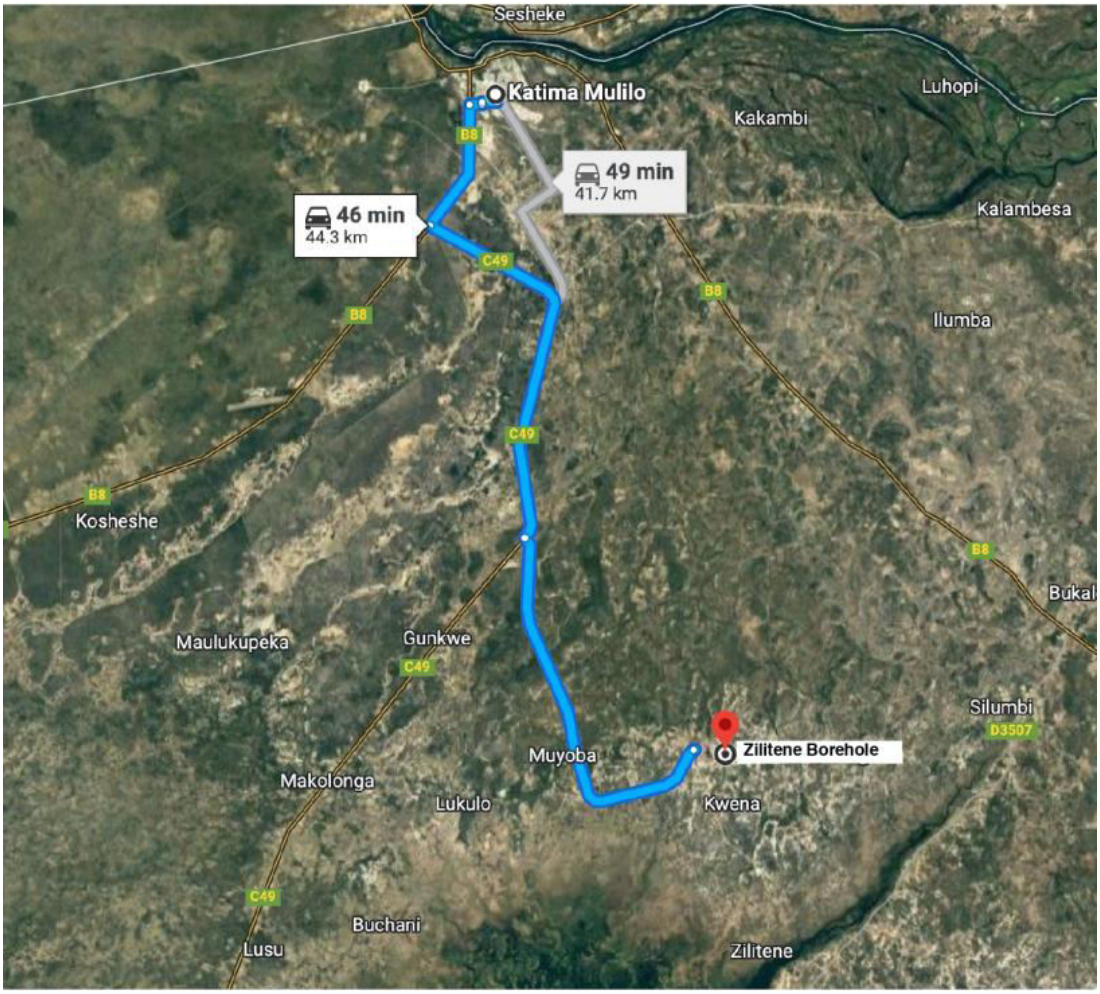
Ministry of Environment, Forestry and Tourism

NAMIBIA INTERGRATED LANDSCAPE APPROACH FOR ENHANCING LIVELIHOODS AND ENVIRONMENTAL GOVERNANCE TO ERADICATE POVERTY

NILALEG

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN REPORT FOR THE DRILLED BOREHOLE AT ZILITENE VILLAGE, ZAMBEZI REGION



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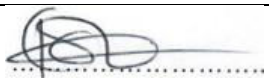
MR. IPEINGE MUNDJULU **RED-DUNE CONSULTING CC**	
PROJECT MANAGER	SIGNATURE
MR. JONAS NGHISHIDI	

ACRONYMS

DEA	Department of Environmental Affairs
DWA	Department of Water Affairs
EA	Environmental Assessment
EAP	Environmental Assessment Practitioner
ECC	Environmental Clearance Certificate
ECO	Environmental Compliance Officer
EIA	Environmental Impact Assessment
EMA	Environmental Management Act (No. 7 of 2007)
EMP	Environmental Management Plan
L	Litre
m^3	Cubic
MEFT	Ministry of Environment Forestry and Tourism
Mm^3	Million Cubic
NILALEG	Namibia Integrated Landscape Approach for Enhancing Livelihoods and Environmental Governance
PPE	Personal Protective Equipment
RD	Red-Dune Consulting CC
SEMP	Social Environmental Management Plan
SM	Site Manager

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EXECUTIVE SUMMARY

The NILALEG Project is supporting the installation of solar-powered boreholes to improve access to clean and safe water for human consumption and agricultural activities in Omaoipanga Focal Landscape at Omaoipanga & Oruhozu Village in Kunene Region, Ruacana Focal Landscape at Okawapehuri (Kunene Region) and Ombambihaka Village in Omusati Region and, Zambezi Focal Landscape at Zilitene Village in Zambezi Region.

This scoping and EMP report for Zambezi Focal Landscape at Zilitene Village in Zambezi Region concluded that there are no significant social and /or environmental impact that the project has caused as well as no foreseeable impacts during project operation. Zambezi Region is home to Mbambwata National Park which support large wildlife population including elephants that are notorious in destruction of water resources installation. This EMP has addressed the anticipated potential impacts that elephants may pose to the borehole infrastructure.

Based on drilling undertaken which determined a maximum daily yield of 9.589m^3 (9,589 L/day) the recommended abstraction of 70% of the total yield is believed to be sustainable and does not pose threat to over abstraction of the ground water. To ensure human and animal health, it is strongly recommended to implement a water quality monitoring program, additionally, the metal casing for the borehole should be monitored from time to time to assess corrosion which may impact borehole yield.

1. Introduction and Background

1.1. Project Overview

The Ministry of Environment, Forestry and Tourism (MEFT) in partnership with the United Nations Development Programme (UNDP) is implementing a six (6) year project called the Namibia Integrated Landscape Approach for Enhancing Livelihoods and Environmental Governance to Eradicate Poverty (NILALEG) Project with funding from the Global Environment Facility (GEF).

The project aims to "promote an integrated landscape management approach in key agricultural and forest landscapes, reducing poverty through sustainable nature-based livelihoods, protecting and restoring forests as carbon sinks, and promoting Land Degradation Neutrality".

Amongst other needs which were identified during the stakeholder consultations undertaken at the beginning of the project, the NILALEG project is supporting the installation of solar-powered boreholes to improve access to clean and safe water for human consumption and agricultural activities in Zambezi Focal Landscape at Zilitene Village in the Zambezi Region.

This EMP is developed for the Zambezi Focal Landscape at Zilitene Village in Zambezi Region.

1.2. Namibian Climate

Generally, Namibia is an arid country, with a large part of country having a climatic condition characterized by high temperatures and, periodic low rainfall. Rainfall decrease from east to west, with Zambezi Region receiving the highest rainfall of 600ml/year to less than 25 ml in the Southwest and West of the country. The country experiences high climatic variability in the form of persistent droughts, unpredictable and highly variable rainfall patterns, temperatures and scarcity of water. High solar radiation, low humidity and high temperatures lead to very high evaporation rates, which vary between 3800 ml per annum in the south to 2600 ml per annum in the north. In many areas, potential evaporation is about five times greater than the average rainfall. Surface water sources such as dams are subject to high evaporation rates.

The study area, Zilitene village is in the Zambezi region. The regions' climatic condition is influenced by the Zambezi River, that of tropical nature with warm to hot temperatures. The warmest temperatures are from September to March, and the coldest between May to August. The dry season fall between April and October while the wet season is falls between November and March.

According to Mendelsohn et al 2002, the average summer temperature is 20ºC while during winter the average temperature is 5 ºC and the average maximum and minimum annual temperature is 35 ºC and 19 ºC respectively.

1.3. Water Resource Availability

1.3.1. Surface Water

The primary surface water in Namibia is found in dams in Ephemeral Rivers and Perennial Rivers which have a potential of 200 Mm^3 and 1,105Mm^3 per annum respectively. The

Ephemeral Rivers in the interior flow during the raining season, where western flowing rivers drains into the Atlantic Ocean, Fish River drains into Orange River, Cuvelai system, which is not a defined River system but rather Iishanas or flood plain drains into Etosha Pan and partially contribute to Kavango, Kwando and Zambezi River.

Perennial River, which has permanent flow are all found on the border of the country. Zambezi in the northeast has a mean annual flow of 40,000 Mm^3, its flow per second, 180Mm^3, is about twice the overall Dams capacity in Namibia at 100Mm^3. The Kwando / Linyati / Chobe has an annual flow of 10,000Mm^3, Kunene 5,500Mm^3 and Orange River with 11,000Mm^3 flow.

1.3.2. Ground Water

Namibia highly relies on ground water. About 50-60% water is ground water which has a potential yield of 360Mm^3. Geologically, the main aquifers are the Karst, Otjwarongo, Omaruru Delta (OMDEL), Lower Kuiseb, Windhoek, Stampriet, Koichab and Ohangwena II.

1.3.3. Other water supply

Unconventional and yet capable water resource in country includes; Desalination of seawater, re-use of semi-purified water for sports grounds and parks, re-cycling of industrial and mining water, reclamation from wastewater effluent, artificial recharge of aquifers, mixing of potable and brackish water, use and purification of brackish water, rainfall harvesting and fog harvesting amongst others.

1.4. Water Supply and demand in Namibia

Namibia has made huge progress since independence in 1990 to increase water supply from 43% supply to 93% and 85% in urban and rural areas respectively by 2019 and the country aims for 100% water supply by 2030. In 2008, total water demand in the country amounted to 334.1Mm^3 against a total supply of 422.5Mm^3, while projected demand by 2025 and 2030 are expected to double at 635.6Mm^3 and 811.7Mm^3 respectively. Irrigation schemes consumes over 40% amount of total water supply in the country and by 2030, irrigation is focused to consume 64.4% of the country water supply[1].

2. The NILALEG Project

2.1. Zambezi Focal Landscape

2.1.1. Population Demography

According to the baseline indicator report for NILALEG by Southern African Institute for Environmental Assessment 2021, the Zambezi Focal Landscape is situated in the eastern part of the Region, Katima Mulilo in the east, to the floodplains of the Zambezi River in the north and to the Chobe River the south. The Focal Landscape measure an area of 219,513 ha.

The 2011 population census indicated that Zambezi region has total population of 90 596 people. Overall 61% of the region population makes up the labour force whereby 62% and 32% of the labour force is employed and unemployed respectively. The region has 7 electoral constituencies Table 1 below.

[1] Integrated Water Resources Management Plan for Namibia, 2010

Table 1. Electoral constituencies of Zambezi Region (Census 2011)

Total Population	
Zambezi	90 596
Kabbe	14 518
Katima Mulilo Rural	16 399
Katima Mulilo Urban	28 362
Kongola	5 658
Linyanti	15 477
Sibbinda	10 182

Urban Localities in Zambezi	
Katima Mulilo	28 362

2.1.2. Geology, topography, and hydrology

According to Mendelsohn *et al 2002*, Zambezi region, is formed up of the Kalahari Basin. The Kalahari Basin was formed from the split between Namibia and South America to form a broad coastal plain which is now the Namib Desert. The Kalahari Basin gradually filled up with sand and water borne deposit. These deposits of sands, clay and calcretes formed the Kalahari Group.

Generally, the Zambezi region is flat and sloping toward the eastern direction. This is because, the geology of the area was formed from the filling up of the coastal plain with Namib sand and water borne deposits. Flooding is frequent in the region because of direct rainfall and rise in the Zambezi River from Angolan inflows.

The lithology of the aquifer in Zilitene is not well known. The geohydrology indicates that the aquifers are found in Kalahari Deposits where soils are clayey loam with low infiltration potentials and faced with evaporation rates higher than rainfall which consequently causes low potential of ground water recharge.

2.1.3. Biodiversity

Zambezi region is the most densely vegetated region in Namibia. Due to its tropical nature, the areas have a tropical forest covered by thick bush, shrubs mature trees which are predominantly Rose Wood and various species of Acacia trees and tall glass in the floodplain while non-flooded areas have trees of mopane *(Colophospermum mopane),* and burkea-terminalia *(Terminalia sericea)*.

The study area is located in the village and due to many human activities, there are no wild animals' only domestic animals were seen in the area.

For this study, the analysis of the borehole operation on biodiversity is positive as it will provide water for domestic animals.

2.2. Zilitene Borehole

2.2.1. Location

The study area, Zilitene village is in the electoral constituency of Katima Mulilo Rural, with a population of about 800 people within 167 households (-17.777833^{0}S, 24.379917^{0}E) Fig 1.

Figure 1. Zilitene Borehole Location

2.2.2. Borehole Information

The borehole at Zilitene village was drilled on 8th March 2022 by Satellite Investment. It is drilled to a depth of 60m and has a diameter of 150mm. This borehole is abstracting water from the lower aquifer which start from depths greater than 50m. These aquifer in the Zambezi are known to have a thickness of up to 125m, formed by coarse grained, semi-consolidated to consolidated sandstone with underlying layer of basal / brackish to saline water.

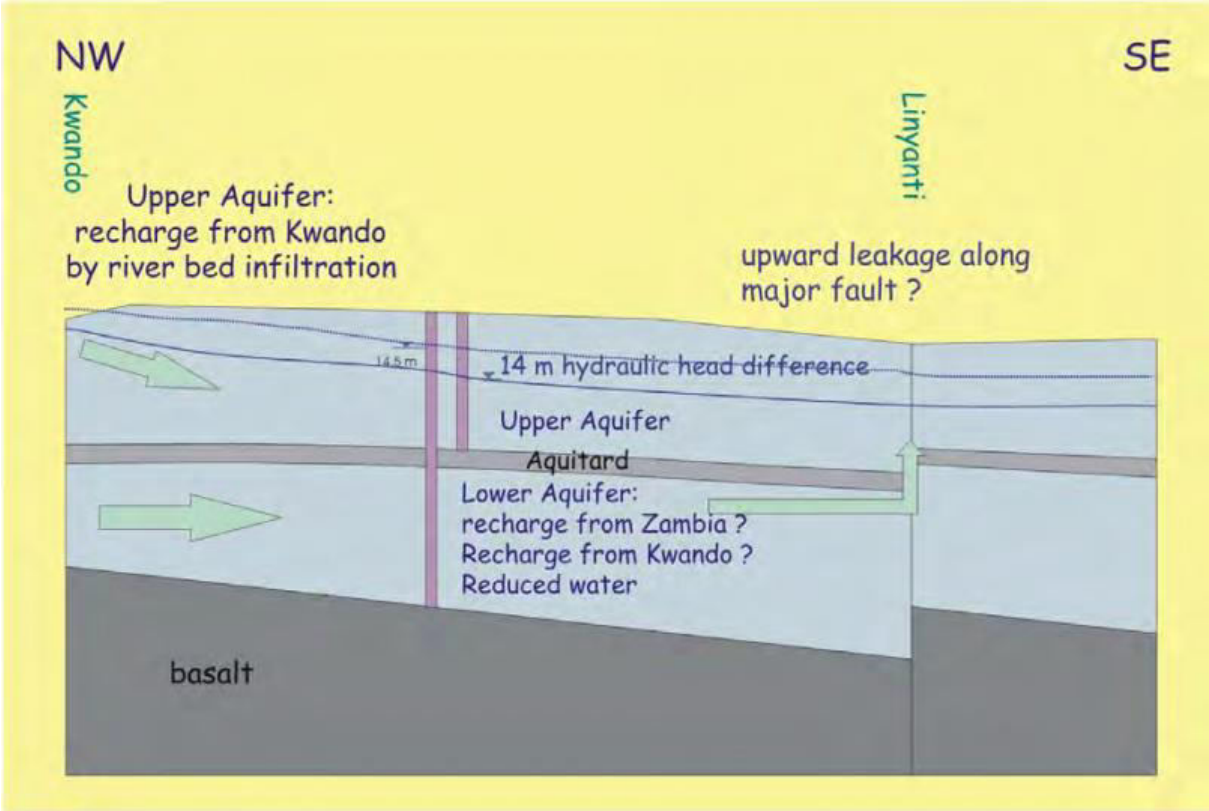

Figure 2. Schematic Concept showing the Structure of the Aquifer System in the Eastern Caprivi (Groundwater Investigations in the Eastern Caprivi Region, Main Hydrogeological Report pp46)

The borehole water tanks and solar panels are fenced within barbed wires (Fig 3). This type of fencing gives project against vandalism, however not against elephants. Although elephants are not known to frequent the area, precaution of an elephant buffer wall is highly recommended (Appendix 2).

Figure 3. Site pictures of Zilitene

The daily pumping hours amounted to about 22 hours yielding 9.589m^3/day (9,589 L/day). Test pumping recommended an abstraction rate of 70% of the maximum yield which amounts to 6.7123m^3 (6,712.3 L/day) where in 22 hours amounting to 305 litres per hour.

The Groundwater Investigations in the Eastern Caprivi Region 2005 study indicated that, per capita water use in Zambezi is 16 L/day and combined 55 L/day for livestock. With the available information on the village population of 800 people, the water demand would equal to 12,800.00 L/capita/day. At the time of this study, the current total water supply in the entire village was not known. When borehole production/yield figures are raised to the national statistics of 85% supply of water in rural areas, the borehole will only be required to supplement per capita water demand of 1,920 L/day hence the yield at 70% of 6,712.3 L/day will be sustainable. Furthermore, Satellite Investment has indicated that, the yield at 70% is sufficient and sustainable for human, animals, and irrigation at the intent area.

3. The need and desirability of the Project

This project is in line with the Integrated Water Resource Management (IWRM) for Namibia which aims to achieve a sustainable water resources management regime, contributing to social equity, economic efficiency, and environmental sustainability. In the study area, a study by WINDHOEK CONSULTING ENGINEERS (WCE) on Rural Water Supply Development Plan for the Caprivi Region, advised against the use of piped water because it would lead to unwanted migration of people and to uncontrolled and illegal connections. The study thus recommended the rehabilitation of some of the existing water points and to drill more boreholes for human consumption in the rural areas. Furthermore, the aridity of the country coupled with effect of climate change requires investments in water resource development to ensure sustainable water supply.

4. Statutory Requirement

The Environmental Management Act (Act No 7 of 2007) (EMA) and its Environmental Impact Assessment Regulation 2012, has listed Water Resource Developments activities not to be undertaken without an Environmental Clearance Certificate (ECC) as follows.

a) 8.1 The abstraction of ground or surface water for industrial or commercial purposes
b) 8.2 The abstraction of groundwater at a volume exceeding the threshold authorised in terms of a law relating to water resources.

The statutory requirement under point (a), 8.1 of the EIA regulation obliges the NILALEG Project to develop an Environmental Management Plan (EMP) for the borehole which have been drilled at Zilitene. The NILALEG project, thus contracted Red-Dune Consulting cc to develop the EMP for the operation of the borehole.

5. Project Scope

The scope of this project is to develop a SEMP for the drilled borehole in Zilitene village. This SEMP is guided by the Environmental Regulations 2012, which aims at identifying possible impacts, assessing the impact and formulate the optimum, practical mitigation measure to minimize the impacts. This SEMP shall address potential social and environmental impacts that the proposed project activities may cause to ensure environmental sustainability.

RD believes that the information provided in this SEMP is sufficient to enable the Environmental Commissioner to issue the ECC for the continued operation of the borehole.

6. Policy, Legal and Administrative Framework

Table 2. Regulatory framework applicable to the project

Legislation	Relevant authority	Applicability
The Namibia Constitution	**Government Republic of Namibia**	The Namibian constitution is the supreme law of the country and makes provision for environmental protection and sustainable development.
Environmental Management Act No. 7 of 2007	**Ministry of Environment, Forestry and Tourism**	The environmental management act No.7 of 2007 aims to promote the sustainable use of natural resources and provides the framework for the environmental and social impact assessment, demands precaution and mitigation of activities that may have negative impacts on the environment and provision for incidental matters. Furthermore, the act provides a list of activities that may not be undertaken without an environmental clearance certificate.
Environmental Assessment Policy (1995)	**Ministry of Environment, Forestry and Tourism**	The Environmental Assessment Policy for Sustainable development and Environmental Conservation emphasize the importance of environmental assessments as a key tool towards implementing integrated environmental management. Sets an obligation to Namibians to prioritize the protection of ecosystems and related ecological processes.

Legislation	Relevant authority	Applicability
		The policy subjects all developments to environmental assessment and provides guideline for the Environmental Assessment. The policy advocates that Environmental Assessment take due consideration of all potential impacts and mitigations measures should be incorporated in the project design and planning stages (as early as possible).
Pollution Control and Waste Management Bill (in preparation)	**MEFT, MHSS and others**	The Pollution Control and Waste Management Bill, intents to regulate and prevent the discharge of pollutants into the air and water as well as providing for general waste management.
Public Health Act (Act No. 36 of 1919)	**Ministry of Health and Social Services**	The Public Health Act aims to protect the public from nuisance and states that no person shall cause a nuisance or shall suffer to exist on any land or premises owned or occupied by him or of which he is in charge any nuisance or other condition liable to be injurious or dangerous to health.
Water Resources Management Act (Act No. 11 of 2013)	**Ministry of Agriculture, Water and Land Reform**	This Act provides a framework for managing water resources based on the principles of integrated water resources management. It provides for the management, development, protection, conservation, and use of water resources. Therefore, water abstraction should satisfy the provisions of the water act (water abstraction / borehole permit should be applied from the respective ministry).
Water Act No, 54 of 1956	**Ministry of Agriculture, Water and Land Reform**	This act states that, all water resources belong to the State. It prevents pollution and promotes the sustainable utilization of the resource. To protect these

Legislation	Relevant authority	Applicability
		resources, this act requires that permits are obtained when activities involve the following: (a) Discharge of contaminated into water sources such as pipe, sewer, canal, sea outfall and (b) Disposal of water in a manner that may cause detrimental impact on the water resources
Soil Conservation Act No. 76 of 1969	**Ministry of Agriculture, Water and Land Reform**	This act promotes the conservation of soil, prevention of soil erosion. Prevent soil salinification.
National Heritage Act No. 27 of 2004	**Ministry of Urban and Rural Development**	The Act makes provision for the protection and conservation of places and objects of heritage significance and the registration of such places and objects. Part V Section 46 of the Act prohibits removal, damage, alteration or excavation of heritage sites or remains, while Section 48 sets out the procedure for application and granting of permits.
Regional Councils Act, 1992 (Act No. 22 of 1992)	**Ministry of Urban and Rural Development**	The Regional Councils Act legislates the establishment of Regional Councils that are responsible for the planning and coordination of regional policies and development. The main objective of this Act is to initiate, supervise, manage and evaluate regional development.

7. Impact Assessment

7.1. Impact Identification

During literature review and site assessment, possible impacts were listed. The criteria used to assess the impacts and the method of determining their significance is outlined in Table 3 below. This process conforms with the Environmental Impact Assessment Regulations of Environmental Management Act, 2007 (Government Gazette No. 4878) EIA regulations. The approach for determining and analysing impacts was undertaken into two steps.

- **Impact Determination**; during this step, the impact is assessed based on severity, spatial scale and its duration.
- **Impact Significance**; various rating exists to determine the overall rating of the impact

Impact significance is determined under two mitigation scenarios; **without mitigation** and **with mitigation**. The confidence of impact mitigation depends on the level of certainty based on available information to assess the impact.

Table 3. Criteria for Impact Evaluation

Risk Event	**Rating**	**Description of the risk that may lead to an Impact**
Impact type	**0**	No Impact
	+VE	Positive
	-VE	Negative
Probability	The probability that an impact may occur under the following analysis	
	1	Improbable (Low likelihood)
	2	Low probability
	3	Probable (Likely to occur)
	4	Highly Probable (Most likely)
	5	Definite (Impact will occur irrespective of the applied mitigation measure)

Confidence level	The confidence level of occurrence in the prediction, based on available knowledge	
	L	Low
	M	Medium
	H	High
Significance (Without Mitigation)	0	None (Based on the available information, the potential impact is found to not have a significant impact)
	L	Low (The presence of the impact's magnitude is expected to be temporal or localized, that may not require alteration to the operation of the project
	M	Medium (This is when the impact is expected to be of short term moderate and normally regionally. In most cases, such impacts require that the projects are altered to mitigate the impact or alternative method of mitigation is implemented
	H	High (The impact is definite, can be regional or national and in long term. The impact could have a no-go implication unless the project is re-designed or proper mitigation can practically be applied
Mitigation	The applied measure / alternative to reduce / avoid an impact	
Significance (With Mitigation)	0	None (Based on the available information, the potential impact is found to not have a significant impact)
	L	Low (The presence of the impact's magnitude is expected to be temporal or localised, that may not require alteration to the operation of the project
	M	Medium (This is when the impact is expected to be of short term moderate and normally regionally. In most cases, such impacts require that the projects are altered to mitigate the impact or alternative method of mitigation is implemented
	H	High (The impact is definite, can be regional or national and in long term. The impact could have a no-go implication unless the project is re-designed or proper mitigation can practically be applied
Duration	Time duration of the impacts	
	1	Immediate
	2	Short-term (0-5 years)
	3	Medium-term (5-15 years)

	4	Long-term (more than 15 years
	5	Permanent
Scale	The geographical scale of the impact	
	1	Site specific
	2	Local
	3	Regional
	4	National
	5	International

7.2. Potential Negative Impacts of the Project

- Over abstraction of water
- Quality of water (Safe for human consumption)
- Loss of habitat and biodiversity from site preparations and occupation
- Safety risk for animals on concrete drinking platforms
- Risk of enticing elephants to frequent the area in search for water
- Conflict of water use among villagers
- Corrosive water (Borehole metal casing corrosion)

7.3. Potential Positive Impact of the project

- Increase of community water supply
- Improved livestock
- Reduced distance of travel by people and animals to water point
- Supply of water during drought

8. The Environmental Management Plan

8.1. Purpose of the EMP

This Environmental Management Plan (EMP) is a risk strategy that contains logical framework, monitoring programme, mitigation measures, and management control strategies to minimize environmental impacts. It further stipulates the roles and responsibility of persons involved in the project. These strategies are developed to reduce the levels of impacts for the projects

8.2. Compliance to the EMP

This EMP is a legally binding document as given under the provisions of the Environmental Management Act, 2007 (Act No. 7 of 2007). Namibia Construction and Technologies cc and its contractors must adhere to the framework of this document

8.3. Roles and Responsibility

8.3.1. Proponent

The proponent, NILALEG Project as representative of Ministry of Environment, Forestry and Tourism shall take overall responsibility for proper implementation of the EMP. It remains the responsibility of the proponent to appoint key personnel for the implementation of the EMP such as Site Manager and ensure that all employees and contractors are conversant with the EMP.

8.3.2. Site Manager

The Site Manager (SM) represents the proponent on site. He/she shall be responsible for daily activities in ensuring environmental protection. All communication with regard to the implementation of EMP must be channelled through the SM

8.3.3. Employees

It shall be responsibility of employees to always adhere to the provision of EMP when on site

8.3.4. Environmental Compliance Officer

Compliance to EMP is enforced by the environmental inspector as provided for under Environmental Management Act (No. 7 of 2007) (EMA)

8.4. Disciplinary Action

This EMP is a legally binding document, non-compliance to the EMP is punishable in accordance to the provision of EMA

9. The EMP table

The is an operational Socio Environmental Management Plan (SEMP). The boreholes have been drilled already, minimal site clearance was undertaken to allow movement of vehicles and drilling equipment. This SEMP will focus on the identified impact under 7.2 & 7.3 above.

9.1. Positive Impacts

Environmental / Social Impact	Objectives	Proposed Mitigation Measures	Monitoring Indicator	Party Responsible
Skill and Knowledge transfer	To ensure minimum capacity for the operation and maintenance of the borehole's infrastructure	1. Identify and train competent people (Preferable youth) to do basic maintenance of the borehole infrastructure	• Training report	Site Manager
Increase in community water supply	To ensure Namibia 100% rural water supply by 2030	2. Aid in increasing water point in the village 3. Limit migration of people due to water scarcity 4. Reduced distance travel by people and animal to water points 5. Improved livelihood and food security through	• Report on sustainable water supply by the borehole	Site Manager

Environmental / Social Impact	Objectives	Proposed Mitigation Measures	Monitoring Indicator	Party Responsible
		irrigation		
Improved livestock	Improved wellbeing of livestock	1. Less stress on livestock long distance movement in search of water, in turn, improved quality of livestock for better market prices 2. Sustainable supply of water during drought	• Reports on livestock survival and improvement on their well being • High survival of livestock during drought	Site Manager

9.2. Negative Impacts

Environmental / Social Impact	Objectives	Proposed Mitigation Measures	Monitoring Indicator	Party Responsible
Over abstraction of underground water	To prevent over abstraction of from the aquifer and to conserve the aquifer.	1. Do not abstract more than 70% of the total yield of what is recommended per day 2. Where possible, install automatic measuring gauge to monitor abstraction 3. Monitor water level periodically but not more than two years 4. Pump test should be carried which will inform the performance of the aquifer 5. Carry out periodic pumping yield to assess aquifer sustainability	• Abstraction monitoring report	Site Manager
Human and Animal Health (Quality of Water fit for human consumption)	To ensure the water is fit for human consumption (Some studies has indicated	1. Ensure that periodic water sample are assessed for quality to ensure fit human consumption 2. Treatment of the groundwater from the Lower Aquifer will be required due its H_2S content (reduced water).	• Water quality monitoring reports	Site Manager

Environmental / Social Impact	Objectives	Proposed Mitigation Measures	Monitoring Indicator	Party Responsible
	high level of Hydrogen sulfide H_2S).			
Safety risk of hooved animals on concrete drinking platform	To ensure safety of hooved animal at water point on concrete platforms surrounding the water trough	1. Ensure that concrete surface of the water trough is kept rugged and rough to avoid slippery that could injure animals	• Physical site inspection	Site Manager
Risk of water infrastructure destruction buy elephant	To prevent infrastructure destruction by elephant	1. There is a barbed wire fence surrounding borehole infrastructures. This may prevent general vandalism but may not deter Elephants although they are not known to frequent the site, therefore it is recommended to build a wall of not less that 2.5m high and thick enough that will prevent elephants access to the water tank and solar infrastructures (Appendix 2)	• Elephant incident report	Site Manager
Conflict of water use buy villagers	To prevent conflict among villager / users of the borehole	1. Raise awareness of the indented purpose of the borehole	• Community consultation and awareness raising report	Site Manager

Environmental / Social Impact	Objectives	Proposed Mitigation Measures	Monitoring Indicator	Party Responsible
		2. Ensure no one is made to be entitled to owning or have controlling power on who should use the borehole		
Corrosion of borehole metal casing (Some studies has indicated high level of Hydrogen sulfide H_2S and PH level of 9 which is highly corrosive).	To the casing are not corroded that may affect pump yields and water quality	1. Some studies have recommended the use of non-corrosive casing. However, ensure periodic monitoring of casing from corrosion	• Corrosion monitoring reports	Site Manager

10. Decommissioning and Rehabilitation Plan

Decommissioning is normally the reverse of construction where all installed equipment / structure must be removed. Supply of water has an infinite timeframe. Unless otherwise of a pressing issue national issue, such as degraded water quality, that would necessitate decommissioning, the borehole is aimed to outlive generations to come. Aging equipment that required replacement should be done by qualified Namibians to ensure smooth operation of the borehole.

As mentioned above, Zambezi region is known to have corrosive underground water. It is critical to develop a strategy for periodic rehabilitation to ensure that the borehole yields are not affected.

11. Conclusion and Recommendations

11.1. Conclusions

This Social Environmental Management Plan was developed post drilling of the boreholes. During site inspection, there were no concern on how few trees and shrubs were cleared to create working space on site and make way for the drilling vehicle. This study was undertaken with high degree of certainty and no impacts was observed which could not be minimized at insignificant levels.

11.2. Recommendations

It is recommended to the approving authority for the issuance of the ECC. Strong emphasis on ensuring on water quality to protect the health of human and animals.

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13. Appendixes

Appendix 1. Borehole Information

Step Drawdown Test Form

Contractor Name: Satellite Investment	Page:1 of 4
Location: Zilitene area	Borehole No: Zilitene
Latitude: 17 46'40.2" S	Longitude: 24 22' 47.7" E
Test: Step Test	Duration: 2 h
Elevation: 839 m	Date: 08 / 03/2022
Test borehole/observation:	Borehole depth: 60
Rest Water Level before start of test:3.1 m	Distance from pumped Borehole: 0 m
Pumping depth: 20 m	Diameter: 150 mm

Pumping Water levels					Recovery Water levels			Comments
Clock Time hh:mm	Pump Time min	Water Level m b collar	Flowmeter Reading m^3/h	EC mS/m	Start Time	Recovery Time min	Water Level m b collar	Comments
10:00	1	3.5						
	2	3.6						
	3	4.1						
	4	5.2	1					
	5	6.7						
	7	7.5		7.5				
	10	8.1						
	15	9.1						
	20	10.5	1.3					
	25	11.8		8				
	30	12.5						
	35	13.5						
	40	14.8						
	50	15.6	1.2					
11:00	60	16						
	70	17.2		7.8				
	80	18.5						
	90	18.8						
	100	18.9						
	110	19.2						
12:00	120	19.5						

Step Drawdown Test Form

Contractor Name: Satellite Investment	Page:1 of 4
Location: Zilitene area	Borehole No: Zilitene
Latitude: 17 46'40.2" S	Longitude: 24 22' 47.7" E
Test: Step Test	Duration: 2 h
Elevation: 839 m	Date: 08 / 03/2022
Test borehole/observation:	Borehole depth: 60
Rest Water Level before start of test:3.1 m	Distance from pumped Borehole: 0 m
Pumping depth: 20 m	Diameter: 150 mm

Pumping Water levels					Recovery Water levels			Comments
Clock Time hh:mm	**Pump Time min**	**Water Level m b collar**	**Flowmeter Reading m^3/h**	**EC mS/m**	**Start Time**	**Recovery Time min**	**Water Level m b collar**	**Comments**
10:00	1	3.5						
	2	3.6						
	3	4.1						
	4	5.2	1					
	5	6.7						
	7	7.5		7.5				
	10	8.1						
	15	9.1						
	20	10.5	1.3					
	25	11.8		8				
	30	12.5						
	35	13.5						
	40	14.8						
	50	15.6	1.2					
11:00	60	16						
	70	17.2		7.8				
	80	18.5						
	90	18.8						
	100	18.9						
	110	19.2						
12:00	120	19.5						

Step Drawdown Test Form

Contractor Name: Satellite Investment	Page:2 of 4
Location: Zilitene area	Borehole No: Zilitene
Latitude: 17 46'40.2" S	Longitude: 24 22' 47.7" E
Test: Step Test	Duration: 2 h
Elevation: 839 m	Date: 08 / 03/2022
Test borehole/observation:	Borehole depth: 60
Rest Water Level before start of test:3.1 m	Distance from pumped Borehole: 0 m
Pumping depth: 20 m	Diameter: 150 mm

Pumping Water levels					Recovery Water levels			Comments
Clock Time hh:mm	Pump Time min	Water Level m b collar	Flowmeter Reading m^3/h	EC mS/m	Start Time	Recovery Time min	Water Level m b collar	Comments
13:01	1	20.8						
	2	20.9						
	3	20.7						
	4	21.4						
	5	21.5						
	7	21.7	1.4					
	10	21.9		7.6				
	15	22.1						
	20	22.2						
	25	22.2	1.3					
	30	22.4		8.1				
	35	22.9						
	40	22.9						
	50	22.9	1.4					
14:01	60	23.1		7.8				
	70	23.1						
	80	23.2						
	90	23.2						
	100	23.3						
	110	23.4						
15:01	120	23.4						

Step Drawdown Test Form

Contractor Name: Satellite Investment	Page:3 of 4
Location: Zilitene area	Borehole No: Zilitene
Latitude: 17 46'40.2" S	Longitude: 24 22' 47.7" E
Test: Step Test	Duration: 2 h
Elevation:	Date: 08 / 03/2022
Test borehole/observation:	Borehole depth: 60
Rest Water Level before start of test:3.1 m	Distance from pumped Borehole: 0 m
Pumping depth: 20 m	Diameter: 150 mm

Pumping Water levels					Recovery Water levels			Comments
Clock Time hh:mm	Pump Time min	Water Level m b collar	Flowmeter Reading m^3/h	EC mS/m	Start Time	Recovery Time min	Water Level m b collar	Comments
16:00	1	23.4						
	2	23.4						
	3	23.4						
	4	23.6						
	5	23.7						
	7	23.8	2.4					
	10	23.9		7.7				
	15	23.9						
	20	24.0						
	25	24.1	2.5					
	30	24.2		8.2				
	35	24.3						
	40	24.4						
	50	24.5	2.5					
17:00	60	24.6		7.9				
	70	24.7						
	80	24.7						
	90	24.8						
	100	24.9						
	110	25.0						
18:00	120	25.1						

Step Drawdown Test Form

Contractor Name: Satellite Investment | Page:4 of 4

Location: Zilitene area | Borehole No: Zilitene

Latitude: 17 46'40.2" S | Longitude: 24 22' 47.7" E

Test: Step Test | Duration: 2 h

Elevation: | Date: 08 / 03/2022

Test borehole/observation: | Borehole depth: 60

Rest Water Level before start of test:3.1 m | Distance from pumped Borehole: 0 m

Pumping depth: 20 m | Diameter: 150 mm

Pumping Water levels					Recovery Water levels			Comments
Clock Time hh:mm	Pump Time min	Water Level m b collar	Flowmeter Reading m^3/h	EC mS/m	Start Time	Recovery Time min	Water Level m b collar	Comments
19:01	1	23.4						
	2	23.4						
	3	23.4						
	4	23.6						
	5	23.7						
	7	23.8						
	10	23.9						
	15	23.9						
	20	24.0	2.4					
	25	24.1						
	30	24.2		7.7				
	35	24.3						
	40	24.4	2.5					
	50	24.5						
20:01	60	24.6		8.2				
	70	24.7						
	80	24.7						
	90	24.8						
	100	24.9						
	110	25.0	2.5					
21:01	120	25.1		7.9				

Main Discharge Test Form

Contractor Name: Satellite Investment	Borehole No: Zilitene
Location: Zilitene area	Longitude: 24 22' 47.7" E
Latitude: 17 46'40.2" S	Duration: 8 h
Test: Step Test	Date: 08 / 03/2022
Elevation: 839 m	Borehole depth: 60
Rest Water Level before start of test:3.1 m	Water Samples: 08/03/2022
Pumping depth: 20 m	Diameter: 150 mm

Pumping Water levels					Recovery Water levels			Comments
Clock Time hh:mm	Pump Time min	Water Level m b collar	Flowmeter Reading m^3/h	EC mS/m	Start Time	Recovery Time min	Water Level m b collar	Comments
23:00	1	8.1						
	2	8.1						
	3	9.1						
	4	10.5						
	5	11.8						
	7	12.5	1					
	10	13.5		7.5				
	15	14.8						
	20	15.6						
	25	16	1.3					
	30	16.2		8				
	35	16.3						
	40	16.4						
	50	16.5	1.2					
0:00	60	16.7		7.8				
	75	16.8						
	90	16.9						
	105	17.0	1.5					
1:00	120	17.2						
	150	17.3						
2:00	180	17.4						
	210	17.5		8.3				
3:00	240	17.7	1.6					
4:00	300	17.8						
5:00	360	17.9						
6:00	480	18.0						

By applying a 20-year safe pumping rate for a well using the method described in: Farvolden, R.N. 1959. Groundwater supply in Alberta. Alberta Research Council. The Total Volume Available from Zilitene Well storage for a 2 hour Yield (L) is given as 2,112.60 litres.

Total Volume Available From Well Storage and 2 Hour Yield (L)	
Equation B.3:	
Available Water (L) = $500\pi(D/2000)^2 H_A + 120Q_{20}$	
Input data:	
Well Diameter (mm) =	150
Results:	
Available Water (L) =	1212.60

Using another method for a 20 year safe pumping rate for a well using the method by van der Kamp, G. and H. Maathuis. 2005. The applicability of Q20 methods for determining sustainable groundwater yields. The available water equates to: 16,976.71 litres.

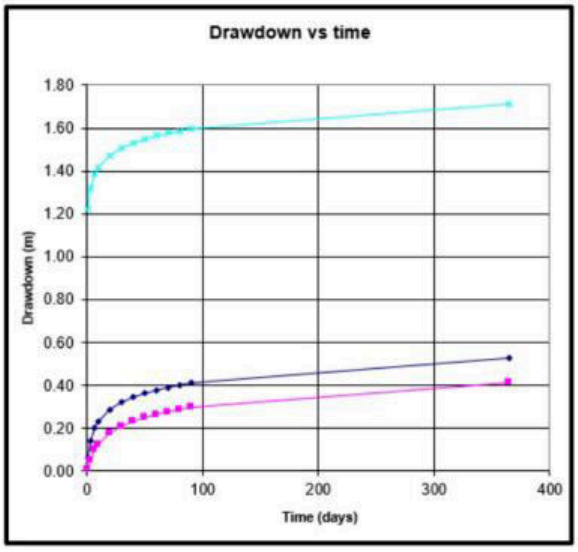
Total Volume Available From Well Storage and 2 Hour Yield (L)	
Equation B.3:	
Available Water (L) = $500\pi(D/2000)^2 H_A + 120Q_{20}$	
Input data:	
Well Diameter (mm) =	150
Results:	
Available Water (L) =	16976.71

Time-drawdown calculations using Theis equation

Aquifer parameters		
T	1.3	m2/d
S	0.000183	

Pumping rate		
Q	1.35	m3/d

Radius (m)	0.076	100	200
Time (days)	Drawdown (m)	Drawdown (m)	Drawdown (m)
1	1.226	0.065	0.009
3	1.316	0.139	0.049
7	1.386	0.204	0.101
10	1.416	0.232	0.126
20	1.473	0.288	0.177
30	1.507	0.321	0.209
40	1.530	0.344	0.232
50	1.549	0.362	0.250
60	1.564	0.377	0.264
70	1.577	0.390	0.277
80	1.588	0.401	0.288
90	1.598	0.411	0.297
365	1.713	0.526	0.412

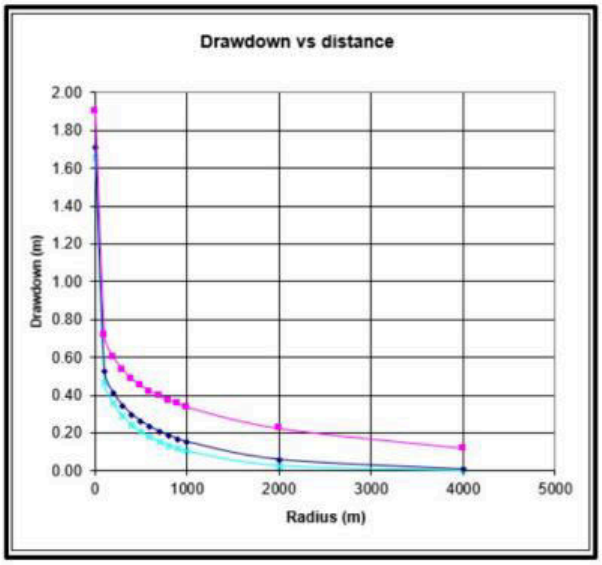


The drawdown gradient indicates an exponential increase at the given pumping rate of 1.35 m³/day with time, for a period of up to 100 days. Significant drawdown decrease is observed from the well to a 100 m radius. Exponential increase indicates sufficient recharge characteristics of the the well.

Distance-drawdown calculations using Theis equation

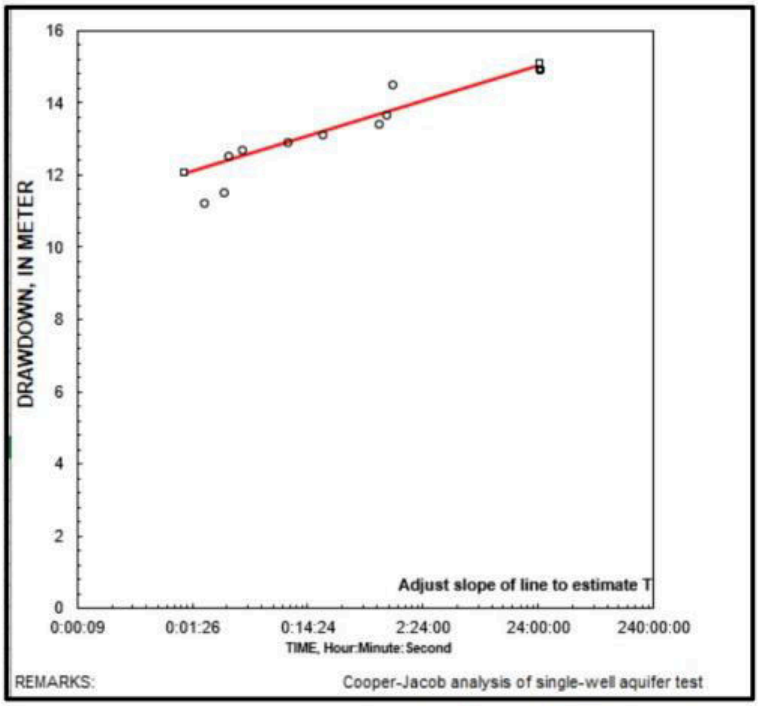
Aquifer parameters		
T	1.3	m2/d
S	0.000183	
Pumping rate		
Q	1.35	m3/d

Time (days)	180	365	3650
Radius (m)	Drawdown (m)	Drawdown (m)	Drawdown (m)
0.076	1.655	1.713	1.903
100	0.468	0.526	0.716
200	0.354	0.412	0.602
300	0.288	0.345	0.535
400	0.241	0.298	0.487
500	0.206	0.262	0.451
600	0.177	0.233	0.421
700	0.154	0.208	0.395
800	0.134	0.187	0.373
900	0.117	0.169	0.354
1000	0.103	0.153	0.337
2000	0.027	0.060	0.224
4000	0.001	0.008	0.119



Drawdown gradient decreases with distance in meters, more or less showing similar signature.

Farvolden Q20 (L/min) =	8.63	
van der Kamp and Maathuis Q20 (L/min) =	140.00	Minimum target volume is 1212.60 L/hour, and it is assumed that this volume will need to be supplied during a 2 hour period to meet the peak demand
Total Volume Available From Well Storage and 2 Hour Yield (L) =	1212.60	
Qlot (L/day) =	9589	Minimum target volume is 9589 L/day
Drawdown Caused by all Wells at Specified Radial Distance (m)	33	
Available Head (m)	20	Target predicted drawdown should be less than 50% of available head
% of Available Head	165%	



From the Cooper-Jacob analysis of the single-well aquifer test above, we can deduce that the daily pumping hours at the pumping test abstraction rate, using the late-time recovery data

$$h_{daily} = 24\ h - \left(\frac{24\ h}{t_0}\right)$$

$$h_{daily} = 24\ h - \left(\frac{24\ h}{14.89}\right) = 24\ h - 1.61\ h = 22.39\ h\ \approx 22\ hours$$

Minimum target volume is 9,589 L/day, and it is assumed that this volume will need to be supplied during a 2 hour period to meet the peak demand.

The safe abstraction rate should not exceed 70% of the maximum abstraction of 9,589 L/day which results in 6,712.3 litres in 22 hours giving 305 litres per hour.

With this target volume, it can be concluded that the borehole is capable of supplying the community for the intended purpose of livestock and irrigation in terms of volume.

Disclaimer:

The pumping test analyses and abstraction recommendations are done on the assumption that the pumping test data are true and accurate recordings of the water level's reaction to abstraction as measured during the pumping tests. Geophysics LDA does not take any responsibility or liability should recommendation rates not be sustainable in a long term due to varying pumping test abstraction rates and/or inaccurate pumping test data.

Appendix 2. Protection of borehole infrastructure by Elephants