



## **Deliverable 3: Progress report on the confirmed borehole positions, pegging and water sampling**

**KAZA Water Infrastructure for Livelihoods Intervention, FP20**

**Version 2**

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## List of Acronyms

Acronym	Long-Form
CRIDF	Climate Resilient Infrastructure Development Facility
KAZA	Kavango – Zambezi Transfrontier Conservation Area
TFCA	Transfrontier Conservation Area
TDS	Total Dissolved Solids
DWAF	Department of Water Affairs and Forestry
FIDIC	International Federation of Consulting Engineers
OD	Outside Diameter



## 1. Introduction and Project Description

SLR Environmental Consulting (Namibia) (Pty) Ltd. (“SLR”) was appointed by the Climate Resilient Infrastructure Development Facility (“CRIDF”) to conduct hydrogeological investigations on the Namibian side of the Kavango – Zambezi Transfrontier Conservation Area (“KAZA TFCA”). This document forms part of the Bankability stage of Phase 1 that is currently underway and it reports back on the pegging of boreholes at the seven sites that were identified for small scale water infrastructure development, with reference to the Activity Code FP20-003.

A detailed hydrogeological description was submitted as part of a technical report after a specialist visit that took place between 23 and 26 June 2014 (CRIDF, 2014). The pegging of the boreholes was done during that period. Additionally, during this visit the existing borehole at Chief Mamili’s place was sampled for the purpose to investigate a “strange taste” that is reported. The purpose of the report is twofold. It reports back on the pegging and sampling of the boreholes that was conducted, but it is also to provide the necessary information for tendering and drilling stages of the project. At this stage, this is still regarded as a progress report that will be finalised once the results of the water quality analyses are received.

## 2. Locality Description

The seven sites are located the Eastern Zambezi Region of Namibia, in the Salambala, Bamunu and Mayuni Conservancies respectively as indicated in Figure 1.

- Site 1, Luchindo in the Salambala Conservancy belongs to Headman Daniel Sezuni & Bornface Sezuni;
- Site 2, belongs to Chief Simasiku Mamili, Bamunu Conservancy;
- Site 3 belongs to Headman Albert Munsu, Bamunu Conservancy;
- Site 4 Nono 1 Village, belongs to Headman Bernard Namita, Bamunu Conservancy;
- Site 5, Nono 2 Village, belongs to Headman Francis Malumo, Bamunu Conservancy;
- Site 6, Big Mukushi, belongs to Chief Mayuni, Big Mukushi, Mayuni Conservancy;
- Site 7, Nakati, is a fairly large settlement area. Feedback and reporting is made to Induna Frederick Kabala.

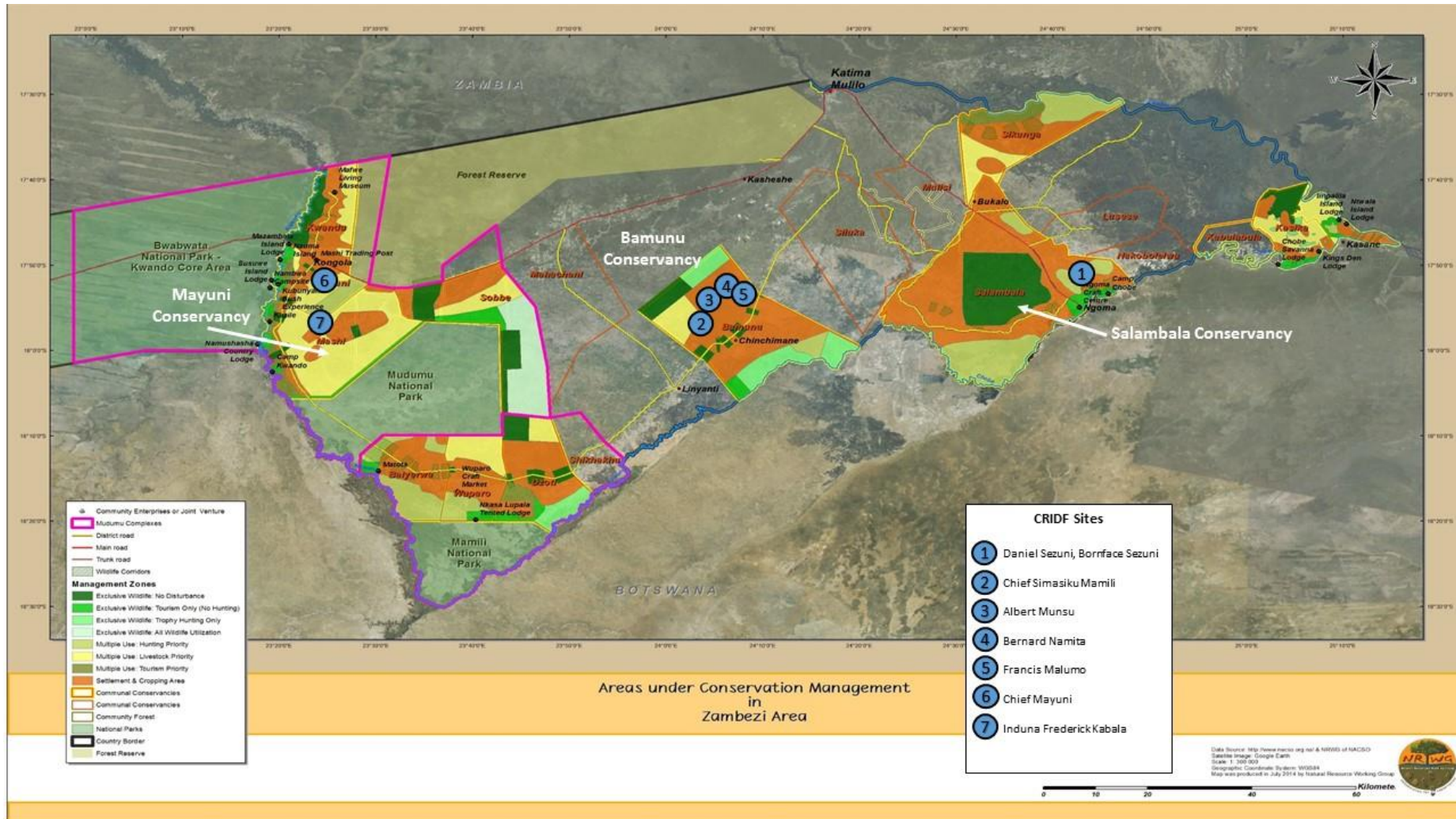


Figure 1: Location of the seven sites in the zambezi region. Source (CRIDF, 2014)



### 3. Geological and hydrogeological framework

The Eastern Zambezi Region is dominated by Kalahari Sequence deposits of which the sedimentation process was controlled by faulting and down lifting of the Caprivi Graben. Underlying the Kalahari is the widespread occurrence of Karoo age basalt. The upper aquifers are often saline in the central areas of the Eastern Zambezi Region (Figure 2). The aquifers are generally productive, classified as medium to high yielding (Van Wyk, Strub, & Struckmeier, 2001).

A comprehensive description of the hydrogeology of the Eastern Zambezi Region is provided in a report done by the German Federal Institute for Geosciences and Natural Resources (BGR) that investigated the different aquifer systems by means of an extensive geophysical investigation and a deep drilling campaign. The BGR investigations found that the central area of the Eastern Zambezi Region, where the saline groundwater occurs, two aquifer systems exists - the "Upper" and "Lower" Aquifer (Figure 3), which are separated by a clay layer (aquitard) at depths between 100-115m (Margane, Baeumle, Schildknecht, & Wierenga, 2005). This exploration drilling has only been done in 4 boreholes in the Linyanti area, and it is still unknown if the lower aquifer has a regional extent. Good quality water and high yields have been reported for the Lower Aquifer.

A summary of the specific hydrogeological conditions expected at each site are provided in Table 1. Please note that at the sites in the Bamunu Conservancy, drilling will be done into the Lower Aquifer in order to obtain good quality water. Also note that in at the Mayuni Conservancy (especially at Big Mukusi), a risk of intersecting saline water and/or clayey horizons exist. Additional geophysical surveys will be required to improve the chances to intersect good quality water with the planned water drilling.

Illustrations with regard to the distribution of water quality, borehole depth, borehole yield and rest water levels are provided in APPENDIX A.

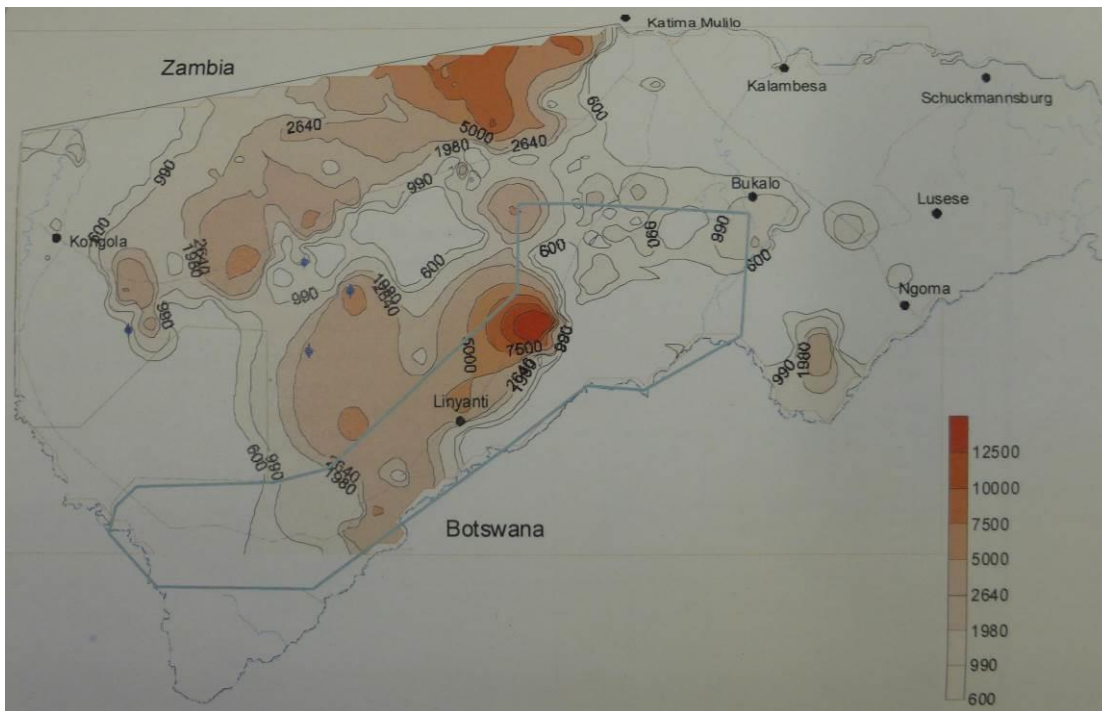


Figure 2: TDS distribution in the Eastern Zambezi REGION (Margane, Baeumle, Schildknecht, & Wierenga, 2005). The legend shows TDS of groundwater in MG/L.

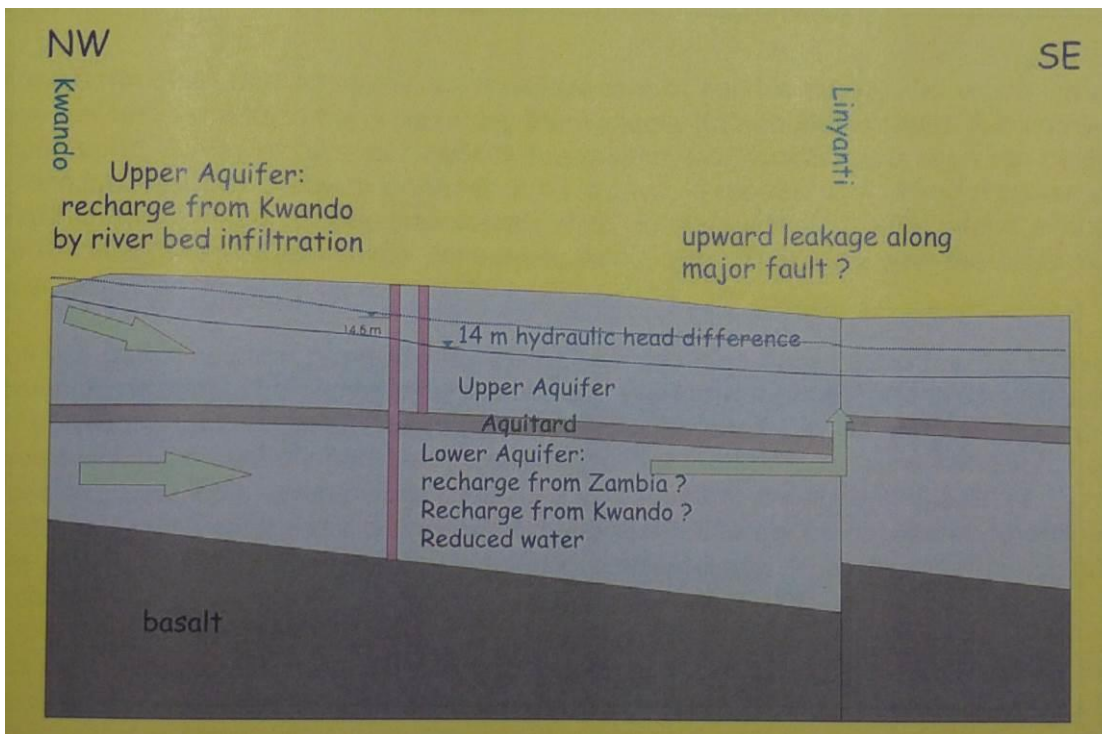


Figure 3: The Upper and lower aquifers identified by the BGR (Margane, Baeumle, Schildknecht, & Wierenga, 2005). the aquitard is at a depth between 100 - 115M.

**Table 1: Summary of the hydrogeological conditions**

Area/conservancy	Locality name	Contact	Aquifer	Expected borehole depth in the area	Expected borehole yield in the area	Expected RWL in the area	Expected water quality	General comments
				[m]	[m <sup>3</sup> /h]	[mbgl]	[Group]	
Salambala Conservancy	Luchindo	Daniel Sezuni (Headman) & Bornface Sezuni	Upper Aquifer	30 to 40	5 to 10	5 to 10	Group A	The site is located in an area with favorable aquifer characteristics in terms of yield and water quality
Bamunu Conservancy		Chief Simasiku Mamili	Lower Aquifer	150 to 200	0 to 5	5 to 10	Group B	Good quality groundwater in Lower Aquifer. WW201625 Have been drilled to a depth of 165m, yielding 13 m <sup>3</sup> /h and with good quality water. A "strange" taste is reported by the community.
		Albert Munsu	Lower Aquifer	150 to 200	0 to 5	5 to 10	Group B	
	Nono 1 Village	Bernard Namita	Lower Aquifer	150 to 200	0 to 5	5 to 10	Group B	
	Nono 2 Village	Francis Malumo	Lower Aquifer	150 to 200	0 to 5	5 to 10	Group B	
Lyamukulu Area	Big Mukusi	Chief Mayuni/Induna Frederick Kabala	Upper Aquifer	50 to 100	5 to 10	15 to 20	Group A	Good quality water is expected, although the site located close to areas where high TDS concentrations occur in the Upper Aquifer. The presence of clay layers might have low yielding or even dry boreholes to effect.
	Nakati	Chief Mayuni/Induna Frederick Kabala	Upper Aquifer	50 to 100	5 to 10	15 to 20	Group A	WW36506 has been drilled to a depth of 70m, yielding 6 m <sup>3</sup> /h and with good quality water.

## 4. Pegging of Boreholes

The boreholes were pegged during the visit 24-26 September 2014. This exercise consisted of hammering an iron peg into the ground at the exact GPS coordinates in the presence of the locality representative. The GPS coordinates and the representatives are summarised under Table 2. It should be established by the drilling contractor that the peg position corresponds to the GPS coordinates before drilling is done. If not, the supervising hydrogeologist should be contacted.

It is important to note that at Chief Mayuni two boreholes were pegged, in case one borehole is dry or salty. The primary drill site as indicated in Table 2 should be drilled first. It is recommended that an EM survey should be done in order to finalise the position of the borehole and to ensure that the borehole is not drilled in an area that contains saline groundwater or clayey sediments.

## 5. Sampling of Chief Mamili's Borehole in the Bamunu Conservancy

The borehole (WW 201625) has been drilled to a depth of 165m, which, if correctly deducted from the borehole completion report has been drilled into the Lower Aquifer from 117-165m. The yield of the boreholes was 13 m<sup>3</sup>/h, and it was installed at a pumping rate of 3m<sup>3</sup>/h. The water unfortunately has a "strange" taste, which is a major problem for the Chief. Causes that are under investigation is the degradation of "drilling mud", the presence of H<sub>2</sub>S due to the presence of sulphide deposits under reducing conditions, or the presence of metals or major ions. The borehole was sampled on 25 September 2014 for major ions, metals and organics (three separate samples) that was sent to respective laboratories for analyses. Once the results are received, this report will be updated.

## 6. Recommendations for Drilling and Test Pumping

The specifications for drilling and test pumping are provided in Table 2.

### 6.1. Standards and specifications

Drilling should be done with the so-called mud rotary method, and the specifications and standards for materials and methods will be according to the minimum specifications of DWAF (Namibia).

### 6.2. Contract management

It is recommended that the FIDIC Conditions of Contracts for Construction (The so-called 'Red Book') should be applied for the contract management.

### 6.3. Salambala and Mayuni Conservancies

Drilling should be done using a 254mm drill diameter, and 165mm OD uPVC casings and screens with 9mm wall thickness should be installed. The screen slot size should be 1mm and a 2-3mm filter gravel pack should be installed.

### 6.4. Bamunu Conservancy

Drilling will be done into the Lower Aquifer where sub artesian conditions exist. This requires the installation of a cement/bentonite seal in order to separate the deeper freshwater aquifer from the upper salt water aquifer. Casing screens and filter gravel should only be installed in the freshwater aquifer section. Like the filter gravel, the bentonite pellets also have to be poured into the annulus between the borehole wall and the casing, thereby sealing the filter section. In order to have sufficient space for the lowering of the bentonite pellets, drilling of the borehole intersecting the Lower Aquifer should be done at a larger diameter, i.e. 311mm. The uPVC casings and screens should have (similarly to the Upper Aquifer wells), 165mm OD with a 9 mm wall thickness. The screen slot size should be 1mm and a filter 2-3mm gravel pack should be installed.

### 6.5. Development of boreholes

Specific emphasis will be placed on the development of the boreholes, in order to remove as much of the drilling mud as practicably possible. Development should be done by means of pumping with a pump installed within a set of straddle packers. The minimum yield of the pump during development should be 10 m<sup>3</sup>/h.

Table 2: Summary of drilling and test pumping specifications

Area/conservancy	Locality name	Contact	Pre-selected drill site		Comment	Bentonite/cement seal	Drill meters to be budgeted for	Drill diameter	Casing diameter	Filter gravel size	Test pumping specifications
			Lat	Long		yes/no	[m]	[mm]	[mm]	[mm]	[mm]
Salambala Conservancy	Luchindo	Daniel Sezuni (Headman) & Bornface Sezuni	17.86196	24.72471	Primary drill site	No	50	254	165 mm OD, 9mm wall thickness, 1mm slot size	2-3 mm	4 hr step drawdown test, 8 hr constant rate test
Bamunu Conservancy		Chief Simasiku Mamili	n/a	n/a	A borehole is exiting. An investigation regarding to "taste" is underway.		n/a	n/a	n/a	n/a	n/a
		Albert Munsu	17.92698	24.05132	Primary drill site	Yes	200	311	165 mm OD, 9mm wall thickness, 1mm slot size	2-3 mm	4 hr step drawdown test, 8 hr constant rate test
	Nono 1 Village	Bernard Namita	17.92893	24.06502	Primary drill site	Yes	200	311	165 mm OD, 9mm wall thickness, 1mm slot size	2-3 mm	4 hr step drawdown test, 8 hr constant rate test
	Nono 2 Village	Francis Malumo	17.93159	24.07641	Primary drill site	Yes	200	311	165 mm OD, 9mm wall thickness, 1mm slot size	2-3 mm	4 hr step drawdown test, 8 hr constant rate test
Mayuni Conservancy			17.85021	23.43226	Primary drill site	No	100	254	165 mm OD, 9mm wall thickness, 1mm slot size	2-3 mm	4 hr step drawdown test, 8 hr constant rate test
	Big Mukusi	Chief Mayuni/Induna Frederick Kabala	17.84895	23.43786	Alternative site to be drilled incase the primary site is "dry"	No	100	254	165 mm OD, 9mm wall thickness, 1mm slot size	2-3 mm	4 hr step drawdown test, 8 hr constant rate test
	Nakati	Chief Mayuni/Induna Frederick Kabala	17.86765	23.40748	Primary drill site	No	100	254	165 mm OD, 9mm wall thickness, 1mm slot size	2-3 mm	4 hr step drawdown test, 8 hr constant rate test

## 7. Conclusions and Recommendations

In accordance with FP20-003's ToR, a site visit as conducted between 24 and 26 September 2014 during which:

1. Boreholes were pegged at in the Salambala, Bamunu and Mayuni Conservancies;
2. Water samples were collected at Chief Mamili's place in order to investigate the reason for the bad taste of the water.

This report provides a brief overview of the hydrogeology of the area, and it supplied all the necessary specifications for the drilling and test pumping of the boreholes. The following is recommended:

1. The information supplied in this report should be used for the compilation of the drilling tenders;
2. The standards and specifications for materials and methods should be according the DWAF standards for drilling and test pumping;
3. Contract management should be according to the FIDIC Redbook for construction;
4. The drilling technique should be mud rotary drilling (direct flush);
5. Drilling in the Bamunu Conservancy should be done at 311mm drill diameter to allow for a cement/bentonite seal;
6. Drilling in Salambala - and Mayuni Conservancies should be done at 254mm drill diameter;
7. Additional EM surveys should be done at the Mayuni Conservancy to ensure the saline groundwater and/or clay are avoided;
8. This report should be updated and finalised once the water quality data from the sampling at Chief Mamili's place is available.

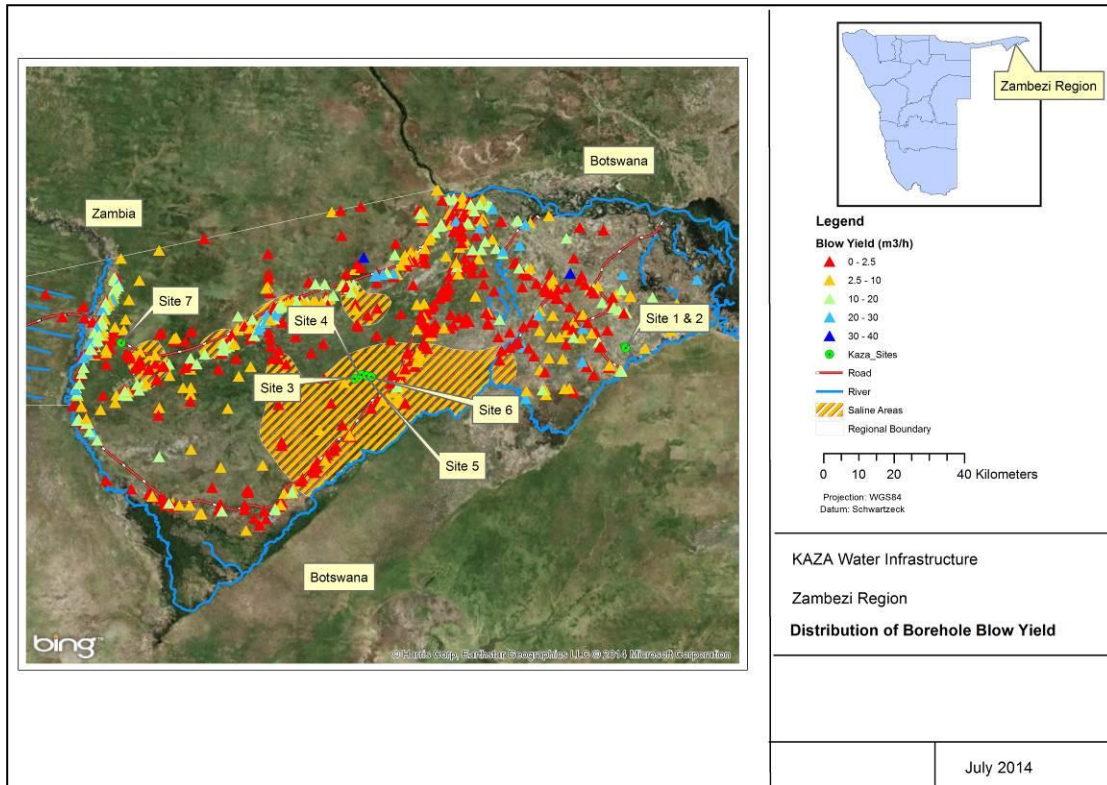
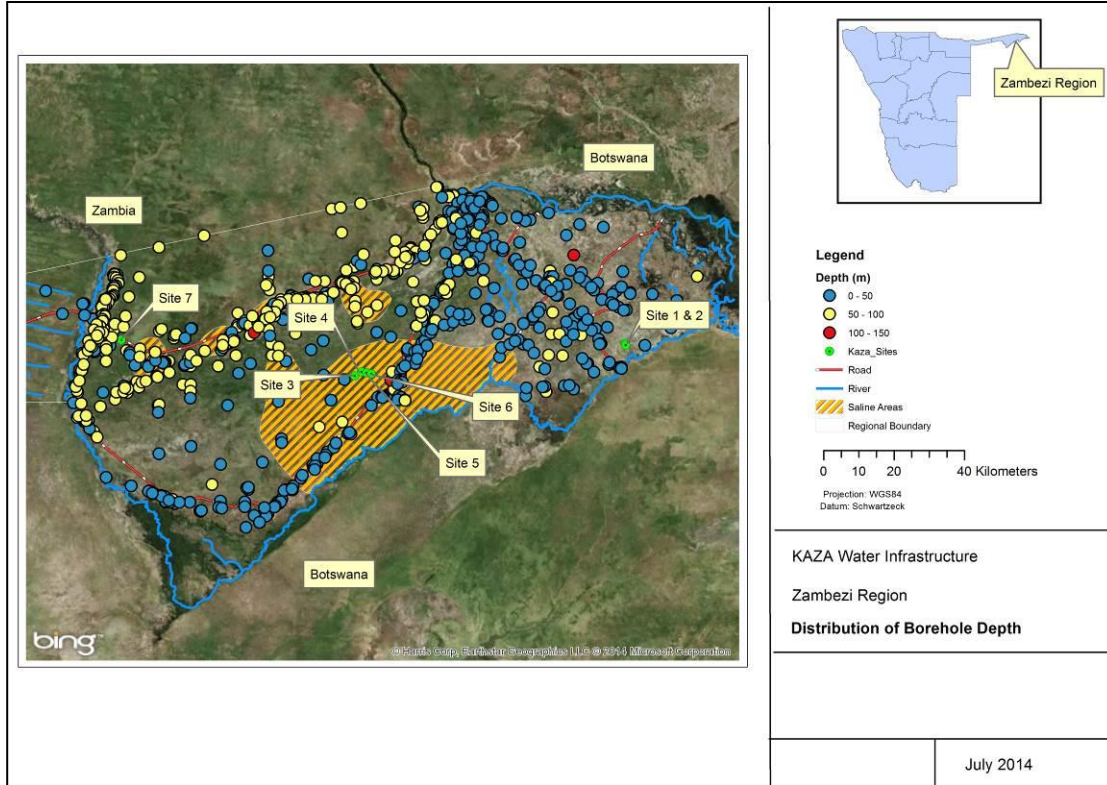
## References

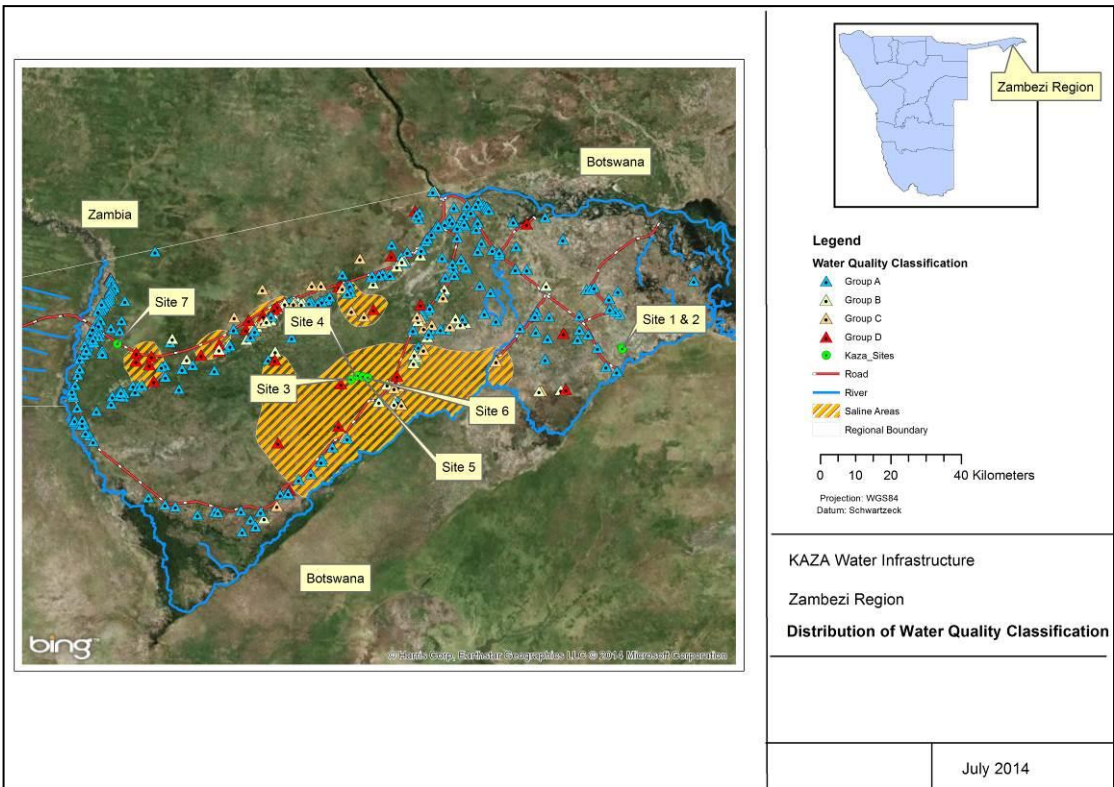
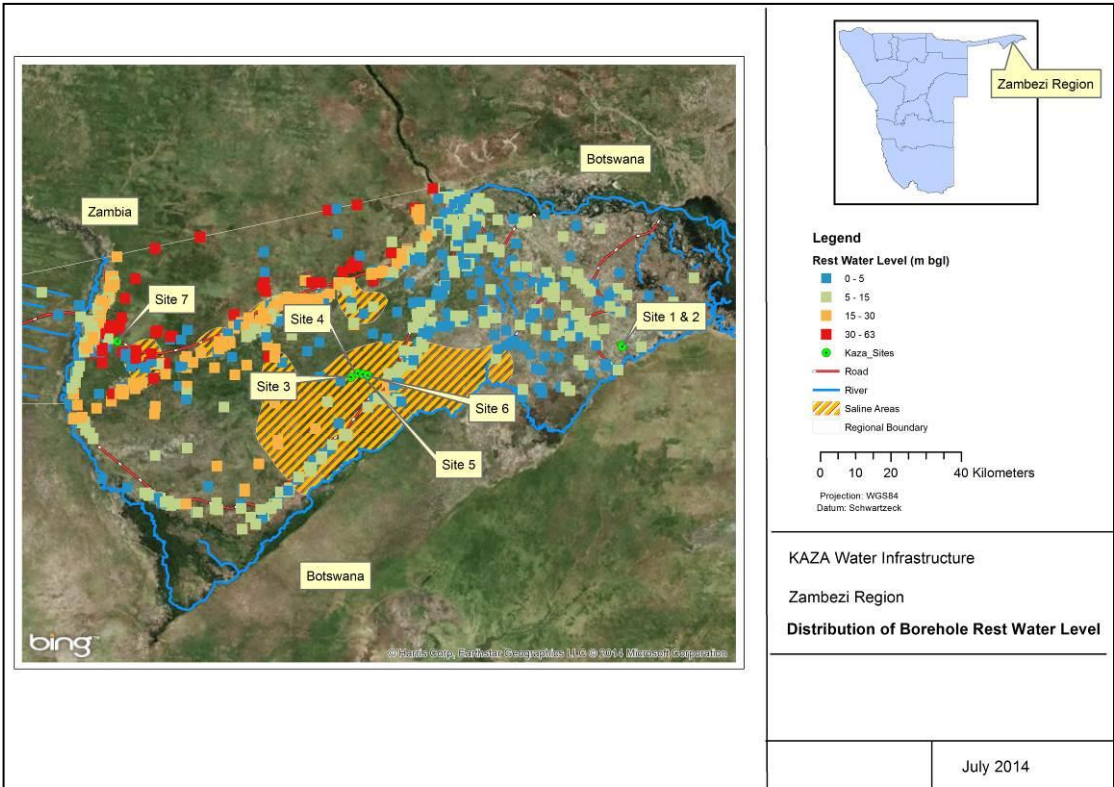
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Appendix A

APPENDIX A: Groundwater information (Source: GROWAS)







CRIDF 

