsibilities: Hydrological analysis and preparing the Hydrology report.

Mambia PV Plant Hydrological Study, Kindia, Guinea| US$ 5 500

Client: Phanes Group | **Date**: August 2019

Client Contact Details: Guillaume Aryal, project Manager; Ph +971 55660 3166

Description: SMEC was engaged by Phanes Group to undertake a Hydrological and Flood Risk Assessment for the proposed Mambia Photovoltaic Solar Plant in Guinea, covering the following aspects:

- Hydrological Analysis
- Hydraulic Modelling
- Floodline Delineation; and
- Flood Risk Assessment.

Several hydrological methods, including Rational Method and SCS method were considered to calculate peak flood discharges for various return periods.

River hydraulics were modelled using the GeoHECRAS software suite developed by CivilGEO Engineering Software. The geometric information for the model was obtained from a drone based photogrammetric survey and roughness coefficients estimated from site surveys, based on the HEC-RAS hydraulic reference manual descriptions.

A floodline map and flood risk report was prepared as input to Environmental Authorisation process with the flood risk assessment considering the following: Depth of floodwaters; Erosion/siltation; Period of Flooding; Potential damage to infrastructure; Loss of vegetation and Loss of Life.

Role: Design Engineer

Responsibility: Hydrological analysis, Hydraulic modelling, Floodline delineation, Flood Risk Assessment and preparing the Hydrology report.

Mohale's Hoek Solar Farm, Mohale's Hoek, Lesotho | US$ 8 600

Client: Phanes Group | **Date**: July 2019

Client Contact Details: Valerio Massimo Bu, Project Manager, Ph +971 4558 7450

Description: SMEC was appointed by Phanes Group to undertake a Hydrology and Flood Risk Assessment for the proposed Mohale's Hoek Photovoltaic Solar Plant in Lesotho. The objectives of the Hydrology and Flood Risk Assessment include: Collection of historical precipitation data; Determination of design or peak floods using empirical methods, statistical/probabilistic methods and deterministic methods; Hydraulic modelling for the 10 and 100 year recurrence interval floods; Determination of 10 and 100 year floodlines using a hydraulic model; Description and determination of flood risk based on flood hazards (based on floodlines) and vulnerabilities (location of proposed critical civil, mechanical and electrical infrastructure, power stations, dwelling units, offices and solar installations); and recommendation of flood mitigation and protection measures.

Role: Design Engineer

Responsibilities: Hydrological analysis, Hydraulic modelling, Floodline delineation and preparing the Hydrology report.

Touna-Bla PV Plant, Bamako, Mali | US$ 7 500

Client: Phanes Group | **Date**: June 2019 – July 2020

Client Contact Details: Guillaume Ayral, Project Development Manager; Ph +971 55660 3166

Description: SMEC was appointed by Phanes Group to undertake a Hydrology and Flood Risk Assessment for the proposed Touna-Bla Photovoltaic Solar Plant in Mali. The objectives of the Hydrology and Flood Risk Assessment Study include: Estimation of pre-development flood magnitudes and flood hydrographs for various design recurrence intervals using at least 3 international recognised methods; Estimation of post development flood magnitudes and flood hydrographs for various design recurrence intervals using at least 3 international recognised methods; 1D Hydraulic modelling for the estimated flood peaks in order to establish the extents of the flood lines for the desired recurrence intervals, along the areas at risk of flooding.; Description and determination of flood risk based on flood hazards (based on floodlines) and vulnerabilities (location of proposed critical civil, mechanical and electrical infrastructure, power stations, dwelling units, offices and solar installations); and recommendation of flood mitigation and protection measures.

Role: Design Engineer

Responsibilities: Hydrological analysis, Hydraulic modelling, Floodline delineation and preparing the Hydrology report.

Polihali Transfer Tunnel, Polihali, Lesotho | US$ 514 000 000

Client: Lesotho Highlands Development Authority | **Date**: May 2018 – Ongoing

Client Contact Details: John Sawyer, Deputy Executive Manager; Ph +266 5225 2271

Description: Design and construction supervision of approximately 38km of water tunnels, majority TBM excavation and minority drill and blast excavation, to transfer water from the new Polihali Dam to the existing Katse Dam, all as part of Phase 2 of the Lesotho Highlands Water Project (LHWP).

Role: Design Engineer

Responsibilities: Hydrological analysis, Hydraulic modelling, Floodline delineation, Concrete Pipes Design, Drainage Channel, AutoCAD Drawings and preparing the Hydrology report.

Henrietta Photovoltaic project, Henrietta, Mauritius| US$ 6 000

Client: Bouygues Construction | **Date**: March 2018 – May 2018

Client Contact Details: Claire Sina, Project Manager; Ph +337 6399 0948

Description: The project focused on developing an Operation and Maintenance Management Plan for the proactive implementation of routine maintenance tasks and providing the municipality with a baseline for cost planning and scheduling resources. The project includes the development and implementation of the plan.

Role: Design Engineer

Responsibilities: Hydrological analysis, Hydraulic modelling Floodline delineation, and preparing the report.

AKS 100MW Photovoltaic Project, Kaduna, Nigeria | US$ 14 000

Client: Sky Power| **Date**: October 2017 – December 2017

Client Contact Details: Giorgio Mauro, Director; giorgiom@skypower.com

Description: Consultancy Services for Technical Pre-Feasibility Studies on 100MW Solar Photovoltaic PV Plant in Kaduna. The overall scope of consultancy services includes the following studies: Geotechnical study, Topographic survey, Water management study and a transport study.

Role: Design Engineer

Responsibilities: Hydrological analysis, Hydraulic modelling, Floodline delineation and preparing the water management study report.

Gamsberg Mine SWMP, Northern Cape Province, South Africa | US$ 1 175 000

Client: Black Mountain Mining | **Date**: Oct2017 – March 2018

Client Contact Details: Avinash Mamtora, Manager; Ph +27 82 881 8761

Description: Preparation of a Storm Water Management Plan for a zinc mine in the Northern Cape province of South Africa. Various measured are required to deal with storm water run-off, both clean and contaminated. These measures include drainage channels, earthen bund walls, pollution control dams, pipelines and pump stations.

Role: Design Engineer

Responsibilities: Hydrological analysis, pipeline and pump station design, Design of stormwater ponds and drainage channel designs, and preparing the design report.

Douglasdale River Improvements Phase 2, Gauteng Province, South Africa | US$ 38 900 Construction Value

Client: Douglasdale Retirement Village | **Date**: March 2017 – July 2017

Client Contact Details: Rob Fraser, Manager; Ph +27 71 863 5183

Description: After assessment of an existing dam situated within the Douglasdale Retirement Village, it was concluded that its spillway capacity was inadequate with a high risk of overtopping the earth-fill embankment. A design was prepared for the upgrade of the spillway to increase its discharge capacity. The watercourse upstream of the dam is prone to erosion. To prevent further erosion of the riverbanks, several erosion control measures were investigated. An erosion control weir was proposed as the most suitable rehabilitation and prevention measure.

Role: Design Engineer

Responsibility: River hydraulics modelling and detailed design of erosion control weirs, and preparing the report.

Loopspruit Floodlines, Gauteng Province, South Africa | US$ 7 000

Client: Shangoni Management Services (Pty) Ltd

Client Contact Details: Nico Brits Manager; Ph +27 12 807 7036

Description: Determination of 1:50 and 1:100-year floodlines for a 2.5 km reach along the Loopspruit River as part of a Water Use Licence Application for a mine.

Role: Design Engineer

Responsibility: Hydrological analysis, river hydraulics modelling and preparing the report.

Verref Pollution Control Dam, Gauteng Province, South Africa | US$ 6 000

Client: Shangoni Management Services | **Date**: May 2017 – November 2017

Client Contact Details: Dawie Marre, Manager; Ph +27 12 807 7036

Description: Assessment of an existing Pollution Control Dam (PCD) to check compliance with the sizing requirements of Regulation No. 704 of the National Water Act, 1998 (Act No. 36 of 1998) which regulates the use of water for mining and related activities aimed at the protection of water resources.

Role: Design Engineer

Responsibility: Hydrological analysis of the dam using a water balance model and the concept design of a new pollution control dam; and preparing the report.

Vorna Valley River Hydraulics Management, Gauteng Province, South Africa | US$ 1 400 000

Client: Johannesburg Roads Agency (JRA) | **Date**: Sep 2016 – April 2018

Client Contact Details: Andre Nel, Planning Manager; Ph +27 82 492 2363

Description: The Vorna Valley watercourse in Midrand regularly floods adjacent properties and has eroded severely in some areas. The project aims to investigate these problems and to implement measures to address them.

Role: Design Engineer

Responsibility: Hydrological analysis, surveying, determining the flood lines and the feasibility of various proposed solutions using GeoHECRAS, designing the flood protection berms, designing gabions for erosion control as well as flood protection, and designing various riprap-lined channels, stilling basins and groynes.

Douglasdale River Improvements Phase 1, Gauteng Province, South Africa | US$ 42 800 Construction Value

Client: Douglasdale Retirement Village | **Date**: Feb 2016 – Nov 2016

Client Contact Details: Rob Fraser, Manager; Ph +27 71 863 5183

Description: Civil Engineering designs on the Stormwater stream running through Douglasdale Retirement Village were required. These designs included: Gabion designs and Rockfill sand trap design (weir).

Role: Design Engineer

Responsibility: Producing the hydrology flood estimation, gabion designs for bank erosion protection and the weir design, site surveying, site monitoring and BOQ.

Tharisa Rail Project, North West Province, South Africa | US$ 35 000 00

Client: Transnet and Tharisa Minerals | **Date**: Feb 2016 – March 2016

Client Contact Details: Lazarus Rapetswa, Manager; Ph +27 12 315 2525

Description: Transnet freight rail and Tharisa Minerals entered a Public Private Partnership to construct a new link line into Tharisa mine, near Marikana, providing access to a new load-out station that will be capable of loading a 150-wagon train.

Role: Hydrologist

Responsibility: Hydrological analysis.

Devland Community Education Campus, Gauteng Province, South Africa | US$ 376 000

Client: Growing up Africa | **Date**: Nov 2017 – Dec 2017

Client Contact Details: Deborah Terhune, CEO; Ph +27 82 826 2237

Description: Growing Up Africa (GUA), A non-profit organization based in the USA is building a multi-purpose community centre in the Devland community located in Soweto. The centre is a single storey educational facility.

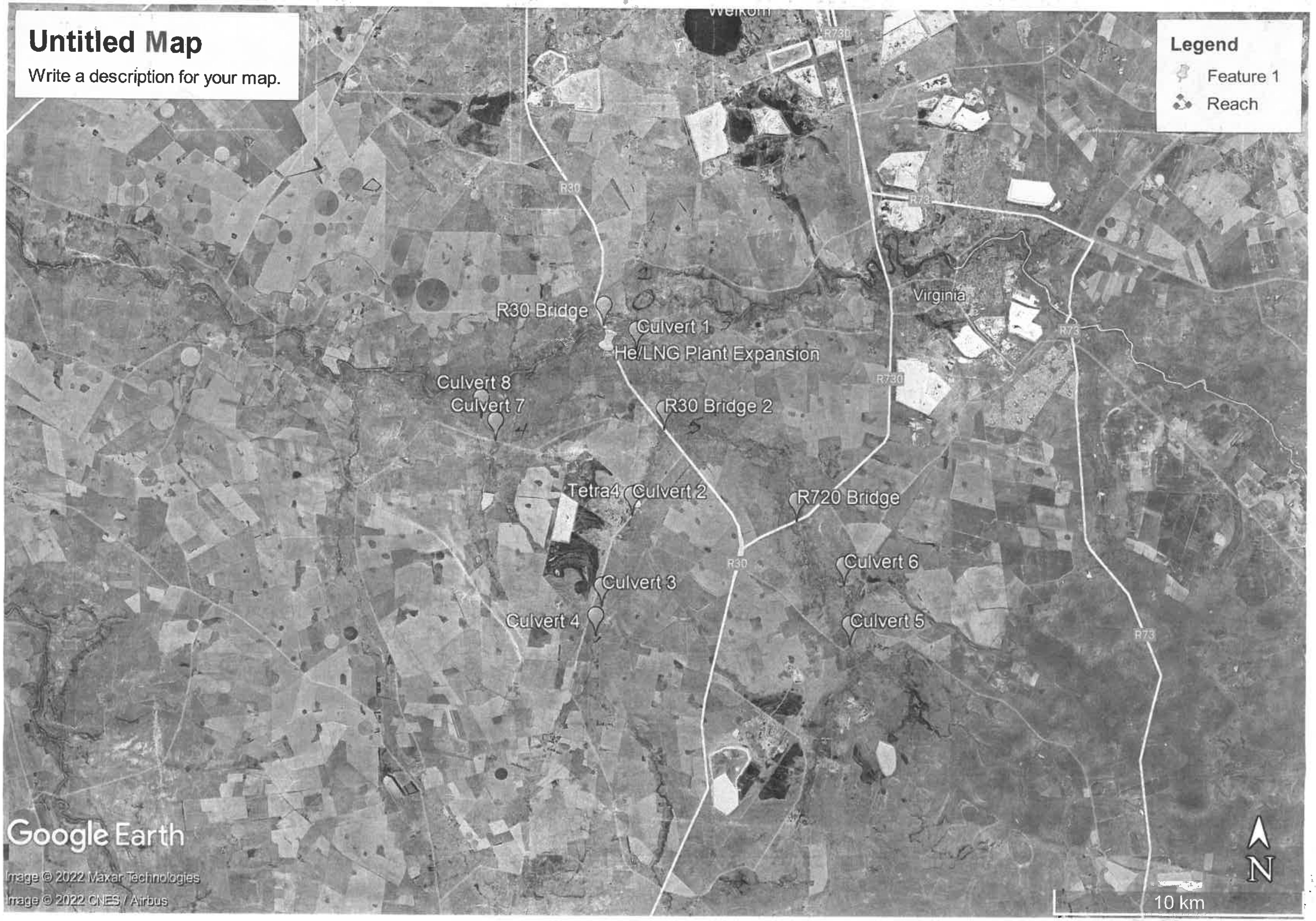
Role: Construction Monitor

Responsibility: Responsible for site monitoring as well as land surveying on site.

Courses & Conferences attended

2016:	SAICE Ingula Pumped Storage Scheme (1 day site visit)
2017:	The CAD Corporation AutoCAD Essentials course (4 days)
2017:	CESA Technical and Business report writing (3 days)
2017:	The CAD Corporation Civil 3D Essentials course (4 days)
2017:	CoJ Stormwater By Laws training workshop (2 days)
2017:	CESA YPF BBBEE debate (1 day)
2018:	SAICE 2017 Infrastructure Report Card Breakfast workshop (1 day)
2018:	SARF Drainage Manual course (2 days)

Appendix F: Site Visit

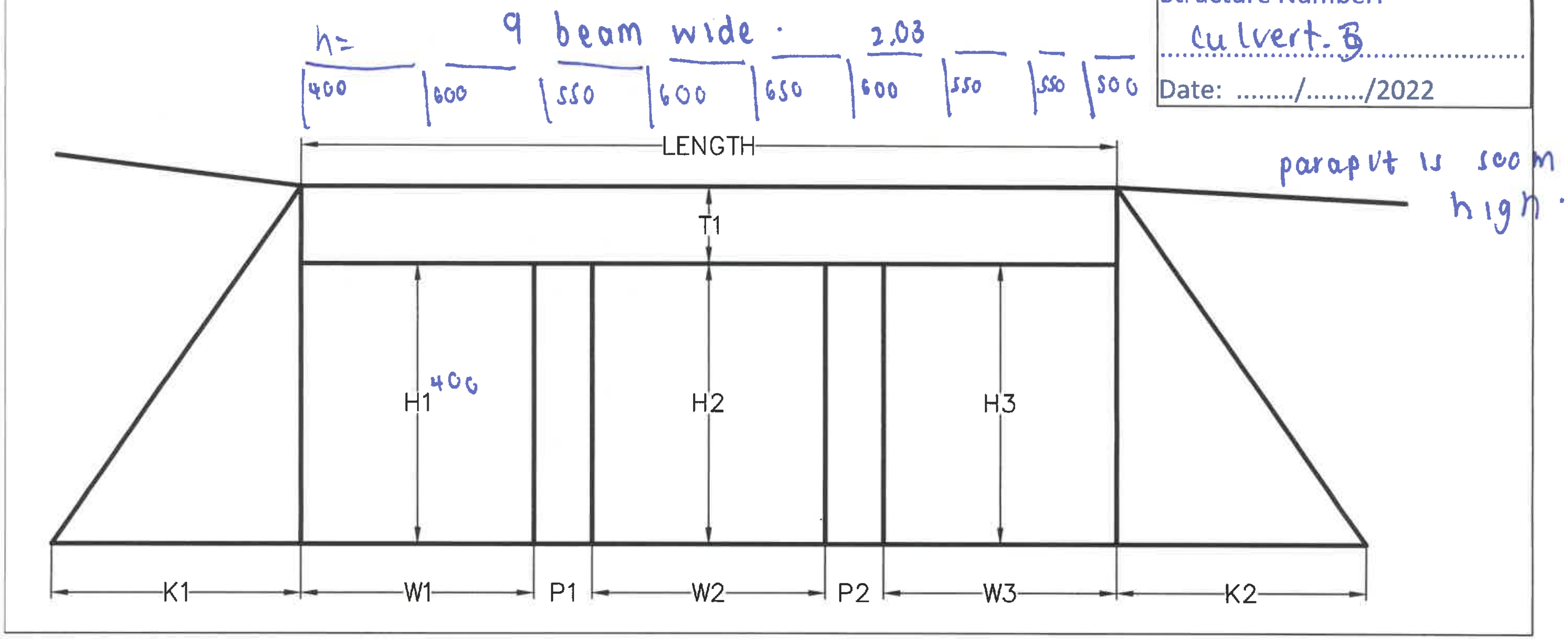

Untitled Map
Write a description for your map.
Legend
Feature 1
Reach
Welkom
R730
R30
R73
R30 Bridge
Culvert 1
He/LNG Plant Expansion
Virginia
Culvert 8
Culvert 7
R30 Bridge 2
Tetra4
Culvert 2
R720 Bridge
Culvert 6
Culvert 3
Culvert 4
Culvert 5
Google Earth
Image © 2022 Maxar Technologies
Image © 2022 CNES / Airbus
N
10 km

2.03 × 0,2

~~2.03~~ 5   1,02

Structure Number: Culvert B

Date: ..../......../2022



H = Height of opening
T = Thickness of bridge deck
P = Thickness of bridge pier
W = Width of opening
K = Width of bridge wing
L = Length of bridge
R = Road width

H1 =	
H2 =	
H3 =	
H4 =	
T1 =	200mm

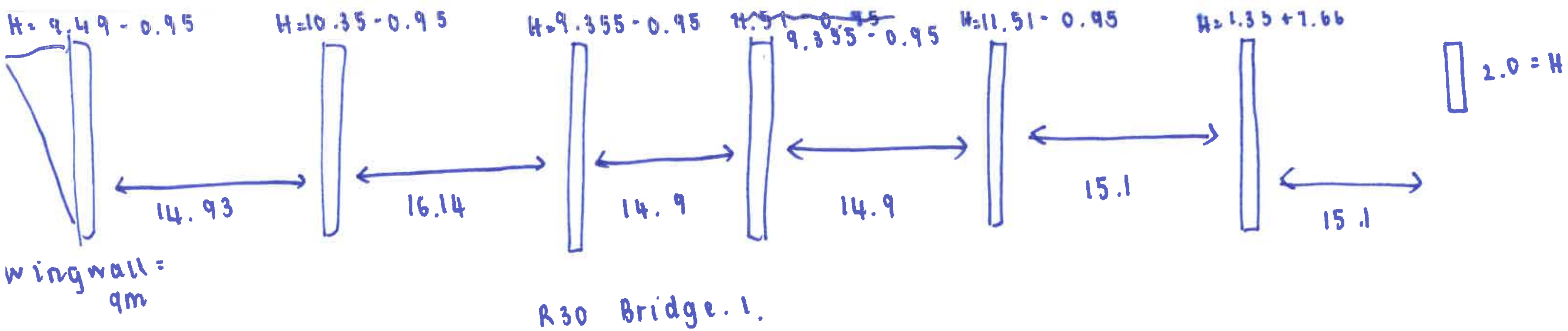
P1 =	
P2 =	
P3 =	
P4 =	
L =	~~5.47m~~ 18,45

W1 =	2,03m
W2 =	2.03m
W3 =	
W4 =	
W5 =	

K1u/s =	
K1d/s =	
K2u/s =	
K1u/s =	
R =	5,47

Comments:

Most of the bays/openings are overgrown.



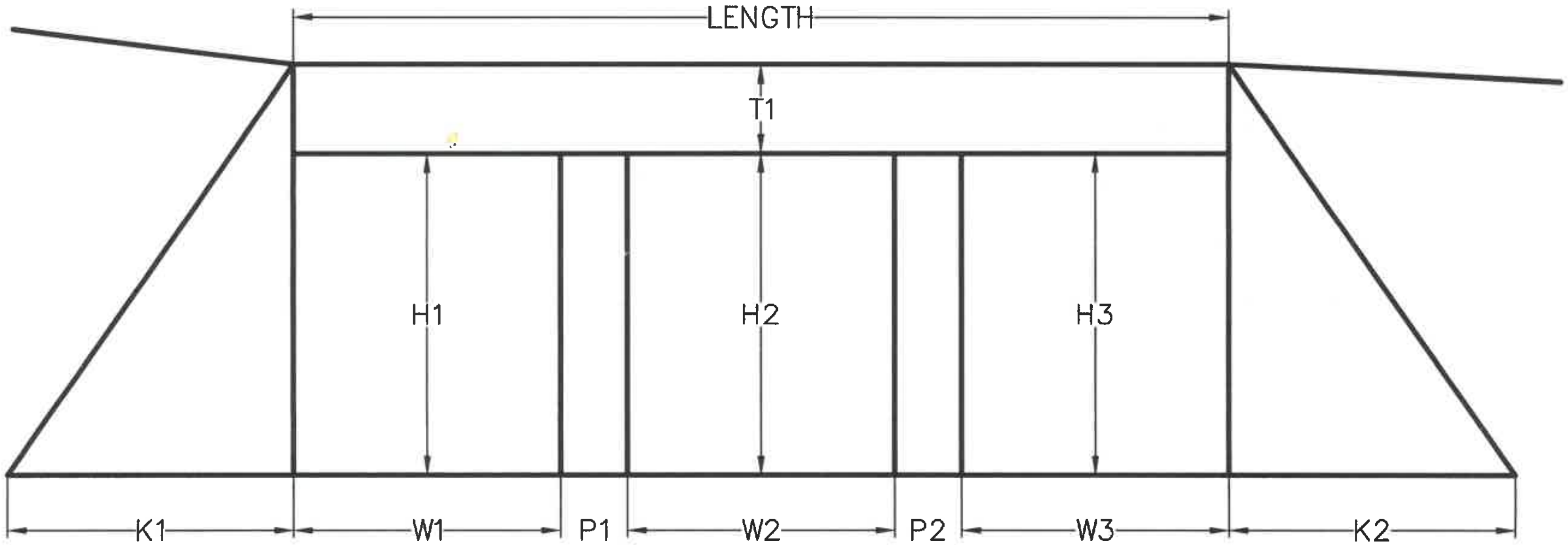
R30 Bridge. 1.

083 2764847
Mirna

450mm pipe - 300/400mm cover

Structure Number: Culvert ,8·

Date: ..../......../2022



H = Height of opening
T = Thickness of bridge deck
P = Thickness of bridge pier
W = Width of opening
K = Width of bridge wing
L = Length of bridge
R = Road width

H1 = ______
H2 = ______
H3 = ______
H4 = ______
T1 = ______

P1 = ______
P2 = ______
P3 = ______
P4 = ______
L = ______

W1 = ______
W2 = ______
W3 = ______
W4 = ______
W5 = ______

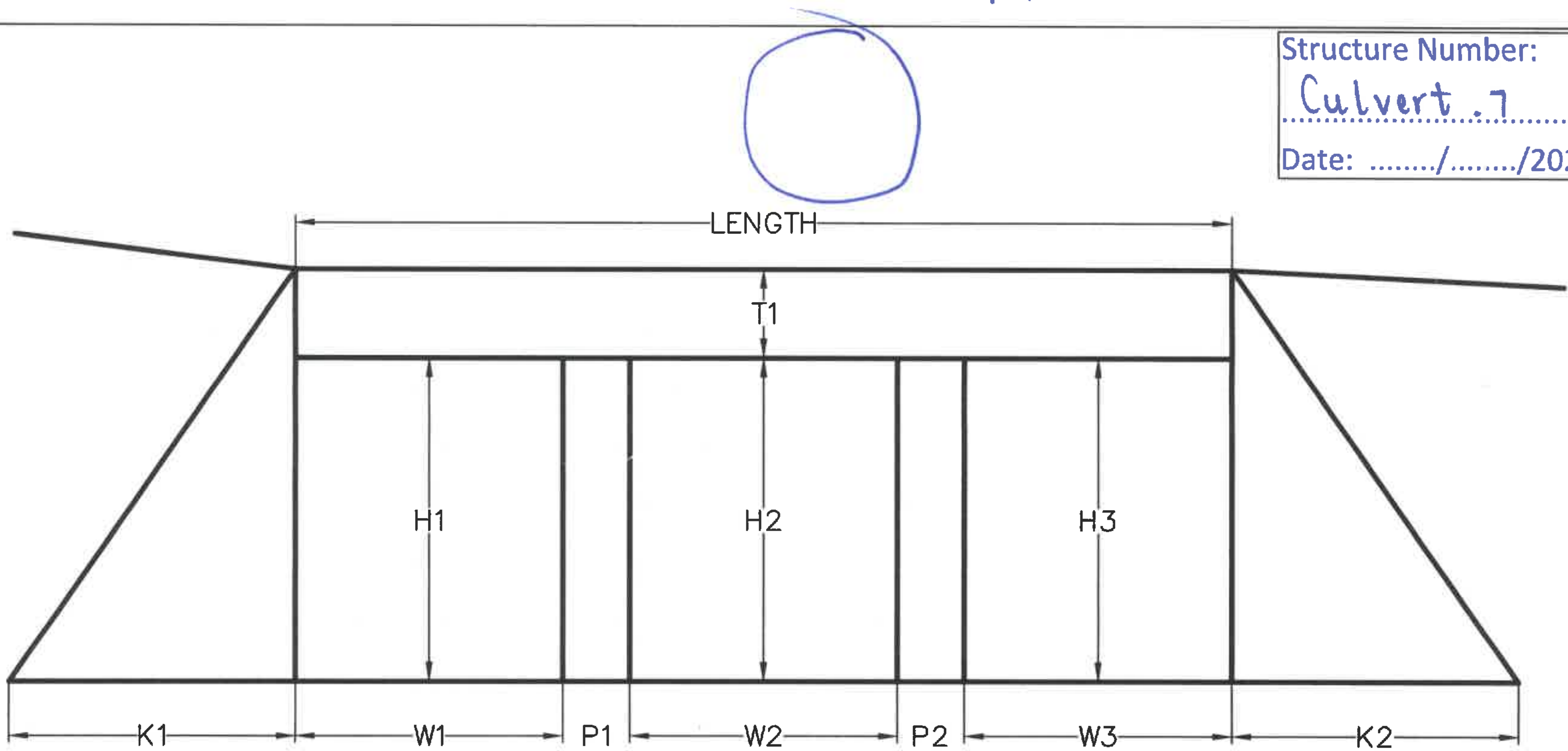
K1u/s = ______
K1d/s = ______
K2u/s = ______
K1u/s = ______
R = ______

Comments:

....

....

450 (model both)
~~600mm~~ pipe with a 400/500mm cover.



Structure Number: Culvert 7

Date: ..../......../2022

H = Height of opening
T = Thickness of bridge deck
P = Thickness of bridge pier
W = Width of opening
K = Width of bridge wing
L = Length of bridge
R = Road width

H1 =	P1 =	W1 =	K1u/s =
H2 =	P2 =	W2 =	K1d/s =
H3 =	P3 =	W3 =	K2u/s =
H4 =	P4 =	W4 =	K1u/s =
T1 =	L =	W5 =	R = 1.6m

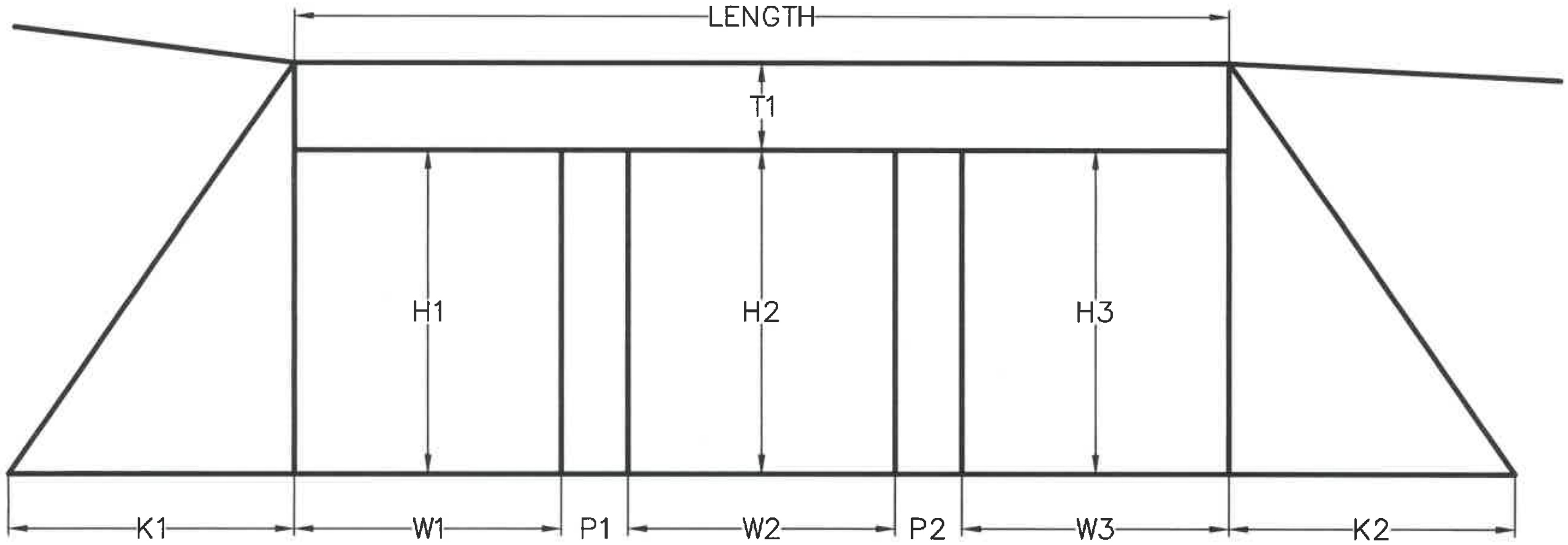
Comments:

....

....

Structure Number: culvert.ff

Date: ..../......../2022



H = Height of opening
T = Thickness of bridge deck
P = Thickness of bridge pier
W = Width of opening
K = Width of bridge wing
L = Length of bridge
R = Road width

H1 = ______
H2 = ______
H3 = ______
H4 = ______
T1 = ______

P1 = ______
P2 = ______
P3 = ______
P4 = ______
L = ______

W1 = ______
W2 = ______
W3 = ______
W4 = ______
W5 = ______

K1u/s = ______
K1d/s = ______
K2u/s = ______
K1u/s = ______
R = ______

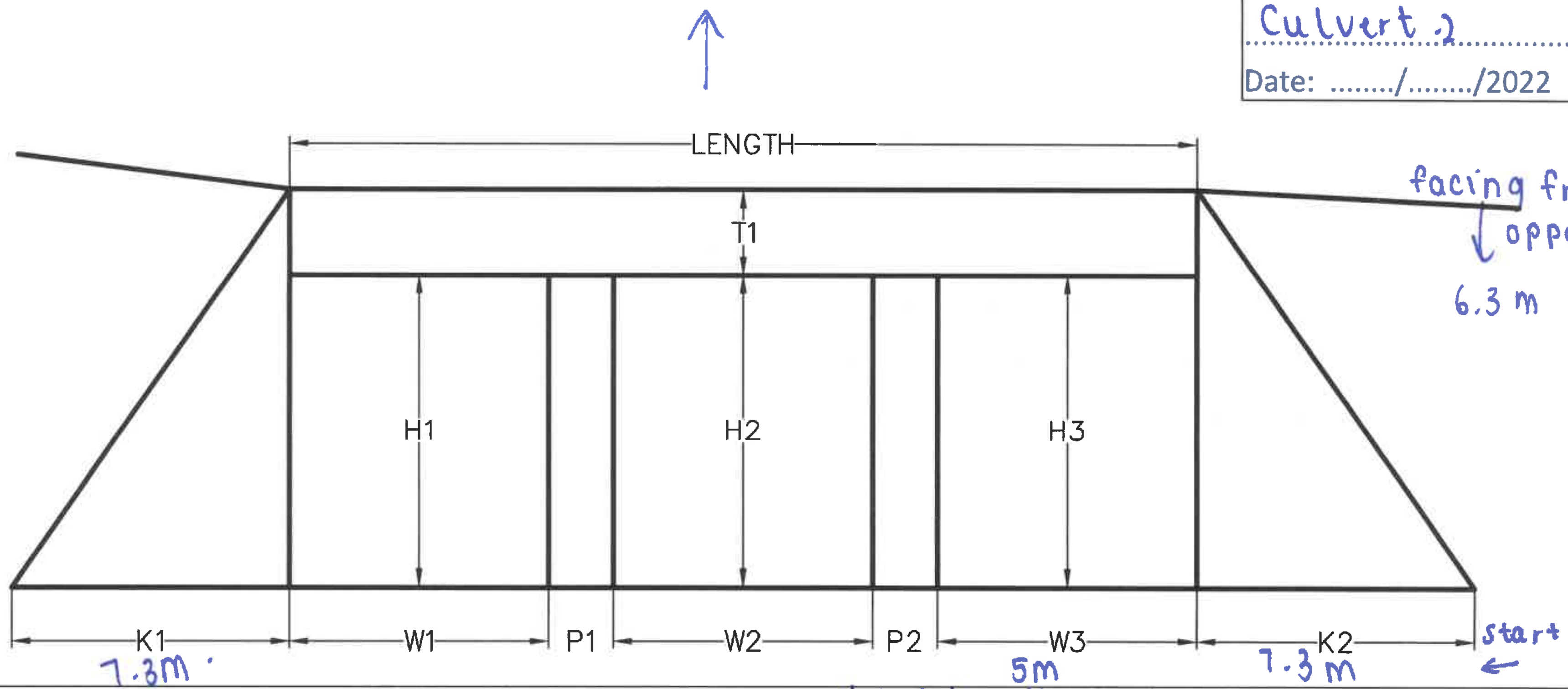
Comments:

culvert pipe abandonned / broken, ~~areat~~ area has beer replaced with building rubble.

Bridge No: 1695/19 81

Structure Number: Culvert 2

Date: ..../......../2022



culvert length: 27.4m

H	= Height of opening
T	= Thickness of bridge deck
P	= Thickness of bridge pier
W	= Width of opening
K	= Width of bridge wing
L	= Length of bridge
R	= Road width

H1 =	~~3.42~~ 3.6
H2 =	~~3.42~~ 2.65
H3 =	3.42
H4 =	
T1 =	0.85m

P1 =	~~0.5m~~ 0.475
P2 =	0.475
P3 =	0.475
P4 =	
L =	12.5m

W1 =	5.02
W2 =	5m
W3 =	5 m
W4 =	
W5 =	

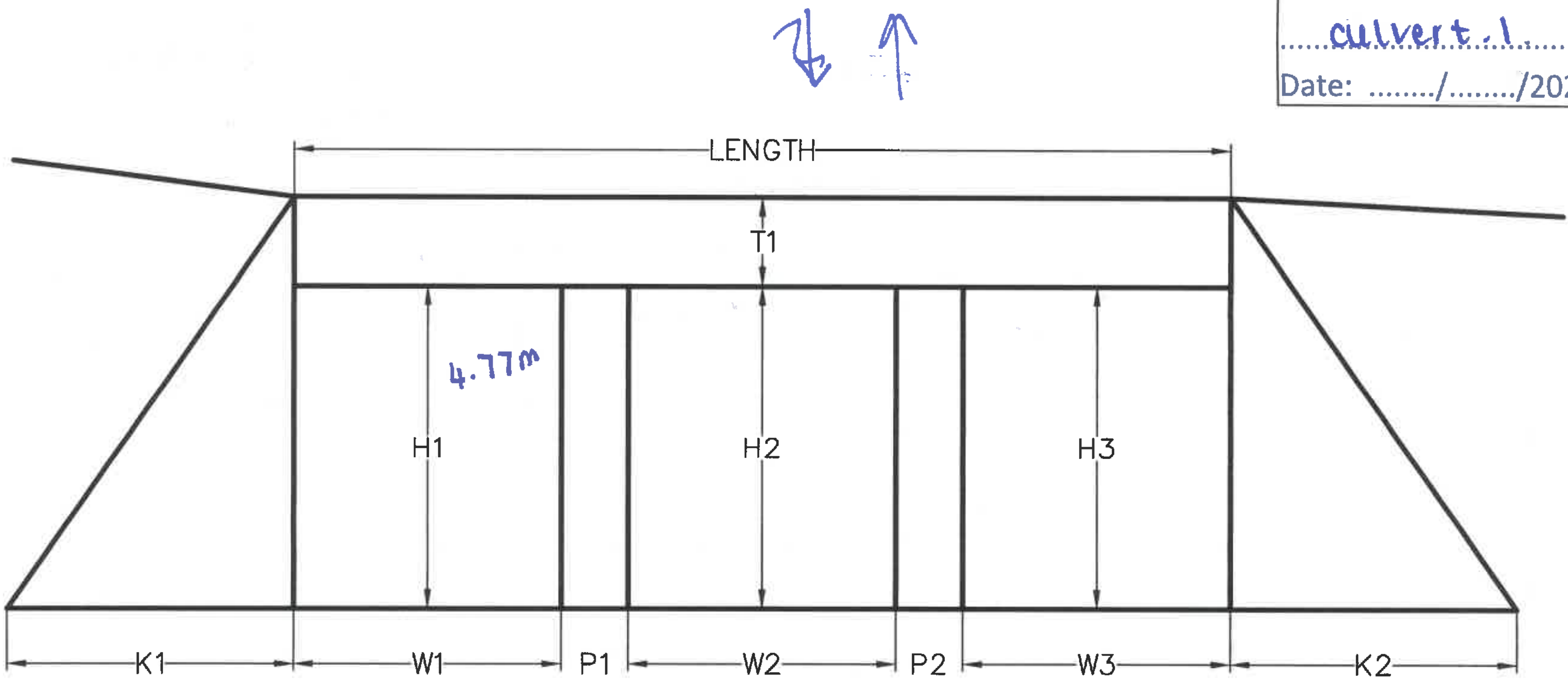
K1u/s =	
K1d/s =	
K2u/s =	
K1u/s =	
R =	

Comments:

Deck thickness and 1m Road cover

Structure Number: culvert .1

Date: ..../......../2022



H = Height of opening
T = Thickness of bridge deck
P = Thickness of bridge pier
W = Width of opening
K = Width of bridge wing
L = Length of bridge
R = Road width

H1 = ____
H2 = ____
H3 = ____
H4 = ____
T1 = 1.3m

P1 = ____
P2 = ____
P3 = ____
P4 = ____
L = 42.85

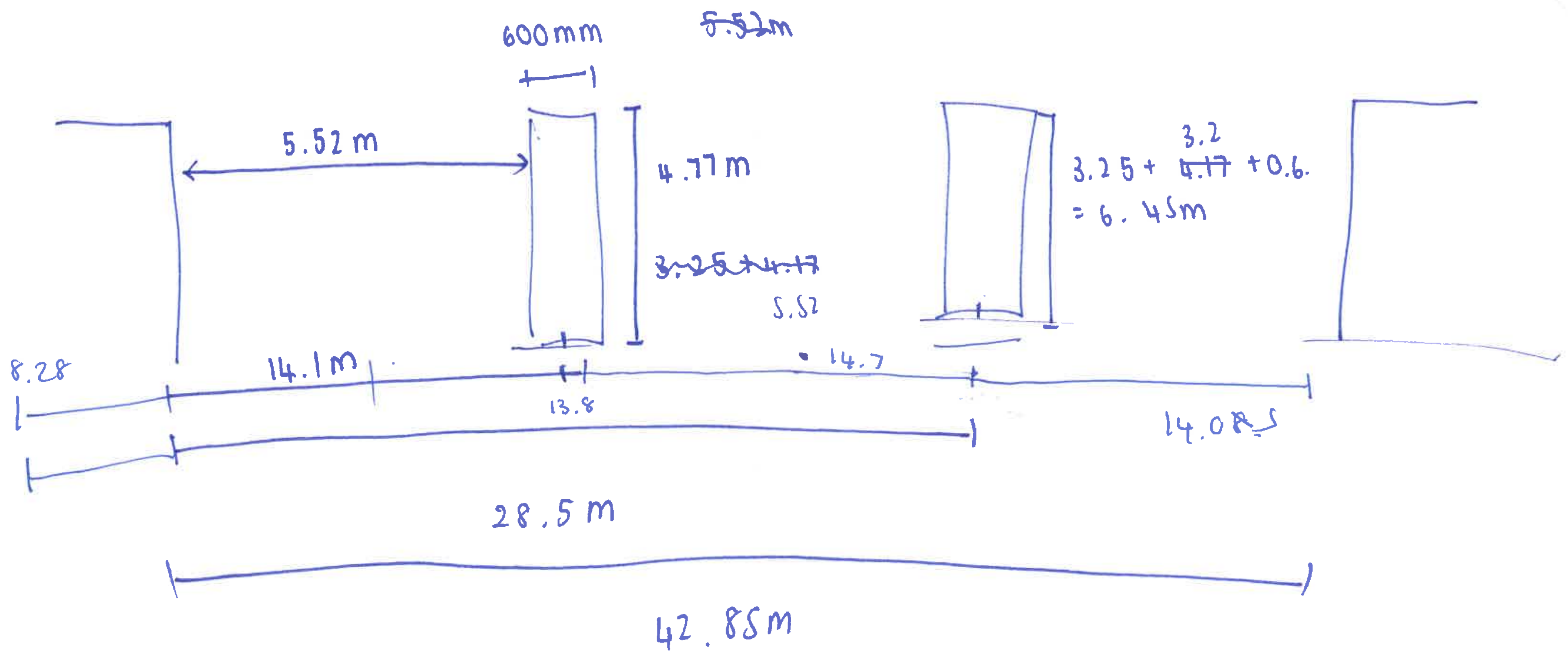
W1 = ____
W2 = ____
W3 = ____
W4 = ____
W5 = ____

K1u/s = ____
K1d/s = ____
K2u/s = ____
K1u/s = ____
R = 9.9 m

Comments:

....

....



2 weirs are water affairs

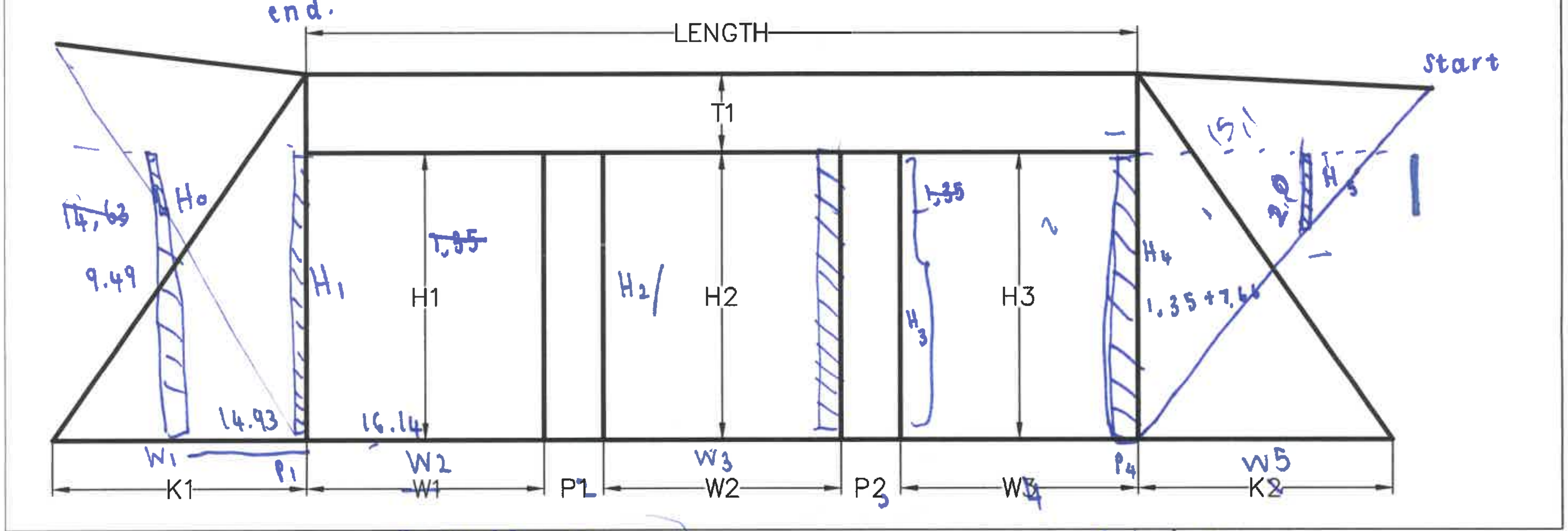
(*) DWS website → look @ historical data for flows @ culvert.1.
→ for report.

Structure Number: R30 Bridge.1

Date: ..../......../2022

6piers

55km



H	= Height of opening
T	= Thickness of bridge deck
P	= Thickness of bridge pier
W	= Width of opening
K	= Width of bridge wing
L	= Length of bridge
R	= Road width

H0 ~~14.63~~ 9.49-0.95

H1 =	~~1,35~~ ~~8.41~~ ~~9.07~~ 10.35 - 0.95
H2 =	9.355 - ~~1,2~~ 0,95
H3 =	11,51 - ~~1,2~~ 0,95
H4 =	1,35 + 7,88 ~~-1,2~~
T1 =	[1,4 m]

P1 =	
P2 =	
P3 =	1,5 m
P4 =	
L =	99 m

width of bridge = 10.3m

W1 =	15,12m / ~~15,2~~
W2 =	
W3 =	14.9
W4 =	15,1
W5 =	15,1

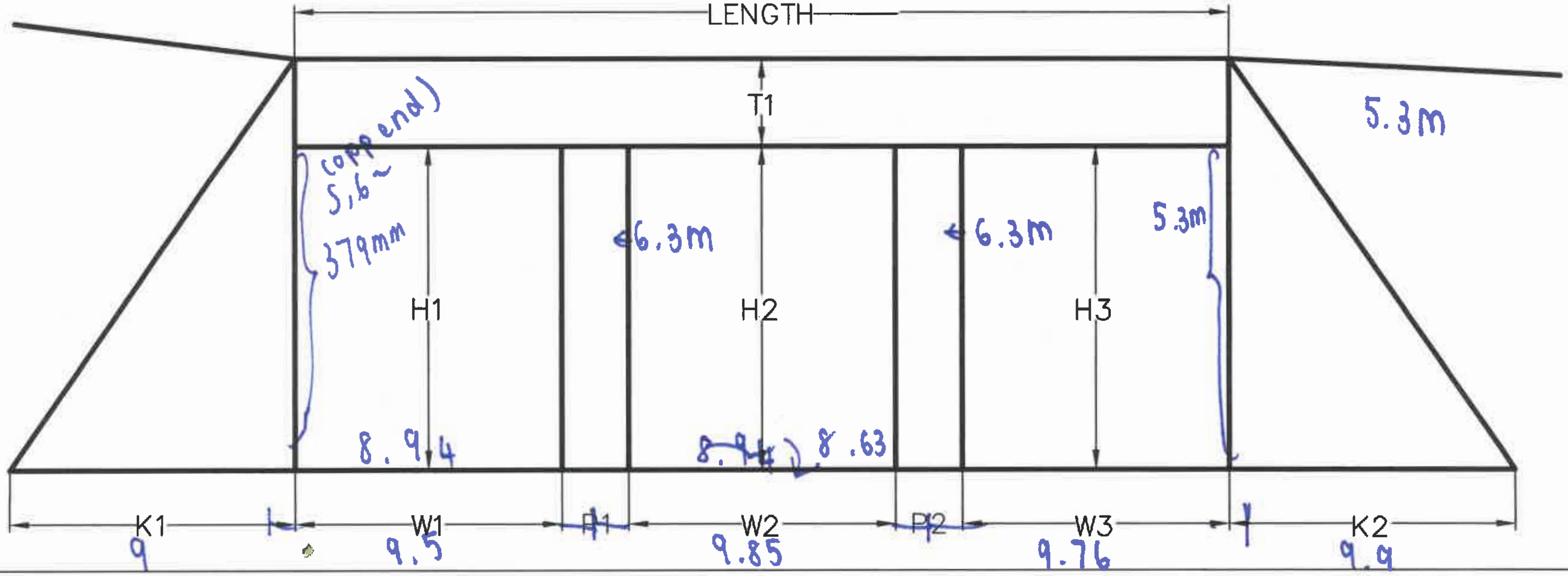
K1u/s =	
K1d/s =	
K2u/s =	
K1u/s =	
R =	10.3 m

Comments:

Use T1, L, R from here. Refer to map for dimension.

Structure Number: R30 bridge.2

Date: ..../......../2022



H = Height of opening
T = Thickness of bridge deck
P = Thickness of bridge pier
W = Width of opening
K = Width of bridge wing
L = Length of bridge
R = Road width

H1 = 6.3
H2 = 6.3
H3 = 6.3
H4 =
T1 = 650mm

P1 = 1.25m
P2 =
P3 =
P4 =
L = ~~26.9~~ 29.5

W1 =
W2 =
W3 =
W4 =
W5 =

K1u/s =
K1d/s =
K2u/s =
K1u/s =
R = 0.85

Comments:

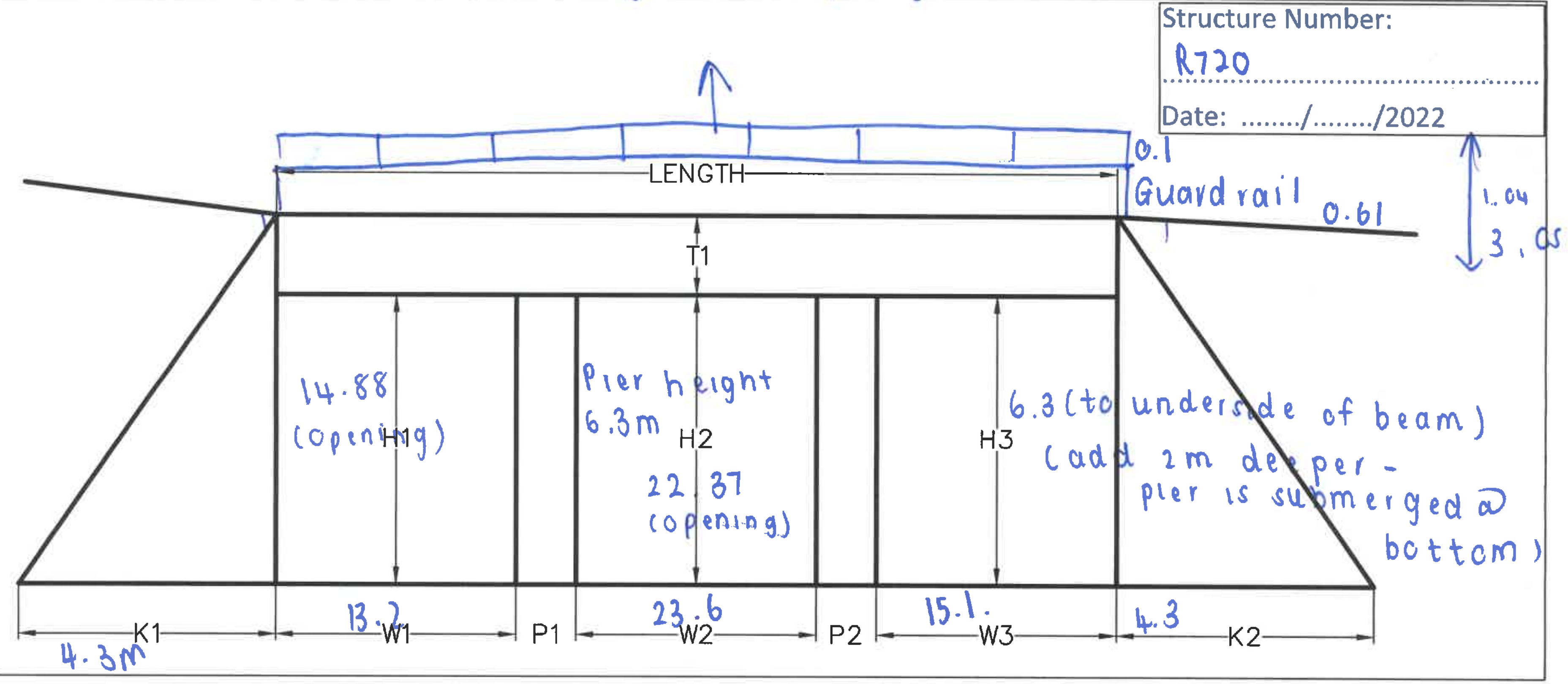
....

....

Bridge : B 875

Structure Number: R720

Date: ..../......../2022



H = Height of opening
T = Thickness of bridge deck
P = Thickness of bridge pier
W = Width of opening
K = Width of bridge wing
L = Length of bridge
R = Road width

H1 =
H2 =
H3 =
H4 =
T1 =

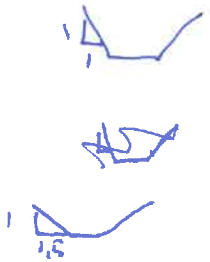
P1 = 1.26m
P2 = 1.26 m
P3 =
P4 =
L =

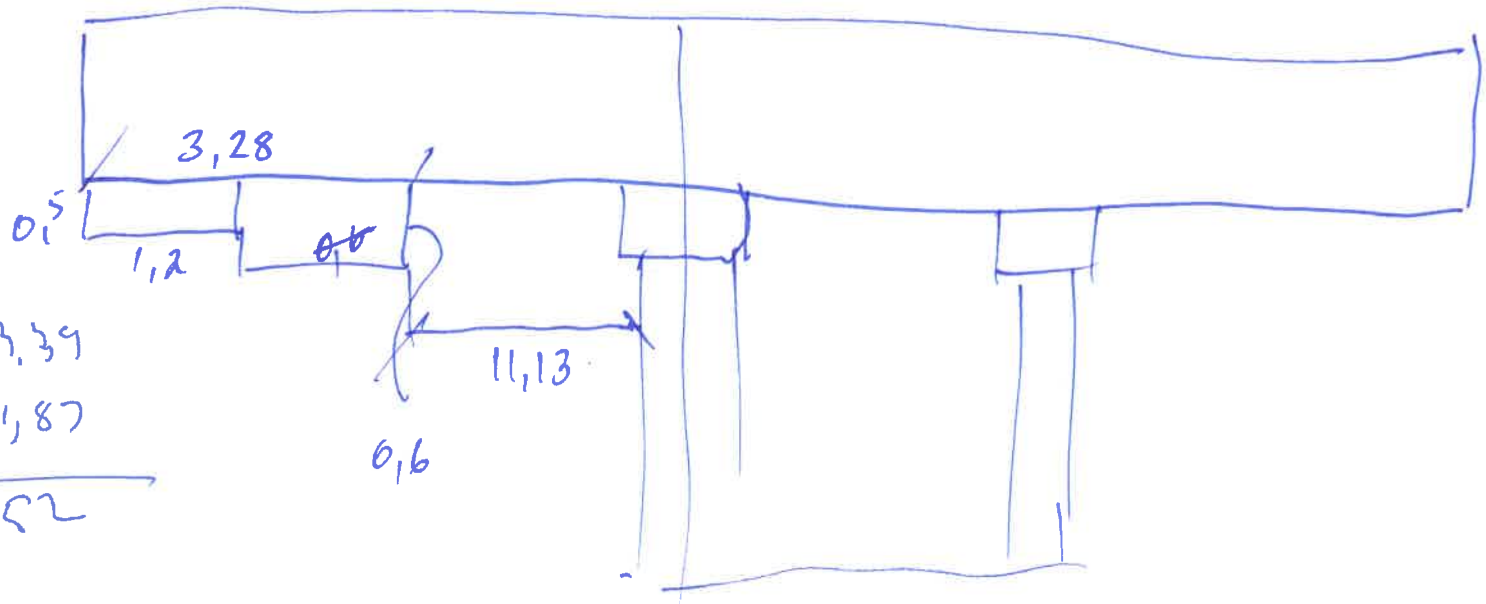
W1 =
W2 =
W3 =
W4 =
W5 =

K1u/s =
K1d/s =
K2u/s =
K1u/s =
R = 13.45

Comments:

1309.6 - 1309.8





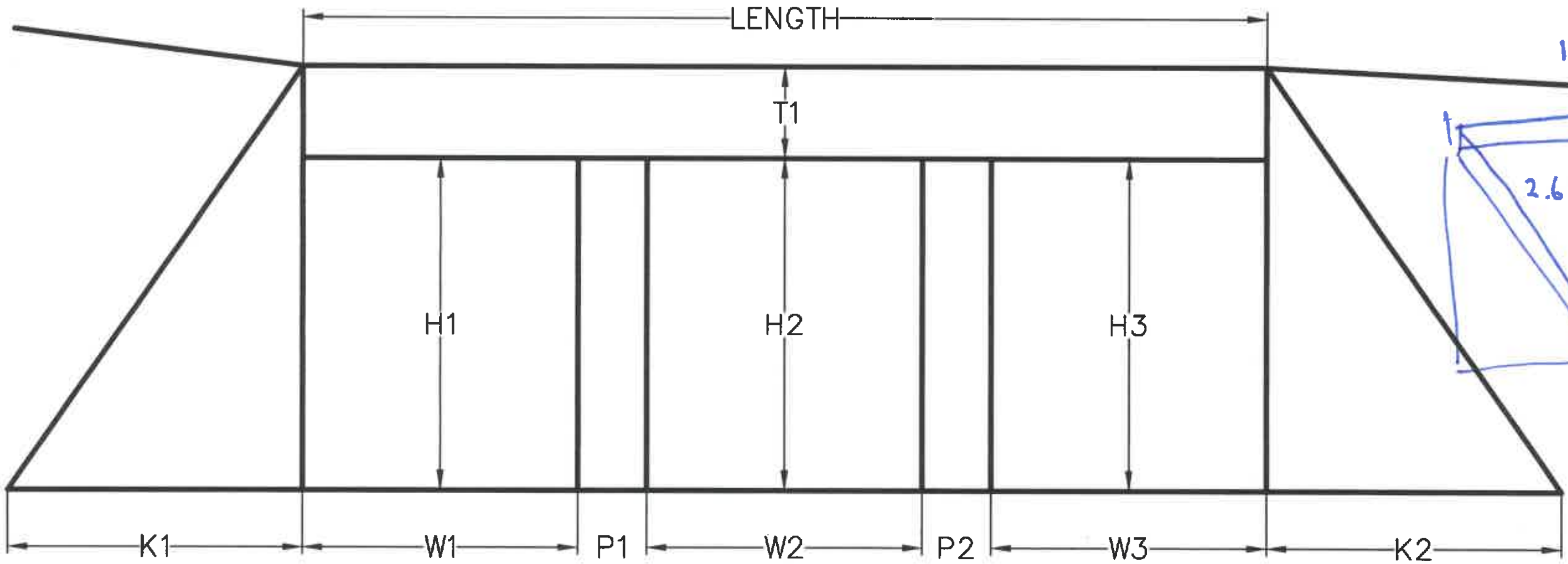
17,79 603,39
16,30 601,87

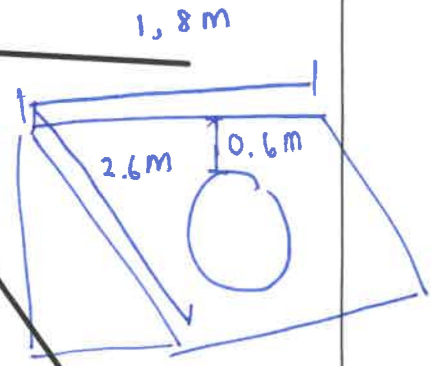
1,49 1,52

Slope is reno matteresses

Rockler culvert →
1,05m diameter (further research)

Structure Number:
Culvert 6.
Date: ..../......./2022





H = Height of opening
T = Thickness of bridge deck
P = Thickness of bridge pier
W = Width of opening
K = Width of bridge wing
L = Length of bridge
R = Road width

H1 =	P1 =	W1 =	K1u/s =
H2 =	P2 =	W2 =	K1d/s =
H3 =	P3 =	W3 =	K2u/s =
H4 =	P4 =	W4 =	K1u/s =
T1 =	L =	W5 =	R = 5m

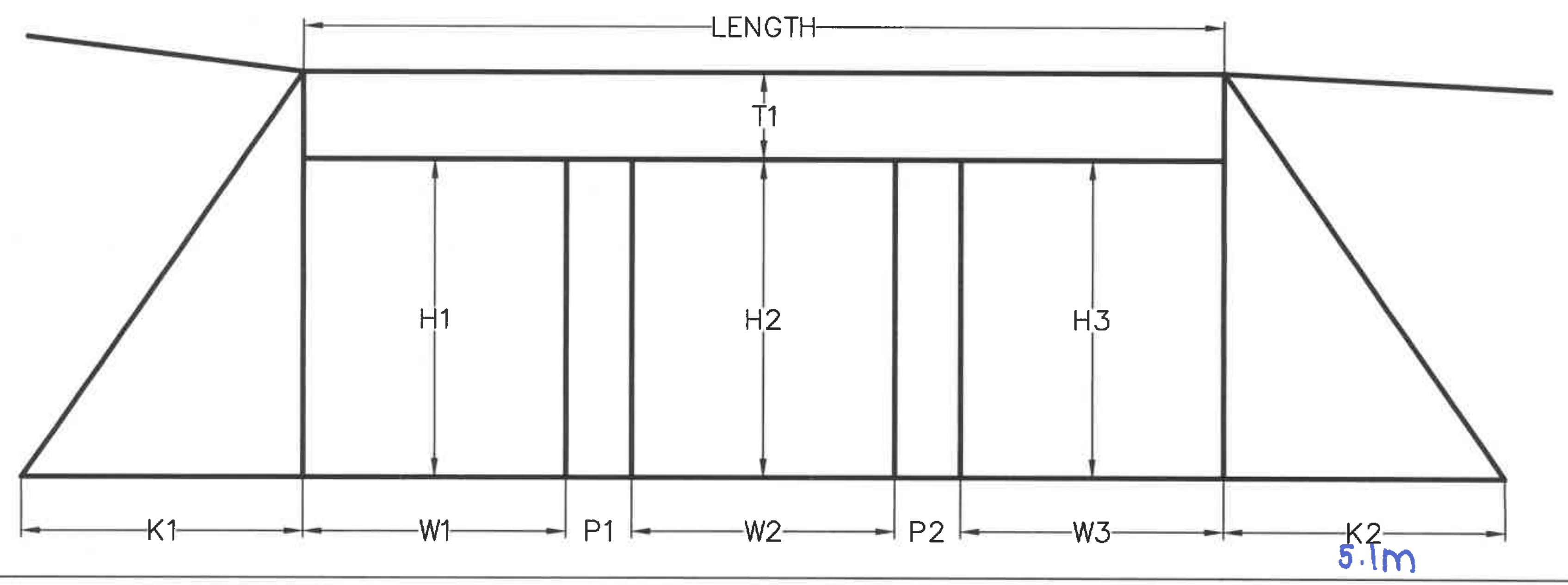
Comments:

....

....

Structure Number: culverts

Date: ..../......../2022



H = Height of opening
T = Thickness of bridge deck
P = Thickness of bridge pier
W = Width of opening
K = Width of bridge wing
L = Length of bridge
R = Road width

H1 =	P1 =	W1 =	K1u/s =
H2 =	P2 =	W2 =	K1d/s =
H3 =	P3 =	W3 =	K2u/s =
H4 =	P4 =	W4 =	K1u/s =
T1 = 0.45 m	L = 25.1.	W5 =	R =

Comments:

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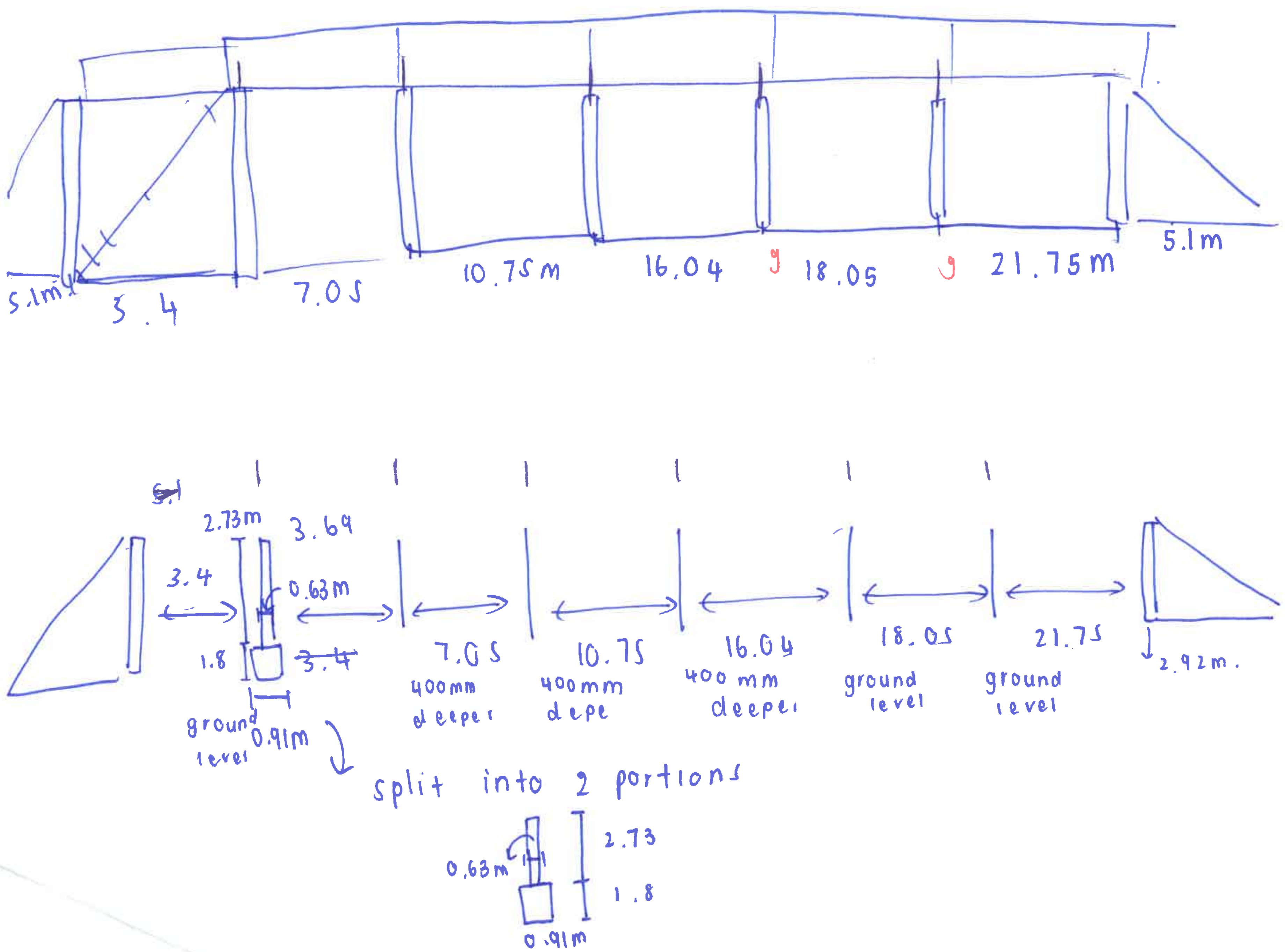

5.1m
3.4
7.05
10.75m
16.04
9
18.05
9
21.75m
5.1m
2.73m
3.69
3.4
0.63m
1.8
3.4
ground level
0.91m
7.05
400mm deeper
10.75
400mm depe
16.04
400 mm deeper
18.05
ground level
21.75
ground level
2.92m.
split into 2 portions
0.63m
2.73
1.8
0.91m

Structure Number:

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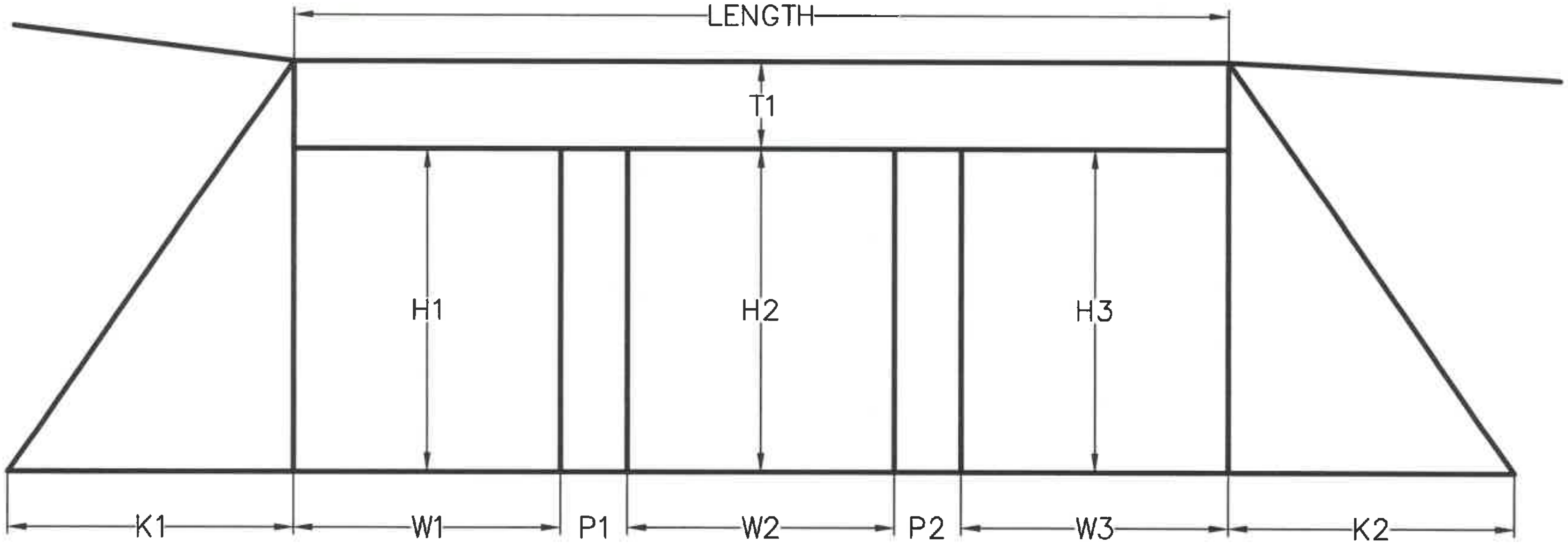
Date: ..../......../2022



H = Height of opening
T = Thickness of bridge deck
P = Thickness of bridge pier
W = Width of opening
K = Width of bridge wing
L = Length of bridge
R = Road width

H1 = ____________
H2 = ____________
H3 = ____________
H4 = ____________
T1 = ____________

P1 = ____________
P2 = ____________
P3 = ____________
P4 = ____________
L = ____________

W1 = ____________
W2 = ____________
W3 = ____________
W4 = ____________
W5 = ____________

K1u/s = ____________
K1d/s = ____________
K2u/s = ____________
K1u/s = ____________
R = ____________

Comments:

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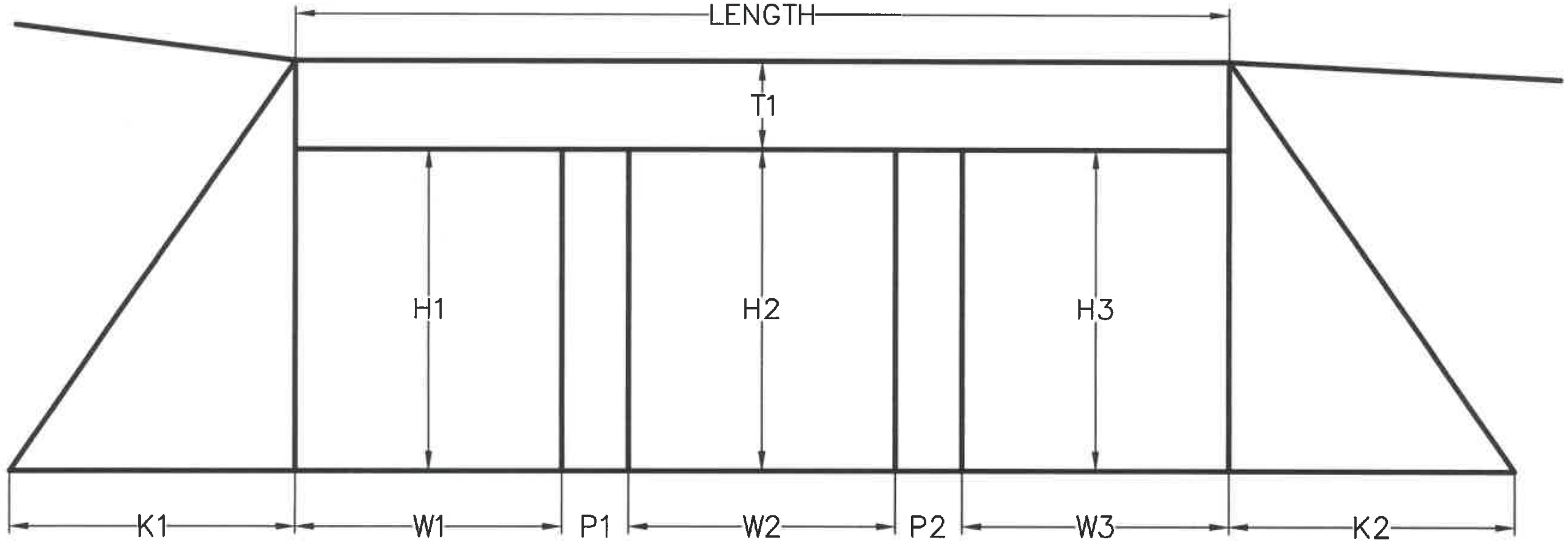
Structure Number:

....

Date: ..../......../2022



H = Height of opening
T = Thickness of bridge deck
P = Thickness of bridge pier
W = Width of opening
K = Width of bridge wing
L = Length of bridge
R = Road width

H1 = ______________
H2 = ______________
H3 = ______________
H4 = ______________
T1 = ______________

P1 = ______________
P2 = ______________
P3 = ______________
P4 = ______________
L = ______________

W1 = ______________
W2 = ______________
W3 = ______________
W4 = ______________
W5 = ______________

K1u/s = ______________
K1d/s = ______________
K2u/s = ______________
K1u/s = ______________
R = ______________

Comments:

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Structure Number:

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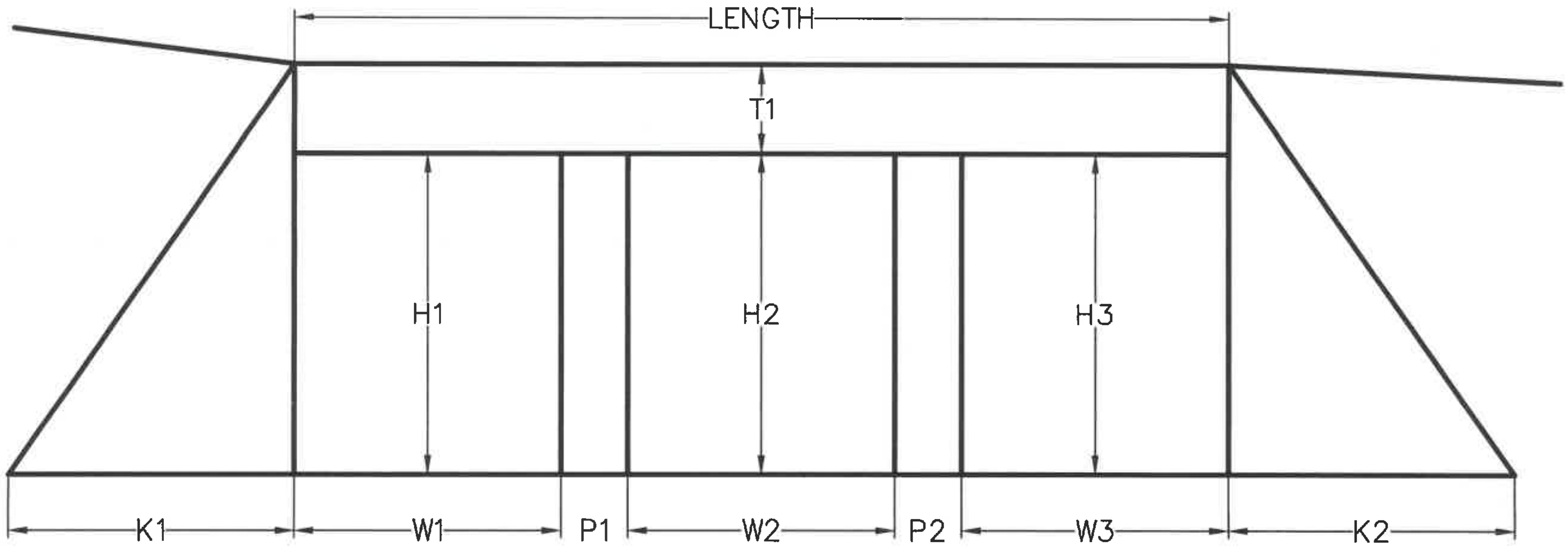
Date: ..../......../2022



H = Height of opening
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H1 = ______________
H2 = ______________
H3 = ______________
H4 = ______________
T1 = ______________

P1 = ______________
P2 = ______________
P3 = ______________
P4 = ______________
L = ______________

W1 = ______________
W2 = ______________
W3 = ______________
W4 = ______________
W5 = ______________

K1u/s = ______________
K1d/s = ______________
K2u/s = ______________
K1u/s = ______________
R = ______________

Comments:

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Structure Number:

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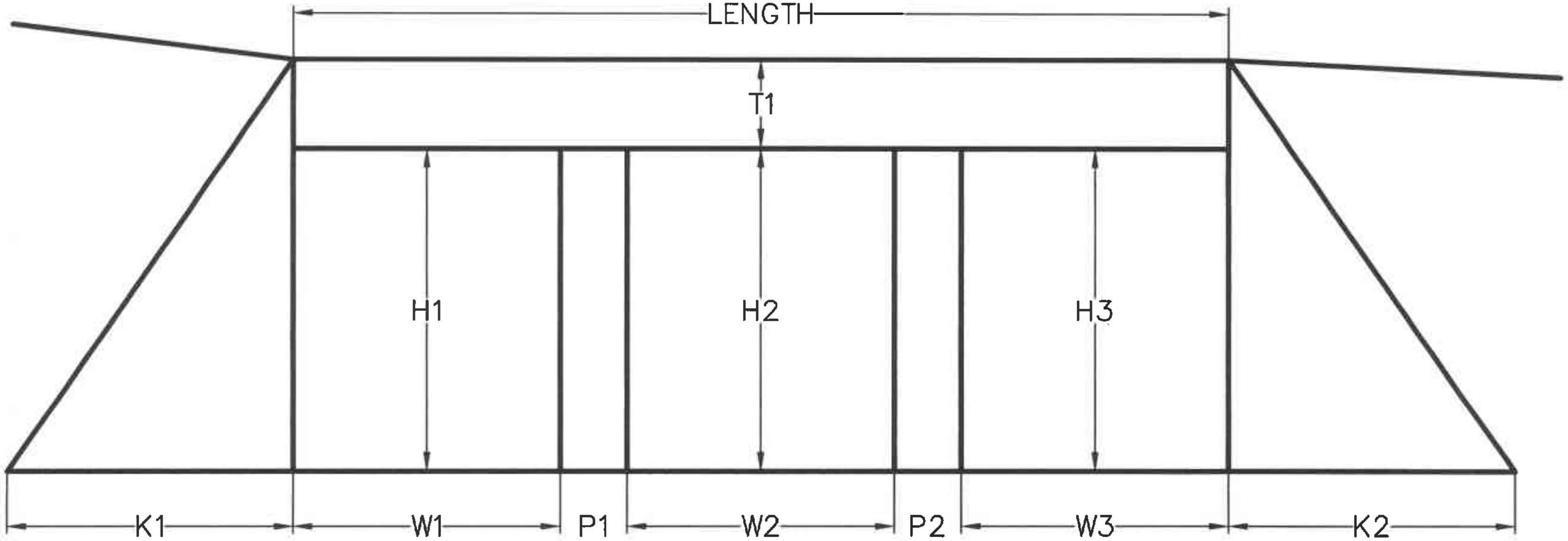
Date: ..../......../2022



H = Height of opening
T = Thickness of bridge deck
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W = Width of opening
K = Width of bridge wing
L = Length of bridge
R = Road width

H1 = ______	P1 = ______	W1 = ______	K1u/s = ______
H2 = ______	P2 = ______	W2 = ______	K1d/s = ______
H3 = ______	P3 = ______	W3 = ______	K2u/s = ______
H4 = ______	P4 = ______	W4 = ______	K1u/s = ______
T1 = ______	L = ______	W5 = ______	R = ______

Comments:

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