# Consulting Services for Environmental Flows Assessment and Water Quality Modelling within the Lesotho Lowlands Water Development Project Phase II (LLWDP II)

# Final EFlows Policy and EFlows Management Plan

**Ministry of Water, Lesotho**

**March 21st, 2022**

**Prepared by**

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| PROJECT | **Consulting Services for Environmental Flow Assessment (EFA) and Water Quality Modelling within the Lesotho Lowlands Water Development Project Phase II (LLWDP II)** | DOCUMENT CODE | 10223685-TVF-RAP-004 |
| SUBJECT | Final EFlows Policy and EFlows Management Plan | ACCESSIBILITY | Restricted |
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**SUMMARY**

This is the Final EFlows Policy and EFlows Management Plan of the *Consulting Services for Environmental Flow Assessment (EFA) and Water Quality Modelling within the Lesotho Lowlands Water Development Project Phase II (LLWDP II)*. It follows the Kick-Off meeting with the Ministry of Water, Lesotho on 18th December 2020 and the mobilization of the Consultant team on January 4th 2021 and delivery of the Final Scoping and Inception Report on May 28th 2021.

This assignment is led by the Ministry of Water Lesotho, through the Lesotho Lowlands Water Development Phase II (LLWDP II) as Client. The study is funded by the World Bank. The LWDP II component will support the implementation of critical bulk water infrastructure in Zones 2 and 3. LLWDP II has hired Multiconsult (Norway), Southern Waters (Republic of South Africa), Deltares (the Netherlands) and Multi-Nodal Development Consultants (Lesotho) to carry out the assessment.

The main objective of the assignment is to develop an Environmental Flows (EFlows) management strategy for the Hlotse River to mitigate impacts related to the planned release of water from Katse Dam into the river and subsequent abstraction for LLWDP II in Zone 2 &3.


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| 01 | 21.03.2022 | Final EFlows Policy and EFlows Management Plan | Leif Lillehammer | Filip Patocka | Gro Dyrnes |
| 00 | 15.10.2021 | Draft EFlows Policy and EFlows Management Plan | Leif Lillehammer | Jørn Stave | Gro Dyrnes |
| REV. | DATE | DESCRIPTION | FINAL EDITING BY | CHECKED BY | APPROVED BY |

# POLICY STATEMENT

The Lesotho Lowlands Authority, as the implementing agent of the Hlotse Adit and Hlotse Abstraction Point, is committed to:

- Providing for protection of the Hlotse River from its source to the border with South Africa for the benefit of people and the environment.
- Ensuring that releases from the Hlotse Adit do not exceed 1.7 $m^3/s$.
- Ensuring that Environmental Flows (EFlows) provisions are met downstream of the Hlotse Abstraction Point; and in all other reaches of the Hlotse River at all times.
- Undertaking independent monitoring of EFlows provisions and river condition, and to communicate results to stakeholders.
- Implementing adaptive management based on the monitoring results.
- Reviewing and revising EFlows provisions, releases and procedures, as needed.
- Covering all costs relating to the implementation of the

These commitments are encapsulated in the EFlows Policy and EFMP.

The EFlows Policy and EFMP applies to the Hlotse River downstream of Hlotse Adit to the border with South Africa.

In accordance with the EFlows Policy, releases from the Hlotse Adit shall not exceed 1.7 $m^3/s$ and EFlows provisions, as laid out in the EFlows schedule, shall be met downstream of the Hlotse Abstraction Point. The EFlows releases are expected to maintain the Hlotse River in a C/D river class condition (see Appendix C4, Table 4 – Composite River condition).

The Commissioner of Water is responsible for implementation of the EFlows Policy and has delegated performance of key aspects of the implementation of this Policy as follows:

- The LLWSDU[1] is responsible for meeting the EFlows, including record keeping.
- LLWSDU is responsible for the implementation of the EFlows Monitoring Programme and all reporting required therein.

[1] LLWSSU = Lesotho Lowlands Water Supply Development Unit

Compliance with the EFlows Policy will be monitored at key points along the Hlotse River Dam. These include relevant Department of Water Affairs' flow gauging weirs, a control site upstream of the Hloste Adit and five downstream EFlows[2] sites. The objectives of the compliance monitoring include: to establish whether or not the agreed EFlows are being met and whether the ecological category is achieved.

Adaptive management will be used to implement the EFlows Policy.

The Commissioner of Water shall be responsible for the final decisions relating to the adaptive management system, after consultation with relevant parties.

All costs relating to the implementation of the EFlows Policy and EFlows Management Plan shall be regarded as Hlotse Adit and Abstraction costs and shall be borne by Lesotho Lowlands Water Supply Development Unit (LLWSDU).

[2] Environmental Flows Sites

# Table of Contents

# LIST OF TABLES



# LIST OF FIGURES

# PREAMBLE

## Lesotho Lowlands Water Development Project

The Lesotho Lowlands Water Development Project Phase II (LLWDP II) is a key program of the Government of Lesotho (GoL) to improve potable water supply. One aspect of LLWDP II is the Lesotho Lowlands Bulk Water Supply Scheme (LLBWSS), which aims to address the water demands in the Lowlands by supplying water to the settlements with populations greater than 2,500. Figure 1 is a schematic of the LLWDP area. This study focuses on Zones 2 and 3.

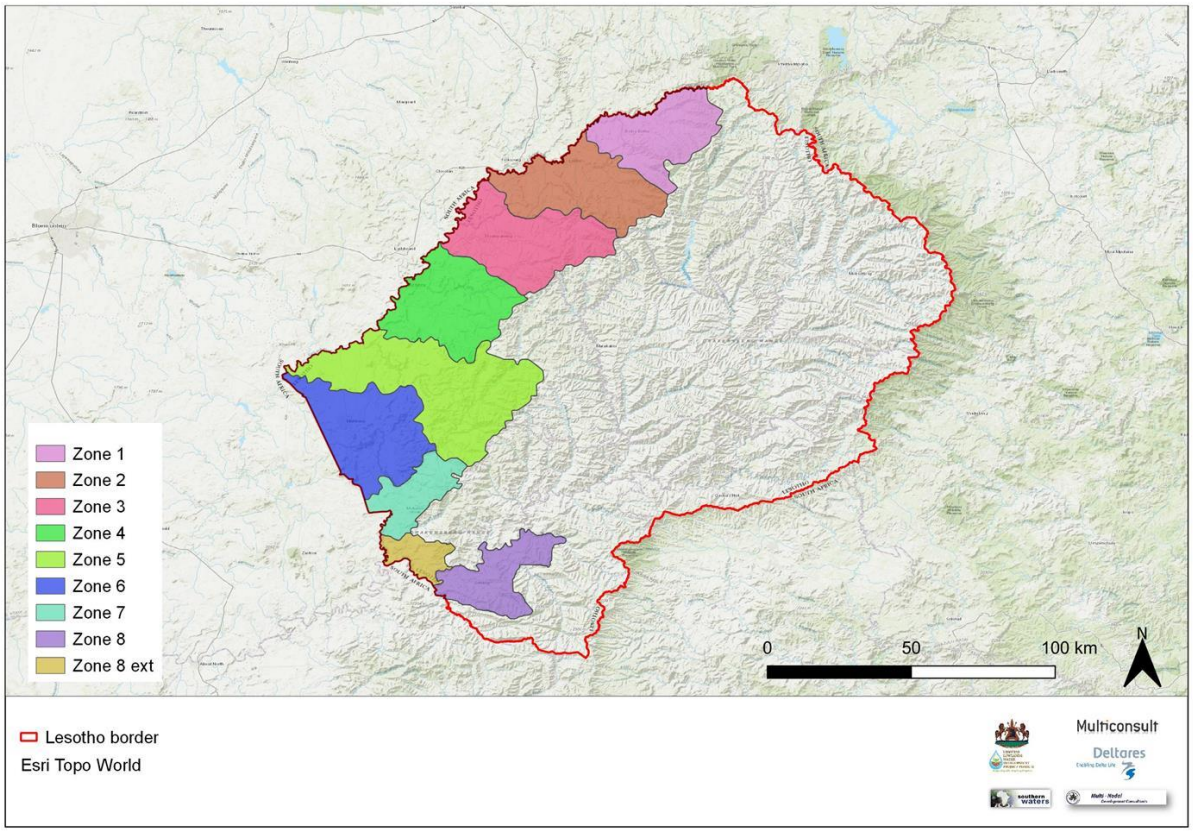



**Figure 0.1 Bulk water supply zones of the Lesotho Lowlands (Aurecon et al. 2018)**

The LLBWSS was established in 2002 through a Cabinet Memorandum, with the mandate to oversee the implementation of the LLWDP in accordance with the provisions of the Lesotho Water and Sanitation Policy of 2007 (LWSP) – Policy Statement 2: Water Supply and Sanitation Services.

## Water Transfer From Katse Dam to Hlotse Adit

Water resource analyses and water demand estimates indicate that there is insufficient water in the Hlotse River during low flow periods to supply the current and future demand forecasts, and to maintain ecological functioning downstream of the proposed water abstraction intake point. This means that flows will need to be augmented during the dry season and time of drought by means of water transfers from Katse Dam (part of the Lesotho Highlands Water Project - LHWP). These can be supplied through an existing tunnel, into the upper reaches of the Hlotse River, via the Hlotse Adit.

## Water Act, 2008

The Lesotho Water Act, 2008 (Act No. 15 of 2008) provides for the management, protection, conservation development and sustainable utilisation of the water resources of Lesotho. Three sections of the Water Act, 2008 have particular relevance to the EFlows Policy and EFlows Management Plan (EFMP).

The first dictates the responsible authority for ensuring implementation of the EFlows Policy and EFMP:

a. "There shall be a Commissioner of Water who shall be a public officer within the Ministry (of Water).
b. The functions of the Commissioner shall be to –
   i. provide policy direction to the departments within the Ministry and water management institutions dealing with water resources;
   ii. implement the water and sanitation policy;
   iii. develop water and sanitation strategies and plans and ensure their implementation and periodical review;
   iv. be custodian of the national water resources data on behalf of the Minister;
   v. coordinate all water management activities including activities related to international waters;
   vi. produce state of the water resources reports once every year;
   vii. carry out such regulatory activities in respect of water resources as are provided for under this Act; and
   viii. advise the Minister concerning the management and utilisation of water resources."

The second incorporates EFlows as legally binding articles in the Water Act, 2008, called "the reserve".

"A reserve shall comprise –
   a. the basic human needs reserve representing the quantity and quality of water resources required to satisfy the basic human needs of those dependent on the concerned water

resource; and

b. the ecological reserve representing the quality and quantity of water required to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the resource."

The third provides guidance for the financing of implementation and monitoring of the reserve, and access to the information:

"31. A water management institution shall, at its own expense, make information at its disposal available to the public in an appropriate manner in respect of –

a. the reserve in relation to the quality and quantity of water resources in the country and allocations made so far;
b. the register of permits issues;
c. the register of borehole drilling contractors; and
d. any other information that the public needs to know under this Act subject to such limitations relating to public security or commercial confidentiality as may be appropriate."

## Environment Act (2008)

The Lesotho Environment Act, 2008 (Act No. 15 of 2008) provides for the protection and management of the environment and sustainable utilisation of natural resources of Lesotho. Although many sections of the Act have relevance to the Hlotse Adit and Abstraction Point and the Hlotse River, four sections have particular relevance to the EFlows Policy.

The first deals with access to premises and data for monitoring purposes and adaptive management:

"23. (1) The Director shall, in consultation with the relevant Line Ministry, monitor:

- all environmental elements with a view of making an assessment of a possible change in the environmental and their possible environmental impacts;
- the operation of an industry, project or activity with a view to determining its immediate and long-term effects of the environment; and
- the operation of all projects in existence at and after the commencement of this Act with a view of determining whether they comply with the provisions of the Act.

(2) The Director may, where he determines that the project does not comply with the provisions of this Act, require that the developer of a project or activity take remedial measures in a manner and within such time as the Director may determine.

(3) An environmental inspector may enter upon any land or premises for the purpose of monitoring environmental effects on the environment or any activities that are carried out on

that land or premises."

The second deals with the requirements of operators to keep reports that will facilitate the auditing of their performance in terms of the terms and conditions of their license:

"24. (1) The Director shall, in consultation with the relevant Line Ministry, be responsible for carrying out periodic environmental audit of activities or projects that are likely to have adverse effects on the environment.

(2) The Director may require:

- the holder of an environmental assessment license;
- the operator or developer of a project or activity for which an environmental impact statement has been made; or
- a person who has legal right in land or the owner of the premises where a project or activity for which environmental impact statements have been made to keep and submit to the Director reports on how far the project or activity conforms in operation with the terms and conditions of the license at such periods as the Director deems necessary."

Section 93 also deals with the need to keep adequate records of operation and management of activities with a potential environmental impact.

The third makes provision for the establishment of water quality standards:

"28. (1) The Director shall, in consultation with the relevant Line Ministry:

a. establish criteria and procedures for the measurement of water quality;
b. establish minimum water quality standards for all the waters of Lesotho for the following different uses:
    - drinking water;
    - water for industrial purposes;
    - water for agricultural purposes;
    - water for recreational purposes;
    - water for fisheries;
    - water for wildlife; and
    - any other water uses which may be prescribed."
    - etc.

The fourth addresses public access to environmental information:

"95. (1) A person who desires to obtain information relating to the implementation of this Act or any other information concerning the management of the environmental or natural resources shall subject to section 93(4) have access to that information."

## EFlows Assessment

An EFlows assessment for the Hlotse River was undertaken in 2021 (Multiconsult 2022a). The assessment focussed on five EFlows sites downstream of the Hlotse Adit to the border with South Africa.

The EFlows assessment resulted in the following EFlows provisions being set for the Hlotse River (Multiconsult, 2022a):

***Guidelines:***

*The guidelines with respect to the future operating rules for the Hlotse Adit and Hlotse Abstraction Point arising from the scenario assessment are:*

- *Releases from Hlotse Adit should not exceed 1.7 m3/s*
- *Releases should be implemented gradually in a manner that limits water level changes in the downstream river (EFlows1) to no more than 0.05 m/hour (MRC 2020)*
- *Abstractions from Hlotse Abstraction Point should not exceed releases from Hlotse Adit in the dry season, plus losses in the channel, and should allow ~0.4 m3/s of the released water to remain in the river, in addition to the water supplied by the Hlotse catchment.*

***Furthermore:***

- *Releases should be implemented in a manner that limits water level changes (up or down) at EFlows1 to ⩽0.05 m/hour*
- *Abstractions at the Hlotse Abstraction Point should not commence before the discharge at Gauge CG25 indicates that the water from the Adit has arrived*
- *Abstractions at the Hlotse Abstraction Point should stop once the discharge readings at Gauge TS3 indicate that the flows have dropped back down to pre-release levels*
- *The recommendation will require complete re-evaluation should additional medium or large-scale[3] abstractions or water-resource development be planned or implemented in the Hlotse River.*

These EFlows requirements should be incorporated into the Hlotse Adit design and into the operation of the Hlotse Abstraction Point.

[3] Relative to the MAR of the Hlotse River

## Supporting documentation

This EFlows Policy and EFMP will need to be supported by the following key documents:

- Hlotse EFlows Baseline Water Quality Monitoring Programme Design
- Hlotse EFlows Baseline Water Quality Sampling Manual
- Hlotse EFlows Training Manual
- Hlotse EFlows Monitoring and Modelling Report
- Hlotse EFlows Scenario Assessment Report
- Hlotse EFlows Baseline Report.

Together, these documents provide the details of the procedures that underlie and support the EFMP. These procedures are subject to on-going review and revision in line with the principles of adaptive management.

## EFlows Policy and EFMP Development Process

Involvement of affected parties in the development of the EFlows Policy and EFMP was given high priority. In line with this Lesotho Lowlands Development Authority and its appointed service providers ensured that representatives of all interested and affected parties had an opportunity to comment on the EFlows Policy and EFMP before it was finalised. Provision for additional and on-going revision of the EFlows Policy and EFMP and/or its supporting procedures is also allowed for in the Policy.

## Operation and Management of Hlotse Adit and Abstraction Point

The LHDA will be responsible for the operation, management and maintenance of the Hlotse Adit and the LLWSDU the Abstraction Point.

## EFlows Policy and EFMP Implementation

The Commissioner of Water will be responsible for implementation of the EFlows Policy and EFMP, and may assign specific tasks outlined herein to WASCO, Department of Water Affairs (DWA) and other institutions and/or service providers, as deemed appropriate.

# 1 PURPOSE

Lesotho Lowlands Development Authority, as the implementing agent of the Hlotse Adit and Abstraction Point, is committed to:

- providing for protection of the Hlotse River downstream of the Hlotse Adit to the border with South Africa for the benefit of people and the environment;
- ensuring that releases from the Hlotse Adit do not exceed 1.7 $m^3/s$;
- ensuring that EFlows provisions are met downstream of the Hlotse Abstraction Point; and in all other reaches of the Hlotse River at all times;
- undertaking independent monitoring of EFlows provisions and river condition, and to communicate results to stakeholders;
- implementing adaptive management based on the monitoring results;
- reviewing and revising EFlows provisions, releases and procedures, as needed, and;
- covering all costs relating to the implementation of the Environmental Flows Management Plan (EFMPs) Policy and EFlows Management Plan (EFMP).

These commitments are encapsulated in this EFlows Policy and EFMP, and are to be achieved by:

- formally documenting the intentions of the Lesotho Lowlands Authority with respect to management of the potential impacts of the Hlotse Adit and Abstraction Point on the Hlotse River and the people who depend thereon;
- providing a set of principles that will govern the implementation of the agreed EFlows;
- designating responsibility for implementation of the EFlows Policy and EFMP;
- providing an adaptive management plan to address any unexpected outcomes in terms of EFlows and river condition, and;
- providing for systematic and periodic auditing of performance.

This means that the EFlows Policy and EFMP will:

- specify the essential components of a system to manage and monitor the effect of water releases from the Hlotse Adit that will:
- monitor volumes and timing of release etc. based on results from the DRIFT EFlows Assessment and;
- ensure that the EFlows releases and the resultant ecological condition of the downstream river are monitored independently and the results made available for public scrutiny.

The EFlows Policy and EFMP's associated procedures provide the detailed technical guidance and information necessary to implement the Policy and EFMP. The procedures comprise four separate but linked documents, as follows:

- The Hlotse River EFlows Scenario Assessment Report (Multiconsult 2022a), which provides the results of the scenario analysis upon which the decisions on EFlows for the river were made.
- The Hlotse River EFlows Baseline Report (Multiconsult 2022b), which summarises the work the EFlows team did in support of the EFlows Scenario Assessment, including the techniques to

collect, analyse and interpret the monitoring data, and summarises the first data collected in September 2021 as part of the EFlows Assessment.

- The Hlotse River EFlows Monitoring and Modelling Report (Multiconsult 2022c), which provides a plan and procedures to monitor adherence to both the agreed EFlows and the expected river condition.
- The Hlotse River EFlows Baseline Water Quality Sampling Manual (Multiconsult 2022d), which provides detailed guidance for the collection and processing of the water quality samples.

# 2 INSTITUTIONAL FRAMEWORK

## 2.1 EFlows Policy and EFMP implementation

The Commissioner of Water is responsible for implementation of the EFlows Policy and EFMP. In keeping with this, as per the Water Act, 2008, the Commissioner will:

- be the custodian of monitoring data collected under the EFlows Monitoring Programme;
- be responsible for making such information available to interested and affected parties, and;
- delegate performance of key aspects of the implementation of the EFlows Policy and EFMP to relevant organisations.

## 2.2 Delegation of responsibilities

In accordance with his authority under the Water Act, 2008, the Commissioner of Water has delegated performance of key aspects of the implementation of the EFlows Policy and EFMP as follows:

- LLWSDP will be responsible for the release of EFlows, including record keeping.
- LLWSDP will be responsible for the implementation of the EFlows Monitoring Programme.

In each case, overall responsibility for performance is to be assigned to a staff member chosen for these duties. Duties include handling the relevant organisational requirements, such as: ensuring required activities are conducted timeously and correctly; keeping detailed records; quality control for data collection and data archiving; annual reporting as per the required format; reporting issues or problems to the Commissioner of Water; and the participation of the relevant staff in the Periodic Inspection Program (Section 6.3).

# 3 SCOPE OF THE EFMP

## 3.1 Ambit

The EFlows Policy and EFMP address the releases of water from Hlotse Adit and the consideration of EFlows requirements for the Hlotse River downstream of the Hlotse Abstraction Point.

## 3.2 Temporal scope

The EFlows Policy and EFMP shall take effect from the start of point at which water from the Hlotse Adit enters the Hlotse River.

The EFlows Policy and EFMP shall apply for the life of Hlotse Adit and/or Abstraction Point.

The implementation of the EFlows Policy and EFMP will be subject to an independent audit in accordance with the Periodic Inspection Program (Section 6.3).

The EFlows Policy and EFMP may be changed only after independent audit, review and consultation with the relevant authorities e.g. the Commissioner of Water, Department of Environmental Affairs, or Department of Water Affairs.

The bulk allocation in the EFlows Policy and EFMP will not be changed within five years of Policy approval, unless compelling reasons for change emerge from review.

## 3.3 Spatial scope

The EFlows Policy and EFMP shall apply to the Hlotse River downstream of Hlotse Adit to the border with South Africa, as represented by the EFlows Sites (Hlotse EFlows Monitoring and Modelling Report, Multiconsult 2022c for further details).

The applicable EFlows sites and their location on the Hlotse River (see Appendix C.2 for coordinates):

1. EFlows 0: A short distance upstream the Hlotse Adit
2. EFlows 1: ~5 km downstream the Hlotse Adit
3. EFlows 2: ~midway between EFlows 1 and 3
4. EFlows 3: ~5 km upstream of the Hlotse Abstraction
5. EFlows 4: ~2 km downstream the Hlotse Abstraction
6. EFlows 5: ~2 km upstream of the confluence between Hlotse and Makhateleng Rivers.

# 4 THE EFLOWS PROVISIONS

## 4.1 Base hydrology

The initial calculation of EFlows is determined relative to the baseline hydrology available at the time of the assessment. Thus, any changes in the baseline hydrology should be reflected proportionately in the EFlows provisions. The techniques used to generate the hydrology used to calculate the EFlows releases in this EFlows Policy and EFMP are described in the Water Resources and Water Quality Assessment Report (Multiconsult 2022e).

## 4.2 Water quantity

The LLWDP II has provided the release and abstraction volumes proposed for the Hlotse Adit and Hlotse Abstraction Point (Table 4.1) from 2024 to 2045 (Gebreselassie 2021).

The releases and abstractions are steady and the volume of water released via the Hlotse Adit, less in-channel losses and EFlows, will be abstracted at the Hlotse Abstraction Point. The releases and abstractions will be limited to four dry months of the year, *viz*.: June, July, August and September (but a five month release might be considered, see Multiconsult 2022a), and are planned to take place as a continuous release/abstraction for the entire four-month period each year.

Table 4.1 Proposed volumes of water release from the Hlotse Adit and abstraction from the Hlotse Abstraction Point (Gebreselassie 2021)

| Year | Month | Days in Month | Water Supply Demand m3/day | Water Supply Demand m3/s | Environmental Flow Requirements m3/s | Water losses in the river channel (QL) m3/s | Required Water Release m3/s | Required Water Release m3/day | Required Water Release Mm3/month | Required Water Release (QRR) Annual Mm3 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2024 | Jun-24 | 30 | 44431 | 0.514 | 0.395 | 0.160 | 1.070 | 92,426 | 2.773 | 11.276 |
| | Jul-24 | 31 | | 0.514 | 0.395 | 0.160 | 1.070 | 92,426 | 2.865 | |
| | Aug-24 | 31 | | 0.514 | 0.395 | 0.160 | 1.070 | 92,426 | 2.865 | |
| | Sep-24 | 30 | | 0.514 | 0.395 | 0.160 | 1.070 | 92,426 | 2.773 | |
| 2025 | Jun-25 | 30 | 44998 | 0.521 | 0.396 | 0.162 | 1.079 | 93,228 | 2.797 | 11.374 |
| | Jul-25 | 31 | | 0.521 | 0.396 | 0.162 | 1.079 | 93,228 | 2.890 | |
| | Aug-25 | 31 | | 0.521 | 0.396 | 0.162 | 1.079 | 93,228 | 2.890 | |
| | Sep-25 | 30 | | 0.521 | 0.396 | 0.162 | 1.079 | 93,228 | 2.797 | |
| 2026 | Jun-26 | 30 | 45591 | 0.528 | 0.408 | 0.165 | 1.101 | 95,094 | 2.853 | 11.601 |
| | Jul-26 | 31 | | 0.528 | 0.408 | 0.165 | 1.101 | 95,094 | 2.948 | |
| | Aug-26 | 31 | | 0.528 | 0.408 | 0.165 | 1.101 | 95,094 | 2.948 | |
| | Sep-26 | 30 | | 0.528 | 0.408 | 0.165 | 1.101 | 95,094 | 2.853 | |
| 2027 | Jun-27 | 30 | 46191 | 0.535 | 0.420 | 0.168 | 1.123 | 97,002 | 2.910 | 11.834 |
| | Jul-27 | 31 | | 0.535 | 0.420 | 0.168 | 1.123 | 97,002 | 3.007 | |
| | Aug-27 | 31 | | 0.535 | 0.420 | 0.168 | 1.123 | 97,002 | 3.007 | |
| | Sep-27 | 30 | | 0.535 | 0.420 | 0.168 | 1.123 | 97,002 | 2.910 | |
| 2028 | Jun-28 | 30 | 46799 | 0.542 | 0.432 | 0.172 | 1.145 | 98,955 | 2.969 | 12.072 |
| | Jul-28 | 31 | | 0.542 | 0.432 | 0.172 | 1.145 | 98,955 | 3.068 | |
| | Aug-28 | 31 | | 0.542 | 0.432 | 0.172 | 1.145 | 98,955 | 3.068 | |
| | Sep-28 | 30 | | 0.542 | 0.432 | 0.172 | 1.145 | 98,955 | 2.969 | |
| 2029 | Jun-29 | 30 | 47416 | 0.549 | 0.444 | 0.175 | 1.168 | 100,953 | 3.029 | 12.316 |
| | Jul-29 | 31 | | 0.549 | 0.444 | 0.175 | 1.168 | 100,953 | 3.130 | |
| | Aug-29 | 31 | | 0.549 | 0.444 | 0.175 | 1.168 | 100,953 | 3.130 | |
| | Sep-29 | 30 | | 0.549 | 0.444 | 0.175 | 1.168 | 100,953 | 3.029 | |
| 2030 | Jun-30 | 30 | 48039 | 0.556 | 0.457 | 0.179 | 1.192 | 102,995 | 3.090 | 12.565 |
| | Jul-30 | 31 | | 0.556 | 0.457 | 0.179 | 1.192 | 102,995 | 3.193 | |
| | Aug-30 | 31 | | 0.556 | 0.457 | 0.179 | 1.192 | 102,995 | 3.193 | |
| | Sep-30 | 30 | | 0.556 | 0.457 | 0.179 | 1.192 | 102,995 | 3.090 | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2031 | Jun-31 | 30 | 48733 | 0.564 | 0.470 | 0.182 | 1.217 | 105,115 | 3.153 | 12.824 |
| | Jul-31 | 31 | | 0.564 | 0.470 | 0.182 | 1.217 | 105,115 | 3.259 | |
| | Aug-31 | 31 | | 0.564 | 0.470 | 0.182 | 1.217 | 105,115 | 3.259 | |
| | Sep-31 | 30 | | 0.564 | 0.470 | 0.182 | 1.217 | 105,115 | 3.153 | |
| 2032 | Jun-32 | 30 | 49436 | 0.572 | 0.483 | 0.186 | 1.242 | 107,284 | 3.219 | 13.089 |
| | Jul-32 | 31 | | 0.572 | 0.483 | 0.186 | 1.242 | 107,284 | 3.326 | |
| | Aug-32 | 31 | | 0.572 | 0.483 | 0.186 | 1.242 | 107,284 | 3.326 | |
| | Sep-32 | 30 | | 0.572 | 0.483 | 0.186 | 1.242 | 107,284 | 3.219 | |
| 2033 | Jun-33 | 30 | 50150 | 0.580 | 0.497 | 0.190 | 1.267 | 109,503 | 3.285 | 13.359 |
| | Jul-33 | 31 | | 0.580 | 0.497 | 0.190 | 1.267 | 109,503 | 3.395 | |
| | Aug-33 | 31 | | 0.580 | 0.497 | 0.190 | 1.267 | 109,503 | 3.395 | |
| | Sep-33 | 30 | | 0.580 | 0.497 | 0.190 | 1.267 | 109,503 | 3.285 | |
| 2034 | Jun-34 | 30 | 50875 | 0.589 | 0.511 | 0.194 | 1.294 | 111,773 | 3.353 | 13.636 |
| | Jul-34 | 31 | | 0.589 | 0.511 | 0.194 | 1.294 | 111,773 | 3.465 | |
| | Aug-34 | 31 | | 0.589 | 0.511 | 0.194 | 1.294 | 111,773 | 3.465 | |
| | Sep-34 | 30 | | 0.589 | 0.511 | 0.194 | 1.294 | 111,773 | 3.353 | |
| 2035 | Jun-35 | 30 | 51610 | 0.597 | 0.525 | 0.198 | 1.321 | 114,094 | 3.423 | 13.919 |
| | Jul-35 | 31 | | 0.597 | 0.525 | 0.198 | 1.321 | 114,094 | 3.537 | |
| | Aug-35 | 31 | | 0.597 | 0.525 | 0.198 | 1.321 | 114,094 | 3.537 | |
| | Sep-35 | 30 | | 0.597 | 0.525 | 0.198 | 1.321 | 114,094 | 3.423 | |
| 2036 | Jun-36 | 30 | 52430 | 0.607 | 0.525 | 0.200 | 1.331 | 115,020 | 3.451 | 14.032 |
| | Jul-36 | 31 | | 0.607 | 0.525 | 0.200 | 1.331 | 115,020 | 3.566 | |
| | Aug-36 | 31 | | 0.607 | 0.525 | 0.200 | 1.331 | 115,020 | 3.566 | |
| | Sep-36 | 30 | | 0.607 | 0.525 | 0.200 | 1.331 | 115,020 | 3.451 | |
| 2037 | Jun-37 | 30 | 53264 | 0.616 | 0.524 | 0.201 | 1.342 | 115,962 | 3.479 | 14.147 |
| | Jul-37 | 31 | | 0.616 | 0.524 | 0.201 | 1.342 | 115,962 | 3.595 | |
| | Aug-37 | 31 | | 0.616 | 0.524 | 0.201 | 1.342 | 115,962 | 3.595 | |
| | Sep-37 | 30 | | 0.616 | 0.524 | 0.201 | 1.342 | 115,962 | 3.479 | |
| 2038 | Jun-38 | 30 | 54110 | 0.626 | 0.524 | 0.203 | 1.353 | 116,919 | 3.508 | 14.264 |
| | Jul-38 | 31 | | 0.626 | 0.524 | 0.203 | 1.353 | 116,919 | 3.624 | |
| | Aug-38 | 31 | | 0.626 | 0.524 | 0.203 | 1.353 | 116,919 | 3.624 | |
| | Sep-38 | 30 | | 0.626 | 0.524 | 0.203 | 1.353 | 116,919 | 3.508 | |
| 2039 | Jun-39 | 30 | 54970 | 0.636 | 0.524 | 0.205 | 1.364 | 117,891 | 3.537 | 14.383 |
| | Jul-39 | 31 | | 0.636 | 0.524 | 0.205 | 1.364 | 117,891 | 3.655 | |
| | Aug-39 | 31 | | 0.636 | 0.524 | 0.205 | 1.364 | 117,891 | 3.655 | |
| | Sep-39 | 30 | | 0.636 | 0.524 | 0.205 | 1.364 | 117,891 | 3.537 | |
| 2040 | Jun-40 | 30 | 55843 | 0.646 | 0.523 | 0.206 | 1.376 | 118,880 | 3.566 | 14.503 |
| | Jul-40 | 31 | | 0.646 | 0.523 | 0.206 | 1.376 | 118,880 | 3.685 | |
| | Aug-40 | 31 | | 0.646 | 0.523 | 0.206 | 1.376 | 118,880 | 3.685 | |
| | Sep-40 | 30 | | 0.646 | 0.523 | 0.206 | 1.376 | 118,880 | 3.566 | |
| 2041 | Jun-41 | 30 | 56815 | 0.658 | 0.537 | 0.211 | 1.405 | 121,418 | 3.643 | 14.813 |
| | Jul-41 | 31 | | 0.658 | 0.537 | 0.211 | 1.405 | 121,418 | 3.764 | |
| | Aug-41 | 31 | | 0.658 | 0.537 | 0.211 | 1.405 | 121,418 | 3.764 | |
| | Sep-41 | 30 | | 0.658 | 0.537 | 0.211 | 1.405 | 121,418 | 3.643 | |
| 2042 | Jun-42 | 30 | 57803 | 0.669 | 0.551 | 0.215 | 1.435 | 124,013 | 3.720 | 15.130 |
| | Jul-42 | 31 | | 0.669 | 0.551 | 0.215 | 1.435 | 124,013 | 3.844 | |
| | Aug-42 | 31 | | 0.669 | 0.551 | 0.215 | 1.435 | 124,013 | 3.844 | |
| | Sep-42 | 30 | | 0.669 | 0.551 | 0.215 | 1.435 | 124,013 | 3.720 | |
| 2043 | Jun-43 | 30 | 58809 | 0.681 | 0.565 | 0.220 | 1.466 | 126,664 | 3.800 | 15.453 |
| | Jul-43 | 31 | | 0.681 | 0.565 | 0.220 | 1.466 | 126,664 | 3.927 | |
| | Aug-43 | 31 | | 0.681 | 0.565 | 0.220 | 1.466 | 126,664 | 3.927 | |
| | Sep-43 | 30 | | 0.681 | 0.565 | 0.220 | 1.466 | 126,664 | 3.800 | |
| 2044 | Jun-44 | 30 | 59831 | 0.692 | 0.580 | 0.225 | 1.497 | 129,375 | 3.881 | 15.784 |
| | Jul-44 | 31 | | 0.692 | 0.580 | 0.225 | 1.497 | 129,375 | 4.011 | |
| | Aug-44 | 31 | | 0.692 | 0.580 | 0.225 | 1.497 | 129,375 | 4.011 | |
| | Sep-44 | 30 | | 0.692 | 0.580 | 0.225 | 1.497 | 129,375 | 3.881 | |
| 2045 | Jun-45 | 30 | 60871 | 0.705 | 0.596 | 0.229 | 1.529 | 132,145 | 3.964 | 16.122 |
| | Jul-45 | 31 | | 0.705 | 0.596 | 0.229 | 1.529 | 132,145 | 4.096 | |
| | Aug-45 | 31 | | 0.705 | 0.596 | 0.229 | 1.529 | 132,145 | 4.096 | |
| | Sep-45 | 30 | | 0.705 | 0.596 | 0.229 | 1.529 | 132,145 | 3.964 | |

The current release pipe at the Adit is 150 mm in diameter and capable of releasing a discharge of 0.364 $m^3/s$. There are plans to increase the diameter of the pipe to 800 mm and therefore the release discharge to a maximum of 3.284 $m^3/s$.

The projected discharge required at the Hlotse Abstraction Point by 2045 was calculated as 0.705 $m^3/s$ and is to be met by a total release of 1.529 $m^3/s$; the sum of the water supply demand, an environmental flow release of 0.596 $m^3/s$ and losses estimated as 15 % of the release (Table 4.1).

Thus, the range of discharges released via the Hlotse Adit considered in the scenarios evaluated in the EFlows assessment (Multiconsult, 2022a) was 0.4, 1.5 (or 1.2) and 2.1 $m^3/s$[4], i.e.; from the current maximum discharge up to a value that exceeds the maximum release discharge required by 2045.

[4] In consultation with LLWDP II

Recommendations to further guide the development of future operating rules for the Hlotse Adit and Abstraction Point are provided in Section 11 from the results of the scenario assessment report (Multiconsult, 2022a)). These must be fine-tuned and developed further once the construction plans are finalized and the discussions between stakeholders about the proposed use of the system for domestic water supply finalized.

Hydrological targets conditions are given in Appendix C3.

# 5 THE EFLOWS MONITORING PROGRAMME

The objectives of the EFlows monitoring are to:

- Collect baseline data to inform and guide the assessment of river condition;
- establish whether or not the agreed EFlows provisions are being adhered to;
- establish whether the overall environmental objective of achieving target river condition is met; and
- use the information gathered to guide necessary management interventions.

## 5.1 Data collection

The following data shall be collected as part of the EFlows monitoring plan:

Hydrology:

- discharge data from gauging weirs
- releases from Hlotse Adit
- abstractions at the Hlotse Abstraction Point.

Water quality:

- in-situ physical water quality
- chemical water quality
- water quality condition.

Geomorphology:

- bed sediment composition
- fixed point photographs
- geomorphological condition.

Vegetation:

- plant diversity and abundance
- vegetation condition.

Macroinvertebrates:

- SASS5 scores for macroinvertebrate diversity and abundance
- macroinvertebrate condition.

Fish:

- fish diversity and abundance;
- fish condition.

## 5.2 Monitoring schedule

The monitoring schedule for one calendar year is given in Table 5.1 The frequency of data collection

varies from continuous logging of data by loggers installed in the river stream (hydrology), to regular and less frequent data collection to take place monthly (water quality), bi-annually (macroinvertebrates and fish) and annually (geomorphology and vegetation). Geomorphology and vegetation monitoring is to take place during low flow (October).

**Table 5.1 EFlows Monitoring schedule**

| Data | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hydrology | | | | | | | | | | | | |
| Water quality | X | X | X | X | X | X | X | X | X | X | X | X |
| Geomorphology | | | | | | | | | | X | | |
| Vegetation | | | | | | | | | | X | | |
| Macroinvertebrates | | | X | | | | | | | X | | |
| Fish | | | X | | | | | | | X | | |

## 5.3 Reporting

See Section 6.

## 5.4 Staffing and skills requirements

Monitoring personnel must be qualified to perform the diverse functions required in the EFlows Monitoring Programme, including data collection, data collation, data analysis, report writing, presentation of results, input to adaptive management decisions and participation in periodic inspection programs. Data collection activities should also be fully resourced with sufficient support personnel and equipment to perform the necessary functions.

The Hlotse Monitoring and Modelling Programme and this EFlows Policy and EFMP recognise that continuity of technical positions is essential to maintaining consistent high standards of practice.

Staff requirements are provided in the Hlotse EFlows Monitoring and Modelling Report.

# 6 REPORTING, RECORD KEEPING AND AUDITING

## 6.1 Record keeping

LLWSDU and DWA should store all data collected in the water reporting system developed for the Lowland Water Supply Project or in a standard data management system adopted by the DWA for data storage and management.

## 6.2 Reporting

LLWSDU, in liaison with DWA, shall produce a Hlotse River EFlows Monitoring Report in December of each year for submission to the Commissioner of Water.

The Annual EFlows Reports shall include, but not necessarily be limited to:

- Implementation of EFlows Procedures Analysis and Compliance, including:
    - documentation of issues or problems related to implementation, if any, and suggested solutions.
- Hydrological Analysis and Compliance, at the appropriate timestep – but no greater than daily:
    - a breakdown of the releases from Hlotse Adit;
    - a breakdown of the abstractions at the Hlotse Abstraction Point;
    - a breakdown of the calculated flows at the Ha Setene gauging station (CG25).
- Measured River Condition Targets Analysis and Compliance, including:
    - comparative analysis of baseline data[5] and monitoring data;
    - trend analysis of monitoring data.

## 6.3 Periodic Inspection Program

The implementation of the EFlows Policy and EFMP shall be subject to periodic auditing and review by external auditors as follows:

- The initial inspection shall be accomplished immediately prior to implementation of releases from the Hlotse Adit and/or abstractions from Hlotse Abstraction Point.
- The second inspection shall be made no later than six months after implementation releases from the Hlotse Adit and/or abstractions from Hlotse Abstraction Point.
- Subsequent periodic inspection shall be at one-year intervals for the following four years, at two-year intervals for the next four years and then, if warranted by the results of the previous inspections, extended to five-year intervals.

## 6.4 Public disclosure of monitoring information

### *6.4.1 Annual EFlows Monitoring Reports*

Once they have been approved by the Commissioner of Water, the LLWSDU shall make the Annual EFlows Monitoring Reports available for download on their website.

[5] Baseline data will be collected from 2022 up to the start of the operation of the Hlotse Adit and Abstraction point planned for 2024, following the guidance provided in the Hlotse EFlows Monitoring and Modelling Report (Multiconsult 2022c).

This shall occur no later than 1st June of the following year.

### *6.4.2 Audit Reports*

Once they have been approved by the Commissioner of Water, LLWSDU shall make the Audit Reports available for download on their website.

This shall occur no later than six months following a Periodic Inspection.

# 7 ADAPTIVE MANAGEMENT SYSTEM

## 7.1 Adaptive management activities

The activities comprising the adaptive management system for the implementation of the EFlows Policy and EFMP are provided in Table 7.1 (boxes numbered as per sequence below).

It is recognised that for the adaptive management system to be effective, the following process are essential:

- release of EFlows in accordance with those stipulated;
- data collection in accordance with the EFlows Monitoring Programme;
- analysis of the results of monitoring in accordance with the EFlows Monitoring and Modelling Programme;
- independent auditing of the above, and;
- cooperation and communication between the Adit operators (WASCO), the organisation responsible for monitoring (Department of Water Affairs) and the Commissioner of Water.

The Adaptive Management System is underlain and supported by the Hlotse EFlows Monitoring and Modelling Programme (Multiconsult 2022c), which provides the necessary guidance to inform each step.

**Table 7.1 The adaptive management system**

| | |
|---|---|
| Activity 1 | Release EFlows in accordance with the schedule. Go to **Activity 2**. |
| Activity 2 | Records of releases from the Hlotse Adit and abstractions from the Hlotse Abstraction Point will be used to assess if the agreed EFlows volumes are being adhered to (Section 4).<br>If the releases are being made in accordance with the schedules provided (Yes), then go to **Activity 4**<br>If the releases are not being made in accordance with the schedules provided (No) then go to **Activity 3**. |
| Activity 3 | The Commissioner of Water, or his representatives, shall liaise with the Hlotse Adit and Abstraction Point operators to resolve any outstanding issues and ensure that the EFlows provisions are being adhered to. Go to **Activity 1**. |
| Activity 4 | Data from the gauge at Ha Setene (CG25) will be used to assess if the hydrological target values (Appendix C, Table 3) are being met.<br>If the hydrological targets are being met at Ha Setene (Yes), then go to **Activity 6.**<br>If the hydrological targets are not being met at Ha Setene (No), then go to **Activity 5**. |
| Activity 5 | If the EFlows target values are not being met at Ha Setene (CG25), the Commissioner of Water shall convene discussions and negotiations with LHDA, DWA, Department of Environment and other interested and affected parties to decide whether or not adjustments can be made to the EFlows provisions.<br>If the EFlows provisions can be adjusted (Yes), then go to **Activity 8**.<br>If the EFlows provisions cannot be adjusted (No), then go to **Activity 7**. |

| | |
|---|---|
| Activity 6 | The biophysical monitoring data from EFlows0, 1, 2, 3, 4 and 5 will be used to assess if the ecological target values (Appendix C.4) are being met at EFlows Sites 1 to 5.<br>If the ecological targets are being met at EFlows1 to 5 (Yes) then go to **Activity 10**.<br>If the ecological targets are not being met at EFlows1 to 5 (No), then go to **Activity 7**. |

| | |
|---|---|
| Activity 7 | If the ecological targets at EFlows1 to 5 are not met, the Commissioner of Water shall convene discussions and negotiations with LHDA, DWA, Department of Environment and other interested and affected parties to decide whether or not adjustments can be made to the ecological targets.<br>If the ecological targets at EFlows1 to 5 can be adjusted (Yes) then go to **Activity 9**.<br>If the ecological targets at EFlows1 to 5 cannot be adjusted (No) then adjust the EFlows releases and schedule to meet the ecological targets. Go to **Activity 8**. |

| | |
|---|---|
| Activity 8 | The agreed EF provisions and the hydrological target at EFlows1 to 5 will be adjusted as per a pattern indicated in the DRIFT database, followed by a revision of the Hlotse Adit and Abstraction Point Operating Rules. This will feed back to Activity 1 as new agreed EFlows. Go to **Activity 1**. |

| | |
|---|---|
| Activity 9 | The ecological target at EFlows1 to 5 will be adjusted to those deemed to result from the existing EFlows releases, based on monitoring data. These will feedback to Activity 10 as the new ecological targets at EFlows1 to 5. Go to **Activity 10**. |

| | |
|---|---|
| Activity 10 | Hlotse Adit and Abstraction Point operators continue with the current Operating Rules and release schedule. Go to **Activity 1**. |

## 7.2 Decision-making and the adaptive management system

The Commissioner of Water shall be responsible for the final decisions relating to the adaptive management system, after consultation with relevant parties.

With respect to the technical decisions relating to Activities 2, 4 and 6, DWA shall provide their recommendations with respect to target attainment to the Commissioner of Water.

## 7.3 Stakeholder involvement

All relevant major stakeholders (dam operators, irrigators, downstream communities, national environmental authorities, etc.) will be involved in discussions if the agreed target condition of the rivers is not being met and may have to be changed (Box 7 in Table 7.1).

There will be public disclosure and involvement for the full period of implementation of the EFlows Policy and EFMP.

There will be an annual external and independent audit of implementation of the EFlows Policy and EFMP (See Section 6).

The audit will make provision for stakeholder inspection and involvement.

# 8 FUNDING

Provision for the financing of the implementation of the EFlows Policy and EFMP has been included in the budget of the Lesotho Lowlands Water Supply Development Authority. The EFlows Policy and EFMP budget includes provision for:

- Time and costs associated with the implementation of the technical aspects of the EFlows Policy and EFMP (Section 5), including:
    - personnel and disbursement costs associated with data collection
    - procurement and maintenance of monitoring equipment
    - costs of sample analyses (water quality)
    - personnel and disbursement costs associated with reporting.
- Design, maintenance and updating of a website to make EFlows information available to the public (Section 6.4).
- *Ad hoc* meetings with interested and affected parties.
- Appointment of an external reviewer in accordance with the Periodic Inspection Program (Section 6.3).
- Periodic meetings between LHDA and the Commissioner of Water, including those as may be necessitated by the Adaptive Management System (Section 7).
- Time and costs associated with technical adjustment of targets as may be necessitated by the Adaptive Management System (Section 7).
- Training and networking.

# Appendix A. APPENDIX A: DEFINITIONS OF KEY CONCEPTS

**Adaptive management** is an approach to managing complex natural systems that builds on learning - based on common sense, experience, experimenting, and monitoring - by adjusting practices based on what was learned (Bornmann 1999).

**DRIFT (**Downstream Response to Imposed Flow Transformations) is an EFlows assessment methodology that uses the present-day flow regime of the river as a starting point, and then holistically describes the biophysical consequences of several possible future flow regimes, or flow scenarios, each of them comprising a different combination of flow reductions.

**EFlows** describe a modified flow regime for a river that is linked to a description of the condition or health of the river that this flow regime achieves. EFlows typically comprise:

- *Low flows,* which occur when the river is not in flood. They are larger and more varied in the wet season than in the dry season. They create different conditions in different seasons, dictating the occurrence and densities of aquatic species.
- *Small floods*, which occur several times within a year. They stimulate spawning in fish, flush out poor quality water, cleanse the riverbed and sort the river stones by size, thereby creating different kinds of habitat. They trigger and synchronize activities as varied as upstream migrations of fish and germination of seedlings on riverbanks.
- *Large floods*, which occur less than once a year. They trigger the same responses as small floods, but, in addition, they provide the scouring flows that shape the river channel. They move and cleanse cobbles and boulders on the riverbed, and deposit silt, nutrients, eggs and seeds on floodplains. They inundate backwaters, secondary channels and floodplains, and trigger bursts of growth in many species. They also recharge soil moisture levels in the banks, enabling seedlings of riparian trees to grow.
- *Flow variability* on a daily, seasonal or annual basis, which acts as a form of natural disturbance. Fluctuations between low flows and small and large floods change conditions through each day and season, creating mosaics of areas inundated and exposed for different lengths of time. The more diverse the physical conditions, the higher the biodiversity and the greater the resilience of the ecosystem to disturbance.

**EFlows provisions** refer to the seasonal pattern and quantities of water needed to maintain the target ecological condition of the Hlotse River.

**Flow regime** refers to the seasonal pattern and quantities of flow in a river, whether natural or modified.

**Geomorphology** refers to the study of the processes and pressures operating on river systems. Changes in the independent variables of discharge, sediment load supplied to reach, and slope give rise to adjustments in the dependent variables of sediment load and particle size, hydraulic

characteristics, and habitats, all of which interact with each other.

**Habitat** refers to the physical environment that surrounds (influences and is utilised by) a species.

**Hydrology** refers to the record of the volume, the timing and magnitude of flows in the river.

**Impoundment** means any in-channel or off-channel storage of relatively large volumes of water behind a control structure.

**Macroinvertebrates** are animals that have no backbone and are visible without magnification. The macroinvertebrate communities in Lesotho streams are dominated by insect larvae, many with a (non-aquatic) flying stage.

**Mean annual runoff (MAR)** refers to the long-term average annual water flow from a catchment; it is a measure of the average amount of water available as natural river flow.

**Monitoring programme** is a programme that observes, regulates, and controls or verifies the operations of a management system. In the context of the MDWSP, the EF monitoring programme is designed to provide information that will allow verification of the release of EFlows at the appropriate time and assessment of the resultant condition of the receiving river system. This information will be used in the adaptive management system to regulate the EF activities to ensure that the target conditions for the downstream river are achieved.

**Periodic inspection program** is the routine scheduling of inspections and audits of project infrastructure and management procedures instituted under the operation of the Hlotse Adit and Abstraction Point.

**Reach** (as in *river reach*) is a stretch of river that has more or less homogenous characteristics throughout, in terms of geomorphology, hydrology and aquatic biota.

**Riparian zone/area** [*inhabiting or situated on the bank of a river*] is that part of the riverine ecosystem which occupies the banks of the river channel and areas immediately adjacent to them, where the influence of river flow/water flowing in the river is felt. It is usually distinguished by an assemblage of plant species, which is different from that in nearby terrestrial habitats, often dominated by woody plants.

**River condition** is described using a set of five or six qualitative descriptions of the category of the riverine ecosystem, from pristine, natural conditions through progressive (or regressive) changes until the ecosystem is so transformed as to be non-functional. The river condition classification used for the Hlotse Adit and Abstraction Point is in alignment with the rivers classification adopted by the Lesotho Highlands Development Authority.

**Sample analysis** in the context of the EFlows Policy refers to the analysis of sediment and water quality samples at an accredited laboratory.

**Water quality** refers to the chemical, physical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose.

# Appendix B. APPENDIX B: ACRONYMS AND UNITS

| | |
|---|---|
| **ASPT** | Average score per taxon |
| **COW** | Commissioner of Water |
| **DWA** | Department of Water Affairs |
| **EF** | EFlows |
| **EFMP** | Environmental Flows Monitoring Programme |
| **KPI** | Key Performance Indicators |
| **LHDA** | Lesotho Highlands Development Authority |
| **LHWP** | Lesotho Highlands Water Project |
| **LLBWSS** | Lesotho Lowlands Bulk Water Supply Scheme |
| **LLWSDP** | Lesotho Lowlands Water Supply Development Project |
| **LLWSDU** | Lesotho Lowlands Water Supply Development Unit |
| **$M.m^3$** | Million cubic metres |
| **$m^3a^{-1}$** | Cubic metres per annum |
| **$m^3s^{-1}$** | Cubic metres per second |
| **MAR** | Mean Annual Runoff |
| **SASS** | South African Scoring System |

# Appendix C. LOCATION OF GAUGING STATIONS, EFLOW SITES AND HYDROLOGICAL TARGETS

This section provides an overview of the location of gauging stations, EFlow sites and hydrological targets.

## C.1. Locations of hydrological gauging stations

The locations of the flow gauging weirs in the study are provided in Appendix Table 1 and Appendix Figure 1.

**Appendix Table 1 Locations of the flow gauging weirs**

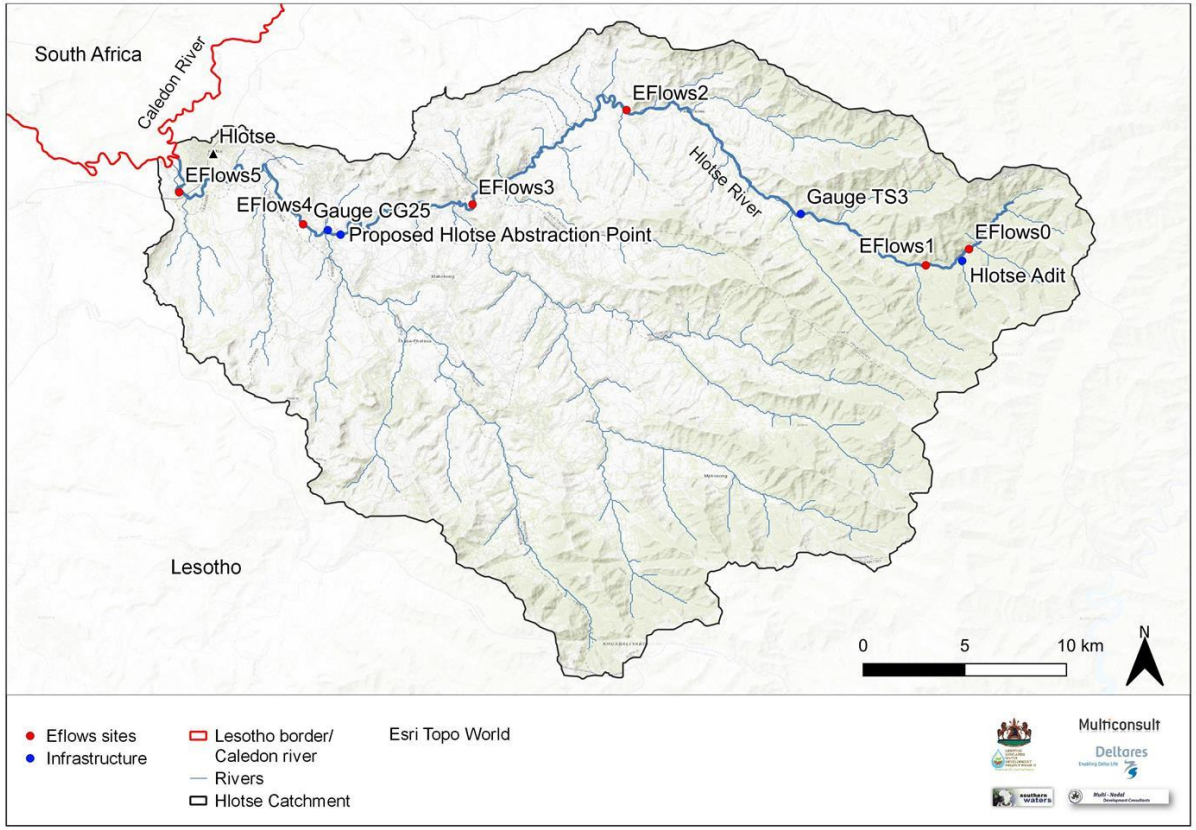
| Gauging Station | Code | River | Coordinates | Description |
|---|---|---|---|---|
| Hlobola | Gauge TS3 | Hlotse | -28° 54' 09.36'', 28° 20' 54.60'' | Future new hydrometric station |
| Ha Setene | CG25 | Hlotse | -28° 54' 45.72'', 28° 6' 48.24'' | Daily flow data since October 1974. |

## C.2. Locations of the EFlows sites

The locations of the five EFlows sites are provided in Appendix Table 2 and Appendix Figure 1.

**Appendix Table 2 Locations of the EFlows sites.**

| EFlows | Coordinates | Description of location |
|---|---|---|
| 0 | -28° 55' 13.38'', 28° 26' 01.08'' | Tsehlanyane National Park. |
| 1 | -28° 55' 42.91'', 28° 24' 42.52'' | 1 km downstream of the Adit. |
| 2 | -28° 51' 00.4'', 28° 15' 37.6'' | 1.5 km along the road upstream of the Hlotse road bridge at the village of Khabos. |
| 3 | -28° 53' 52.1'', 28° 10' 57.2'' | Upstream of the village Seetsas. |
| 4 | -28° 54' 28.2'', 28° 05' 48.8'' | Downstream of abstraction point at the village of Moliboeas. |
| 5 | -28° 53' 29.90'', 28° 02' 03.13'' | Downstream of road bridge at entrance to Hlotse Town. |




**Appendix Figure 1** **Map showing the location of the EFlows sites, and the hydrological gauging stations in the Hlotse River, in relation to the Hlotse Adit and Abstraction Point**

## C.3. Hydrological targets

The releases from the Hlotse Adit and abstractions from the Hlotse Abstraction Point (Appendix C Table 3) shall be made in such a manner as to ensure that the EFlows provisions are met at Ha Setene (CG25). Floods with a return period ≥ 2 years do not have a timing attached to them, but are expected to occur on average once every two years.

A summary of the post- Adit recommended flow regimes at EFlows4 is provided below and more details are provided in Chapter 11.3 and Appendix B of the scenario assessment report (Multiconsult, 2022a).

Table 3 EFlows provisions at Gauge CG25 to maintain a D-category (Option 2: Sc 04-0 - Adit)

<table>
<tr><th rowspan="2">Month</th><th rowspan="2">Low flows (excludes all floods ($m^3/s$) Monthly average</th><th colspan="5">Floods (Average daily peak)</th><th></th></tr>
<tr><th>Class 1: 7.30 $m^3/s$ ~ 3days duration</th><th>Class 2: 17.50 $m^3/s$ ~ 5days duration</th><th>Class 3: 34.10 $m^3/s$ ~ 5days duration</th><th>Class 4: 61.70 $m^3/s$ ~ 6days duration</th><th>Inter-annual floods</th><th>TOTAL volumes $M.m^3$</th></tr>
<tr><td>Oct</td><td>2.49</td><td>1</td><td rowspan="3">2</td><td></td><td></td><td rowspan="12">Not included in EFlows volume</td><td rowspan="6">Excluding inter-annual floods 243</td></tr>
<tr><td>Nov</td><td>3.90</td><td>1</td><td rowspan="2">2</td><td></td></tr>
<tr><td>Dec</td><td>5.61</td><td>1</td><td rowspan="3">1</td></tr>
<tr><td>Jan</td><td>6.85</td><td>1</td><td rowspan="4">4</td><td rowspan="3">2</td></tr>
<tr><td>Feb</td><td>8.19</td><td>1</td></tr>
<tr><td>Mar</td><td>9.18</td><td>2</td><td rowspan="2">1</td></tr>
<tr><td>Apr</td><td>6.88</td><td>1</td><td></td><td rowspan="6">Including inter-annual floods 263</td></tr>
<tr><td>May</td><td>5.43</td><td>2</td><td rowspan="5">1</td><td></td></tr>
<tr><td>Jun</td><td>4.62</td><td>2</td><td></td></tr>
<tr><td>Jul</td><td>3.61</td><td>1</td><td></td></tr>
<tr><td>Aug</td><td>2.85</td><td>1</td><td></td></tr>
<tr><td>Sep</td><td>2.42</td><td>2</td><td></td></tr>
<tr><td>$M.m^3$</td><td></td><td>21.6</td><td>25.2</td><td>28.2</td><td>24.3</td><td>20</td><td></td></tr>
<tr><td>%MAR</td><td></td><td>8.3</td><td>9.7</td><td>10.9</td><td>9.4</td><td></td><td></td></tr>
</table>

## C.4. Ecological targets

The baseline ecological conditions of the Hlotse River at each EFlows site are given in Appendix Table 3. The data collection and methods used to calculate the conditions for each discipline and the river overall are provided in the Hlotse EFlows Monitoring and Modelling Report (Multiconsult 2022c).

The target conditions for the river at each EFlows site will be that of the baseline conditions and is as follows:.

**Appendix Table 3 Baseline conditions in the Hlotse River (September 2021)**

| Discipline | EFlows1 | EFlows2 | EFlows3 | EFlows4 | EFlows5 |
|---|---|---|---|---|---|
| Geomorphology | C | C | C | C | D |
| Vegetation | C | E | E | E/F | F |
| Invertebrates | A/B | C/D | B | E/F | C |
| Fish | E | D | E | E | E |
| River | C | C/D | C/D | D/E | D |

# Appendix D. **REFERENCES**

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