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Nile Basin Environmental Flows Study Repository

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Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:
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of the Federal Republic of Germany

Document Sheet

This Technical Report series publishes results of work that has been commissioned by the member states through the three NBI Centers (Secretariat based in Entebbe- Uganda, the Eastern Nile Technical Regional Office based in Addis Ababa - Ethiopia and the Nile Equatorial Lakes Subsidiary Action Program Coordination Unit based in Kigali - Rwanda. The content there-in has been reviewed and validated by the Member States through the Technical Advisory Committee and/or regional expert working groups appointed by the respective Technical Advisory Committees.

The purpose of the technical report series is to support informed stakeholder dialogue and decision making in order to achieve sustainable socio-economic development through equitable utilization of, and benefit from, the shared Nile Basin water resources.

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Content

1 Project overview

HYDROC GmbH (the consultant) has entered into a contract with GIZ (the client), conducting "Coarse Environmental Flow Assessment for the Nile Basin". The contract was signed and became effective on 09. July 2018. Contract duration is foreseen as nine months with the project workplan drawn up over this period as provided in the consultants proposal.

The client in their Request for Proposal as well as the consultant in his proposal have described the overall project as well as the work packages that are required to carry out the project in detail, with the work packages forming the base for project implementation and developing the required deliverables. Work packages are foreseen as follows:

- Work Package 0: Inception Phase: Scoping and Alignment
- Work Package 1: Develop E-Flows Assessment for major river stretches
- Work Package 2: Support the integration of the E-flows assessment into the Nile Basin -DSS and conduct scenario analysis
- Work Package 3: Nile Basin Environmental Flows Assessment Report
- Work Package 4: Training / blended learning module on NBI environmental flows strategy and the coarse assessment
- Work Package 5: E-flow Repository and Technical Guidance

Work Package 5 - " E-flow Repository and Technical Guidance " is covered in this report and particularly includes:

Work Package 5 as per ToR:

- Design the Nile E-Flows repository; requirements, specifications, etc. (a separate technical note will be provided with sufficient details and insight). The consultant will develop the E-Flows repository design, specifications, contents, as well as the underlying typology.
- Support NBI to build and commission a repository of E-flows with all necessary inputs and resources required together with the established or determined for all parts or sub-systems of the Nile. The web-based repository shall include all fields and attributes of all studies and meta-database of all environmental flow assessments carried out in the Nile Basin (by different actors).
- Submit the guidance Technical Report: Nile E-Flows Repository Users' Manual.
- Recommend further (downstream) work; in view of NBI niche and programs.

Deliverable: E-flows repository and technical guidance

2 The eflows repository

2.1 Overview of the eflows repository

As per the ToR, the objective of the assignment is to design and populate an eflow repository, to provide an overview and database of existing eflow study results in the Nile basin. The design of the eflows repository is based on the available information in the respective reports and the data was organized in a structured manner, taking into account that the data would later be integrated into the NBI Integrated Knowledge Portal, i.e. a neutral format was chosen and the information organized in MS EXCEL worksheets. In addition, the original reports were collected and provided.

The data itself was obtained through national consultations in the Nile basin countries by national staff members, and in addition by utilizing available web-tools for searching respective platforms. The information was screened for suitability to ensure sufficiently detailed information. In cases where data was referred to only through secondary reports (i.e. references) with limited information content, information could not be used. Technical guidance on the repository is laid out in the following section. Overall, data of 32 studies from six Nile basin countries have been identified and integrated in the repository.

2.2 Technical guidance on eflows repository

The eflow repository and technical guidance was developed based on ToR requirements and in coordination with the Nile Basin Initiative expert in charge for the Nile Basin Integrated Knowledge Portal (IKP). The repository includes environmental flow study results that have previously been developed in the Nile Basin as part of other projects, including key parameters and results as well as links to the study reports themselves. The structure of the repository was discussed with the responsible NBI IKP expert (Sowed Wamala). As the Integrated Knowledge Portal (IKP) is not yet implemented, the repository has been developed in a generic format (MS EXCEL) for easy migration at a later stage. The information was sorted by country and site, though the data can be queried for any other parameter as well.

The following attributes were tabulated:
ID
1. Title of study
2. Year of study
3. River stretch that was studied
4. Who did the study (consultant)
5. Who financed the study (donor)
6. Who was the implementing agency
7. Who now holds the data
8. Methodology used (short description)
9. Methodology details
10. Parameters considered

11. Results (short description)
12. Results (tabulated)
13. Executive Summary of original report

Data was collected by national experts in the different Nile basin countries, utilizing their knowledge and access to local information. The eflow repository is organized by country. Overall 32 studies from six countries (Tanzania, Kenya, Rwanda, Uganda, Sudan, and Ethiopia) are included. Other Nile Basin countries (Burundi, DRC, South Sudan, Eritrea, and Egypt) have not yet carried out eflow studies in the Nile basin.

The repository therefore includes a full overview of eflow study results (currently 32), carried out in different parts of the Nile basin and is therefore the most comprehensive set of eflow information in the basin currently available. Table 1 provides an overview of the studies, with their titles representing their content.

Table 1: Overview of projects included in the repository

Country	ID	River	Year	Title
Tanzania	1.1	Mara	2010	Assessing Reserve Flows for the Mara River (Assessing Reserve Flows for the Mara River Kenya and Tanzania)
	1.2	Mara	2012	Environmental Flow Recommendations for Reserve Flows in the Mara River, Kenya and Tanzania
	1.3	Mara	2012	Environmental Flow Recommendations for Reserve Flows in the Mara River (Kenya and Tanzania)
	1.4	Selected Rivers in Tanzania and Kenya	2011	Critical analysis of environmental flow assessments of selected rivers in Tanzania and Kenya
	1.5	Mara	2014	Comparing flow regime, channel hydraulics, and biological communities to infer flow-ecology relationshops in the Mara River of Kenya and Tanzania
Kenya	2.1	Nzoia, Yala, Sio, North Awach	2011	Variation of flow of water from Rivers Nzoia, Yala and Sio into Lake Victoria
	2.2	Kibos	2013	Environmental Flow Assessment Using HEC-EFM and GIS: A Case Study of Kibos River
	2.3	Lake Victoria catchment – Kenyan section	2003	An introduction to Lake Victoria catchment, water quality, physical limnology and ecosystem status (Kenyan sector)
	2.4	Lake Victoria river system	2006	Meteorology and Hydrology of the Lake Victoria Basin: Kenyan Sector

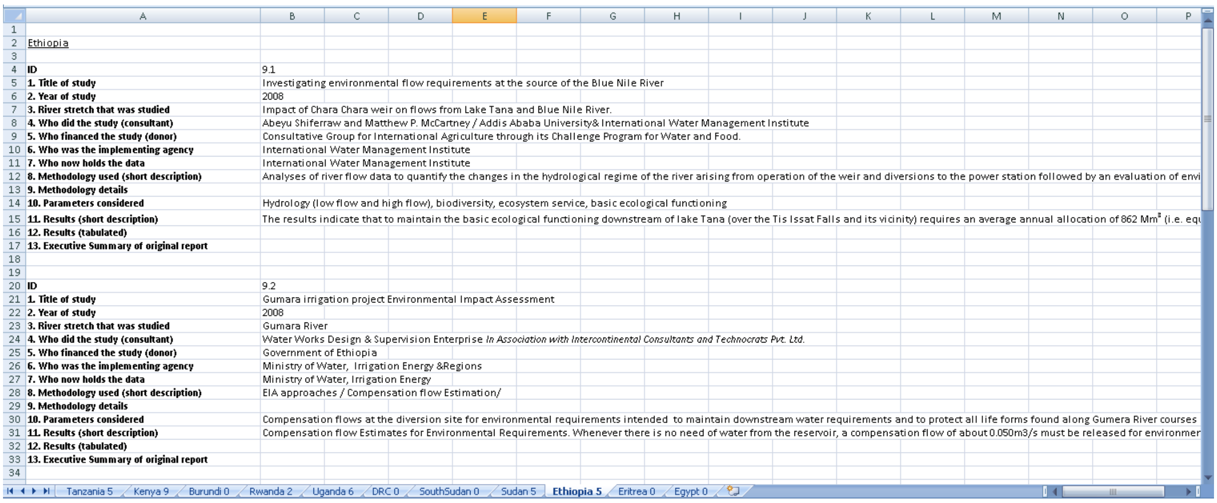
	2.5	Mara	2014	Comparing flow regime, channel hydraulics, and biological communities to infer flow–ecology relationships in the Mara River of Kenya and Tanzania
	2.6	Mara River source to entry to Tanzania	2007	Assessing Reserve flows of the Mara River (LVBC 2010)
	2.7	Nyando	2011	Hydrologic Analysis of Nyando River Using SWAT
	2.8	Ten sites in the Mara basin	2016	Demonstration of the Nile E-flows Framework in the Mara River, Lake Victoria Basin.
	2.9	Malaba	2016	Demonstration of the Nile E-flows Framework in the Malaba River, Victoria Nile Basin
Burundi	3.x	n/a	n/a	n/a
Rwanda	4.1	Kagera (Rusumo Falls)	2013	Environmental and Social Impact Assessment for the Proposed Rusumo Falls Hydroelectric Project
	4.2	Kagera (Rusumo Falls)	2016	Demonstration of the Nile E-Flows Framework in the Kagera River at Rusumo Falls, Lake Victoria Basin
Uganda	5.1	Victoria Nile (Karuma Falls)	2014	Feasibility Study Report for Karuma Hydro Power Plant & Its Associated Transmission Line Works (Section 1 Hydro Power Plant)
	5.2	Rwimi	2016	Supplementary Report on Aquatic Species & Water Audit for Rwimi Small Hydro Power Project
	5.3	Sironko	2014	River Sironko Hydrology - Assessment for the Sironko mini-hydropower project
	5.4	Kanyampara / Lubilia	2011	River Lubilia Water Resources Assessment for the Lubilia mini-hydropower project
	5.5	Waki	2013	Ecological flow - Waki Hydro Power Project
	5.6	Victoria Nile	2016	Environmental and social impact assessment for Ayago Hydropower Station (Volume 1)
DRC	6.x	n/a	n/a	n/a
South Sudan	7.x	n/a	n/a	n/a
Sudan	8.1	Dinder	2016	Demonstration of the Nile E-flows Framework in the Dinder River, Blue Nile Basin
	8.2	Main Nile downstream Merowe dam	2006	Independent Review of the Environmental Impact Assessment for the Merowe Dam Project (Nile River, Sudan)
	8.3	Blue Nile downstream Sennar dam	2013	Operation Manual for Release Structures: Roseires and Sennar dams
	8.4	Blue Nile downstream	2012	Roseires Dam Heightening Project (DHP) Reservoir Operation Study

		Roseires dam		
	8.5	Atbara River downstream the Atbara Dams Complex	2016	Sedimentation and Operation Study for Atbara Dams Complex
Ethiopia	9.1	Blue Nile	2008	Investigating environmental flow requirements at the source of the Blue Nile River
	9.2	Gumara	2008	Gumara irrigation project Environmental Impact Assessment
	9.3	Megech	2010	Environmental and social impact assessment of about 20,000 ha irrigation and drainage schemes at Megech Pump (Seraba),Ribb And Anger Dam/ Environmental and social impact assessment of the ribb irrigation and drainage project/
	9.4	Blue Nile	2011	Concepts of Environmental Flow Assessment and Challenges in the Blue Nile Basin, Ethiopia (as bookchapter in "Nile River Basin, 2011")
	9.5	Blue Nile	2009	Estimating environmental flow requirements downstream of the Chara Chara weir on the Blue Nile River
Eritrea	10.x	n/a	n/a	n/a
Egypt	11.x	n/a	n/a	n/a

The content included in the repository was selected in order to allow for:

1. a full understanding of the study background (title, year, river, consultant, donor, implementing agency, and data holder),
2. a description of the methodology used, as well as
3. the study results, exploiting the report itself as well as the report executive summary where available.

Users, interested in eflows study results, can respectively query the repository, searching for eflow data and/or description for sites for which studies exist. In its current form in MS EXCEL, filters as well as key word search can be used. An example of the current Repository setup is shown in Figure 1. For detailed information the original reports need to be consulted.



	A	B
1		
2	Ethiopia	
3		
4	**ID**	9.1
5	**1. Title of study**	Investigating environmental flow requirements at the source of the Blue Nile River
6	**2. Year of study**	2008
7	**3. River stretch that was studied**	Impact of Chara Chara weir on flows from Lake Tana and Blue Nile River.
8	**4. Who did the study (consultant)**	Abeyu Shiferraw and Matthew P. McCartney / Addis Ababa University& International Water Management Institute
9	**5. Who financed the study (donor)**	Consultative Group for International Agriculture through its Challenge Program for Water and Food.
10	**6. Who was the implementing agency**	International Water Management Institute
11	**7. Who now holds the data**	International Water Management Institute
12	**8. Methodology used (short description)**	Analyses of river flow data to quantify the changes in the hydrological regime of the river arising from operation of the weir and diversions to the power station followed by an evaluation of envi
13	**9. Methodology details**	
14	**10. Parameters considered**	Hydrology (low flow and high flow), biodiversity, ecosystem service, basic ecological functioning
15	**11. Results (short description)**	The results indicate that to maintain the basic ecological functioning downstream of lake Tana (over the Tis Issat Falls and its vicinity) requires an average annual allocation of 862 Mm^3 (i.e. equ
16	**12. Results (tabulated)**	
17	**13. Executive Summary of original report**	
18		
19		
20	**ID**	9.2
21	**1. Title of study**	Gumara irrigation project Environmental Impact Assessment
22	**2. Year of study**	2008
23	**3. River stretch that was studied**	Gumara River
24	**4. Who did the study (consultant)**	Water Works Design & Supervision Enterprise *In Association with Intercontinental Consultants and Technocrats Pvt. Ltd.*
25	**5. Who financed the study (donor)**	Government of Ethiopia
26	**6. Who was the implementing agency**	Ministry of Water, Irrigation Energy &Regions
27	**7. Who now holds the data**	Ministry of Water, Irrigation Energy
28	**8. Methodology used (short description)**	EIA approaches / Compensation flow Estimation/
29	**9. Methodology details**	
30	**10. Parameters considered**	Compensation flows at the diversion site for environmental requirements intended to maintain downstream water requirements and to protect all life forms found along Gumera River courses
31	**11. Results (short description)**	Compensation flow Estimates for Environmental Requirements. Whenever there is no need of water from the reservoir, a compensation flow of about 0.050m3/s must be released for environmer
32	**12. Results (tabulated)**	
33	**13. Executive Summary of original report**	
34		

Figure 1: Example of the current repository setup in MS EXCEL

At the same time, the repository also shows the limitations of existing eflows studies, and users who are interested in specific eflows aspects can use the repository to identify gaps and sharpen methodologies and requirements for future eflow studies. In that regard it is evident that many of the eflow studies have suffered from limited data availability. The repository can respectively be used to identify gaps in existing studies and define monitoring requirements for improved eflow assessments.

The content of the repository was standardized as much as possible, while for the methodology and results the different approaches, parameters and formats as given in the respective reports had to be considered, i.e. the tabulated results have been taken individually from the respective studies, containing various levels of detail. How this will later be structured in the IKP will depend on the final IKP structure. The repository data is currently organized in a manner that the data can be copied from the existing worksheets and reorganized in any form.

2.3 Recommendations of further work

The Integrated Knowledge Portal (IKP) that is currently being developed by NBI and in which it was planned to integrate the repository information has not been available by the end of the Coarse Eflows study under which the eflows repository has been developed. The data has been compiled and provided in a neutral format so that once the IKP becomes available the eflows repository data can be integrated in any required form.

Significant efforts have been spent collecting and evaluating existing eflows related studies in the different Nile basin countries. Further study results should be added to the repository as they become available. To ease integration it is recommended to include a template on the IKP website that can be used by entities that carry out eflows assessments for providing the eflows data they generated. Further, donors and implementing agencies could be approached with the request that for any eflows related work carried out by them, the respective consultant should send an update using the eflows template to the IKP. Making the IKP publicly available online would further enhance its visibility and provide an incentive for projects to publish their results on the IKP website.

Despite voluntary updates, it is recommended to periodically update the eflow repository through a dedicated consultancy or as part of another project in order to ensure that the repository is kept up to date and respectively remains useful.

The repository shows that so far a limited number of eflow studies have been conducted in the Nile basin and that in some countries no studies have been carried out at all, despite significant ecosystems and ecosystem services being dependent on environmental flows. It is recommended to respectively promote eflow studies specifically in those countries and regions where so far no eflow studies have been conducted.

The eflow studies described in the repository are in manycases suffering from a lack of data and information, limiting their level of confidence and leading to uncertainties of the results. It is respectively recommended to conduct a detailed gap analysis and setup monitoring initiatives that will allow for future better eflow studies by providing actual and up to date data. Such monitoring initiative would be essential to improve future eflow study results (as well as a variety of other assessments considering future development planning).

Annex : Tabulated repository information (without data tables)

Tanzania

ID	1.1
1. Title of study	Assessing Reserve Flows for the Mara River (Assessing Reserve Flows for the Mara River Kenya and Tanzania)
2. Year of study	2010
3. River stretch that was studied	Mara River Tanzanian side which is Located near the Mara Bridge on the border between the Masai Mara National Reserve and Serengeti National Park. Because this site is within the two major protected areas of Kenya and Tanzania, the only land use in the vicinity is wildlife rangeland and the only economic activity is tourism.
4. Who did the study (consultant)	LVBC & WWF-ESARPO
5. Who financed the study (donor)	The United States Agency for International Development-East Africa (USAID-EA)
6. Who was the implementing agency	Lake Victoria Basin Commission with other partners Global Water for Sustainability (GLOWS) Program and the WWF-Eastern and Southern Africa Regional Programme Office (WWF-ESARPO)
7. Who now holds the data	Lake Victoria Basin Commission
8. Methodology used (short description)	The Building Block Methodology. This Mara EFA was launched during an initial workshop in 2006 convened to provide technical guidance on the methodology to an international team of specialists recruited to undertake the analytical components of the assessment.
9. Methodology details	Reconnaisance: with Scoping, Habitat integrity Conservation importance, Geomorphological assessment, Define study area and site selection, Biological survey, Social surveys, Water quality assessment. Pre-feasibility: with Hydraulic analysis, Hydrological analysis, Starter documents, Stakeholder participation, Site visit, Set EMC, Specialist work session, EFR mode. Site selection began with geomorphological surveys that classified the river into three uniform macro-reaches based on gradient, channel pattern and bed structure. During initial field visits, the multidisciplinary group of specialists chose a representative site for each macro-reach. The selected sites exhibit fluvial processes characteristic of the macro-reach, as well as represent the interests of multiple stakeholders in the basin. Additionally, these sites incorporate small-scale habitat diversity; as such, all sites were placed on 100 meter-long, straight stretches of the river that included runs, pools and riffles. Classification of Sites to Present Ecological State and Resource Quality Objectives. In order to appropriately target management activities, the Lake Victoria South Catchment Management Strategy identifies Resource Quality Objectives (RQOs) for each of the catchment's major river basins. These RQOs are determined according to natural hydrological boundaries, social and economic development patterns and communal interests of the people. The water resources are classified as being of high (1), medium (2) or low (3) importance to ecology (E), livelihood (L) and commercial development (C). According to this strategy, the Upper Mara was categorized E1L2C3, indicating the area is of high importance for ecological concerns related to water resources management, medium importance for livelihoods acknowledging the importance of small-scale subsistence farming, and relatively low importance for commercial development. The Lower Mara was ranked E1L2C2, indicating a high importance for ecological purposes, and medium importance for livelihood activities, with a majority of the population still dependent of water resources for subsistence farming; however, commercial activity is also of medium importance, acknowledging the importance of tourism and larger scale farming enterprises. To align the EFA process with the catchment management strategy in targeting management strategies, physical and biological components at each site were ranked according to their present and desired ecological state. Present Ecological State (PES) recognizes the natural, or reference, conditions at each site and includes a judgment of

how far each site has changed from those conditions. Sites could be ranked from A (natural) to F (critical/extremely modified). Then sites were assigned a Trajectory of Change, indicating whether each component was getting better or worse under the current river management regime. Sites were also classified according to their Ecological Importance and Sensitivity (EIS), indicating their importance for maintenance of ecological diversity and system functioning on local and wider scales, their ability to resist disturbance and their capability to recover from disturbance. Finally, sites were assigned an Ecological Management Category (EMC), summarizing the overall objective or desired state for each site. Sites could be ranked from A (natural) to D (largely modified); categories E and F were excluded from consideration because they were not considered sustainable. Although categories varied somewhat among site components, the summary for all three sites was the same. The PES at all study sites was ranked as B, indicating some degree of modification from the natural state. Furthermore, all sites were found to be declining in quality under the current management regime. This is cause for concern, as all sites were also ranked Very High in their EIS. Pristine conditions are not likely to be achievable in this system given its importance to the Livelihood sector; however, the RQO's for both the Upper and Lower Mara indicate high ecological importance. Thus, an EMC of category B was chosen, suggesting management actions act to maintain current levels of system structure and functioning and to prevent further modification and degradation.

10. Parameters considered

Hydrology - provides information on the past and present flow regime of the river. Hydraulics - provides information on how discharge, width, depth, wetted perimeter and velocity are related in the river reaches. Geomorphology - provides information on the shape of the river channel and accumulation of sediments arising from fluvial processes such as erosion, transport and deposition. Water Quality - the present characteristics of the river and considers the influences of altered flow levels on the presence and concentration of compounds that could be harmful to humans and aquatic life. Riparian Vegetation - is a good indicator of both low flow and high flow requirements. Individual species have different and often highly specific inundation and soil moisture requirements for their regeneration. Macro-invertebrates - Aquatic invertebrates are very sensitive indicators of water quality and flow regime in rivers and overall ecological health of the system. Fish - fish populations are excellent indicators of river health in terms of water quantity and quality, which in turn provides other important services to people. Social Indicators - The upper reaches of the Mara River Basin have the highest population densities and the majority of people living there depend on small-scale agriculture and animal husbandry. In the middle reaches of the Mara, the main livelihoods are nomadic pastoralism or participation to some degree in the tourism industry, although there is also commercial agriculture in this region. The lower reaches of the Mara River in Kenya pass through Masai Mara National Reserve. As this is a protected area, human population is limited and clustered around hotels and lodges. Crossing into Tanzania the river supports Serengeti National Park and then flows through a region of mixed small-scale agriculture and pastoralism. Communities living adjacent to the Mara Swamp also depend upon fish harvested from the wetland system. A large proportion of people in the Mara River Basin live below the poverty level.

11. Results (short description)

At Site 3 on the border between Kenya – Tanzania and Masai Mara National Reserve – Serengeti National Park, the reserve accounts for, on average, 35% of the average monthly flow recorded over the 26 years of available flow data from the nearest gauging station.

12. Results (tabulated)

Site 3 on the border between Kenya - Tanzania and Masai Mara National Reserve - Serengeti National Park

13. Executive Summary of original report

The Kenya Ministry of Water and Irrigation (MOWI), formed in 2003, has as its fundamental goal conserving, managing and protecting water resources for socioeconomic development. In 2002, the Water Act was passed to provide for the management, conservation, use and control of water resources and for the acquisition and regulation of rights to use water. The Tanzania Ministry of Water and Irrigation was formed in 2005 to ensure that water resources are developed and managed sustainably in collaboration with all stakeholders and to facilitate participatory irrigation. In 2008, Tanzania passed the Water Resources Management Act to provide for a legal and institutional framework for sustainable management and development of water resources, to outline principles for water resources management, to make provisions for prevention and control of water pollution, and to provide for participation of stakeholders and the implementation of the National Water Policy. Within both the Kenya Water Act (2002) and the Tanzania Water Resources Management Act (2008), reserve flows were defined as that quantity and quality of water necessary to satisfy basic human need and to protect aquatic ecosystems, and they were given the first priority in water resource allocation. Under these laws, the water authorities of Kenya and Tanzania are obligated to establish reserve flows for the Mara River in order to guarantee sufficient flows at all times to meet basic human water needs and protect ecosystems for their critical goods and services, which underpin sustainable development. Environmental Flow Assessments (EFAs) are becoming the global standard for determining the amount of water required to sustain aquatic ecosystems and satisfy basic human needs, accounting for both components of the reserve. The responsibility for establishing and maintaining the reserve in the Mara River lies with the Lake Victoria South Catchment Area of the Kenya Water Resource Management Authority and the Lake Victoria Basin Water Office of the Tanzania Ministry of Water and Irrigation. This study is a joint effort by the Kenyan and Tanzanian water authorities, under the auspices of the Lake Victoria Basin Commission of the East African Community and in cooperation with NGO and university partners, to establish the reserve flow for the Mara River in the section of the river extending from the Mau Forest to the protected areas of the Serengeti-Masai Mara ecosystem. The reserve refers to both the quantity and quality of river flows, and it has highest priority in water allocation plans. Thus, allocations of water for agriculture, industry, and municipal supplies exceeding 25 litres per day per person should be made only from the portion of flow in excess of the reserve. Under severe low-flow conditions, allocations for these uses may need to be curtailed or temporarily halted in order to maintain the reserve flow. The immediate establishment and implementation of the reserve in the Mara River is critical due to increasing extractive demands, especially during droughts, and threats to basic water needs of Mara residents and to the basin’s world-renowned biodiversity. The human population in the Mara River Basin is estimated to be growing at an annual rate of more than 3%. This has been accompanied by a greater than 50% increase in agricultural lands in the last two decades at the expense of nearly a quarter of the basin’s forests and grasslands. In addition to the associated effects of deforestation, water abstractions for livestock, agricultural irrigation and other industries are on the rise. The Mara is not a large river, and the ever increasing abstractions are certain to, at some point in the future, severely degrade the riverine ecosystem and even impinge upon the most basic water needs of people living along the river. The effects of such a dry down would be profound, both to people, livestock, wildlife, and the basin’s economy. It could very likely, for example, cause a crash in the wildebeest population, leading to a breakdown in the entire migration cycle that sustains the Serengeti-Masai Mara ecosystem. The implications of a disruption to such a significant natural process are far-reaching. The reserve flow was determined by a team of Kenyan, Tanzanian, and international scientists using a structured, science-based approach to determine how much water must be left in the river to protect the aquatic ecosystems and meet resource quality objectives. The Building Block Methodology was applied. This method was developed in South Africa during the 1990s and is among the most robust and widely applied holistic methods that address both the structure and function of all components of the river ecosystem. The assessment of the reserve flow was launched during an initial workshop in 2006 convened to provide technical guidance on the methodology to a team of specialists recruited to carry out the analytical components of the assessment. Specialists included a geomorphologist, hydrologist, hydraulic engineer, aquatic ecologist, riparian ecologist, water quality specialist, and socio-economist. The team of specialists identified three appropriate study sites in distinct geomorphological reaches of the basin and conducted site assessments of physical, biological and social indicators during low and medium flows in 2007. Status of critical indicators was related to in stream flow levels using hydrological and hydraulic analysis. The findings of each specialist were used to determine a modified flow regime for the river that would serve as the reserve. The assessment found that during years of normal rainfall the reserve is easily met and ample river water is available for extractive uses. At Site 3 on the border between Kenya–Tanzania and Masai Mara National Reserve–Serengeti National Park, the reserve accounts for, on average, 35% of the average monthly flow recorded over the 26 years of available flow data for the river near that site. At Site 1 on the Amala River, the recommended reserve flow levels account for 25% on average of recorded flows during maintenance years. It is important to note, however, that the percent of flow held in the reserve varies over the course of a year, mirroring the natural highs and lows of the system. The majority of water available for abstraction is therefore concentrated in a few months when flows are high. Far less water is available for abstraction during dry season months. The situation during drought years is quite different, as the assessment found that, presently, the reserve is not being met during several months of the year at Sites 1 and 2. The observation that drought year reserve flows are not being met in the upper and middle reaches of the Mara may be the first clear evidence of a trend toward unacceptable alterations of the Mara River's flow regime. Upstream impacts are necessarily linked to downstream resources, and poorly managed water abstraction above the wildlife reserves will ultimately affect the downstream reaches as well. The Mara River currently has no major dams acting to significantly modify its flow regime. Thus, reserve flow prescriptions must be achieved by improving management of the catchment and controlling permits for abstractions. The unequal distribution of flows throughout the year also poses the challenge of developing and implementing sustainable technologies for harvesting and storing wet season runoff for consumptive use during dry months. Monitoring of flows and abstraction levels will be critical to determine the current state of the reserve and the amount available for further consumptive use. Because the Mara is a trans-boundary river, these efforts must be closely coordinated between responsible institutions in the two countries. The reserve estimates in this assessment have not taken into account the environmental flow requirements of the Mara Swamp, which may be different. The reserve also does not include flow volumes necessary to meet the extractive water needs of Tanzanian communities and industries between Serengeti National Park and the Mara Swamp. Thus, flow levels reaching Tanzania must be high enough not only to sustain the reserve but also to meet Tanzanian extractive water needs. This assessment for the Mara River has applied a structured and scientifically sound process for determining the requirements of the reserve flow and thus is an essential step towards estimating the amount of water available for consumptive use. It is important to note that this is a first assessment of the reserve based on the best available data and expertise of the scientific team. Continued monitoring of the river's flow levels and ecological status will be critical to determine if the prescribed flow regime is sufficient, if more water needs to be set aside for the reserve, or if more water can be permitted for consumptive use.

ID	1.2
1. Title of study	Environmental Flow Recommendations for Reserve Flows in the Mara River, Kenya and Tanzania
2. Year of study	2012
3. River stretch that was studied	Site 3 – Mara River at Kenya-Tanzania Border: Location: Border between Kenya and Tanzania, and the Maasai Mara National Reserve and Serengeti National Park, just downstream of the Purungat Bridge. Land Use: Wildlife grazing and tourism.... Site 4 – Mara River at Kogatende: Location: Inside the Serengeti National Park 2 km downstream from the Kogatende Rangers' Station. Land Use: Wildlife grazing and tourism.... Site 5 – Mara River at Mara Min: Location: In Tanzania at the gauging station 5H2, Mara Mines, south of Murito Village and north of the Mara Wetland. Land Use: Moderate levels of farming and livestock grazing with large-scale and artisanal gold

	mining nearby
4. Who did the study (consultant)	LVBC.
5. Who financed the study (donor)	U.S. Agency for International Development (USAID)
6. Who was the implementing agency	Lake Victoria Basin Commission with other partners Global Water for Sustainability (GLOWS) Program and the WWF-Eastern and Southern Africa Regional Programme Office (WWF-ESARPO)
7. Who now holds the data	Lake Victoria Basin Commission (LVBC)
8. Methodology used (short description)	The Mara EFA team elected to use the Building Block Methodology (BBM), which is widely used in Africa and provides reliable environmental flow recommendations with minimum data requirements (King et al. 2000). Two of the primary advantages of the BBM are 1) it recognizes the importance of a variable flow regime and 2) it prescribes quantitative flow targets for different periods of the year. Rivers are very dynamic systems, and both low and high flows, and even floods and droughts, play important roles in their ecological function. The BBM method first brought together a team of specialists comprised of a social scientist, hydrologist, hydraulics engineer, fluvial, water quality specialist, riparian vegetation specialist, fish specialist and macro-invertebrate specialist. Specific tasks undertaken were;
9. Methodology details	Study site selection: The selected sites exhibit fluvial processes characteristic of the macro-reach, as well as represent the interests of multiple stakeholders in the basin. Additionally, these sites incorporate small-scale habitat diversity; as such, all sites were placed on 100 meter-long, straight stretches of the river that included runs, pools and riffles. At site-3 visit was conducted during March 26-31, 2007, to capture low flows and during July 16-21, 2007, to capture high flows. Due to unexpected rains, low flows were not captured during these sampling periods, so these sites were re-assessed for low flows from 21- 24 February, 2009. At Sites 4 and 5, field visits were conducted during 7-10 February, 2012, to capture low flows, and during 8-12 May, 2012, to capture high flows. Social Indicators: Participatory surveys were conducted in communities nearby each study site. Physical Indicators: Hydrology - in order to determine historic patterns of flow in the Mara and its tributaries, historic rainfall and discharge records were obtained for the basin. Rainfall and stream flow records were used to develop indices for hydro meteorological extremes (droughts and floods) across the basin over the period of record. The Standardized Precipitation Index (SPI) and the Effective Drought Index (EDI) were used to determine hydro-meteorological extremes, and the Stream flow Drought Index (SDI) and the Normalized Runoff Index (NRI) were used to determine hydrological extremes. Individual months of each year of record were analyzed according to these indices, and the resulting patterns were used to determine average monthly flow during both normal and drought years. The indices were also used to determine frequency of floods and droughts. Hydraulic - Hydraulic cross-sections were established along 65-200 meter reaches at each site in order to capture variability in habitat types and hydraulic regimes. Each site included 4-6 transects. through sections of riffles, pools and runs. Hydraulic models were developed to relate discharge to the other measured flow parameters, a HEC-RAS model was used on the basis of issues of data availability. During the low flow assessment at each site, morphological features along each cross-section were identified and described in terms of substrate material, degree of erosion and deposition and frequency of inundation. Sediments were sampled for particle-size distribution analysis, and median particle size was used to identify the velocity required to mobilize sediments. Water Quality - In order to evaluate overall water quality in the basin and identify potential threats, a water quality survey was done throughout the length of the Mara River Basin in May-June, 2005 and 2006, and the findings were incorporated into the EFA. Vegetation - Vegetation surveys were conducted in sample plots placed along transects running perpendicular to the river bed. Macro invertebrates - Macro-invertebrates at each site were analyzed according to number of taxa and

number of individuals. Taxa and sites were also characterized using the South African Sensitivity Score (SASS) and Average Score Per Taxon (ASPT), a scale from 1-15, in which a higher value indicates the taxa or community's overall sensitivity to water quality (Dickens and Graham 2002). Fish - In 2012, Sites 4-5 were surveyed using gill nets in deeper sections and a seine net and electro shocker in shallower sections. Flow Setting Workshop - This involved classification of Sites: Ecological Management Category and Determining Reserve Flows.

10. Parameters considered	Physical Indicators: Hydrology, Hydraulics, Geomorphology, Water Quality. Biological Indicators: Riparian Vegetation, Aquatic macro-invertebrates, Fish
11. Results (short description)	Reserve Flow Recommendations: At Site 3, on the border between Kenya – Tanzania and Masai Mara National Reserve – Serengeti National Park, maintenance year reserve flows account for 45% of mean annual runoff and are exceeded on average 61% of the time. Average available discharge exceeds maintenance year reserve flows throughout the year, leaving sufficient water available for extraction. Drought year reserve flows account for 15% of mean annual runoff and are exceeded on average 86% of the time. Drought year reserve flows only exceed available discharge slightly in November, although very little water is available for extraction throughout the rest of the year. At Site 4, inside the Serengeti National Park, maintenance year reserve flows account for a total of 54% of mean annual runoff and are exceeded on average 61% of the time. Maintenance year reserve flows exceed average available discharge over all months, leaving sufficient water available for extraction. Drought year reserve flows account for 11% of mean annual runoff and are exceeded on average 86% of the time. Drought year reserve flows only exceed available discharge slightly in November, but more water is available for extraction from March to September. At Site 5, near Mara Mines in Tanzania, maintenance year reserve flows account for a total of 42% of mean annual runoff and are exceeded on average 61% of the time. Maintenance year reserve flows exceed average available discharge over all months, leaving sufficient water available for extraction. Drought year reserve flows account for 8% of mean annual runoff and are exceeded on average 86% of the time. Similar to Site 4, drought year reserve flows only exceed available discharge slightly in November, but more water is available for extraction from March to September.
12. Results (tabulated)	Environmental flow requirements for Site 3 in the lower Mara River Basin. FDC- Flow Duration Curve; MCM- million cubic meters; MAR- median annual runoff
13. Executive Summary of original report	Both the Kenyan and Tanzanian national water policies and laws call for protection of a reserve n all aquatic ecosystems (GoK 2002, 2007; URT 2002, 2009). The reserve is generally defined as he minimum water levels that must be left in the system in order to sustain, as a first priority, basic human needs and aquatic ecosystems. These policies and laws recognize that healthy river systems require minimum flow levels to be sustained, but that rivers in turn provide a multitude of ecosystem services for communities, including clean drinking water, food, building materials, and religious and cultural roles. Environmental Flow Assessments (EFAs) have become the scientifically accepted way of determining minimum flow levels needed to sustain healthy rivers. EFAs are structured, science-based approaches that combine hydrological information about a river system with social, physical and biological indicators to determine the minimum sustainable flow levels needed to maintain all components of the river ecosystem. EFAs recognize that rivers have natural periods of both high and low flows, and that these variations play important roles in river ecosystem functioning and thus should be protected as components of the reserve. In 2006, the Transboundary Water for Biodiversity and Human Health in the Mara River Basin (TWB-MRB) project, implemented under the Global Water for Sustainability Program (GLOWS) with funding from the U.S. Agency for International Development (USAID), began the process of developing an EFA for the Mara River Basin, Kenya and Tanzania. This undertaking was a collaborative effort between Florida International University (FIU) and WWF Eastern and Southern Africa Regional Programme Office (WWF-ESARPO), and it was done in partnership with the Lake Victoria Basin Commission (LVBC) of the East African

Community, Kenyan and Tanzanian water resource managers, regional and international scientists, and other stakeholders in the basin. The Mara River, a trans-boundary river shared between Kenya and Tanzania, was selected as the site for this effort due to the tremendous social, biological and economic value the river has for both countries, as well as the current threats facing the river and the people and ecosystems that rely upon it. Deforestation, over-grazing by livestock, unregulated extraction of water and untreated inputs of sewage and solid waste all threaten the quantity and quality of water provided by the Mara River, which are critical to maintaining all the other ecosystem services upon which people and wildlife in the basin rely. Currently, the Mara is still flowing and in good condition, which makes this the perfect time to put in place measures to ensure this state into the future. The EFA process for the Mara River began in 2006 and consisted of several phases: an assessment of key sites in the upper and middle reaches of the basin, additional surveys in the upper and middle reaches during critical low flow periods to determine the sufficiency of preliminary EFA recommendations, and assessment of key sites in the lower portion of the basin. This present EFA report for the Mara River Basin represents a synthesis of the past six years of work conducted in the Mara River Basin, and presents major findings and environmental flow recommendations from all phases of EFA work for the entire Mara River Basin, Kenya and Tanzania. The Building Block Methodology (BBM) was applied in determining environmental flows for the Mara River. This method involves a team of specialists comprised of a social scientist, hydrologist, hydraulics engineer, fluvial geomorphologist, water quality specialist, riparian vegetation specialist, fish specialist, and macroinvertebrate specialist. This team selected representative sites in distinct reaches of the basin; surveyed social, physical and biological characteristics of the river as a function of flow levels; and evaluated their dynamics during low and high flow events. The scientists relied on critical indicators to suggest minimum sustainable flow levels for each component of the river ecosystem during different "building blocks" of the river's hydrograph. Flow recommendations were made for both drought years, when flows are needed to just sustain river function at base levels, and for maintenance years, when normal river processes should be occurring. The final EFA prescription is a modified flow regime on a month by month basis that can be presented as a set of flow targets for water resource managers. This EFA found that there is sufficient water in the Mara River during years of normal rainfall to allow for water extraction throughout the year at all sites. At Site 1 on the Amala River, the recommended Reserve flow levels account for 28% of mean annual runoff during maintenance years. At Site 3 on the border between Kenya – Tanzania and Masai Mara National Reserve – Serengeti National Park, the Reserve accounts for 45% of mean annual runoff. At Site 5, the reserve accounts for an average of 42% of mean annual runoff. It is important to note, however, that the percent of flow held in the reserve varies over the course of a year, mirroring the natural highs and lows of the system. The majority of water available for abstraction is therefore concentrated in the months when flows are highest. During drought years, the situation is quite different. Recommended reserve flows exceed the historical average flows for three months at Site 1, two months at Site 2, and one month at Sites 3-5, and they leave little water available for extraction during the remaining months, particularly at Sites 1 and 3. The observation that drought year reserve flows, particularly in the upper and middle reaches of the Mara, may be the first clear evidence of a trend toward unacceptable alterations of the Mara River's flow regime. There could be several explanations for the difference between environmental flow recommendations and average drought year flows. First, determination of environmental flows should be an ongoing process that relies on the cautionary principle to protect sufficient minimum flows; however, continued monitoring could reveal that required reserve levels are lower than prescribed here. Second, the prescribed reserve levels could prove to be accurate, but levels of extraction could be unsustainably high during dry seasons of drought years and need to be reduced. Third, prescribed reserve levels could be accurate and abstraction levels could be reasonable, but land-use practices in the basin may have sufficiently altered the hydrograph of the river such that dry season drought year low flows are unnaturally low, suggesting that land rehabilitation in the upper catchment is necessary for the reserve to be restored. This EFA did not take into account the water needs of the Mara Wetland, which may be different. Additional surveys should be done in that critical ecosystem to ensure sufficient reserve flows are available to maintain its ecosystem function. This EFA is also a living document that should be updated as needed as the river continues to be monitored and determinations are made if sufficient water quantity and quality is being provided to maintain desired ecosystem services. In order to implement the findings of this EFA and to protect reserve flows in the Mara River Basin, several key recommendations were proposed: 1) use EFA recommendations to determine allowable water extraction permit levels; 2) monitor discharge and extraction levels in the river in order to reduce extractions if the reserve is threatened; 3) develop small-scale, off-catchment storage capacity to capture high flows for use during low flow periods; 4) develop capacity of both water resource managers and community Water Resource User's Associations (KE) and Water User's Associations (TZ) to monitor and protect reserve flows; 5) decrease land degradation, particularly in riparian areas, to promote natural water storage and maintain higher flows in dry seasons. The recommendations of this EFA have been adopted and recommended for implementation by the Lake Victoria Basin Council of Ministers of the East African Community. This document represents a tremendous effort on the part of many concerned stakeholders to protect and provide for a healthy, flowing Mara River. As one of the first trans-boundary EFAs to be completed and adopted by a regional governing body, the Mara River EFA has already been a tremendous success. However, the true measure of its success will take place on the ground, over the scale of many years to come, as the Mara River continues to provide a functioning ecosystem, to the equal benefit of both the people and natural ecosystems that depend upon it.

ID	1.3
1. Title of study	Environmental Flow Recommendations for Reserve Flows in the Mara River (Kenya and Tanzania)
2. Year of study	2012
3. River stretch that was studied	Mara River
4. Who did the study (consultant)	Global Water for Sustainability Program - Florida International University
5. Who financed the study (donor)	USAID
6. Who was the implementing agency	LVBC
7. Who now holds the data	
8. Methodology used (short description)	The EFA process for the Mara River began in 2006 and consisted of several phases: an assessment of key sites in the upper and middle reaches of the basin, additional surveys in the upper and middle reaches during critical low flow periods to determine the sufficiency of preliminary EFA recommendations, and assessment of key sites in the lower portion of the basin.
9. Methodology details	The Building Block Methodology (BBM) was applied in determining environmental flows for the Mara River. This method involves a team of specialists comprised of a social scientist, hydrologist, hydraulics engineer, fluvial geomorphologist, water quality specialist, riparian vegetation specialist, fish specialist, and macroinvertebrate specialist. This team selected representative sites in distinct reaches of the basin; surveyed social, physical and biological characteristics of the river as a function of flow levels; and evaluated their dynamics during low and high flow events. The scientists relied on critical indicators to suggest minimum sustainable flow levels for each component of the river ecosystem during different "building blocks" of the river's hydrograph. Flow recommendations were made for both drought years, when flows are needed to just sustain river function at base levels, and for maintenance years, when

normal river processes should be occurring. The final EFA prescription is a modified flow regime on a month by month basis that can be presented as a set of flow targets for water resource managers.

10. Parameters considered

This EFA found that there is sufficient water in the Mara River during years of normal rainfall to allow for some water extraction throughout the year at all sites. At Site 1 on the Amala River, the recommended Reserve flow levels account for 28% of mean annual runoff during maintenance years. At Site 3 on the border between Kenya – Tanzania and the Masai Mara National Reserve – Serengeti National Park, the Reserve accounts for 45% of mean annual runoff. At Site 5, the reserve accounts for an average of 42% of mean annual runoff. It is important to note, however, that the percent of flow held in the reserve varies over the course of a year, mirroring the natural highs and lows of the system. The majority of water available for abstraction is therefore concentrated in the months when flows are highest. During drought years, the situation is quite different. Recommended reserve flows exceed the historical average flows for three months at Site 1, two months at Site 2, and one month at Sites 3-5, and they leave little water available for extraction during the remaining months, particularly at Sites 1 and 3. The observation that recommended drought year reserve flows leave little water available, particularly in the upper and middle reaches of the Mara, may be the first clear evidence of a trend toward unacceptable alterations of the Mara River's flow regime. There could be several explanations for the difference between environmental flow recommendations and average drought year flows. First, determination of environmental flows should be an ongoing process that relies on the cautionary principle to protect sufficient minimum flows; however, continued monitoring could reveal that required reserve levels are lower than prescribed here. Second, the prescribed reserve levels could prove to be accurate, but levels of extraction could be unsustainably high during dry seasons of drought years and need to be reduced. Third, prescribed reserve levels could be accurate and abstraction levels could be reasonable, but land-use practices in the basin may have sufficiently altered the hydrograph of the river such that dry season drought year low flows are unnaturally low, suggesting that land rehabilitation in the upper catchment is necessary for the reserve to be restored.

11. Results (short description)

12. Results (tabulated)

Environmental Flow Requirements for Site 1 in the upper Mara River Basin

13. Executive Summary of original report

Both the Kenyan and Tanzanian national water policies and laws call for protection of a reserve in all aquatic ecosystems (GoK 2002, 2007; URT 2002, 2009). The reserve is generally defined as the minimum water levels that must be left in the system in order to sustain, as a first priority, basic human needs and aquatic ecosystems. These policies and laws recognize that healthy river systems require minimum flow levels to be sustained, but that rivers in turn provide a multitude of ecosystem services for communities, including clean drinking water, food, building materials, and religious and cultural roles. Environmental Flow Assessments (EFAs) have become the scientifically accepted way of determining minimum flow levels needed to sustain healthy rivers. EFAs are structured, science-based approaches that combine hydrological information about a river system with social, physical and biological indicators to determine the minimum sustainable flow levels needed to maintain all components of the river ecosystem. EFAs recognize that rivers have natural periods of both high and low flows, and that these variations play important roles in river ecosystem functioning and thus should be protected as components of the reserve. In 2006, the Transboundary Water for Biodiversity and Human Health in the Mara River Basin (TWB-MRB) project, implemented under the Global Water for Sustainability Program (GLOWS) with funding from the U.S. Agency for International Development (USAID), began the process of developing an EFA for the Mara River Basin, Kenya and Tanzania. This undertaking was a collaborative effort between Florida International University (FIU) and WWF Eastern and Southern Africa Regional Programme Office (WWF-ESARPO), and it was done in partnership with the Lake Victoria Basin Commission (LVBC) of the East

African Community, Kenyan and Tanzanian water resource managers, regional and international scientists, and other stakeholders in the basin. The Mara River, a trans-boundary river shared between Kenya and Tanzania, was selected as the site for this effort due to the tremendous social, biological and economic value the river has for both countries, as well as the current threats facing the river and the people and ecosystems that rely upon it. Deforestation, over-grazing by livestock, unregulated extraction of water and untreated inputs of sewage and solid waste all threaten the quantity and quality of water provided by the Mara River, which are critical to maintaining all the other ecosystem services upon which people and wildlife in the basin rely. Currently, the Mara is still flowing and in good condition, which makes this an opportune time to put in place measures to ensure this state into the future. The EFA process for the Mara River began in 2006 and consisted of several phases: an assessment of key sites in the upper and middle reaches of the basin, additional surveys in the upper and middle reaches during critical low flow periods to determine the sufficiency of preliminary EFA recommendations, and assessment of key sites in the lower portion of the basin. This present EFA report for the Mara River Basin represents a synthesis of the past six years of work conducted in the Mara River Basin, and presents major findings and environmental flow recommendations from all phases of EFA work for the entire Mara River Basin, Kenya and Tanzania. The Building Block Methodology (BBM) was applied in determining environmental flows for the Mara River. This method involves a team of specialists comprised of a social scientist, hydrologist, hydraulics engineer, fluvial geomorphologist, water quality specialist, riparian vegetation specialist, fish specialist, and macroinvertebrate specialist. This team selected representative sites in distinct reaches of the basin; surveyed social, physical and biological characteristics of the river as a function of flow levels; and evaluated their dynamics during low and high flow events. The scientists relied on critical indicators to suggest minimum sustainable flow levels for each component of the river ecosystem during different "building blocks" of the river's hydrograph. Flow recommendations were made for both drought years, when flows are needed to just sustain river function at base levels, and for maintenance years, when normal river processes should be occurring. The final EFA prescription is a modified flow regime on a month by month basis that can be presented as a set of flow targets for water resource managers. This EFA found that there is sufficient water in the Mara River during years of normal rainfall to allow for some water extraction throughout the year at all sites. At Site 1 on the Amala River, the recommended Reserve flow levels account for 28% of mean annual runoff during maintenance years. At Site 3 on the border between Kenya – Tanzania and the Masai Mara National Reserve – Serengeti National Park, the Reserve accounts for 45% of mean annual runoff. At Site 5, the reserve accounts for an average of 42% of mean annual runoff. It is important to note, however, that the percent of flow held in the reserve varies over the course of a year, mirroring the natural highs and lows of the system. The majority of water available for abstraction is therefore concentrated in the months when flows are highest. During drought years, the situation is quite different. Recommended reserve flows exceed the historical average flows for three months at Site 1, two months at Site 2, and one month at Sites 3-5, and they leave little water available for extraction during the remaining months, particularly at Sites 1 and 3. The observation that recommended drought year reserve flows leave little water available, particularly in the upper and middle reaches of the Mara, may be the first clear evidence of a trend toward unacceptable alterations of the Mara River's flow regime. There could be several explanations for the difference between environmental flow recommendations and average drought year flows. First, determination of environmental flows should be an ongoing process that relies on the cautionary principle to protect sufficient minimum flows; however, continued monitoring could reveal that required reserve levels are lower than prescribed here. Second, the prescribed reserve levels could prove to be accurate, but levels of extraction could be unsustainably high during dry seasons of drought years and need to be reduced. Third, prescribed reserve levels could be accurate and abstraction levels could be reasonable, but land-use practices in the basin may have sufficiently altered the hydrograph of the river such that dry season drought year low flows are unnaturally low, suggesting that land rehabilitation in the upper catchment is necessary for the reserve to be restored. This EFA did not take into account the water needs of the Mara Wetland, which may be different. Additional surveys should be done in that critical ecosystem to ensure sufficient reserve flows are available to maintain its ecosystem function. This EFA is also a living document that should be updated as needed as the river continues to be monitored and determinations are made if sufficient water quantity and quality is being provided to maintain desired ecosystem services. In order to implement the findings of this EFA and to protect reserve flows in the Mara River Basin, several key recommendations were proposed: 1) use EFA recommendations to determine allowable water extraction permit levels; 2) monitor discharge and extraction levels in the river in order to reduce extractions if the reserve is threatened; 3) develop small-scale, off-catchment storage capacity to capture high flows for use during low flow periods; 4) develop capacity of both water resource managers and community Water Resource User's Associations (KE) and Water User's Associations (TZ) to monitor and protect reserve flows; 5) decrease land degradation, particularly in riparian areas, to promote natural water storage and maintain higher flows in dry seasons. The recommendations of this EFA have been adopted and recommended for implementation by the Lake Victoria Basin Council of Ministers of the East African Community. This document represents a tremendous effort on the part of many concerned stakeholders to protect and provide for a healthy, flowing Mara River. As one of the first trans-boundary EFAs to be completed and adopted by a regional governing body, the Mara River EFA has already been a tremendous success. However, the true measure of its success will take place on the ground, over the scale of many years to come, as the Mara River continues to provide a functioning ecosystem, to the equal benefit of both the people and natural ecosystems that depend upon it.

ID	1.4
1. Title of study	Critical analysis of environmental flow assessments of selected rivers in Tanzania and Kenya
2. Year of study	2011
3. River stretch that was studied	Selected Rivers in Tanzania and Kenya
4. Who did the study (consultant)	Chris Dickens
5. Who financed the study (donor)	various
6. Who was the implementing agency	IUCN
7. Who now holds the data	
8. Methodology used (short description)	
9. Methodology details	
10. Parameters considered	
11. Results (short description)	Tabulated on monthly basis in report
12. Results (tabulated)	Tabulated on monthly basis in report
13. Executive Summary of original report	

ID	1.5

1. Title of study	Comparing flow regime, channel hydraulics, and biological communities to infer flow-ecology relationshops in the Mara River of Kenya and Tanzania
2. Year of study	2014
3. River stretch that was studied	Mara River
4. Who did the study (consultant)	McClain et al.
5. Who financed the study (donor)	n/a
6. Who was the implementing agency	n/a
7. Who now holds the data	
8. Methodology used (short description)	
9. Methodology details	
10. Parameters considered	Hydrology, ecology
11. Results (short description)	
12. Results (tabulated)	
13. Executive Summary of original report	

<u>Kenya</u>

ID	2.1
1. Title of study	Variation of flow of water from Rivers Nzoia, Yala and Sio into Lake Victoria
2. Year of study	2011
3. River stretch that was studied	Nzoia, Yala, Sio and North Awach Rivers
4. Who did the study (consultant)	Sangale Felix, Okungu John, and Opango Peterlis
5. Who financed the study (donor)	Lake Victoria Environmental Project management (World Bank and USAID)
6. Who was the implementing agency	EAC
7. Who now holds the data	East African Community's institutional repository
8. Methodology used (short description)	NAM hydrological model. NAM is a lumped, conceptual rainfall – run-off model, simulating the overland flow, inter-flow and base flow components of the moisture contents in four storages. NAM hydrological model simulates the rainfall-runoff processes occurring at the catchment scale
9. Methodology details	
10. Parameters considered	Hydrological, metrological
11. Results (short description)	River Nzoia has a catchment area of 12,842 km2, a length of 355 Km and a mean discharge of 118 m3/s • River Yala has a catchment area of 3,351 km2, a length of 261 Km and a mean discharge of 27.4 m3/s • River Sio has a catchment area of 1,437 km2, a length of

	km and a mean discharge of 12.1 m3/s. North Awach Rivers have a catchment area of 1,985 km2 and a mean discharge of 3.8 m3/s.
12. Results (tabulated)	
13. Executive Summary of original report	The continuous collection of both hydrological and Meteorological data has been a problem in most areas of the world. Therefore, such data normally have gaps in the time series. For proper water quality management of any river or lake basin there must be a basis for quantification of pollution loads transported in the water. This is only possible if discharge data is known for the duration of study. In order to fill gaps existing in such data, a modelling approach can be employed to generate the missing data. An appropriate model must therefore be used in such cases. The changes in discharge depend on precipitation but can also be heavily influenced by various activities in the catchment. Estimation of flow for rivers Sio, Nzoia and Yala draining the northern catchment of the Kenyan basin of Lake Victoria was carried out for a 50-year period. This study used the NAM hydrological model in order to fill in the missing data for a time series and estimate the flow. In order to generate initial continuous rainfall data for a minimum of 5 years, employing a double mass curve technique using the data measured at different stations did a correlation. Lake level (stage) was used to estimate rainfall for the gaps after the correlation. Continuous data for 50 years from 1950 to 2000 was finally generated and used for the calculation of discharge for the three rivers. The variation in discharge for the 50 years period was therefore evaluated. The average discharge results showed that Nzoia had a discharge of 118 m3/s; Sio 12.1 m3/s and Yala had 27.4 m3/s. There was a general increase in flow over the years contributing to the water balance of the lake and also pointing to increase in rainfall run-off possibly resulting from degradation of the catchment.

ID	2.2
1. Title of study	Environmental Flow Assessment Using HEC-EFM and GIS: A Case Study of Kibos River
2. Year of study	2013
3. River stretch that was studied	Kibos River
4. Who did the study (consultant)	Wakjira Umetta Wakitolie
5. Who financed the study (donor)	University of Nairobi/ SEURECAEAST AFRICA PLC
6. Who was the implementing agency	Kisumu Water Supply and Sanitation Company
7. Who now holds the data	Kisumu Water Supply and Sanitation Company
8. Methodology used (short description)	The Ecosystem Functions Model (EFM) is a planning tool that aids in analysing ecosystem response to changes in flow regime. The Hydrologic Engineering Centre (HEC) of the U.S. Army Corps of Engineers has developed HEC-EFM to enable project teams to visualize existing ecologic conditions, highlighting promising restoration sites, and assess and rank alternatives according to the relative change in ecosystem aspects. Central to HEC-EFM analyses are "functional relationships." These relationships link characteristics of hydrologic and hydraulic time series (flow and stage) to elements of the ecosystem through combination of four basic criteria: 1) season, 2) flow frequency, 3) duration, and 4) rate of change. There is no limit to the number or category of relationships that may be developed and it has an interface to facilitate entry and inventory of criteria
9. Methodology details	
10. Parameters considered	Hydrological, ecosystem services, biodiversity and socio-economic

11. Results (short description)	Environmental flow 0.247m3/s
12. Results (tabulated)	
13. Executive Summary of original report	Historically, water has been managed from a supply perspective with an emphasis on short-term economic growth from the use of the water. In this respect many municipalities, water service boards and other local authorities strive to supply water in abundance to their community. This has led to unprecedented environmental degradation. This has been witnessed in the over-consumption of Upper Athi River and Upper Tana River for supply to the City of Nairobi. There is a danger of similar situation recurring on the Kibos River for abstraction to the City of Kisumu. The water-resources planners such as water supply, hydropower, and irrigation engineers, need to give due emphasis to understanding of the need for environmental flows required to maintain the health of the ecosystem of these rivers. Most of the methods developed so far are project specific or basin specific and cannot be readily applied in Kenya as hydrological and physical characteristics of the rivers/basins for which the methods are developed, are different from that of Kenyan rivers/basins. There is therefore a need to select standard methods and software/s which can be used at national level irrespective of the type and scale of project under consideration. his research has used HEC-Ecological Functioning Model(EFM) an open source software in water resources planning (in the Kenyan context) through modeling of Kisumu Water Supply and Sanitation Long Term Action Plan, using Kibos River as source of water. The three environmental indicators employed for the research are fish (Labeo, Clarias and Barbus), micro-invertebrates in general and Nyamasaria swamp as wetland. The methods applied for assessment of risk level are modified method derived from Davies and Humphries (1996) for Risk Levels Assessment based on Modified Key Ecological Variables and the method developed by Tannent in 1976 for identified critical minimum flows required for Fish, Wildlife and Recreation in streams. .The research has revealed that there will be environmental change on Kibos River due to the proposed intake/diversion weir on Kibos River. It is expected that there will be significant migration of fishes from the affected reach of the river to the reach upstream of the diversion weir and to the river reach downstream of Awach and Kibos confluence. This can only happen if the run-of-river scheme treatment plant is operated at 48,000 m3/day throughout the year. If the city is supplied at 36,000 m3/day as run-of-river scheme and if necessary mitigation measures are taken the water supply project can be compatibly integrated in the ecosystem.

ID	2.3
1. Title of study	An introduction to Lake Victoria catchment, water quality, physical limnology and ecosystem status (Kenyan sector)
2. Year of study	2003
3. River stretch that was studied	Lake Victoria catchment – Kenyan section
4. Who did the study (consultant)	J.O. Okungu, S. Njoka, J.O.Z. Abuodha and R. E. Hecky
5. Who financed the study (donor)	LVEMP 1 – USAID
6. Who was the implementing agency	Lake Victoria Commission – LVEMP
7. Who now holds the data	Lake Victoria Commission
8. Methodology used (short description)	Three models, SACRAMENTO, SMAP and NAM were used to get the river discharge measurements. It is also used to estimate the runoff from ungauged catchments and also to assure quality of data through comparisons of model expectations with the observed data. The Sacremento Model was used in the Lake Victoria Decision Support System (LVDSS). The NAM model was also used as it was

	found to be friendly, easier to input data, easier to calibrate, and, even although theoretically simpler, gave equally good results. NAM is, like the Sacremento model, classified as a Conceptual Model with the following characteristics: • Lumped (the entire catchment is considered as a single unit with uniform properties). • The flow of water through the system is conceptualised into a number of reservoirs. • The parameters partly reflect the physical properties of the catchment. The SMAP model is also a Conceptual Model, but simpler in structure than Sacremento and NAM because it has fewer reservoirs. It is best suited to use with monthly rainfall data and was therefore chosen for use on the areas that had inadequate data.
9. Methodology details	
10. Parameters considered	hydrology
11. Results (short description)	The main rivers and their discharge percentages are: Nzoia - 39%, Gucha-Migori - 20%, Sondu - 14%, Yala - 13%, Nyando - 6% and Sio- 4%. The remaining 4% comes from various streams such as Awach Seme, Awach Kibos, Awach Kano (clustered as North Awach) and Awach Tende and Awach Kibuon (clustered as South Awach).
12. Results (tabulated)	
13. Executive Summary of original report	

ID	2.4
1. Title of study	Meteorology and Hydrology of the Lake Victoria Basin: Kenyan Sector
2. Year of study	2006
3. River stretch that was studied	Lake Victoria river system in Kenya
4. Who did the study (consultant)	F. Sangale, H. Njuguna, J.O. Okungu, J.O.Z. Abuodha & R. E. Hecky
5. Who financed the study (donor)	Embassy of Netherlands
6. Who was the implementing agency	Lake Victoria Commission – Lake Victoria Environmental Management Project (LVEMP)
7. Who now holds the data	Lake Victoria Commission – EAC database
8. Methodology used (short description)	The NAM model, (a conceptual model) which originates from the Danish Technical University. In this model, the entire catchment is lumped and assumed to be a single unit with uniform characteristics, the flow of water through the system conceptualized into a number of reservoirs and the parameters partly reflect the physical properties of the catchment.
9. Methodology details	
10. Parameters considered	Hydrology, Water quality
11. Results (short description)	4% comes from various streams such as Awach Seme, Awach Kibos, Awach Kano (clustered as North Awach) and Awach Tende and Awach Kibuon (clustered as South Awach) (LVEMP 2002). Below is the actual discharges in the table below:
12. Results (tabulated)	
13. Executive Summary of original report	This study reports of the results of extensive field monitoring of river flows and lake levels, rainfall and evaporation. The study's aim was to elucidate main trends and periods of meteorology and hydrology as revealed by time series of rainfall, evaporation, river discharge and lake levels and which could be used as input towards computation of nutrient and sediment load introduced into Lake

Victoria. Hydro-metrological data for the period running 1950-2004 were analysed and form the basis for computing the pollution loadings (catchment and atmospheric) into the lake and as well as calculation of the lake water balance. Continuous rainfall and evaporation records were applied and data gaps filled were necessary. Full records of land discharges were obtained from rainfall records using the NAM model. Model performance was evaluated on the ability to simulate the total flow for catchments, rather than the peak and minimum flows, for pollution estimation. The implication of the results in the eutrophication related processes in the lake are also discussed in this report.

ID	2.5
1. Title of study	Comparing flow regime, channel hydraulics, and biological communities to infer flow–ecology relationships in the Mara River of Kenya and Tanzania
2. Year of study	2014
3. River stretch that was studied	Mara River
4. Who did the study (consultant)	Michael E. McClain, Amanda L. Subalusky, Elizabeth P. Anderson, Shimelis Behailu Dessu, Assefa M. Melesse, Preksedis M. Ndomba, Joseph O.D. Mtamba, Rashid A. Tamatamah and Cosmas Mligo
5. Who financed the study (donor)	USAID – Transboundary Water for Flow–ecology relationships in the Mara River Biodiversity and Human Health in the Mara River Basin
6. Who was the implementing agency	WWF - Eastern and Southern Africa Regional Program Office
7. Who now holds the data	WWF/Florida International University
8. Methodology used (short description)	Flow discharge data were analysed in a spreadsheet and using the Indicators of Hydrologic Alteration (IHA) software (Version 7.1).
9. Methodology details	
10. Parameters considered	Hydrology, biodiversity, ecosystem services
11. Results (short description)	Flow discharge data from the three long-term gauging stations in the Mara River basin describe the perennial flow regime of the river, which is confined to the Amala and Nyangores tributaries in the headwaters of the river basin and the mainstream Mara River extending to Lake Victoria. The effect of seasonal flows in ephemeral tributaries is also evident in the mainstream flow regime described by the record from the Mara Mines station. Below is a summary of the discharges
12. Results (tabulated)	
13. Executive Summary of original report	Equatorial rivers of East Africa exhibit unusually complex seasonal and inter-annual flow regimes, and aquatic and adjacent terrestrial organisms have adapted to cope with this flow variability. This study examined the annual flow regime over the past 40 years for three gauging stations on the Mara River in Kenya and Tanzania, which is of international importance because it is the only perennial river traversing the Mara Serengeti ecoregion. Select environmental flow components were quantified and converted to ecologically relevant hydraulic variables. Vegetation, macroinvertebrates, and fish were collected and identified at target study sites during low and high flows. The results were compared with available knowledge of the life histories and flow sensitivities of the riverine communities to infer flow–ecology relationships. Management implications are discussed, including the need to preserve a dynamic environmental flow regime to protect ecosystems in the region. The results for the Mara may serve as a useful model for river basins of the wider equatorial East Africa region

ID	2.6
1. Title of study	Assessing Reserve flows of the Mara River (LVBC 2010)
2. Year of study	2007
3. River stretch that was studied	Mara River source to entry to Tanzania
4. Who did the study (consultant)	Florida International University
5. Who financed the study (donor)	Global Water for Sustainability Program (GLOWS) - USAID
6. Who was the implementing agency	WWF EARPO & LVBC
7. Who now holds the data	WWF
8. Methodology used (short description)	Building Blocks Method - Developed in South Africa by local researchers and DWAF, through application in numerous water resource development projects to address EFRs for entire riverine ecosystems under conditions of variable resources;
9. Methodology details	
10. Parameters considered	Hydrology, Biodiversity, Ecosystem services, socioeconomic
11. Results (short description)	
12. Results (tabulated)	
13. Executive Summary of original report	

ID	2.7
1. Title of study	Hydrologic Analysis of Nyando River Using SWAT
2. Year of study	2011
3. River stretch that was studied	Nyando River
4. Who did the study (consultant)	A. O. Opere and B. N. Okello - University of Nairobi, Department of Meteorology and Department of Civil Engineering
5. Who financed the study (donor)	European Geosciences Union
6. Who was the implementing agency	Lake Victoria Commission
7. Who now holds the data	Lake Victoria Commission and the Authors
8. Methodology used (short description)	SWAT, which is an interface of Arc View GIS, It uses Arc View to prepare input data and display the model output as spatial maps, charts or time series data. SWAT is a continuous time model that operates on a daily/sub-daily time step. It is physically based and can operate on large basins for long periods of time. The basic model inputs are rainfall, maximum and minimum temperature, radiation, wind speed, relative humidity, land cover, soil and elevation (DEM). The watershed is subdivided into sub-basins that are spatially related to one another.
9. Methodology details	

10. Parameters considered	Hydrology, ecosystem services
11. Results (short description)	Environmental Flow 13m^3/s
12. Results (tabulated)	
13. Executive Summary of original report	The Nyando River is one of the major Rivers in the Lake Victoria Basin. It drains parts of Nandi, Kericho and Nyando districts. It has a catchment area of about 3600km−2 of Western Kenya and an average discharge of approximately 15m3 s−1, and has within it some of the most severe problems of environmental degradation and deepening poverty found anywhere in Kenya. The Nyando River drains into the Winam Gulf of Lake Victoria and is a major contributor of sediment.

ID	2.8
1. Title of study	Demonstration of the Nile E-flows Framework in the Mara River, Lake Victoria Basin.
2. Year of study	2016
3. River stretch that was studied	Ten sites in the Mara basin
4. Who did the study (consultant)	HYDROC GmbH
5. Who financed the study (donor)	GIZ
6. Who was the implementing agency	NBI
7. Who now holds the data	NBI
8. Methodology used (short description)	PROBFLO (NBI environmental flow assessment framework)
9. Methodology details	Fieldwork for data collection, conceptual model development, PROBFLO assessment
10. Parameters considered	climate, hydrology, hydraulics, habitat, socioeconomy
11. Results (short description)	
12. Results (tabulated)	
13. Executive Summary of original report	The holistic application of the PROBFLO EFM in the Mara River resulted in the proposal of EFRs for ten sites, with consideration of their associated regional geographic areas, in the Mara Basin. These EFRs ranged from 24% of the MAR in the Mara River upstream of the Mara Reserve to 31% in the Mara River upstream of the Mara Wetland with wetland requirements partially considered. The risk assessment demonstrated that the socio-ecological wellbeing of the rivers in the Mara Basin are currently in a moderately modified state. Threats identified include numerous flow and non-flow impacts associated with land use in the Basin in particular. The assessment demonstrated that EFRs can be generated from the PROBFLO EFM that will maintain the overall wellbeing of the socio-ecological endpoints considered in an acceptable state.

ID	2.9
1. Title of study	Demonstration of the Nile E-flows Framework in the Malaba River, Victoria Nile Basin
2. Year of study	2016

3. River stretch that was studied	Malaba River
4. Who did the study (consultant)	HYDROC GmbH
5. Who financed the study (donor)	GIZ
6. Who was the implementing agency	NBI
7. Who now holds the data	NBI
8. Methodology used (short description)	coarse assessment (desk based on exosting data, probflo approach
9. Methodology details	
10. Parameters considered	
11. Results (short description)	Flow requirements to meet Category A to D categories range from 58.48% MAR (132.5 Mm3/yr) to 17.85% MAR (40.4 Mm3/yr).
12. Results (tabulated)	
13. Executive Summary of original report	

<u>Burundi</u>

ID	3.x
1. Title of study	No Nile related environmental flow studies have been carried out
2. Year of study	
3. River stretch that was studied	
4. Who did the study (consultant)	
5. Who financed the study (donor)	
6. Who was the implementing agency	
7. Who now holds the data	
8. Methodology used (short description)	
9. Methodology details	
10. Parameters considered	
11. Results (short description)	
12. Results (tabulated)	
13. Executive Summary of original report	

<u>Rwanda</u>

ID	4.1

1. Title of study	Environmental and Social Impact Assessment for the Proposed Rusumo Falls Hydroelectric Project
2. Year of study	2013
3. River stretch that was studied	500 metre section downstream of Rusumo Falls
4. Who did the study (consultant)	Artelia Eau & Environment
5. Who financed the study (donor)	Nile Equatorial Lakes Subsidiary Action Program (NELSAP)
6. Who was the implementing agency	Governments of Burundi, Rwanda and Tanzania
7. Who now holds the data	Nile Equatorial Lakes Subsidiary Action Program (NELSAP)
8. Methodology used (short description)	The Tennant (or Montana) method was retained for determining the environmental flow. Methods used included: Hydrological methods; Hydraulic rating methods; Habitat rating method, and Holistic methods.
9. Methodology details	
10. Parameters considered	Hydrology, Biodiversity
11. Results (short description)	An environmental flow of 23 cubic metres per second was proposed. This flow represents 10% of the average flow (230 cubic metres per second) of the River. This minimum flow should allow fair conditions for maintaining the environmental conditions according to the Tennant (or Montana) method. The adoption of 10% was considered to be largely sufficient to maintain the environmental conditions to an acceptable level. It may be possible to reduce the minimum environmental flow in order to increase power production.
12. Results (tabulated)	
13. Executive Summary of original report	

ID	4.2
1. Title of study	Demonstration of the Nile E-Flows Framework in the Kagera River at Rusumo Falls, Lake Victoria Basin
2. Year of study	2016
3. River stretch that was studied	Kagera River at Rusumo Falls
4. Who did the study (consultant)	HYDROC GmbH
5. Who financed the study (donor)	GIZ
6. Who was the implementing agency	NBI
7. Who now holds the data	NBI
8. Methodology used (short description)	Coarse assessment (desk based on exosting data, probflo approach
9. Methodology details	
10. Parameters considered	
11. Results (short description)	The hydrological study for the Rusumo Falls provide the annual flows listed below indicating that the Kagera River at the Rusumo Falls

	is a temperate river as the fluctuations between minimum and maximum flow is in the ratio 1:3. Average MAF rate is 210 m3/s; Average maximum annual flow rate is 336 m3/s; Average minimum annual flow rate is 116 m3/s. The hydrological study also indicated an increase in flow since 1961 due to increased precipitation which is likely to continue into the future. Based on all this data, a minimum EFR of 23 m3/s is proposed. This is 10% of the average flow (1971 – 2009) of the river and should allow for fair conditions for maintaining environmental conditions
12. Results (tabulated)	
13. Executive Summary of original report	

<u>Uganda</u>

ID	5.1
1. Title of study	Feasibility Study Report for Karuma Hydro Power Plant & Its Associated Transmission Line Works (Section 1 Hydro Power Plant)
2. Year of study	2014
3. River stretch that was studied	Measurement for the river way hydrological section and water surface line along the river as well as the axis channel from the place near the upstream side of the dam site to the place near the downstream side of the tailrace outfall
4. Who did the study (consultant)	Sinohydro Corporation Limited and HYDROCHINA HUADONG
5. Who financed the study (donor)	Export-Import Bank of China
6. Who was the implementing agency	Uganda Electricity Generation Company Limited
7. Who now holds the data	Uganda Electricity Generation Company Limited
8. Methodology used (short description)	The weir formula and the Manning’s formula were respectively used to calculate the rating curves at the open diversion channel outlet, the dam site, and 8# and 9# construction adit portals.
9. Methodology details	
10. Parameters considered	Hydrology and sediments, Geology, Biodiversity, Aquatic species
11. Results (short description)	Lake Victoria and Lake Kyoga are upstream of the dam site of the Project, so the runoff is affected by the regulation storage effects of two natural lakes. The discharge of the Nile River downstream has small daily changes, runoff is more evenly distributed in a year, basically maintaining at 990m^3/s or so.Ÿ If the fishway is arranged at the right bank, the ecological flow discharging outlet and trash discharging outlet are jointly used, and the discharging flow is 50~100m3/s, under the impact of the deep plunge sill downstream of the dam site, the water will be discharged mainly from the center of the main riverbed.
12. Results (tabulated)	
13. Executive Summary of original report	

ID	5.2
1. Title of study	Supplementary Report on Aquatic Species & Water Audit for Rwimi Small Hydro Power Project

2. Year of study	2016
3. River stretch that was studied	Two stations chosen along River Rwimi i.e. at the dam and 100m below the dam.
4. Who did the study (consultant)	Geo-Tropic Consult Ltd
5. Who financed the study (donor)	KFW financed the Hydropower
6. Who was the implementing agency	Eco Power Holdings Ltd
7. Who now holds the data	Eco Power Holdings Ltd
8. Methodology used (short description)	Monitoring of river quality was based on macro invertebrate's assemblages because they represent an enormous diversity of body shapes, survival strategies, and adaptations.
9. Methodology details	
10. Parameters considered	Aquatic Species, Socio-economics
11. Results (short description)	The average overall water requirements by the neighboring communities was found to be 14 m^3/day which is equivalent to a minimum of 0.000162083 m^3/s volume of river flow downstream. A recommendation that at least 0.001m3/s of water should be left/allowed in the river as environmental flow to meet the water requirements of the flora and fauna in the river as well as maintain the other ecological functions of the river. These include maintaining the benthic community, the substratum and the existing microhabitats. In addition, the flora and fauna in the river requires sufficient water to maintain the other ecological functions of the river. It is recommended that some volume of water be retained in the river (environmental flow) to allow survival of the fish, others such as amphibian's population and to maintain the diversity and abundance of these sensitive organisms such as algae between the weir and the power house. The river is extensively used by the adjacent communities on both side of the river for water abstraction, bathing , fishing and for recreation.
12. Results (tabulated)	
13. Executive Summary of original report	

ID	5.3
1. Title of study	River Sironko Hydrology - Assessment for the Sironko mini-hydropower project
2. Year of study	2014
3. River stretch that was studied	River Sironko immediately downstream of the point of confluence of between Sironko and River Guragado
4. Who did the study (consultant)	Vala Associates Ltd
5. Who financed the study (donor)	Vala Associates Ltd
6. Who was the implementing agency	Vala Associates Ltd
7. Who now holds the data	Vala Associates Ltd
8. Methodology used (short description)	This assessment adopted the hydrological method (Desktop Estimates, Look Up Table), in particular the Tennant method, owing to its simplicity where by the environmental flow regimes are prescribed on the basis of the average daily discharge or the mean annual flow

	(MAF). In general cases, 10% of the MAF is recommended as a minimum instantaneous flow to enable most aquatic life to survive, while 30% MAF is recommended to sustain a good habitat.
9. Methodology details	
10. Parameters considered	Hydrology, Geology, Land cover
11. Results (short description)	A comprehensive hydrology assessment has been carried out on River Sironko, in order to assess the potential of the hydropower site (to provide an indication of its safe capacity and hydrological reliability) that was identified on the river immediately downstream of the point of confluence of between Sironko and River Guragado. The daily discharge data of the Mt Elgon Rivers is highly skewed. Even though the average daily discharge of River Sironko is 2.03 m3/s, the median discharge (Q50) of the two sites are 1.14m3/s. This is an important note that should carefully be taken into consideration when designing the corresponding hydropower facilities for the sites. The Flow Duration Curve for the river was computed; the discharge of 3.47m3/s is exceeded 15% of the time while 0.6 m3/s is exceeded 70% of the time. An environmental flow reserve of 0.2m3/s was proposed for the river section that will be looped by the canal/penstock system.
12. Results (tabulated)	
13. Executive Summary of original report	

ID	5.4
1. Title of study	River Lubilia Water Resources Assessment for the Lubilia mini-hydropower project
2. Year of study	2011
3. River stretch that was studied	River Kanyampara discharge station and the Lubilia River takeoff point
4. Who did the study (consultant)	VS Hydro (pvt) Limited
5. Who financed the study (donor)	Lubilia Kawembe Hydro Limited (owned by DI Frontier Market Energy and Carbon Fund K/S Fund, a Danish private equity fund). Others FMO & KfW.
6. Who was the implementing agency	Lubilia Kawembe Hydro Limited
7. Who now holds the data	Lubilia Kawembe Hydro Limited
8. Methodology used (short description)	Analyzed its catchment characteristics and the discharge patterns including its low and high flows to provide an indication of its safe capacity and hydrological reliability.
9. Methodology details	
10. Parameters considered	Hydrology, Geology, Vegetation cover
11. Results (short description)	River Lubilia is situated in western Uganda originating from the Ruwenzori Mountain Ranges, and flowing southerly to join the bigger Lubilia-Tako, which forms a natural border with the Democratic Republic of Congo before draining into Lake Edward. The Lubilia catchment receives annual maximum and minimum of 1529mm and 1245mm respectively with an average mean of 1388mm. It is therefore a fairly wet sub-catchment. Annual Maximum flows for 2 to 10,000 year return period for R. Lubilia take off point e.g. 2years at 7.97 m3/sec as maximum river discharge. Annual minimum series for R. Lubilia takeoff from which the extreme low flows were

	computed and it is expected that once in every 50 years, there is a day with negligible or zero mean flow.
12. Results (tabulated)	
13. Executive Summary of original report	

ID	5.5
1. Title of study	Ecological flow - Waki Hydro Power Project
2. Year of study	2013
3. River stretch that was studied	Intake point up to downstream of environmental flow pipe
4. Who did the study (consultant)	Geo-Tropic Consult Ltd
5. Who financed the study (donor)	SN Power Invest of Norway
6. Who was the implementing agency	Hydromax
7. Who now holds the data	Hydromax
8. Methodology used (short description)	Flow measurement based
9. Methodology details	
10. Parameters considered	Hydrology, Biodiversity
11. Results (short description)	The Directorate for Water Resources Management (DWRM) approved a Surface Water Abstraction Permit in November 2013. This Permit provides for water abstraction of up to 299,808 m^3/s per day, equivalent to an average of 3.47 m^3/s. The minimum flow requirement provided in the note is 0.38 m3/s. This requirement represents only about 11 per cent of the mean annual flow. There is an attempts to mimic natural flow variation as the eco-flow pipe has been placed below the weir intake a
12. Results (tabulated)	
13. Executive Summary of original report	

ID	5.6
1. Title of study	Environmental and social impact assessment for Ayago Hydropower Station (Volume 1)
2. Year of study	2016
3. River stretch that was studied	Intake point up to downstream of environmental flow pipe
4. Who did the study (consultant)	WSS Services Uganda Ltd
5. Who financed the study (donor)	Export-Import Bank of China
6. Who was the implementing agency	Uganda Electricity Generation Company Limited
7. Who now holds the data	China Gezhouba Construction Company (CGCC) International Limited

8. Methodology used (short description)	The selection of ecological flow was based on Tenant (1976) methodology i.e. minimum environmental flow for general rivers should be no less than 10% of average annual flow, but for rivers with larger flow (average annual flow more than $80m^3/s$), it can be adapted and redefined without exceeding 5% of average annual flow.
9. Methodology details	
10. Parameters considered	Hydrology, Biodiversity
11. Results (short description)	The average annual runoff of Nile is $994m^3/s$ at dam site, much more than $80m^3/s$, based on which, ecological flow was calculated as $100m^3/s$. Therefore, 50m3/s was taken as the minimum ecological flow of dam site downstream river way for the Project. The annual discharge data from 1940-2000 has been used to calculate the Maximum, Average and Minimum flow at Ayago. Basing on the average flows at Ayago, an ecological flow equivalent to 10% of the discharge i.e. 99.4 (approx. 100) cumecs was recommended to avoid impacting on the ecology and to keep the system in a health state.
12. Results (tabulated)	
13. Executive Summary of original report	

DRC

ID	6.x
1. Title of study	No Nile related environmental flow studies have been carried out
2. Year of study	
3. River stretch that was studied	
4. Who did the study (consultant)	
5. Who financed the study (donor)	
6. Who was the implementing agency	
7. Who now holds the data	
8. Methodology used (short description)	
9. Methodology details	
10. Parameters considered	
11. Results (short description)	
12. Results (tabulated)	
13. Executive Summary of original report	

South Sudan

ID	7.x

1. Title of study	No Nile related environmental flow studies have been carried out
2. Year of study	
3. River stretch that was studied	
4. Who did the study (consultant)	
5. Who financed the study (donor)	
6. Who was the implementing agency	
7. Who now holds the data	
8. Methodology used (short description)	
9. Methodology details	
10. Parameters considered	
11. Results (short description)	
12. Results (tabulated)	
13. Executive Summary of original report	

<u>Sudan</u>

ID	8.1
1. Title of study	Demonstration of the Nile E-flows Framework in the Dinder River, Blue Nile Basin
2. Year of study	2016
3. River stretch that was studied	Dinder River
4. Who did the study (consultant)	HYDROC GmbH
5. Who financed the study (donor)	GIZ
6. Who was the implementing agency	NBI
7. Who now holds the data	NBI
8. Methodology used (short description)	PROBFLO (NBI environmental flow assessment framework)
9. Methodology details	Fieldwork for data collection, conceptual model development, hydrological assessment, PROBFLO assessment
10. Parameters considered	Climate, hydrology, hydraulics, habitat, socioeconomy
11. Results (short description)	
12. Results (tabulated)	
13. Executive Summary of original report	The EFR for the Dinder River, with considerations of the water inundation requirements of the Mayas in the DNP, was established in the study. Due to the limited data available for the study, the EFR was established at 47.9% of the MAR or 1485.137 Mm3/yr. These

flows are almost entirely required to maintain the instream habitat and inundate the Maya's of the Dinder River during the high flow period. Additional requirements include the suitable duration of connectivity in the river between the Dinder Reserve and the Blue Nile. A better understanding of the flow-ecological component relationships in the Dinder River is required. This includes a better understanding of the Dinder River-Maya relationships which is of great ecological importance in the study area.

ID	8.2
1. Title of study	Independent Review of the Environmental Impact Assessment for the Merowe Dam Project (Nile River, Sudan)
2. Year of study	2006
3. River stretch that was studied	Main Nile downstream Merowe dam
4. Who did the study (consultant)	Cristian Teodoru, Alfred Wüest, Bernhard Wehrli
5. Who financed the study (donor)	Encouraged by International Rivers Network (IRN)
6. Who was the implementing agency	eawag, aquatic research, Switzerland
7. Who now holds the data	eawag, aquatic research, Switzerland
8. Methodology used (short description)	Literature review in particular Aswan High Dam; Assess possible environmental changes by Merowe Dam; evaluate Merowe EIAR.
9. Methodology details	
10. Parameters considered	Sediment load, aquatic biodiversity, water quality, water level variations
11. Results (short description)	Reduced sediment load downstream Merowe dam; Expected erosion of the river bed and the side banks downstream the dam;
12. Results (tabulated)	
13. Executive Summary of original report	

ID	8.3
1. Title of study	Operation Manual for Release Structures: Roseires and Sennar dams
2. Year of study	2013
3. River stretch that was studied	Blue Nile downstream Sennar dam
4. Who did the study (consultant)	Lahmeyer International
5. Who financed the study (donor)	DIU, MoWREI, Sudan
6. Who was the implementing agency	Lahmeyer International
7. Who now holds the data	DIU, MoWREI, Sudan
8. Methodology used (short description)	Based on previous studiers for minimum downstream release and environmental flow requirements downstream of Sennar dam (8 Mm3/day)
9. Methodology details	

10. Parameters considered	Lump sum of minimum daily flow
11. Results (short description)	Lump sum of minimum daily flow of 8 Mm3/day
12. Results (tabulated)	
13. Executive Summary of original report	

ID	8.4
1. Title of study	Roseires Dam Heightening Project (DHP) Reservoir Operation Study
2. Year of study	2012
3. River stretch that was studied	Blue Nile downstream Roseires dam
4. Who did the study (consultant)	SMEC International Pty Ltd
5. Who financed the study (donor)	DIU, MoWREI, Sudan
6. Who was the implementing agency	SMEC International Pty Ltd
7. Who now holds the data	DIU, MoWREI, Sudan
8. Methodology used (short description)	Assumption based on earlier studies of 8 Mm3/day at Khartoum
9. Methodology details	
10. Parameters considered	Lump sum of minimum daily flow
11. Results (short description)	Lump sum of minimum daily flow of 8 Mm3/day
12. Results (tabulated)	
13. Executive Summary of original report	

ID	8.5
1. Title of study	Sedimentation and Operation Study for Atbara Dams Complex
2. Year of study	2016
3. River stretch that was studied	Atbara River downstream the Atbara Dams Complex
4. Who did the study (consultant)	Mr. Karel Hynert
5. Who financed the study (donor)	DIU, MoWREI, Sudan
6. Who was the implementing agency	Deltares, the Netherlands
7. Who now holds the data	DIU, MoWREI, Sudan
8. Methodology used (short description)	Assumption of minimum daily flow, agreed with the client
9. Methodology details	

10. Parameters considered	Lump sum of minimum daily flow
11. Results (short description)	2 Mm3/day downstream Upper Atbara Dams Complex, and downstream Khashm elGirba Dam.
12. Results (tabulated)	
13. Executive Summary of original report	

Ethiopia

ID	9.1
1. Title of study	Investigating environmental flow requirements at the source of the Blue Nile River
2. Year of study	2008
3. River stretch that was studied	Impact of Chara Chara weir on flows from Lake Tana and Blue Nile River.
4. Who did the study (consultant)	Abeyu Shiferraw and Matthew P. McCartney / Addis Ababa University& International Water Management Institute
5. Who financed the study (donor)	Consultative Group for International Agriculture through its Challenge Program for Water and Food.
6. Who was the implementing agency	International Water Management Institute
7. Who now holds the data	International Water Management Institute
8. Methodology used (short description)	Analyses of river flow data to quantify the changes in the hydrological regime of the river arising from operation of the weir and diversions to the power station followed by an evaluation of environmental flow requirements, derived from hydrological indices, through application of the South African Desktop Reserve Model (DRM
9. Methodology details	
10. Parameters considered	Hydrology (low flow and high flow), biodiversity, ecosystem service, basic ecological functioning
11. Results (short description)	The results indicate that to maintain the basic ecological functioning downstream of lake Tana (over the Tis Issat Falls and its vicinity) requires an average annual allocation of 862 Mm^3 (i.e. equivalent to 22% of the mean annual flow). Under natural conditions there was considerable seasonal variation, but the absolute minimum mean monthly allocation, even in dry years, should not be less than approximately 10 Mm^3 (i.e. 3.7 $m^{3/}s^{-1}$). This study provides sound options that could be used to improve the current situation and to alleviate the environmental problems in the downstream of Laka Tana; especially in the vicinity of the Tis Issat Falls, in order to maintain the aquatic biodiversity and to keep the visual amenity of the Falls
12. Results (tabulated)	
13. Executive Summary of original report	

ID	9.2
1. Title of study	Gumara irrigation project Environmental Impact Assessment
2. Year of study	2008

3. River stretch that was studied	Gumara River
4. Who did the study (consultant)	Water Works Design & Supervision Enterprise *In Association with Intercontinental Consultants and Technocrats Pvt. Ltd.*
5. Who financed the study (donor)	Government of Ethiopia
6. Who was the implementing agency	Ministry of Water, Irrigation Energy &Regions
7. Who now holds the data	Ministry of Water, Irrigation Energy
8. Methodology used (short description)	EIA approaches / Compensation flow Estimation/
9. Methodology details	
10. Parameters considered	Compensation flows at the diversion site for environmental requirements intended to maintain downstream water requirements and to protect all life forms found along Gumera River courses in general and labeobarbus fish species in particular.
11. Results (short description)	Compensation flow Estimates for Environmental Requirements. Whenever there is no need of water from the reservoir, a compensation flow of about 0.050m3/s must be released for environmental requirements at river segments between the dam and Gumera-Sendega Gumera rivers confluences. The total net effect of water released for environmental requirements at the diversion site that could be used for irrigation is less than 50 Mm3/year.
12. Results (tabulated)	
13. Executive Summary of original report	

ID	9.3
1. Title of study	Environmental and social impact assessment of about 20,000 ha irrigation and drainage schemes at Megech Pump (Seraba),Ribb And Anger Dam/ Environmental and social impact assessment of the ribb irrigation and drainage project/
2. Year of study	2010
3. River stretch that was studied	Megech Pump (Seraba)&,Ribb
4. Who did the study (consultant)	BRL Engineers &MCE
5. Who financed the study (donor)	Government of Ethiopia
6. Who was the implementing agency	Ministry of Water Resources Of Ethiopia
7. Who now holds the data	Ministry of Water Resources of Ethiopia
8. Methodology used (short description)	EIA, based on McCartney *et al.* (2008), Desktop Reserve Model (DRM)
9. Methodology details	
10. Parameters considered	Hydrology and biodiversity
11. Results (short description)	For the period 2001 to 2006, average annual flows over the falls (i.e., 1,305 Mm3) exceeded the annual total maintenance flow requirements predicted by the model (i.e. 862 Mm3) However, more detailed analysis shows that in most months average flows were significantly less than the environmental flow requirements predicted by the model. For several months average flows were less than 70% of the estimated requirement

12. Results (tabulated)	
13. Executive Summary of original report	

ID	9.4
1. Title of study	Concepts of Environmental Flow Assessment and Challenges in the Blue Nile Basin, Ethiopia (as bookchapter in "Nile River Basin, 2011")
2. Year of study	2011
3. River stretch that was studied	Blue Nile
4. Who did the study (consultant)	Reitberger, McCartney
5. Who financed the study (donor)	n/a
6. Who was the implementing agency	n/a
7. Who now holds the data	Reitberger, McCartney
8. Methodology used (short description)	Three methods: The Global Environmental Flow Calculator, the Desktop Reserve Model, and the Tennant Method
9. Methodology details	
10. Parameters considered	Hydrology, ecology
11. Results (short description)	21-28% of the mean annual flow may be sufficient to sustain basic ecological functioning
12. Results (tabulated)	See publication for different methods results on monthly basis
13. Executive Summary of original report	The paper reports the findings of the first attempt to rigorously quantify environmental flows in the Blue Nile River. Three desktop hydrological methods, the Global Environmental Flow Calculator, the Desktop Reserve Model, and the Tennant Method, were aplied at three locations. With reasonable consistency they indicate that 21-28% of the mean annual flow may be sufficient to sustain basic ecological functioning. The results, which are low confidence estimates, need to be confirmed with much more detailed studies, but provide a basis for discussion and can contribute to the early phase of planning.

ID	9.5
1. Title of study	Estimating environmental flow requirements downstream of the Chara Chara weir on the Blue Nile River
2. Year of study	2009
3. River stretch that was studied	Blue Nile
4. Who did the study (consultant)	McCartney, Shiferaf, Seleshi
5. Who financed the study (donor)	n/a
6. Who was the implementing agency	n/a
7. Who now holds the data	McCartney, Shiferaf, Seleshi

8. Methodology used (short description)	Desktop Reserve Model
9. Methodology details	
10. Parameters considered	Hydrology
11. Results (short description)	862 Mm3/a (i.e. equivalent to 22% of the mean annual flow)
12. Results (tabulated)	See publication for tabulated results
13. Executive Summary of original report	The Desktop Reserve Model was used to determine both high and low flow requirements... The results indicate that to maintain the basic ecological functioning in this case requires an average annual allocation of 862 Mm3 (i.e. equivalent to 22% of the mean annual flow). Under natural conditions there was a considerable seasonal variation, but the absolute minimum mean monthly allocation, even in dry years, should not be less than approcimately 10 Mm3 (i.e. 3-7 m3/s). These estimates make no allowance for maintaining the asethetic quality of the falls, which are popular with tourists.

<u>Eritrea</u>

ID	10.x
1. Title of study	No Nile related environmental flow studies have been carried out
2. Year of study	
3. River stretch that was studied	
4. Who did the study (consultant)	
5. Who financed the study (donor)	
6. Who was the implementing agency	
7. Who now holds the data	
8. Methodology used (short description)	
9. Methodology details	
10. Parameters considered	
11. Results (short description)	
12. Results (tabulated)	
13. Executive Summary of original report	

<u>Egypt</u>

ID	11.x
1. Title of study	No Nile related environmental flow studies have been carried out
2. Year of study	

3. River stretch that was studied

4. Who did the study (consultant)

5. Who financed the study (donor)

6. Who was the implementing agency

7. Who now holds the data

8. Methodology used (short description)

9. Methodology details

10. Parameters considered

11. Results (short description)

12. Results (tabulated)

13. Executive Summary of original report

ONE RIVER

ONE PEOPLE

ONE VISION

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ENTRO

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