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## “Management of Competing Water Uses and Associated Ecosystems in Buzi, Pungwe and Save Basins”



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*AN ASSESSMENT OF HYDROMETRIC NETWORK AND  
RECOMMENDATIONS FOR UPGRADING IN BUPUSA RIVER BASIN*

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September 2021



## 1. EXECUTIVE SUMMARY

This report presents the findings of the Hydrometric Network Study conducted under the GEF BUPUSA Project in the Pungwe, Save and Buzi Basins shared between Mozambique and Zimbabwe. The report proposes the stations for upgrading for the purpose of flow monitoring and water resources assessment, floods and drought monitoring, flood forecasting and operationalisation of the Buzi, Pungwe and Save River Basins Transboundary water sharing agreements. This task involves reviewing the current hydrometric network for the Buzi, Pungwe and Save River Basins and recommending the strategic network required to meet the above objectives.

Consultations were conducted with key persons from DNGRH ARA-Centro, IP, ARA-Sul, IP, and Department of water resources, ZINWA Runde, and ZINWA Save. Key partners also paying a role in the strengthening of the hydrometric network were consulted. The partners include UNDP, UNOPS, UNESCO, and GIZ. A review of the archival information which included regional reports and strategies were also used in the assessment. Desktop studies were undertaken to understand the river distribution network, hence identify potential monitoring stations.

A baseline assessment was conducted to establish the state of stations on the ground in the basin and to also assess the feasibility of installing telemetry equipment on existing stations. The baseline study also assessed the state of the already existing telemetry equipment installed by PP2, GIZ and Hydromet projects. Staff members from DNGRH, ARA-Centro ARA SUL and Department of Water Resources, Zimbabwe, ZINWA HQ, ZINWA Save and ZINWA Runde took part in all the field expeditions as part of exchange of knowledge and consensus building on the network design.

The assessment showed that the existing hydrometric station network in the Pungwe Buzi and Save Basins largely vary in terms of infrastructural investment. Zimbabwe has, by far, more hydrometric stations than Mozambique. Most of such stations on the Zimbabwean side were constructed as a legal requirement for gauging stations upstream and downstream of public and private dams. The project was targeting stations which already exist but equipped with old recorders which are non-telemetry but key for transboundary water resources management and flood management in particular. However, Mozambique has relatively fewer housing infrastructure for the stations and thus the data loggers are vulnerable to vandalism. In Zimbabwe the selected stations will need a few repairs to also protect them against vandalism.

Some of the stations in either country offer real-time transmission of data, having benefited from either ongoing or completed projects such as PP2, GIZ, Hydromet etc. Most of the stations play an important role in transboundary water resources management, but a number



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of them now require replacement of batteries and sensors. This enables the quick sharing of data as well as transparency. The study also highlights the need for capacity building, repairs to existing key stations and the need to consider sustainability of stations in the post-project phase.

The study prioritised 12 stations, (Table 1), to be upgraded to real time in order to improve data collection and sharing as part of the transboundary integrated water management between Mozambique and Zimbabwe. The proposed hydrometric stations will greatly improve the transboundary water resources management and minimize the impact of floods to the more than 6 million people living within the basin. It should however be noted that the proposed network of 12 stations will not adequately cover the flood prone areas and e-flows monitoring. All efforts will be made to work with partners involved in the basin strengthening the flood monitoring efforts. The report therefore proposes repairs to some telemetry stations set up by other projects. It also proposes other stations deemed necessary by the two states in improving the flood warning. Once the sites for e-flows are identified there may be need for upgrading some more stations in order to improve on transboundary water resources management. Prioritisation has been mainly on Pungwe and Save basins since there is ongoing support on upgrading network in the Buzi Basin for both Mozambique and Zimbabwe.

*Table 1: Priority Hydrometric Stations for Zimbabwe and Mozambique*

<b>Country</b>	<b>River Name</b>	<b>Station Number</b>	<b>Station Name</b>
Mozambique	Pungwe	E67	Mafambisse
Mozambique	Pungwe	E651	Gorongosa
Mozambique	Buzi	E246	Goonda
Mozambique	Pungwe	E75	Metuchira EN1
Mozambique	Save	E86	Massangena
Mozambique	Save	E47	Vil Franca do Save
Zimbabwe	Save	E149	Save Causeway G/W
Zimbabwe	Buzi	F18	Ypress
Zimbabwe	Pungwe	F22	Katiyo Natural Control
Zimbabwe	Runde	E74	Runde Tokwe Confluence
Zimbabwe	Honde	F23	Honde
Zimbabwe	Chiredzi	Chiredzi Bridge	Chiredzi Bridge

The study also reviewed existing hardware and software as data will be transmitted to key centres in both Mozambique and Zimbabwe. Details of the requirements are outlined in Annex B. On the list of equipment, the report also identifies the need to include flow measuring devices. The current rating tables being used to compute the discharge may be outdated as some of the river dimensions have changed significantly particularly after Cyclone Eline in 2000 and Cyclone Idai in 2019 respectively.

Capacity needs assessments were also conducted during this study. Results show the need for training on installation, operation and maintenance of the data loggers, and operation of the software for data retrieval and sharing.

The study shows that some of the data loggers installed are currently not functioning because of dead batteries, thus putting data collection at risk. The study identified the need for



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procurement of spares for the identified loggers. This will complement the proposed network. It is proposed that member states should include in their annual budget, resources for operations and maintenance in order to keep the network running. There are however some stations which have been proposed but will require civil works for dataloggers in order to reduce vandalism.

Preliminary assessment showed that the existing hydrometric station network in the Buzi Pungwe and Save basins largely vary in terms of infrastructural investment. Zimbabwe has, by far, more hydrometric stations than Mozambique. Mozambique will still need to build more data shelters to house the recorders. Most of such stations on the Zimbabwean side were constructed as a legal requirement for gauging stations upstream and downstream of public and private dams. Over the years the two countries have been upgrading the recorders from analogue to digital (data loggers) through different projects namely, PP2, GIZ, PPCR-Hydromet, and SADC HYCOS. Of late other players have come to support e.g. UNOPS, UNESCO, UNDP and AfDB.



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## 2. BACKGROUND AND HISTORY OF THE PROJECT

The GEF-funded project “Management of competing water uses and associated ecosystems in Pungwe, Buzi and Save basins” is being implemented by the International Union for Conservation of Nature (IUCN) and executed by GWP-SA together with the GoM and GoZ. It targets the conservation and sustainable use of the transboundary water resources, including their risk mitigation components within the Buzi, Pungwe and Save river basins shared bilaterally by Mozambique and Zimbabwe. The 3 basins are located along the Beira corridor, an important economic corridor that links Beira harbour to the hinterland, with associated impacts on the environment (pollution from mining activities, intensive agriculture, deforestation, saline water intrusion etc). Populations in the basins have become highly vulnerable to climate hazards (i.e., floods, droughts, cyclones) whose occurrence is likely to increase with climate change aggravation. The strong development of upstream water uses is now raising the issue of water allocation and its dimension of environmental flows that has particular importance in a transboundary context. These resources are of highest importance for the communities that derive their livelihood from their ecosystem services, in a context of endemic poverty and low resilience. The project seeks to promote holistic approaches to the water-energy-food nexus, with specific interest in connected ecosystems. It has a double focus of developing capacities for managing water resources and designing participatory and community-based strategies.

The project’s main objective is to strengthen the management of transboundary water resources and connected ecosystems for sustained ecological benefits and improved resilience for the riparian communities. This contributes to GEF’s Strategic Objective 1 which seeks to conserve, sustainably use, and manage biodiversity, ecosystems and natural resources globally, taking into account the anticipated impacts of climate change – and is consistent with the focal area strategy for international waters (IW) as it will contribute to the conservation of the 3 basins’ aquatic ecosystems and wetlands through the sustainable management of transboundary water basins. The need for developing transboundary cooperation for water resources management has been materializing for years through several initiatives, including the signing of the Pungwe Buzi transboundary agreements (the Save agreement is under preparation, and the wish to establish a bilateral tri-basin river basin organisation. In each component, the project will contribute to support transboundary cooperation for water resources management, either with the development of joint initiatives (joint hydrological monitoring campaigns), common tools development (TDA/SAP, adoption of guidelines for e-flows implementation), bilateral capacity building or through experience sharing (on community-based early warning systems for instance):

- Component 1 will contribute to strengthening water-related risk management through the reinforcement of monitoring systems, the development of real-time



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operational tools, and the empowerment of communities in their flood mitigation autonomy.

- Component 2 will focus on enhancing ecosystem services through quantitative water management, including operationalisation of environmental flows (assessment and legal framework establishment), and through water quality improvement.
- Component 3: National inter-ministry committees and technical advisory teams would contribute to the development of a regional Transboundary Diagnostic Analysis and subsequently to the preparation of a Strategic Action Plan.

Benefits of collaboration on transboundary basins and adoption by cooperating states of a Transboundary Water Resource Management approach will contribute to strengthening community resilience to floods and droughts, mitigation of these risks, improve water allocation, and address environmental issues. Results and impacts will include increased transboundary water cooperation including a coordinated approach for flood and drought risks management and mainstreaming of these risks in the decision-making process, strengthened capacities for water management linking appropriate scales of intervention, increased communities' autonomy and ownership in water-related risk management, reduced vulnerability of the local communities to flood and drought.

GEF BUPUSA Project is a joint initiative between the Governments of Mozambique and Zimbabwe funded by Global Environmental facility, implemented by IUCN and being executed by GWP.

This activity falls under component 1 as outlined in the project document.

***Outcome 1.1: Management of floods and droughts in the Pungwe, Save and Buzi basins is improved and related risks mitigated***

Output 1.1.1: Improved water resources monitoring, early warning and information system in support of flood risk management

A sustainable and robust monitoring and information system is an essential element for water & climate risks mitigation. Reliability of water information and availability of long-term data series are a prerequisite for any planning or operations of quantitative water resource management.

*Activity 1.1 - Strengthen the regional hydro-met monitoring network*



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*Baseline: both countries have an existing monitoring network in place based on the support of several projects to strengthen the networks such as the PP2, Hydromet project. However, the existing monitoring network still suffers from weaknesses, such as:*

- Lack of sustainability of installed stations (vandalism, maintenance, robustness of material...),
- Lack of real-time transmission,
- Inadequate network density for accurate forecasting and monitoring.

In collaboration with the DNGRH, the ARA-Centro, ARA-Sul, the INAM and the INGC in Mozambique, and the MLAFWRR, CPU and ZINWA in Zimbabwe, the project will work to identify the need for strengthening the real-time meteorological and hydrological networks for improving the understanding of climate impacts on water resources. This will improve data collection, analysis, and strengthen data sharing and cooperation between the countries both sharing similar climate change impacts. This activity will contribute to defining the stations with common water resources and flood management interest, for which data acquisition and sharing is particularly important.

Specific attention will be given to the sustainability of the network, such as its robustness, and long-term operations and maintenance. The implementation will build on national experience acquired during other initiatives such as the HydroMet project (*refer to 3.3.3*), Zambezi and Limpopo basins.

This activity shall rely on the intervention of the national hydrology and meteorological services (ARA-Centro, ARA-Sul and INAM in Mozambique, ZINWA and MECT-Meteorological Department in Zimbabwe). The Team IWRM experts will provide technical support for network development strategy and implementation using lessons learnt from previous experiences including station's location and hardware and enable transboundary coordination through 2 regional workshops, 4 national meetings and 2 training sessions.

### **3. OVERALL OBJECTIVE**

The overall objective of this assignment is to contribute to the Improvement of transboundary water resources monitoring, early warning and information system in support of flood risk management of the three river basins.

#### **3.1 Specific Objectives**

- To recommend a telemetric network to support the flood management in the three river basins
- To support the operationalisation of the transboundary water resources agreements between the government of Mozambique and Zimbabwe.

To achieve the above objectives the following activities were carried out:

#### **3.2 Key Activities**

- Reviewing the current hydrometric network for the Buzi, Pungwe and Save River Basins;



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- Conducting a fieldwork for hydrometric network assessment;
- Liaising with the water authorities to agree on the key stations;
- Recommend the optimum network required for flow monitoring, water resources assessment and flood warning;
- Preparing of the specifications for the hydrometric instruments required for the preferred stations;
- Reviewing and recommending modifications to the existing structures and anti-theft devices required for the housing shelters for the telemetry equipment;
- Preparing of the bill of quantities and estimated costs for the extra-works required to secure the equipment.
- Identifying and liaising with other partners also assisting the two countries on establishing or upgrading existing networks.
- Reviewing and recommending software in use for receiving data from telemetry stations;
- Recommending the sustainable management of the proposed network
- Reviewing and recommend human capacities to manage the network

### **3.3 Expected Outputs**

The overall objective would be supported by the following specific outputs:

- Report on the assessment of the hydrometric network for the Save, Pungwe and Buzi River basins.
- Recommendation of the prioritized network required for transboundary water resources management and flood management
- Detailed specifications for the hydrometric instruments.
- A Bill of quantities for the modifications of the housing shelters.
- Recommendation of the software and hardware requirements for use for receiving/sharing data from telemetry stations.
- Recommendation on the sustainable management of the transboundary hydrometric network.
- Recommendation on the capacity building of staff on the operation and maintenance of the equipment.

## **4. METHODOLOGY**

### **4.1 Desktop Review**

A desktop review of the network was conducted for the three river basins in order to have a background information of the river distribution network, hence identify potential monitoring stations.

The following documents were also accessed as they contain relevant information for this assignment:



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- Pungwe Water Sharing Agreement
- Buzi Water Sharing Agreement
- Save Water Sharing Agreement (Draft)
- CRIDF Report - Save River Basin Strategy Implementation - Save Sustainable Water Management
- Revised SADC Protocol on Shared Watercourse Systems (2002)
- Pungwe River basin Joint water resources management and development Strategy (2002-)
- Save River Joint Integrated Water Resources Management Study (2013)
- Updating the Sector Study on Surface Water Resources of the Buzi River Basin (2015)
- Save River Basin Monograph (2011)
- Updating the Sector Study on Surface Water Resources of the Pungwe River Basin (2013)
- Mozambique Water Act (1991)
- Zimbabwe Water Act (1998)
- ZINWA Act (1998)
- Enhanced Knowledge and Information Systems for the Save Basin (2011)
- Enhanced Knowledge and Information Systems for the Buzi Basin (2011).

Information was also collected from hydrometric stations stored in the data base and station files at the water authorities as well as archival information which included regional reports and strategies.

#### **4.2 Stakeholder Consultations**

Consultations were held with water authorities prior and during to the design of the assignment. The key contact persons for the were the following DNGRH, ARA Centro, ARA Sul and Department of Water Resources Management and Utilization, ZINWA Head Office, ZINWA Save, ZINWA Runde, (ZINWA Save).

#### **4.3 Baseline Assessment**

A baseline assessment was conducted to establish the state of existing stations in the basin. Consultations were conducted with key persons from DNGRH, DWD, ARA-Centro, ARA-Sul and ZINWA HQ, ZINWA Save and ZINWA Runde. The staff also took part in the field visit.

Follow up interviews were also held with other partners involved in strengthening the hydrometric network in BUPUSA.



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A total of 19 stations were visited in Zimbabwe and 18 in Mozambique. Field visits were carried out in the three river basins from 23 August to 10 September in both countries. During the field visit discussions with water authorities were held in order to prioritise the stations that were critical for the network.

#### **4.4 Criteria for selection**

The discussions were guided by suitability of hydrometric stations in addressing the following:

- transboundary flood management
- operationalisation of the water sharing Agreements
- e-flows monitoring at transboundary
- suitable structures for housing the equipment
- existence of network for telemetry

To complement the fieldwork, consultative meetings were also held with the authorities, after the field missions. See details of meetings in Annex C. Prioritization of stations was to a large extent decided by member states.



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## 5. RESULTS

### 5.1 Hydrological stations visited in the BUPUSA

Table 2: Visited Hydrometry Stations in Mozambique

River Name	Station Number	Location	Latitude	Longitude	Type of Equipment	Status
<b>Mozambique</b>						
Save	E420	Mavue	-21.31878	32.42017	Gauge Plate	Operational
Save	E86	Massangena	-21.553611	32.951111	Gauge Plate	Operational
Save	E47	Vila Franca do Save	-21.130000	34.560000	Datalogger	Operational
Save	E573	Nova Mambone	-20.987500	35.011389	Gauge Plate	Operational
Pungue	E-64	Pungwe Fronteira	-18.1976	33.2247	Datalogger	Not Operational (Gauge plate reading only)
Pungue	E-65	Pungwe Sul	-18.4397	33.3547	Datalogger	Not operational (Gauge plate reading only)
Pungue	E-67	Mafambisse	-19.1868	33.8754	Gauge Plate	Operational
Inhazonia	E-70	Nhacangare	-19.2639	34.12778	Datalogger	Vandalized (Gauge plate reading only)
Inhazonia	E-72	Inhazonia	-18.9859	34.0851	Gauge Plate	Operational
Metuchira	E-74	Metuchira EN6	-18.4400	33.3536	Datalogger	Vandalized (Gauge plate reading only)



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Metuchira	E-75	Metuchira EN1	-18.3484	33.0695	Gauge Plate	Vandalized (Gauge plate reading only)
Pungue	E-651	Gorongosa Ponte N1	-18.5547	33.2769	Datalogger	Vandalized (Gauge plate reading only)
Buzi	E263	Munhinga	-19.4492	33.3111	Data Logger	Vandalized (Gauge plate reading only)
Chinyika/Buzi	E427	Chinyika	-20.6	32.94722	Datalogger	Not operational (Gauge plate reading only)
Buzi	E-456	Goonda	-19.9167	33.86667	Datalogger	Operational
Lucite/Buzi	E-246	Dombe	-19.9667	33.4	Gauge Plate	Operational
Buzi	E-84	Macuiana	-20.4458	32.8603	Datalogger	Operational
Mussorize	E-654	Mussorize	-20.720	32.7189	Gauge Plate	Operational



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Table 3: Visited Hydrometry Stations in Mozambique

River Name	Station Number	Station Name	Latitude	Longitude	Type of Equipment	Status
<b>Zimbabwe</b>						
Mutirikwi	E4	Mutirikwi Headways	-20.834	31.279	Gauge Plates & Kent Recorder	operational
Chiredzi	E17	Maware Ranch	-20.75	31.63	Ecolog 500 & Kent Recorder	Only Kent recorder operational
Mutirikwi	E36	Nyajena weir D/S	-20.854	31.286	Kent Recorder	Operational
Save	E43	Save Gorge C/S	-21.233	32.324	Gauge plates & Data logger	Data logger vandalised
Runde	E74	D/S TOKWE CONFLUENCE	-21.13	31.27	Logger	Non-operational, tower destroyed by cyclone
Devure	E118	Devuli CHISURGWE	-19,9	32,13	Kent Recorder & Gauge Plates	operational
Umvumvumvu	E125	OLD CASHEL ROAD BRIDGE	-19,52	32,62	gauge plates, kent recorder and ecolog	all operational
Odzi	E130	ODZI GORGE	-19,77	32,4	ecolog 500 & Kent Recorder	only kent recorder operational
Save	E149	Save Causeway G/W	-20,99	32,8	Kent Recorder	non-operational



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Save	E161	Save Nyamashanga	-19,69	32,27	kent recorder	operational
Nyahode	F7	Nyahodi Nyarurwa Flume and G/W	-19,86	32.80	Data Logger	Destroyed by cyclone
Rusitu	F11	Rusitu Power Station Notch	-20.033	32.733	Data Logger	Covered under UNOPS project
Buzi	F18	YPress	-20,27	32,67	GW, Data Logger, Gauge Plates	Data logger not operational
Chisuka	F19	BANGAZAAN DAM U/S G/W	-20,2	32,6	Kent Recorder	Non-operational
Buzi	F20	BANGAZAAN DAM G/W	-20,22	32,6	Kent Recorder	operational
Buzi	F21	BANGAZAAN DAM D/S G/W	-20,25	32,62	Kent Recorder, Gaige plates	operational
Pungwe	F22	KATIYO NATURAL CONTROL	-18,22	33,03	Data Logger, Kent recorder, Gauge Plates	operational, logger giving inaccurate records on low flows
Pungwe	F23	Honde	-18,43	32,96	Data Logger	Vandalised
Honde	F24	Pungwe Murara	-18,5	32,85	Data Logger, Gauge Plates	non-Operational, no spares, gauge plates can't capture low flows





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Station Number	Latitude	Longitude	Reasons for Prioritization	Rating (out of 5)	Comments
E149	-20.998	32.157	<ul style="list-style-type: none"> <li>transboundary flood management</li> <li>operationalisation of the water sharing Agreements</li> <li>e-flows monitoring at transboundary</li> <li>suitable structures for housing the equipment</li> <li>existence of network for telemetry</li> </ul>	5	Chosen instead of E43 because its more secure, there is an observer, Radar system to be installed under the bridge with provides a stable section for Transboundary water resources Management
F18	-20.27	32.67	<ul style="list-style-type: none"> <li>transboundary flood management</li> <li>operationalisation of the water sharing Agreements</li> <li>e-flows monitoring at transboundary</li> <li>suitable structures for housing the equipment</li> <li>existence of network for telemetry</li> </ul>	5	Strategically located at the border hence suitable for transboundary water resources management and also for e-flows, good network for telemetry however the structure needs to be modified to capture the ow flows
F22	-18.407	32.998	<ul style="list-style-type: none"> <li>transboundary flood management</li> <li>operationalisation of the water sharing Agreements</li> <li>e-flows monitoring at transboundary</li> <li>suitable structures for housing the equipment</li> <li>existence of network for telemetry</li> </ul>	5	Strategically located at the border hence suitable for transboundary water resources management and also for e-flows, good network for telemetry however the structure needs to be modified to capture the ow flows
E74	-21.13	31.27	<ul style="list-style-type: none"> <li>transboundary flood management</li> <li>operationalisation of the water sharing Agreements</li> </ul>	4	Located on the Runde, a major tributary to Save, Station will support transboundary water



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			<ul style="list-style-type: none"> <li>● suitable structures for housing the equipment</li> <li>● existence of network for telemetry</li> </ul>		management and operationalisation of the Save water sharing Agreement
F23	-18.506	32.901	<ul style="list-style-type: none"> <li>● transboundary flood management</li> <li>● operationalisation of the water sharing Agreements</li> <li>● e-flows monitoring at transboundary</li> <li>● suitable structures for housing the equipment</li> <li>● existence of network for telemetry</li> </ul>	4	Strategically located at the border hence suitable for transboundary water resources management and also for e-flows, good network for telemetry however the structure needs to be modified to capture the ow flows
Chiredzi Bridge	-21.011	31.747	<ul style="list-style-type: none"> <li>● transboundary flood management</li> <li>● operationalisation of the water sharing Agreements</li> <li>● e-flows monitoring at transboundary</li> <li>● suitable structures for housing the equipment</li> <li>● existence of network for telemetry</li> </ul>	5	This will replace E17 located on Chiredzi river as there is poor access, poor network connectivity and prone to vandalism.
E67	-19.503	34.543	<ul style="list-style-type: none"> <li>● transboundary flood management</li> <li>● operationalisation of the water sharing Agreements</li> <li>● e-flows monitoring at transboundary</li> <li>● suitable structures for housing the equipment</li> <li>● existence of network for telemetry</li> </ul>		Located at the mouth of Pungwe river, is critical for transboundary water resources management, flood warning and e-flows. The radar is proposed to be installed underneath of new bridge, the network is good



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				5	
E651	-18.9859	34.0851	<ul style="list-style-type: none"> <li>● transboundary flood management</li> <li>● operationalisation of the water sharing Agreements</li> <li>● e-flows monitoring at transboundary</li> <li>● suitable structures for housing the equipment</li> <li>● existence of network for telemetry</li> </ul>	5	<p>Strategically located and can support flood management in the lower part of the Pungue basin.</p> <p>The radar is proposed to be installed underneath of new bridge, the network is reasonable and good for water resources management</p>
	-18.966	33.4	<ul style="list-style-type: none"> <li>● transboundary flood management</li> <li>● operationalisation of the water sharing Agreements</li> <li>● e-flows monitoring at transboundary</li> <li>● existence of network for telemetry</li> </ul>		<p>E246 is cited as a strategic station in the Buzi water sharing agreement, it is important for water resources management. The network coverage is good for telemetric. It is highly recommended that some civil works for the data logger shelter be constructed.</p> <p>Therefore, the immediate key station is Goonda (E456), and the</p>



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E246				4	possibility of installing RADAR at this station can be considered
E-75	-18.263	34.16	<ul style="list-style-type: none"> <li>● transboundary flood management</li> <li>● operationalisation of the water sharing Agreements</li> <li>● strategic for water resources managing</li> <li>● existence of network for telemetry</li> </ul>	5	E75 is critical for management in Lower Pungue. There are two possibilities for installation of data logger either in PP2 shelter or underneath the bridge. During the rainy season the area downstream is vulnerable to flood
E86	-21.553	32.951	<ul style="list-style-type: none"> <li>● transboundary flood management</li> <li>● operationalisation of the water sharing Agreements</li> <li>● e-flows monitoring at transboundary</li> <li>● existence of network for telemetry</li> </ul>	4	The station is strategic because it provides information on the flow coming into Mozambique from Zimbabwe. The information will complement data from Runde E74, Chiredzi New station and E149 on Save. However, at the moment there is no infrastructure in place to accommodate data loggers.
E47	-21.13	34.56	<ul style="list-style-type: none"> <li>● transboundary flood management</li> <li>● operationalisation of the water sharing Agreements</li> <li>● e-flows monitoring at transboundary</li> <li>● existence of network for telemetry</li> </ul>	5	Located at the mouth of Pungwe river, is critical for transboundary water resources management, flood warning and e-flows. The radar is proposed to be installed underneath the new bridge; the network is good.



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Note: Rating is out of 5 considering the criteria set above





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Table 4: Estimated Works and Budget for Priority Stations in Zimbabwe

Station No	Station Name	Station Requirements e.g., modifications, spares	Estimated costs of materials and equipments
<b>Priority Stations (Zimbabwe)</b>			
E149	Save Causeway G/W	<ul style="list-style-type: none"> <li>• Radar</li> </ul>	6000
E74	Runde	<ul style="list-style-type: none"> <li>• Data Logger</li> <li>• Sensor Box (5 bags cement, reinforcement and aggregate)</li> <li>• Data Plate</li> </ul>	4000 300 100
F18	Buzi Ypress	<ul style="list-style-type: none"> <li>• Data Logger</li> <li>• Data Plate</li> </ul>	4000 100
F22	Katiyo Natural Control	<ul style="list-style-type: none"> <li>• Data Logger</li> <li>• Trenching to lower the sensor for low flows (2 bags cement + aggregate + Steel pipe)</li> <li>• Data Plate</li> </ul>	4000 200 100
F23	Honde	<ul style="list-style-type: none"> <li>• Data Logger</li> <li>• Fabrication of anti-theft system and Security Door</li> <li>• Securing of the cable conduit (3 bags cement + steel bracers + aggregate)</li> <li>• Data Plate</li> <li>• Batteries</li> </ul>	4000 600 300 100 200
Chiredzi Bridge	Chiredzi Bridge (New)	<ul style="list-style-type: none"> <li>• Radar</li> <li>• Data Plate</li> </ul>	6000 100
<b>Additional Stations</b>			
F24	Pungwe Murara	<ul style="list-style-type: none"> <li>• Trenching to lower the sensor for low flows (2 bags cement + aggregate + Steel pipe)</li> <li>• Security Door</li> <li>• Batteries</li> </ul>	200 100 600 100



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		• Data Plate	100
E141	Rusape Dam D/S (moving logger from F18)	<ul style="list-style-type: none"> <li>• Batteries</li> <li>• Data Plate</li> <li>• Cables</li> </ul>	<p>200</p> <p>100</p> <p>250</p>
		<b>Sub-Total</b>	<b>31 750</b>
		<b>Contingency (5%)</b>	<b>1 587.50</b>
		<b>Total</b>	<b>33 337.50</b>



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Table 5: Estimated Works and Budget for Priority Stations in Mozambique

Station Code	Station Name	Station Requirements e.g modifications, spares	Estimated costs
<b>Priority Stations (Mozambique)</b>			
E67	Mafambisse	<ul style="list-style-type: none"> <li>• Radar</li> <li>• Data Plate</li> </ul>	6000 100
E456	Gorongosa	<ul style="list-style-type: none"> <li>• Radar</li> <li>• Data Plate</li> </ul>	6000 100
E75	Metuchira	<ul style="list-style-type: none"> <li>• Radar</li> <li>• Data Plate</li> </ul>	6000 100
E47	Vila Franca do Save	<ul style="list-style-type: none"> <li>• Radar</li> <li>• Data Plate</li> </ul>	6000 100
E86	Massangena	<ul style="list-style-type: none"> <li>• Data logger</li> <li>• Civil works for Shelter</li> <li>• Data plate</li> </ul>	4000 4000 100
E246	Dombe	<ul style="list-style-type: none"> <li>• Data logger</li> <li>• Civil works for Shelter</li> <li>• Data plate</li> </ul>	4000 4000 100
<b>Additional Stations</b>			
E65	Pungue Sul	<ul style="list-style-type: none"> <li>• Antenna</li> <li>• Batteries</li> </ul>	200 100
E427 Chinyika	Chinyika	<ul style="list-style-type: none"> <li>• Antenna</li> <li>• Sensor cable</li> <li>• Batteries</li> <li>• Steel Pipes</li> <li>• Data Plate</li> <li>• Sensor Box (5 bags cement, reinforcement and aggregate)</li> </ul>	250 200 100 200 100 300
E263	Munhinga	<ul style="list-style-type: none"> <li>• Antenna</li> </ul>	250



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		<ul style="list-style-type: none"> <li>• Sensor cable</li> <li>• Batteries</li> <li>• Steel Pipes</li> <li>• Data Plate</li> <li>• Sensor Box (5 bags cement, reinforcement and aggregate)</li> </ul>	200 100 200 100 300
		<b>Contingency (10%)</b>	<b>432</b>
		<b>Total</b>	<b>43,632.00</b>

Due to limitations in the number of data loggers suggested under this project it is recommended that the project supports the modifications suggested and procure the spares required. This will further increase the hydrometric network coverage and thus further improve on transboundary water resources management. In Zimbabwe data loggers in F22, F18 will be replaced with new data loggers. The older loggers will move to E141 and F23 respectively. Only accessories such as batteries and cables will be replaced to meet the dimensions of the target sites. In case of Mozambique no data loggers will be moved, however new batteries and cables and antennas will need to be replaced.

## 6.2 Major works Required

The field visit in both countries has also identified major works that may be required. This is particularly the case in Mozambique where the absence of data logger shelters put a major threat in terms of vandalism to the data loggers leading to the loss of data. In Appendix F there is a standard design of the shelters required. Table 6 shows the identified stations and estimated costs.

Table 6: Estimated Works and Budget for Mozambique

Country	River	Station Nr.	Station Name	Major Works	Costs (USD)
Moz	Save	E86	Massangena	Data Logger	4000
				Civil works for shelter+	4000
				Data Plate	100
Moz	Massangena	E246	Dombe	Data Logger	4000
				Civil works for shelter+	4000
				Data Plate	100



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				<b>TOTAL</b>	<b>16 200</b>
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## 7. TRAINING

Training on the installation, operation and maintenance of the data loggers will be required for each catchment authority. It is suggested that at least three members of staff from each catchment who are responsible for the management of the loggers should be trained. The supplier should organise a theory session on data loggers as well as practicals to demonstrate complete installation downloading and maintenance of the data loggers and Radar. The supplier should also be reachable in case some technical support in case of technical problems arising.

## 8. STRATEGY FOR INSTALLATION

The works on the 6 priority stations in each country will be done by relevant water authorities with support from IWRM experts. It is anticipated that there is enough expertise to carry out the works as demonstrated in previous projects. However, the water authorities may require support to cover field expenses. For those stations that require civil works we recommend that installation should be done next year after rainy season.

## 9. SOFTWARE & HARDWARE REQUIREMENTS

There will be need for receiving software to be installed at offices. Some hardware has been proposed as shown in Annex B. The supplier should provide the software to enable water authorities to download and share the data collected. Staff from water authorities should also be trained on the software applications.

## 10. SUSTAINABILITY

Sustainability is key to the management of the stations, in order to obtain continuous flow of data with minimum disruption, there is a need to ensure that the data loggers are well maintained and spares should be readily available and replaced on time. All precaution should be made to minimise vandalism. In order to ensure sustainability, each government should ensure that adequate budgets are set aside for operation and maintenance of the stations. However, it has observed that over the years because of computing demands, hydrological services have not obtained adequate resources. It is therefore advisable to have the key network funded under the proposed BUPUSA institution in the near future. The training of technicians on installations, operation and maintenance of dataloggers as well as software should be ongoing



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## 11. Ongoing Initiatives

In Mozambique there was support on the installation of data loggers through, PP2, GIZ hydromet, Most of the recent work done was done last year on repairs to stations damaged by Cyclone Idai. However, most of the project have been completed and currently the only support on the hydrometric stations is through the government budget. In Zimbabwe there is ongoing support mainly triggered by the destruction of hydrometric station by cyclone Idai. Most of the support is concentrated on Buzi catchment where UNOPS is supporting the construction and installation of 8 hydrometric stations. Further support is from UNDP which is also equipping 2 stations in Save and UNSCO. The number could not be verified at the time of preparing this report. GCF project is also installing about 10 data loggers as part of their resilience building on local communities. However, most of the stations are meant to support the management of 21 irrigation stations. One of the projects TDH will complement the project efforts through installation of one telemetry station on the Save River for flood warning downstream where there is a refugee camp which is often affected by floods. This station will also be a key station for complementing flood management efforts in place under this project.

## 12. Complementary Projects and Target Stations

UNOPS and UNDP are undertaking various projects that are covering a number of stations that might have been added to the list of priority stations on the BUPUSA project. The stations are detailed as below:

Station Code	Station Name	River Name	Sub-Basin	Status
F7	Nyahodi Nyarurwa Flume and G/W	Nyahode	Buzi	Non-functional (destroyed by cyclone)
F11	Rusitu Power Station Notch	Rusitu	Buzi	Non-functional (to be funded by UNOPS)



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## ANNEXES

### Annex A: Status of Stations Visited

Zimbabwe

	Station Code	Station Name	River Name	Sub-Basin	Latitude	Longitude	Status
1	F22	Pungwe Katiyo	Pungwe	Pungwe	-18.407	32.998	Operational Not capturing low flows below the gauge plate
2	F24	Pungwe Murara	Pungwe	Pungwe	-19.402	32.934	Non-operational (Batteries need replacement) Does not capture low flows below the gauge plate
3	F23	Honde	Honde	Pungwe	-18.506	32.901	Non-operational (Vandalised-no equipment)
4	E125	UMvumvumvu Old Cashel Road Bridge G/W	Umvumvumvu	Buzi	-19.753	32.609	Equipped with a recorder (no logger)
5	F7	Nyahodi Nyarurwa Flume and G/W	Nyahode	Buzi	-19.86	32.80	Non-operational (destroyed by cyclone)



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6	F11	Rusitu Power Station Notch	Rusitu	Buzi	-20.033	32.733	Non-operational (to be funded by UNOPS)
7	E43	Save Gorge C/S	Save	Save	-21.233	32.324	Non-operational (vandalised)
8	E149	Save Causeway G/W/Jack Quinton Bridge	Save	Save	-20.998	32.157	Non-operational (channel migration) No Logger
9	F18	Buzi Ypress	Buzi	Buzi	-20.27	32.67	Non-operational (Batteries)
10	F19	Chisuka Bangazaan Dam U/S G/W	Chisuka	Buzi	-20.2	32.67	Non-operational
11	F20	Buzi Bangazaan Dam U/S G/W	Buzi	Buzi	-20.22	32.6	Operational
12	F21	Buzi Bangazaan Dam D/S G/W	Buzi	Buzi	20.25	32.62	Operational
15	E118	Devuli Chisurgwe	Devure	Save	-19.9	32.13	Partially Operational (manual recorder)
16	E130	Odzi Gorge	Odzi	Save	-19.77	32.41	Operational
17	E161	Save Nyamashanga	Save	Save	-19.69	32.733	Visited but not assessed. No access to the tower as water was flowing but observer takes readings on gauge plates
18	E74	Runde/Tokwe	Runde	Runde	-21.13	31.27	Non-Operational Tower Destroyed by floods (sensor removed)
19	E17	Ruware Manjirenji D/S	Chiredzi	Runde			Non-operational (no logger)



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20	E4	Mutirikwi Headways	Mutirikwi	Runde			operational. Equipped with a recorder. Observer take readings
21	E36	Nyajena weir D/S	Mutirikwi	Runde			Non-operational (no logger)

Mozambique

	Country	River	Station Number	Location	Latitude	Longitude	Type of Equipment	Status
1	Moz	Save	E420	Mavue	-21.31878	32.42017	Gauge Plate	Operational (Manual)
2	Moz	Save	E86	Massangena	-21.55361	32.951111	Gauge Plate	Operational (Manual)
3	Moz	Save	E47	Vila Franca do Save	-21.13000	34.560000	Datalogger	Operational (Manual)
4	Moz	Save	E573	Nova Mambone	-20.98750	35.011389	Gauge Plate	Operational (Manual)
5	Moz	Pungue	E-64	Pungwe Fronteira	-18.1976	33.2247	Datalogger	Not Operational (Gauge plate reading only)
6	Moz	Pungue	E-65	Pungwe Sul	-18.4397	33.3547	Datalogger	Not operational (Gauge plate reading only)



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7	Moz	Pungue	E-67	Mafambisse	-19.1868	33.8754	Gauge Plate	Operational
8	Moz	Inhazonia	E-70	Nhacangare	-19.2639	34.12778	Datalogger	Vandalized (Gauge plate reading only)
9	Moz	Inhazonia	E-72	Inhazonia	-18.9859	34.0851	Gauge Plate	Vandalized (Gauge plate reading only)
10	Moz	Metuchira	E-74	Metuchira EN6	-18.4400	33.3536	Datalogger	Vandalized (Gauge plate reading only)
11	Moz	Metuchira	E-75	Metuchira EN1	-18.3484	33.0695	Gauge Plate	Vandalized (Gauge plate reading only)
12	Moz	Pungue	E-651	Gorongosa Ponte N1	-18.5547	33.2769	Datalogger	Vandalized (Gauge plate reading only)
13	Moz	Buzi	E263	Munhinga	-19.4492	33.3111	Data Logger	Vandalized (Gauge plate 14reading only)
14	Moz	Chinyika/Buzi	E427	Chinyika	-20.6	32.94722	Datalogger	Not operational (Gauge plate reading only)
15	Moz	Buzi	E-456	Goonda	-19.9167	33.86667	Datalogger	Operational (Datalogger)
16	Moz	Lucite/Buzi	E-246	Dombe	-19.9667	33.4	Gauge Plate	Operational (Manual)



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17	Moz	Buzi	E-84	Macuiana	-20.4458	32.8603	Datalogger	Operational (Manual)
18	Moz	Mussorize	E-654	Mussorize	20° 42' 23."	32° 43' 06"	Gauge Plate	Operational (Manual)



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## Annex B: Telemetry Specifications

### 1.0 Data Loggers and Sensors

Equipment	Description / Requirements
Water level sensors including Cables (+150m)	<ul style="list-style-type: none"> <li>- Range: 0 - +10 m, unless otherwise specified in the gauging station schedule.</li> <li>- Resolution: 1mm</li> <li>- Accuracy: <math>\leq 0.1\%</math> of full range = 10 mm for a 10 m range sensor.</li> <li>- Minimum of specification: IP 68 protection.</li> <li>- Operating temperature: -10 to +70°C.</li> <li>- Power consumption: sleep - &lt; 600 <math>\mu</math>A; active - &lt; 4.0 mA.</li> <li>- Maximum dimensions of sensor head: 200 mm long and 25 mm diameter</li> <li>- The pressure transducer shall be vented to atmosphere</li> <li>- Provision shall be made to prevent the ingress of moisture into the breather vent tube e.g. changeable desiccant container with reusable desiccant.</li> <li>- The pressure sensors shall be calibrated by the Contractor prior to installation.</li> <li>- All necessary accessories and cabling</li> </ul>
GPRS/GSM telemetry loggers	<ul style="list-style-type: none"> <li>- The logger must be robust, reliable and well proven in similar environments.</li> <li>- The data logger must be universal i.e., it can be used for various hydrological field station parameters – the minimum shall be water level, and rainfall. Therefore, it must have impulse in-put for the rain gauge.</li> <li>- Operating temperature: -10°C to +70°C.</li> <li>- Recording frequency shall be changeable (minimum 5 minutes), but 1 hour is probably adequate for the majority of gauging stations.</li> <li>- A multichannel data logger with integrated GSM/GPRS modem and power supply is the basic requirement.</li> <li>- Facility to set alarms into the GPRS logger e.g., if the water level rises to a certain threshold or a certain rainfall amount occurs in a given time; if battery levels are getting below a critical level.</li> <li>- The alarm management shall include the ability to undertake SMS messaging to at least 8 different mobile phone numbers or by email (GPRS) or to a fax.</li> <li>- Suitable web-based software shall be provided with the telemetry/GPRS loggers so that the data can be reviewed, checked, quality controlled checked and transferred to the DNGRH, INAM and ARAs database at the appropriate receiving office.</li> <li>- The data logger must be compact and should if possible be able to fit into a small diameter pipe (&lt; 100 mm diameter) or small box.</li> </ul>



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- The data logger must be universal i.e. it can be used for various hydrological field station parameters – the minimum shall be water level, and rainfall. Therefore, it must have impulse input for the rain gauge.
- Minimum protection IP65 – higher specification preferred (It should be noted that the loggers may need to be installed in a tube on a river bank).
- Power supply internal lithium battery, sufficient for > 5 years preferred. Preference will be given to systems that do not require the use of solar panels and external batteries.
- Serial flash; no loss of data in case of power failure.
- Minimum memory capacity of 4 MB (more than 250,000 values).
- Real time clock, battery buffered, with accuracy of +/- 1 minute per month.
- Exact free definable time range for downloading of data without erasing old data.
- Must have an integrated GSM/GPRS modem with FTP data push option (different protocols). Contractor will be responsible for ensuring that the proposed system is compatible with Mozambican and Zimbabwean networks.
- Option for Bluetooth interface. User friendly, robust and intuitive software.
- Optional external antenna.
- Automatic reset of modem in case of network failure.
- All control and set up options, data download and programming of data logger shall also be done by online session similar to all functions at site by direct connection to a PC without any difference.
- Different recording modes: min. time-, and event controlled.
- Ability to download data without ceasing measurement.
- At least one RS232 interface for operation, one RS485 sensor interface.
- Options for SDI-12 sensor and Bluetooth interfaces.
- Full control, operation and adjustment of data logger by palmtop, portable PC or via online connection.
- Lightning protection to be provided.
- All necessary accessories and cabling.
- Training required for installation, troubleshooting and operation in both Mozambique and Zimbabwe.

**Radar Sensors**



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<p><b>Radar Sensor</b></p>	<ul style="list-style-type: none"> <li>- Measuring range up to +30 m (98.43 ft)</li> <li>- Deviation <math>\leq 2</math> mm</li> <li>- Beam angle 4°</li> <li>- Measuring frequency W-band (80 GHz technology)</li> <li>- Output signal 4 ... 20 mA/HART</li> <li>- Mounting connection Thread G1, 1 NPT, R1</li> <li>- Process pressure -1 ... +3 bar (-100 ... +300 kPa/- 14.5 ... +43.51 psig)</li> <li>- Process temperature -40 ... +80 °C (-40 ... +176 °F)</li> <li>- Ambient temperature -40 ... +80 °C (-40 ... +176 °F)</li> <li>- Bluetooth standard Bluetooth 5.0 (downward compatible to Bluetooth 4.0 LE)</li> <li>- Effective range Bluetooth typ. 25 m (82 ft)</li> <li>- Operating voltage 12 ... 35 V DC</li> <li>- Protection rating IP66/IP68 (3 bar) acc. to IEC 60529, Type 6P acc. to UL 50</li> <li>- Data storage for at least 5 years</li> <li>- Data logger should have a display</li> <li>- Cellular Communication Modem (GPRS/GSM)</li> <li>- Direct communication with the data logger to download data using a laptop with not more than 1 hour delay. Eg 1000hrs reading to be viewed latest by 1100hrs.</li> <li>- Should be able to send a signal or alarm when a river reaches a certain threshold to at least 20 stakeholders/ people.</li> <li>- Battery in built and long lasting for at least 3 years and an additional spare battery (N.B) solar powered system susceptible to vandalism)</li> <li>- Single channel (water/ river level) data logger with high resolutions</li> <li>- Critical spare components should be provided</li> <li>- Radar logger should be mounted under the bridge and with a waterproof protection device and anti-vandalism protection</li> <li>- Training required for installation, troubleshooting and operation in both Mozambique and Zimbabwe.</li> <li>-</li> </ul>
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## 2.0 Acoustic Dopplers

Equipment	Description & Specifications
Larger ADCP	<p data-bbox="490 472 501 488">-</p> <p data-bbox="490 501 757 525">Transducer frequency:</p> <ul data-bbox="490 531 898 778" style="list-style-type: none"> <li>- 1200 kHz (possibly 600 KHz) ;</li> <li>- depth range 0.3 m – 25 m;</li> <li>- velocity range <math>\pm 5</math> ms<sup>-1</sup>;</li> <li>- accuracy 2 mms<sup>-1</sup>;</li> <li>- resolution 1 mms<sup>-1</sup>;</li> <li>- number of cells &gt; 100;</li> <li>- cell size 0.05m to 2m;</li> <li>- blanking distance 0.05m.</li> </ul> <p data-bbox="490 780 860 804">Data output rate 1-2Hz (typical)</p> <p data-bbox="490 842 696 866">Bottom Tracking:</p> <ul data-bbox="490 873 846 991" style="list-style-type: none"> <li>- velocity range 9.5m/s;</li> <li>- depth range 0.5m to 30m;</li> <li>- accuracy 2 mms<sup>-1</sup>;</li> <li>- resolution 1mms<sup>-1</sup>;</li> </ul> <p data-bbox="490 1029 741 1053">Depth Measurement:</p> <ul data-bbox="490 1059 797 1145" style="list-style-type: none"> <li>- range 0.5 m to 30 m;</li> <li>- accuracy 1% or 1 cm;</li> <li>- resolution 1 mm</li> </ul> <p data-bbox="490 1184 714 1208">Standard Sensors:</p> <ul data-bbox="490 1214 1016 1396" style="list-style-type: none"> <li>- temperature tilt (pitch and roll) compass;</li> <li>- range -5°C to 40°C , 15° 0-360° ;</li> <li>- accuracy 0.4°C to 0.5° , 2°;</li> <li>- resolution 0.01°C 0.01° 0.01°;</li> <li>- operating temperature -5°C to 45°C;</li> <li>- storage temperature -20°C to 60°C.</li> </ul>



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	<p>The equipment shall be supplied with a differential GPS.</p> <ul style="list-style-type: none"> <li>- the ADCP shall be supplied with a Bluetooth modem;</li> <li>- the equipment shall be supplied with the appropriate software;</li> <li>- flotation device – the instrument shall be supplied with a flotation device that is robust and can be deployed from the side of a boat, using tow ropes and from current meter gauging cable-ways.;</li> </ul>
D-GPS	<p>General Requirements:</p> <ul style="list-style-type: none"> <li>- compatible with ADCP system</li> <li>- hardware and software as a integrated solution</li> <li>- based on satellite augmentation systems (SABS)</li> <li>- same or stand-alone power supply</li> <li>- position accuracy: &lt;0.30 m</li> <li>- update rate: &lt;20Hz</li> <li>- position conversion to co-ordinate system used for the streams</li> <li>- accurate referencing to boat in order to allow conversion of Doppler velocity into actual water velocity and direction.</li> </ul> <p>Receiver Type</p> <ul style="list-style-type: none"> <li>- Frequency: Dual L1/L2, C/A Code.</li> <li>- No. of channels: 12 Channels</li> <li>- Initializations: Real time on the fly, 10seconds.</li> <li>- Measurement techniques: Multi path and interference rejection</li> <li>- Memory: removable USB of 1GB or more</li> <li>- Data recording time: 0.1 to 60 sec., 20Hz or more.</li> <li>- Data downloading: cable RS 232 or card reader.</li> </ul> <p>GPS Antenna</p> <ul style="list-style-type: none"> <li>- Type: L1/L2 Antenna</li> <li>- Mounting: Tripod/ Pole</li> </ul> <p>Power</p> <ul style="list-style-type: none"> <li>- Operating time: &gt; 6 hours of continuous work time or supplied with extra battery.</li> <li>- Input Voltage Range: 6 to 30 VDC</li> </ul> <p>Environment</p>



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	<ul style="list-style-type: none"> <li>- Operating and storage Temperature: -10° to + 60° C.</li> <li>- Protection against water, humidity, dust: IP67</li> </ul>
Floating device	<p>The Floating device shall be able to carry the instruments with the following specifications:</p> <ul style="list-style-type: none"> <li>- Dive-resistant;</li> <li>- Flexible and rugged body;</li> <li>- Resistant to high velocities: &gt;5m/s;</li> <li>- Should fit all the instruments, including the GPS;</li> <li>- Resistant to flipping and submersion;</li> <li>- Lightweight and easy to transport;</li> <li>- Recommended dimensions(L/W/H): 130 / 68 / 11 cm.</li> </ul>

### 3.0 Server and Software

Equipment	Description / Requirements
Office computers and software for the telemetry	<p><b>Computer Server:</b></p> <ul style="list-style-type: none"> <li>- Processor -- 3.2 GHz Quad-core - Intel Xeon 4C E3-1270v2 69W with 16GB or more RAM</li> <li>- Motherboard -- Server grade with 4 x ECC DDR4 RAM</li> <li>- Memory -- 16 GB with expansion slots for additional memory</li> <li>- OS Disks -- (2 in RAID 1 mirror) 500 GB, 7200 RPM, 16 MB cache, SATA</li> <li>- Data disks -- (2 in RAID 1 mirror) 1 TB, 7200 RPM, 16 MB cache, SATA</li> <li>- Power supply -- 400 watts</li> <li>- DVD -- Combo DVD +/- RW, (DVD-ROM, DVD-RW, CD-RW)</li> <li>- Available Expansion Slots -- 1 PCIe 3.0 x8 full height 1 PCIe 2.0 x 4 after any cards installed</li> <li>- Sound -- Basic sound card or on-board, supplied with speakers</li> <li>- Video Monitor -- LCD 17 inch, 1280X1024</li> <li>- Ports -- 6 USB 2 ports with additional support for PS/2 Keyboard and Mouse, 2 RJ-45 Network ports</li> <li>- Network -- Two 10/100/1000 Mbps Ethernet</li> <li>- Form factor – Full tower</li> <li>- Keyboard – Standard full size (US English and Portuguese)</li> <li>- Mouse -- 2 button optical wheel mouse – USB</li> </ul>



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	<ul style="list-style-type: none"> <li>- Additional Cooling -- Extra dual ball bearing case fans</li> <li>- Electrical Supply -- 220V AC 50 HZ, Mozambican socket</li> <li>- External drive (for backups) -- 500 GB USB external hard drive</li> <li>- UPS – For 4 hours operation.</li> <li>- The Operating System Requirements must meet or exceed the following: Microsoft Windows Server 2012, Microsoft SQL Server 2012, SQL Server Management Studio, and IIS Server for web browser access to the database(s).</li> </ul> <p><u>Desktop Computer:</u></p> <ul style="list-style-type: none"> <li>- Processor -- 2.4 GHz Core i5</li> <li>- Motherboard -- Desktop grade</li> <li>- Memory -- 6 GB DDR3 RAM</li> <li>- Hard drives -- (2 in RAID 1) 500 GB, 7200 RPM, 16 MB cache, SATA</li> <li>- Power supply -- 300 Watt</li> <li>- DVD -- Combo; DVD +/- RW, DVD-ROM, CD-RW/DVD</li> <li>- Available Expansion Slots -- 2 PCI, 1 PCIe after cards installed</li> <li>- Sound -- Basic sound card or on-board, supplied with speakers</li> <li>- Video -- LCD 17 inch, 1280X1024</li> <li>- Ports -- 4 USB Ports, (1) audio in, (1) audio out, (1) VGA, (1) Display Port, (1) RJ- 45 Ethernet, (1) serial, PS/2 keyboard, PS/2 mouse</li> <li>- Network -- 10/100/1000 Mbps Ethernet</li> <li>- Form factor -- Micro Tower</li> <li>- Keyboard – Standard full size (US English and Portuguese)</li> <li>- Mouse -- 2 button optical wheel mouse – USB</li> <li>- Additional Cooling -- Extra dual ball bearing case fan</li> <li>- Media card reader -- Multiple formats</li> <li>- OS and Software -- Microsoft Windows 7 Professional Edition 32 bit OS with recovery media and Microsoft Professional Office Suite</li> <li>- Electrical Supply -- Nominal 220V AC 50 HZ, Mozambican socket.</li> </ul>
Office modems and software	<p><u>Modem:</u></p> <ul style="list-style-type: none"> <li>- Type -- GSM &amp; GPRS Class 10 &amp; Edge mobile station Class B</li> <li>- Processor – 32 bit</li> <li>- Air Interface -- Quad Band; 900 MHz &amp; 1800 MHz</li> <li>- Max. Output Power -- 2W @900 MHz &amp; 1W @1800 MHz</li> </ul>



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- Antenna -- 3dB gain; Magnetic mount passive with 5M cable length
- Power Consumption – Active: 320mA (typical Average+); dle: 30mA; Standby: 8mA
- Non Volatile Memory -- SD Card upto 8GB to store records
- PC Interface -- For Settings and Configuration
- Field Interface -- For Data collection from the Logger
- GPS Interface -- In built GPS Receiver
- Power Requirement -- 5-24VDC; 3W (average)
- Power Inputs -- TWO

Software:

- The central receiving station has a fast broadband internet connection with a static IP address to receive remote station data through GPRS and a GSM modem with SIM to receive remote station data through SMS. The central receiving station runs a FTP server application to receive the GPRS data from the remote station.
- A database management system with good compatibility with other databases and data formats.
- The central data processor should have capacity to detect missing data, process data in predefined statistics (mean, maximum, minimum, standard deviation), transfer/export to the main database in appropriate formats (e.g ASCII, CSV), carry scheduled backup of configuration and data, display the data in different formats, by graph, table, or GIS layers.
- The software used should have capabilities to automatically process and display real time data as well as “Archived” historical data.
- The data management software should have capacity to process data on several time steps (minute, hourly, daily, and monthly).
- The central telemetry gateway should be able to control many units to enable future expansions.
- The base station must support multi-user access and have GUI configuration facilities to enable full configuration and management of remote stations. Also, it should be able manage each remote station in an easily organized manner and be able to configure, amongst others, data sample processing, data sensing frequency, modems, and resetting remotely from the central station.
- Be able to check the functioning of each sensor and battery voltages, communications, etc remotely. The telemetry gateway should have different connection ports for the LAN and the central data server.

**Annex C: Meetings**

**Meeting with the Provincial Development Coordinator, Masvingo Province**



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**Meeting Date: 03 September 2021**

**Time: 0830 hrs.**

**Venue: Masvingo PDC's Office**

**1.0 Present**

<b>Name</b>	<b>Designation</b>	<b>Organisation</b>
<b>Dr. J. Sakupwanya MR. E. K. Madamombe</b>	<b>Provincial Development Coordinator GEF BUPUSA Regional Coordinator</b>	<b>GoZ GWPSA</b>
<b>Mr. A. Misi</b>	<b>IWRM Technical Advisor</b>	<b>GWPSA</b>
<b>Mr. G. T. Mundondwa</b>	<b>Hydrologist</b>	<b>MLAFWRR</b>
<b>Mr. A. Kwashi</b>	<b>Data Officer</b>	<b>ZINWA Data &amp; Research</b>

**2.0 Apologies : None**

<b>Item</b>	<b>Discussion</b>
<b>3.0 Welcome Remarks</b>	<ul style="list-style-type: none"> <li>The PDC welcomed the team and requested the Regional Coordinator to proceed with the introductions and agenda of the meeting.</li> </ul>



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#### 4.0 Introductions and Meeting Agenda

- Mr. Madamombe introduced the team to the PDC.
- He then highlighted that the main objective of the meeting was to appraise the PDC's office of the GEF BUPUSA project being implemented in the BUPUSA basin to address transboundary water management issues.
- He summarily presented the 3 main components of the project viz;
  - o Component 1: Flood and Drought Warning and Mitigation
  - o Component 2: Conserving and restoring ecosystems for sustainable livelihoods
  - o Component 3: Integrated basin planning for the Pungwe - Buzi – Save River Basins
- He indicated that field work had already commenced in both countries, with the first field work mission having concentrated on assessing the status of existing hydrometric network stations in the basins and ongoing projects in the basins.
- This would inform the hydrometric network design or selection of priority stations for the project.
- It was further highlighted that the project was building upon the existing hydrometric network that was set-up in previous projects, but with the main objective of addressing transboundary water management issues between the two riparian states; Mozambique and Zimbabwe.
- In conclusion, the Regional Coordinator also highlighted that he was coordinating the signing of the Save Agreement and would require full support at every level for the signing process to be successful.
- The PDC expressed gratitude having such project being implemented to address water resources management and transboundary issues within the province and the basins.
- He indicated that the project would be very important in addressing pertinent issues pertaining to flooding, water resources conflicts and transboundary water management.
- He further highlighted that he would assist the project, especially on the signing of the Save Agreement.
- In closing, he urged the team to continually upraise his office on the project progression.



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## 2. 5.0 Closing

- Mr. Madamombe thanked the PDC for affording the team an opportunity for a meeting.
- He indicated that there would be further engagement of his office on the project, especially on the Save Agreement, to expedite the signing process.
- Having no further business to discuss, the meeting was adjourned.

## Buzi, Pungwe and Save Field Work Wrap-Up Meeting

**Meeting Date: 28 August 2021**

**Time: 0800 hrs.**

**Venue: Save Catchment Offices**

### 1.0 Present

<b>Name</b>	<b>Designation</b>	<b>Organisation</b>
MR. E. K. Madamombe	GEF BUPUSA Regional Coordinator	GWPSA
Mr. A. Misi	IWRM Technical Advisor	GWPSA
Eng. T. Muyambo	Catchment Manager	ZINWA Save



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Mr. J. Masimba	Hydrology Technician	ZINWA Save
Mr. G. T. Mundondwa	Hydrologist	MLAFWRR
Mr. A. Kwashi	Data Officer	ZINWA Data & Research

## 2.0 Apologies : None

Item	Discussion
3.0 Welcome Remarks	<ul style="list-style-type: none"><li>· Mr. Madamombe welcomed everyone to the meeting and expressed gratitude for a successful field mission in the Buzi, Pungwe and Save Basins for hydrometric assessments.</li></ul>



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#### 4.0 The GEF BUPUSA Project Brief

- Mr. Madamombe took time to brief the meeting about the GEF BUPUSA Project and its objectives. He highlighted that the project has 3 main components of the project viz;
  - Component 1: Flood and Drought Warning and Mitigation
  - Component 2: Conserving and restoring ecosystems for sustainable livelihoods
  - Component 3: Integrated basin planning for the Pungwe, Buzi and Save River Basins
- He alluded to the fact that the project was important in the context of transboundary water management, especially given that the BUPUSA basin was shared between the two riparian states, Mozambique, and Zimbabwe.
- He opened the discussion floor and requested the Catchment manager to give a brief on hydrometric stations in the basins while highlighting issues that needed to be addressed.



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## 5.0 Save Basin Hydrometric Network Status

- The Catchment Manager highlighted that there are a number of projects being undertaken in the BUPUSA basin by organizations such as UNOPS, UNDP and UNESCO
- She further highlighted that the organizations mainly targeted areas impacted by cyclone IDAI and Irrigation schemes.
- Hydrometric stations such as F11 and F7 were already under the purview of UNOPs who were upgrading the stations to real time.
- On the other hand, UNDP is specifically targeting irrigation schemes with the objective of addressing irrigation water management issues in the basins.
- She reiterated the need for constant updating of all related developments during implementation so as to prevent duplication of efforts by the BUPUSA project.
- Eng. Muyambo further alluded to the major problem of vandalism and battery replacement on existing hydrometric stations.
- She further highlighted that some of the stations were giving inaccurate flow records due to channel dynamics as is the case on F22 and F24 which no longer capture low flows, hence the need for necessary adjustments. This has impacted on data accuracy availability.

### Comments:

- The meeting discussed on the issue of project sustainability which is key to the project success. Due to the restructuring process within ZINWA, this presented a huge gap on personnel availability to run the project post the implementation phase.
- Capacity building was identified as a strategic tool on ensuring project sustainability.
- In the context of vandalism, it was highlighted that there was need for fabrication of Anti-Theft systems and improve on the presence of observers at the stations as this would reduce instances of vandalism.
- On resolving the problem of battery failure, it was recommended that rechargeable batteries be used, and solar systems be installed on the stations.
- It was further stressed that, the data capturing frequency may be adjusted depending on the seasonality. Thus, dry seasons should have low frequency.



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<p>6.0 Selection of Priority Stations</p>	<ul style="list-style-type: none"> <li>· The meeting identified priority Hydrometric Stations for the SAVE basin. The stations were selected based on their suitability for addressing transboundary water management issues.</li> <li>· The following Stations were prioritized: <ul style="list-style-type: none"> <li>○ Jack Quinton (E149)</li> <li>○ Buzi Ypress (F18)</li> <li>○ Katiyo Estate (F22)</li> </ul> </li> <li>· It was also proposed that existing equipment at the above stations can be moved to upstream gauging stations to optimize the network. This would aid better understanding the upstream hydrological dynamics which is important for water resources management.</li> <li>· The following stations were identified as other key stations: <ul style="list-style-type: none"> <li>○ Murara (F24)</li> <li>○ E118</li> <li>○ E125</li> <li>○ E141</li> <li>○ Chpita and</li> <li>○ F11</li> </ul> </li> </ul> <p>It was agreed that the unit on F18 will be moved to E141 while the F22 one will be moved to F23 (Honde). Instead of the planned 3 stations for Save, the total number of stations to be either installed or repaired will be about Nine (9)</p>
<p>7.0 Meeting Closure</p>	<ul style="list-style-type: none"> <li>· Mr. Madamombe highlighted the need for focus and objectivity to ensure timely and successful implementation of the project.</li> <li>· There having no further business to discuss, the meeting was adjourned.</li> </ul>

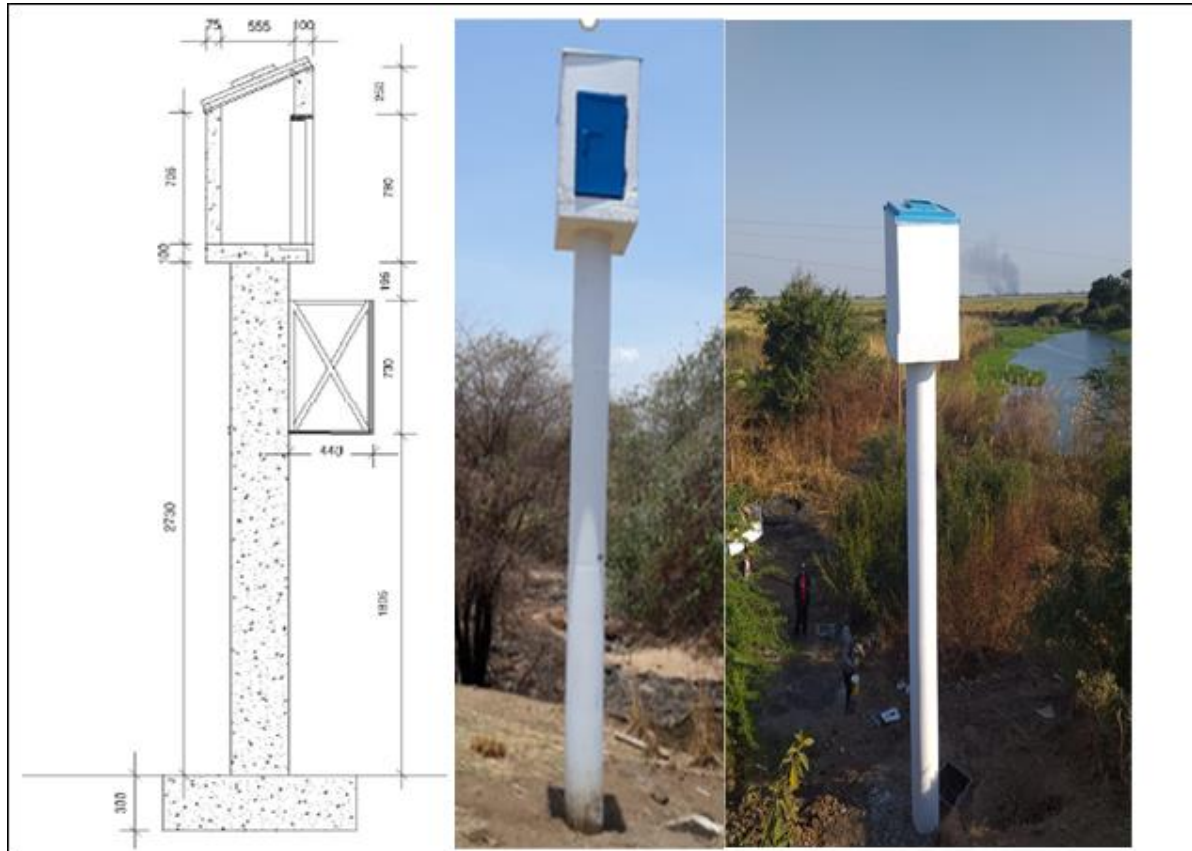
**Annex D: Standard design of the shelters, Mozambique.**



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**Annex E: Field Work Template**

**TEMPLATE FOR HYDROMETRIC NETWORK ASSESSMENT FOR THE BUZI, PUNGWE AND SAVE BASINS.**

- 1. River Name: .....
- 2. Station Number: .....
- 3. Location: .....
- 4. Site Location: X .....
- Y .....

5. Year Commissioned: 

DD	MM	YYYY
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**6. Type of Station:**

- (a) Natural Control Section (with civil works)
- (b) Gauging station (with civil works)
- (c) Natural Control Section with Gauge Plates

**7. Type of Instrument:**

- (a) Gauge Plates
- (b) Data Logger(s)  Model:.....

**8. Network Coverage**

- (a) Name of Service provider: .....
- (b) Signal Strength
  - Weak
  - Medium
  - Excellent

**9. Purpose of the Station (tick)**

- (a) Transboundary
- (b) Irrigation
- (c) Water Quality
- (d) Water Allocation
- (e) E-flows



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- (f) Floods
- (f) Climate Observation
- (g) Water Resources Management



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Any other purpose, *please specify*:

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**10. Operational Status**

- (a) Operational
- (b) Non-operational

If non-operational please provide details

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**11. Works Required**

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**12. Estimated Costs (US\$-in words):**

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**13. Accessibility**

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**14. Station Observer**

(a) Name.....

(b) Contact (s).....

**15. Sketch Diagram**

**16. Pictorial Evidence**

**17. Overall Recommendation**

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.....

**Assessment Done By:**

Name	Signature	Date