ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT REPORT FOR THE PROPOSED IRRIGATION EXPANSION AT MNGETA FARM, MNGETA VILLAGE, MNGETA WARD, KILOMBERO DISTRICT, MOROGORO REGION, TANZANIA

ENVIRONMENT FLOW ASSESSMENT SUPPLEMENT

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1. PREAMBLE

This chapter sets the scene as background to this Supplement.

1.1. Environmental Flow Permits and KPL

The ESIA by KPL of its proposed Irrigation Expansion Project at Mngeta Farm, was in response to a plan to upgrade 3,036 ha from current rain-fed to pivot irrigation. This Supplement clarifies the decision arrived at by KPL to determine the maximum water abstraction taking into consideration the Environmental Flow (EF) requirements of both the Mngeta River and the larger Kilombero floodplain.

1.1.1. Rufiji Basin Water Board Environmental Flow Assessment (EFA):

The Rufiji Basin Water Board (RBWB) participated with KPL in a 10-month routine hydrological study of flow rates of the Mngeta River. In the process, they re-calibrated the flow curve, and revalidated that the KPL's 4 year flow recording data is comparable against the 30 year of flow records previously recorded by Halcrow (1990). This information was used by RBWB as part of their Environmental Flow Assessment (EFA) of the Project. Accordingly, KPL received a water use permit dated 24.9.14, issued by the RBWB allowing 72,524 m^3/day average abstraction on the condition that an Environmental Flow (EF) was maintained at a minimum of $1m^3$/s.

RBWB sets the absolute minimum EF for the KPL Project at $1m^3$/s.

1.1.2. National Environmental Council Environmental Flow Assessment (EFA):

Based on their field validation and desk assessment of the Environmental and Social Impact Assessment (ESIA), the National Environment Management Council (NEMC) issued KPL an EIA Certificate dated 24.11.14. They approved that the Project had no adverse environmental impact, however, they required adherence to an Environmental Flow (EF) of 60% of river flow (i.e., the Project was allowed to extract 40% of water from the Mngeta River for irrigation activities throughout the year).

Unclear is the interpretation. Does NEMC imply abstraction of 40% of total annual flow, or 40% of average monthly flow at any one time? The latter was inferred in the KPL ESIA study, and extrapolating from the 30 year data set by Halcrow (1990)(See Annex 1), KPL notes:

a. **Lowest Year Abstraction:** The lowest average monthly 34 year minimum recorded was 5.7m^3/s. Therefore, this was used to calculated the lowest possible EF at 60% of minimum, is 3.4m^3/s. This is the *"absolute 30-year, worst case EF scenario"*. This allows KPL a maximum extraction of 2.3m^3/s during the lowest probable seasonal flow.
b. **Average Year Abstraction:** The lowest average monthly 34 year average recorded however is 9.2m^3/s. Therefore, this can be used to estimate the lowest average EF, which at 60% is set at 5.5m^3/s. This is the *"30 year lowest average case EF scenario"*. This allows KPL a maximum extraction of 3.7m^3/s based on the average low seasonal flow.

NEMC sets the absolute minimum EF for the KPL Project at 3.4m^3/s and the lowest average at 5.5m^3/s.

1.1.3. KPL Compliance to Government Regulated EF

The Government has therefore set KPL's EF at an absolute minimum of between 1-3.6 m^3/s.

KPL in the ESIA, adopted the more conservative, "*30 year worst case EF scenario"* by calculating their highest abstraction rate permissible at a level not to exceed 2.3m^3/s (i.e., 40% of the lowest average monthly flow ever recorded in 30 years). In their most recent estimate based on a revised cropping pattern designed by Digby (2015), KPL anticipate water abstraction is 2.11m^3/s as the maximum irrigation requirement at any one time.

This implies KPL extraction will:

a. Never exceed the absolute EF limits set by Government of between 1-3.7m^3/s, and
b. At an extraction maximum of 2.11m^3/s, will accommodate the maintenance of the EF in low flow seasons.

1.2. Additional Environmental Flow Requests

KPL during the process of discussing with OPIC for a loan to complete the irrigation project, a question has come back on 28.1.15, that the OPIC Environmental analyst considers the key issue as the hydrology. Accordingly, OPIC note:

a. The proposed Project would withdraw a significant percentage of the Mngeta River flows – up to 35% in the month of November.
b. The RBWB has apparently determined that the required minimum ecological flow in the river is set at 2.5 m^3/sec, which infers that the November withdrawal rate is acceptable.
c. Unfortunately there is nothing in the documentation that demonstrates that the 2.5 m^3/sec number has any basis.
d. Downstream of the withdrawal is a very sensitive ecological area (both a protected Ramsar site and an important bird area (IBA). Documentation on the Ramsar site indicates that the greatest threat to the protective area is intensification of agriculture in the area.

OPIC therefore requested of KPL:

a. A more detailed and complete demonstration for the selection of 2.5 m3/sec as the ecological flow.
b. The investor may need to bring in a more specialized consultant to provide this demonstration.

This Supplement to the ESIA Report is therefore in response to the request from OPIC and presents the fact in order to substantiate the justification for the EF as set by RBWB and NEMC. It supports KPL's compliance. It draws on a recent EFA conducted by CDM (2014) in their Preliminary Hydrology Report of the USAID funded-Kilombero Valley Irrigation Schemes. CDM has just conducted a more detailed EFA of the whole Kilombero Floodplain. In addition, this EFA Supplement introduces new information provided by the KPL advising irrigation engineer, Digby (2015) who has designed a more efficient cropping pattern requiring less water.

This EFA report by KPL, is in two parts, notably:

a. To look at Mngeta River and KPL farm in the context of its significance of probable impact to the larger Kilombero Wetland and
b. To look at the EF of the Mngeta and Kibasira wetlands, using the "Tenant Method" of EFA as adopted by CDM.

2. DEFINITION OF ENVIRONMENTAL FLOWS

This chapter elaborates the approach to the KPL EFA in line with national requirements and definitions.

2.1. Definition of Environmental Flows in Tanzania

CDM (2014), note that Tanzania has adopted the principle of EF in the National Water Policy (2002) and it promulgates this principle in the concept of the "environmental reserve" in the Water Resources Management Act (WRMA) No. 11 of 2009, where the term *environmental reserve* is defined (in Part I, Section 3), as:

"The quantity and quality of water required for:

a. Satisfying basic human needs by securing a basic water supply for people who are now or who shall in the reasonably near future, be (i) relying upon, (ii) taking water from; or (iii) being supplied -from the relevant water resources; and
b. Protecting aquatic ecosystem in order to secure ecologically sustainable development and use of relevant water resources.

The Act further stipulates "… the preference for water allocations shall be prioritized as follows:

a. Domestic purposes;
b. Environmental reserve; and
c. Socio-economic activities depending on the availability of water resources."

On this basis, CDM (2014), for the USAID irrigation projects, have used the "Tenant Method" and assumed a minimum allowance of EF as 10% of the mean monthly flow (on a monthly basis) as set aside for all of the Kilombero rivers that they studied. This was determined as the minimum, "Hands-Off Flow" (HOF), water reserved for environmental and domestic uses.

2.2. Environmental Flows Defined

CDM (2014) go on to note that an EF is referred to in literature as: in-stream flow, minimum flow requirements, ecological flow, ecological reserve, environmental reserve and riparian flow. The EF is the water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits, an ecologically acceptable flow regime designed to maintain a river in an agreed or pre-determined state.

CDM (2014) conclude that the EF is a compromise between water resources development on one hand, and river maintenance in a healthy or at least reasonable condition, on another. From an ecological point of view, the major criteria for determining EF should include the maintenance of the whole river cycle, both spatial and temporal patterns of river flow. The seasonal flow variability should be maintained as it affects the structural and functional diversity of rivers and their floodplains. This in turn influences the species diversity of the river (Quoting Bunn and Arthington, 2002). Thus EF should not only encompass the amounts of water needed but also when and how this water should be flowing in the river.

All components of the hydrological regime have certain ecological significance. For example, high flows of different frequency are important for channel maintenance, species reproduction, wetland flooding and maintenance of riparian vegetation. Moderate flows may be critical for cycling of organic matter from river banks and for fish migration, while low flows of different magnitudes are important for algae control, water quality maintenance and the use of river resources by local people.

CDM (2014) go on to note, Environmental Flow Assessments (EFAs) are used to make informed decisions about water management that protect the environment in order to foster sustainable social and economic development. An important measure for mitigating the potential negative impacts to river ecology caused by changes in the natural river flow is the planned releases of environmental flows downstream from dams, or limits on the amount of water that can be abstracted from a channel. The aim is not to change the seasonal patterns; however, the amplitude may vary.

3. ENVIRONMENTAL FLOW ASSESSMENT AND THE MNGETA AND KIBASIRA WETLAND

This chapter relates to the Mngeta River and its immediate wetlands the Kibasira Swamp.

3.1. Description of Mngeta and Kibasira Wetlands:

The Mngeta River arises in the adjacent hills, the Udzungwa mountains, drains a catchment of 342km^2 and flows for 15-20km from the foothills, past Mngeta Farm and drains into a 7,500 ha permanent vegetation covered marshland, the Kibasira Swamp. The Mngeta River at this point merges to become the greater Kilombero floodplain and is joined by the flood waters of Kilombero, Kihansi and Rupia Rivers, which, in peak flood, flood back into the surrounding Kibasira wetlands. In addition, local rivers such as Njage and Mchombe also join the Mngeta and also make up part of the Kibasira wetland system. The total combined flow of all 6 rivers into the Kibasira wetlands therefore contribute to its seasonal hydrological patterns and its ecology.

In addition, the high water table in this area is also believed to maintain the riparian forest that forms part of the Kibasira marshland. The shallow margins of the Kibasira wetland are 80-90% covered in emergent aquatic vegetation like papyrus and sedges. The deeper waters have submerged aquatic vegetation, and only at the Mngeta inlet to the swamp, is there a little area of open water.

In a crude flow estimate by KPL, 70% of low season outflows appear to exit the Kibasira at Kivalu. This stream flows for 5-6km before becoming one with the Kilombero River. The remainder of the Kibasira outflows emerge through a myriad of streams in the south east linked to the Kihansi River. During high flood seasons, the Kihansi, Kilombero, Njage, Mchombe and the nearby Rupia rivers burst their banks and the flood merges into the greater Kibasira floodplain. This expands the wetland flooded area several fold, and can be categorized by reversed flows from Kihansi into the Kibasira. In low season, the inflows from the Mngeta, Njage and Mchombe drain into and result in outflows from the Kibasira.

The Kibasira wetland and the lower reaches of the Mngeta flood plain are therefore driven by river inflows and outflows from 6 rivers coupled with seepage from the ground water table, and therefore the lower Mngeta ecology is not entirely dependent on the Mngeta River flows.

3.2. Applying Tenants EFA to KPL

The most common worldwide method applied to EFA is the "Tenant Method", which CDM (2014) used to define the target river flows of the Kilombero Project based on an empirical, "Rule of Thumb", using simple indices of % mean annual minimum flow to determine the minimum EF, notably:

a. 10% of the flow is minimum required for poor quality of habitat and aquatic species survival.
b. 30% of the flow is the minimum required for a satisfactory quality of habitat and aquatic species survival.
c. 60% of the flow is the minimum required for an excellent quality of habitat and aquatic species survival.

Using the Ministry of Water 30-year historical flow data, sourced from the Halcrow Report (1990) and the RBWB/KPL 2011-2014 data (Annex 1 and 2), applying the above formula for the Tenant Method, the results are shown in the table below, notably:

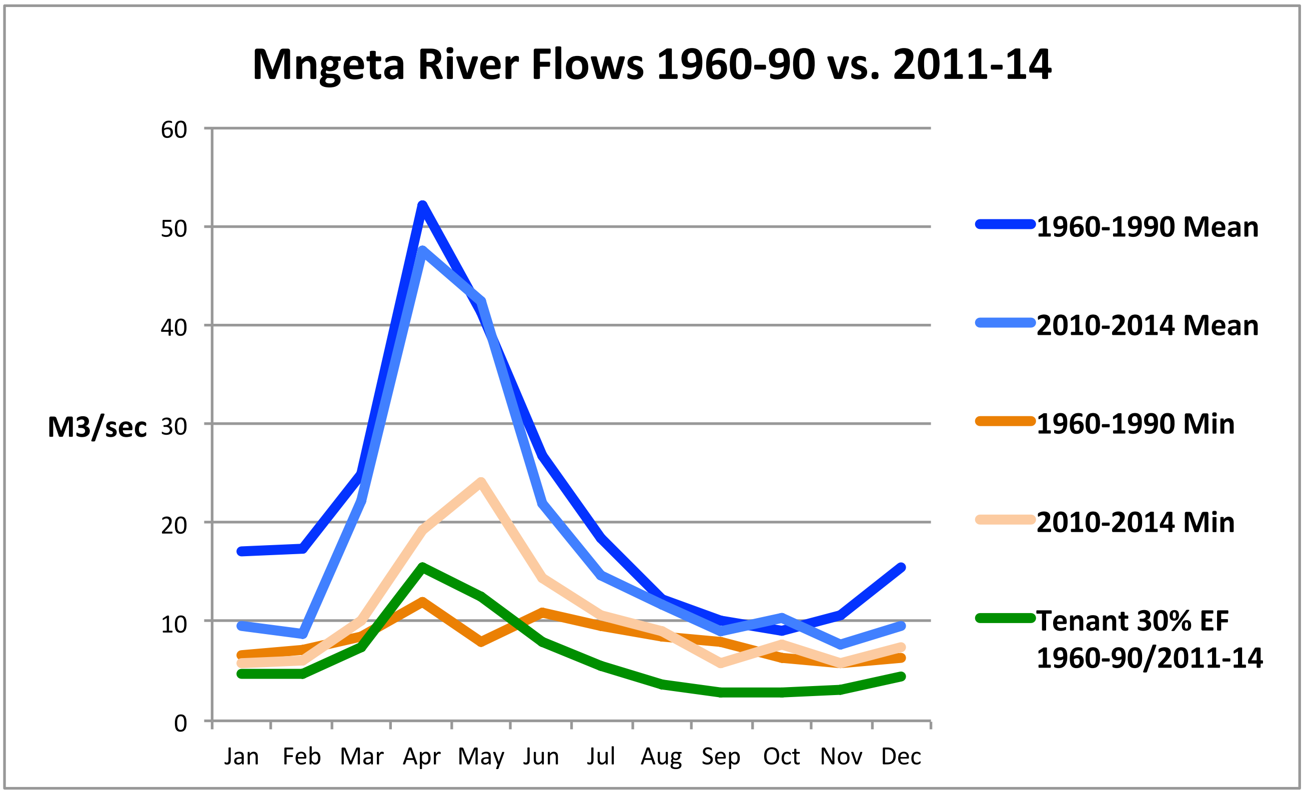
a. At 30% of the annual mean, the EF requirement is 2.77 m^3/s in lowest flow month of October

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1960-90/2011-14 Mean	16.0	16.1	24.6	51.5	41.5	26.2	18.1	12.2	9.9	9.2	10.5	14.8
1960-90/2011-14 Max	39.3	66.9	60.0	90.4	83.0	89.6	90.1	18.8	14.2	15.1	22.5	33.9
1960-90/2011-14 Min	5.7	6.1	8.4	12.0	8.0	11.0	9.7	8.4	5.9	6.4	5.7	6.2
Tenant Environmental Flow 30%	4.79	4.83	7.39	15.44	12.45	7.87	5.44	3.65	2.97	2.77	3.14	4.45

3.3. Validation of KPL Readings of 2011-14 and Halcrow 1960-90

In late 2010, KPL, in collaboration with the Rufiji Basin Water Board, re-established the gauging station at the site of the previous Ministry of Water gauging station and over a 4-year period recalibrated the flow. There appears to be no significant difference as yearly flow profiles similar to the 2011-14 period are found in the 1960-90 period. The table and chart below compare the 1960-1990 flows versus the 2011-2014, which implies the Tenant flow applies equally to current flow senario.

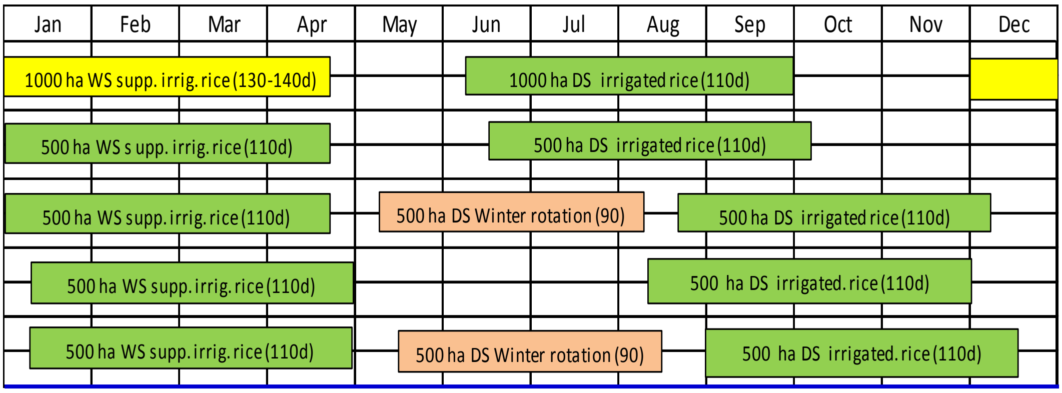
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1960-1990 Mean	*17.2*	*17.4*	*25*	*52*	*41.4*	*26.8*	*18.6*	*12.2*	*10*	*9.1*	*10.8*	*15.4*
2010-2014 Mean	9.56	8.7	22.3	47.7	42.4	22.0	14.7	11.9	9.0	10.4	7.7	9.7
1960-90 Max	*39.3*	*66.9*	60	*90.4*	*83*	*89.6*	*90.1*	*18.8*	*14.1*	*13.6*	*22.5*	*33.9*
2011-2014 Max	12.5	13.5	38.8	79.6	68.8	31.1	21.6	17.1	14.2	15.1	10.4	12.4
1960-1990 Min	*6.6*	*7.2*	*8.4*	*12*	*8*	*11*	*9.7*	*8.4*	*7.9*	*6.4*	*5.7*	*6.3*
2010-2014 Min	5.7	6.1	10.2	19.4	24.0	14.4	10.8	9.1	5.9	7.7	5.8	7.5



3.4. Irrigation Demand versus Environmental Flows

This section looks at the water demand of the final cropping pattern.

Cropping Pattern, Digby Irrigation Design (Feb 2015)



The final KPL irrigation design (Digby 2015), taking into account cropping experience, agronomic requirements, energy efficiency and potential hydrological limitations, proposes a dry season default irrigation demand, based on the dry-season cropping pattern above of:

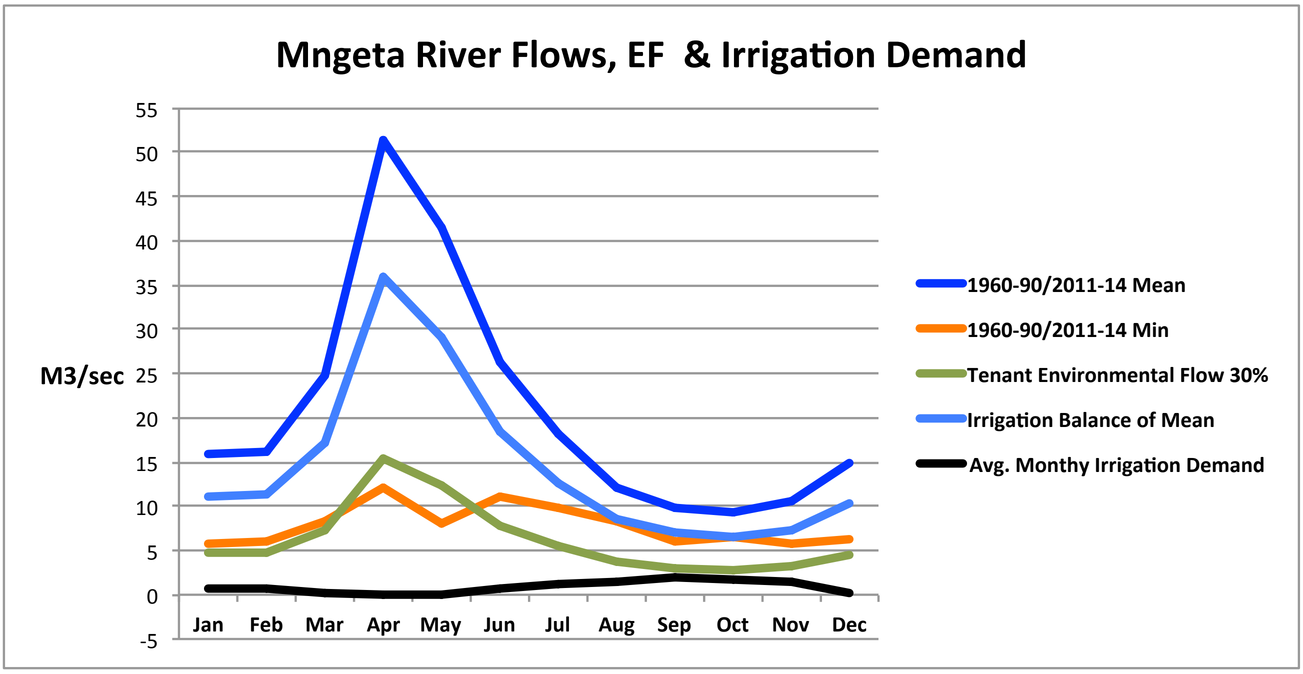
KPL Water Requirement (Digby, 2015)

	Water requirements in m^3/s							80% irrigation efficiency						Area	3036.5	ha						
Month		Jun			Jul			Aug			Sep			Oct			Nov			Dec		
	Decade	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	Days	10	10	10	10	10	11	10	10	11	10	10	10	10	10	11	10	10	10	10	10	11
rice110	Full irrig	0.42	0.71	0.85	0.97	1.17	1.36	1.31	1.28	1.54	1.87	2.04	2.11	1.77	1.70	1.73	1.72	1.61	1.18	0.32	0.02	0.00
maize122	Part irrig	0.42	0.62	0.71	0.77	0.63	0.47	0.27	0.10	0.19	0.34	0.26	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00

The maximum irrigation abstraction is 2.11m3/sec for only a ten-day decade at the end of September.

The table and chart below compare the 34 Year (1960-90/2011-14) Mngeta mean and minimum flows, the 30% mean Tenant Environmental Flow and the balance available for irrigation—the mean flows after subtracting the EF. The chart and table cover both the supplementary irrigated rainy season crop (mid-Dec through Apr) and the dry season rice crops. The intra-season rotation crop requires negligible irrigation and a dry season maize crop substantially less irrigation than rice.

Mngeta River Flows m3/sec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1960-90/2011-14 Mean	16.0	16.1	24.6	51.5	41.5	26.2	18.1	12.2	9.9	9.2	10.5	14.8
1960-90/2011-14 Min	5.7	6.1	8.4	12.0	8.0	11.0	9.7	8.4	5.9	6.4	5.7	6.2
Tenant Environmental Flow 30%	4.8	4.8	7.4	15.4	12.5	7.9	5.4	3.6	3.0	2.8	3.1	4.4
Irrigation Balance of Mean	11.2	11.3	17.2	36.0	29.1	18.4	12.7	8.5	6.9	6.5	7.3	10.4
Avg. Monthy Irrigation Demand	0.66	0.58	0.23	0.01	0.05	0.7	1.2	1.4	2	1.7	1.5	0.17



As a fall back scenario, during the worst case of dry season low flows not permitting the water needs, boreholes will be used to supplement up to 30% of the irrigation canal. Boreholes have now been factored in along two canals as part of the final irrigation design (Digby, 2015).

3.5. Seasonal Abstraction vs Mean Water Flow

When comparing seasonal abstraction pattern per cropping plan vs the 1960-90 and current 2011-14 data for the highest probable water abstraction:

a. KPL water abstraction for 8 months of the year will be below 7% of mean monthly flows and never more than 20% at any one time
b. KPL water abstraction for 8 months will be below 12% of the minimum monthly flows, and never more that 34% at any one time

This implies that the water extracted from the river under a worst case scenario ranges monthly from 0 to 34%, effectively always leaving at least 66% of the flows in the river.

3.6. Mngeta River, Kibasira and Ground Water

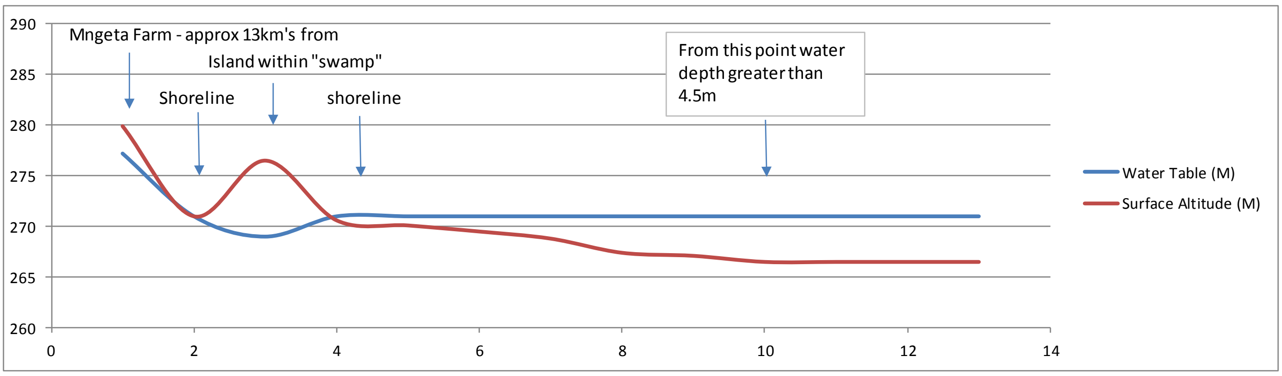
The Mnegta River below the pump site and the Kibasira wetlands are largely uninhabited due to flooding, and the river and wetland has a minimal, if not negligible domestic water demand.

On the ecological side, the KPL ESIA objective took into consideration the need of maintaining the flow in the Mngeta River and Kibasira Wetlands, and ensuring an EF during the dry season. The aim of KPL cropping plans and water abstraction are not to let the Kibasira wetland dry out in the dry season.

An additional consideration on the hydrology of the Mngeta and Kibasira is its relationship to the ground water table. Digby (2015) drawing from recent KPL measurements of groundwater (by Jailos, 2014), assessed the potential for use for irrigation supplement, and concluded that the ground water on the Mngeta farm is both shallow and copious. Previous boreholes drilled on KPL (within the floodplain) to a depth of 120 meters have revealed no bedrock to this depth. This supports the observation that the valley is largely sediments and therefore ground water is plentiful. Digby (2015) estimates it is probable that the source of recharge is from the seepage from the Mngeta River downstream of the rocky floor where it emerges from the hills, as well as from runoff from the hills and from local infiltration of rainfall. He acknowledges that ground water is plentiful (the water table only varies by 1-5 meters throughout the year on the farm depending on surface topography).

Groundwater depth observations within the Kibasira wetland suggest that the wetland is exposed ground water table. Therefore, this implies, the wetland is not totally reliant solely on river inflow, but is re-charged by groundwater too. This is supported by the attached GPS level readings (Jailos, 2014). This cross section of ground level and water table suggests Kibasira swamp is a marshland and its lakes are part of an exposed water table.

Water Table Readings from Mngeta Farm Through Kibasira Wetlands (Jailos, 2014)



There is a positive hydraulic gradient from the Mnegta farm towards the swamp. At the farm, the water table is at a higher elevation than water surface level at Kibasira swamp. This implies water flows underground, from the Farm towards the wetland and the swamp and its hydrology is also based on recharge by this groundwater. This is in addition to the incoming water from river inflows. The depth of the water is controlled by the outflow level at the lowest point, possibly the outlet of the Kibasira, at Kivalu and towards Kihansi.

Given that the Kibasira is in water-logged soils, and fed by groundwater, it is likely therefore to have a much lower EF requirement from the Mngeta River to retain its ecological integrity.

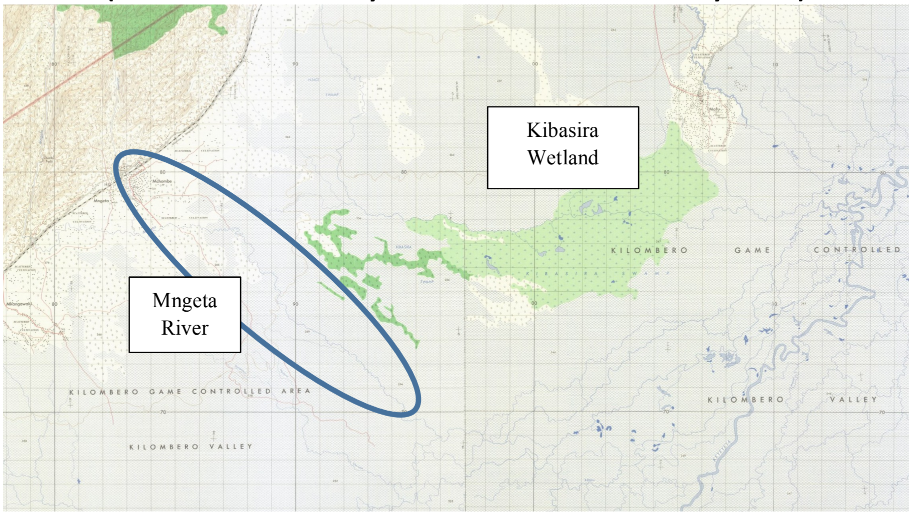
Digby (2015) went on to suggest that given the copious nature of this groundwater, the irrigation requirement of the Project could potentially be supplemented by 30% by pumping from ground water boreholes. The final irrigation plan includes boreholes along the two canals to supplement river water if necessary. The figure of 33% for supplementary irrigation is indicative. It has been taken by Digby to mitigate possible risk of dissolved minerals in ground water (by diluting with river water) not because groundwater is considered a limiting factor.

3.7. Kibasira Wetland and Mngeta River Inter-dependence

During the ESIA, community consultations revealed that pre- the extreme floods of 1998/9, the Mngeta River was not connected to the Kibasira wetland. Survey ordinance maps from 1965 (see below) clearly show that the Mngeta river did not always flow into the Kibasira wetlands.

Given that historically the Kibasira was always a wetland, it suggests the possibility that the copious levels of groundwater measured on Mngeta Farm are part of a larger underground hydrological system, which includes the 7,500 ha Kibasira wetland.

1965 Ordinance Survey Map of Kibasira Wetlands Showing Mngeta and Kibasira (Note at this time they were unconnected water systems)



Digby (2015) surmised that the ground water is recharged by subterranean flows from the many rivers and runoff emerging from the mountain escarpment as well as heavy rainfall in the valley and adjacent land itself, and given the water logged nature of the area, this is sufficient to create and maintain the marshland known as Kibasira wetlands, potentially without Mngeta river inflows.

3.8. Endangered Kibasira Fauna and Flora

The ecological studies by a team of specialists of the fish, birds, mammals, amphibians, insects and plants in the Mngeta River and the Kibasira wetlands, found neither IUCN listed near threatened nor endangered species. All the teams of specialists concluded that there was no likelihood that biodiversity was at risk during the low flow seasons. Most flora and fauna in the area were resilient to climate variables and could tolerate the lower flows for the 10-15 day periods.

Some of the fish species use the area as a breeding ground, but mostly in the high flow season and so would not be affected by the dry season low flow. Likewise, migratory birds were more prolific in the wetland during the wet season.

According to the Environmental Management Classes listed by CDM (2014), it is likely that the KPL scheme is adjacent to a "Category B habitat", classified as "*largely intact habitat and biodiversity, despite the water extraction*".

Environmental Management Classes (EMC)(CDM, 2014)

EMC	Ecological description	Management perspective
A: Natural	Pristine condition or minor modification of in-stream and riparian habitat.	Protected rivers and basins. Reserves and national parks. No new water projects (dams, diversions etc.) allowed.
B: Slightly modified	Largely intact biodiversity and habitats despite water resources development and/or basin modifications.	Water supply schemes or irrigation development present and / or allowed.
C: Moderately modified	The habitats and dynamics of the biota have been disturbed, but basic ecosystem functions are still intact. Some sensitive species are lost and/or reduced in extent. Alien species present.	Multiple disturbances associated with the need for socio-economic development, e.g. dams, diversions, habitat modification and reduced water quality
D: Largely modified	Large changes in natural habitat, biota and basic ecosystem functions have occurred. A clearly lower than expected species richness. Much lowered presence of intolerant species. Alien species prevail	Significant and clearly visible disturbances associated with basin and water resources development, including dams, diversions, transfers, habitat modification and water quality degradation
E: Seriously modified	Habitat diversity and availability have declined. A strikingly lower than expected species richness. Only tolerant species remain. Indigenous species can no longer breed. Alien species have invaded the ecosystem.	High human population density and extensive water resources exploitation.

4. ENVIRONMENTAL FLOWS AND THE KILOMBERO VALLEY

4.1. Description of Kilombero Wetland and Kilombero Ramsar Site

The RIS (2002) describes the Kilombero River, with a catchment area of about 33,450 to 40,330 km^2 (based on different estimates) has a floodplain about 260 km long and up to 52 km wide, covering about 6,265 km^2 at high water (RIS, 2002). It receives water from 37 permanent rivers in Kilombero District (1 of which is Mngeta) and 5 rivers in Ulanga District.

Much larger rivers enter the floodplain from the south and then divide into a myriad of tributaries in the central part of the floodplain, which descends only 40 m over a distance of 210 km. The seasonal change in water dynamics is huge and the plains themselves sometimes become totally flooded during the wet season, which drives it ecology. The plains dry up during the dry season with the exception of the main river channels and river margins as well as the areas with permanent swamps and water bodies (such as the Kibasira).

The Mngeta is therefore only one of 42 rivers whose hydrology make up the ecology of the Kilombero floodplain, and consequently the Mngeta flows make up a very small portion of the overall Kilombero Ramsar site.

4.2. Environmental Flows and Domestic Needs in Kilombero Valley

Domestic water use in the Kilombero was listed by CDM (2014) as the water required to fulfill the basic water supply and sanitation needs, for drinking, food preparation, bathing, laundry, dishwashing and cleaning or for waste disposal. Other uses include, water for cooking, watering flowers, watering gardens, flushing the toilets, mopping, washing utensils, washing clothes, constructing houses, brick making, pottery, cooling the milling engine, washing motorcycle/bicycles, local wine making (*Komoni*), watering animals (cows, goats, poultry, pigs), construction of brick kilns, bathing and drinking.

In the villages, there are various institutions such as dispensaries, churches, mosques, schools, guest houses, canteens that use water at a different rate as compared to household level. However, all these establishments and settlement are on higher ground, generally outside the floodplain to avoid inundation in the high flood seasons. The myriad of streams and rivers that flow into the floodplain, and ground water wells, basically provision domestic water needs.

In the Mngeta catchment, downstream of the water pump station, especially Kibasira wetland, is part of the inundated floodplain and very few people living permanently in the area. Likewise, the main floodplain of the Kilombero river, has a very low resident population due to the annual inundation in the wet season. In addition, for health reasons, most households use shallow wells and draw water from ground water. For fear of crocodiles, few use the river. Mostly migrant fishermen live on temporary island camps in the swamp.

The KPL Farm abstraction is likely to have a minimal effect on the EF in the main Kilombero for domestic needs, and the minimum flow set by RBWB of $1m^3/s$ would accommodate any such requirement.

4.3. EF in Kilombero and Farming

The threat of intensification of agriculture in the Kilombero referred to in RIS (2002) is traditional rain-fed and floodwater rice farming. These prevailing, smallholder farming system, occur mostly in 2 forms:

a. As rain-fed cultivation in the wet
b. Flood water recession farming towards the end of the flood season

Rain-fed farming is located in the higher reaches, away from inundated floodplains, while the recession flood farming occurs in the upper, accessible flooded areas. These areas are not connected to the Mngeta River nor the mainstream of the Kilombero and so will not be affected by the KPL irrigation off-take. They depend largely on rainfall or catchment run-off.

Livestock on the other hand, albeit "illegal", penetrate the Ramsar Site in the dry in search of grazing and water, and they cause excessive damage to swamp vegetation and stream damage. However, livestock are not dependent on the Mngeta River downstream of the pump station for grazing, although small numbers do water in the Kibasira marshes. The lower, EF at $1m^3/s$ would cater for this requirement. Livestock in the main Kilombero floodplain depend on the myriad of streams and rivers for watering.

4.4. Environmental Flows and Fish Species in Kilombero Valley

Most riverine fishes in the Kilombero River catchment, spawn just at the beginning of the rains, during periods of first flooding and consequently are not affected by low season flows (CDM, 2014).

Spawning normally occurs on recently inundated vegetation when rivers break their banks, or on floodplains, during peak floods. Egg and juvenile survival is dependent on the maintenance of a consistent water level created by floods during the early stages. Therefore, for the optimal functioning of a floodplain as fish breeding and nursery, fluctuating seasons of low and high flow, are required. It is therefore essential to maintain EF requirements and not restrict the annual peak floods for successful fish reproduction in the wet or flood season. Large daily fluctuations during the flood season, can leave fish stranded, altering spawning behavior and egg and juvenile survival. Natural flood heights, intensities and timing must match the natural conditions to avoid reproductive failure.

As Mngeta will draw very low levels of water in the wet season, it is unlikely to affect the greater Kilombero floodplain flood patterns and so have negligible impact on fish migration and breeding patterns.

4.5. Environmental Flows and Fisheries in Kilombero Velley

The RIS (2002) notes fishing has traditionally been the primary resource use in the Kilombero Valley, and between 23-27 types of fish, are caught on a regular basis mostly: tilapia *Oreochromis*, catfish *Clarius* and *Bagrus*, tiger fish *Hydrocynus*, *Distichodus*, *Mormyrus*, *Schilbe*, *Citharinus* and *Alestes.* The estimated annual harvest ranges between 9,500 tons – 12,000 tons fish, by 5,000 - 10,000 full time fishers and 15,000 - 25,000 part time fishers. Fishing effort is reportedly highest during the flood period between April and May. By comparison, there is little fishing in Mngeta and Kibasira swamp, and this is not affected by flows, but dependent on the bigger floodplain ecology, and high flood waters which are not impacted by the irrigation off-take rates.

The RIS (2002) describes that many fish species are common to all rivers in the Kilombero and Rufiji Basin. There have been recorded large seasonal differences in catches, suggesting seasonal movements within the two systems. Fish migrate upstream to spawn, usually at the beginning of the rains as flood water rise in November and the river bursts it banks. Peak spawning activity is recorded at first floods, in November-December (RIS 2002 quotes RUBADA, 1981). A second spawning period seems apparent peaking in March/April in the shallow water of the inundated floodplain.

The RIS (2002) therefore suggests that there is a long reproductive period of fish in Kilombero, consequently, this is a characteristic that will not be impacted by of variations in water level in the low flow seasons caused by unreliable rains or by irrigation take-off. By March young fish are waiting to invade the floodplain. This allows them to take advantage of the high flows, high level of nutrients available from this productive area as it floods, and provides them some protection from predators.

The Mngeta river does have some of the migratory species like Hydrocynus, Labeo and Clarias species that are potamodromous, ie they migrate up rivers when in spat, so as to breed in flooded areas. These migratory species would take advantage of the floods in the wet months to find passage through the Kibasira Swamp and breed in the upper reaches. As the fish breeding patterns in both the Kilombero and the Kibasira are associated with high season flows and floods, so they are not affected by the low season abstractions of the KPL scheme.

4.6. Environmental Flows and Birds and Mammal Species in Kilombero Valley

The Kilombero Valley Floodplain provides an important dry season habitat for many large mammals from the Selous (e.g. buffalo, elephant) and the valley has the highest animal density found in the Selous ecosystem (RIS 2002 quoting TWCM 1999). However, their migration through from Selous to the Kilombero and up the Udsungwa mountains, some 300 km, making use of the nearby Ruipa game corridor has been curtailed by human settlement and traditional farming. These mammals are not dependent on the Kibasira nor Mngeta Rivers for grazing, water or safe passage, and so the abstraction has minimal consequences.

The crocodile population of the Kilombero links with that of the Selous is recognized as having one of the most significant populations of Nile crocodile in Africa (RIS 2002 quotes Games and Severe, 1999). For this reason the Kilombero, Mngeta and Kibasira waters are not much used by local residents for fear of crocodile attacks. The valley did contain almost 75% of the world's population of Puku (*Kobus vardoni)*. A large population of Hippopotamus is present, which probably plays an important role in maintaining the ecosystem functions in the floodplain and keeps waterways open. Again, due to human settlement in the adjacent Kilombero upper reaches, no puku nor hippo occur in the Mngeta and Kibasira wetlands. Buffalo have been reported in the lower Kibasira reaches, but here the waters and floodplain are more dependent on the Kihansi River flows, which seasonally, also recharge the Kibasira.

The Kilombero Valley is also an Endemic Bird Area (EBA), with three species endemic, the Kilombero Weaver (*Ploceus burnieri*) and two, as yet, un-described Cisticolas. The Kilombero valley is also an Important Bird Area (IBA) for migratory waterbirds. The floodplain is important for large and significant breeding populations of two river specialists: African Skimmer and White-headed Plover. The dynamic annual flooding in the Valley is essential for feeding of these and migratory wading bird species.

Given the vastness of the Kilombero valley and the fact that human pressures around the Mngeta River and Kibasira swamp has diminished the once significant mammal migration routes, it is not likely that the low season off take of the KPL irrigation scheme will not have any effect on the EF to sustain mammals. The EF of 60% of lowest level would sustain the integrity of the Kibasira Swamp should it be home to any key species, and ensure water is available for larger mammals to drink.

Noting that wading birds take advantage of the high season of floods to forage in the floodplain, as the KPL water abstraction is minimal in this peak flood period of the vast Kilombero wetland, therefore the low season abstraction rates are of little impact as most wading birds would have migrated by this time.

5. ENVIRONMENTAL FLOWS OF MNGETA AND ITS CONTRIBUTION TO KILOMBERO

5.1. Mngeta Catchment Vs Kilombero

Halcrow (1990) estimated Mngeta catchment at 321km^2 versus the 33,450km^2 of the total Kilombero catchment, while the RIS places Kilombero catchment at 40,330km^2. This makes the catchment of the Mngeta less than 0.8% of the total Kilombero catchment area. In a study for KPL, Ambiotek (2013), concluded the Mngeta flows were 0.99% of the Kilombero flows and therefore the downstream impact of the EF on the Kilombero River, the Kilombero Ramsar site and the IBA were considered minimal and insignificant. The Ramsar Site and IBA hydrology depended on the EFA of the whole ecological flows of the "Kilombero valley" and its vast floodplain and numerous rivers, almost 42 in number. Mngeta river contributions, by comparison are very low, less than 1% of "total flow", making it one of the smallest rivers contributing to the Kilombero wetland.

The floodplain ecology and productivity of the Kilombero wetland is powered by the seasonal floods at the peak of the high flow season. The floodplain area is minimally affected by the low flow season as the water recession, means that the floodplain water courses dries up and the mainstream EF maintains only the riverine ecology of the Kilombero River, maintaining flows in the myriad of main and smaller river channels. Mngeta's contribution to this low season river flow is very low, less than 1%.

5.2. Mngeta Flows Vs Kilombero

Ambiotek (2013) estimated Mngeta at 0.99% of the Kilombero Valley catchment, contributes 0.88% of the total wetland rainfall. Halcrow (1990) examined 30 years of hydrological data from 1960-1990 of Mngeta and 27 years of Kilombero River flows from 1957-1984 at Swero. They note that at the lowest monthly average flow recorded in this period (ie 5.7 m^3/s in November 1971, See Annex 1). This Mngeta River flow was a low 3.6% of the average monthly Kilombero River flow at that time, estimated at 158 m^3/s as the 30 year average lowest flow.

Using the KPLs irrigation scheme newly calculated maximum abstraction rate of 2.11m^3/s (Digby, 2015), this implies, in the lowest month, KPL will still allow an EF of 3.59 m^3/s. This is above the target set by NEMC of 3.4m^3/s (ie 40% of the lowest). The 30 year average Kilombero low season monthly flow is 158m^3/s, therefore the significance of the KPL off take from the Mngeta River is an average low 1.3% of the lowest Kilombero flows recorded in 30 years history during the month of November.

Mngeta contributions to the downstream Kilombero Valley, the Kilombero Ramsar Site and IBA, is therefore very low proportionately when compared to the other 41 plus rivers flowing into the wetland, and the impact of the KPL low season off take is significantly low, likely to be less than 1%.

6. CONCLUSION ON ENVIRONMENTAL FLOW OF MNGETA RIVER

From the above we summarize:

a. The absolute minimum environmental flow requirement of KPL at any one time in the Mngeta River downstream of the pump station is set by RBWB at 1 m^3/s (a condition that there can never be "no flow" into the Kibasira and Kilombero swamp).
b. The ideal environmental flow required of KPL should be 60% of flow at any one time which in the lowest monthly average minimum flows equates to an absolute lowest EF of 3.4m^3/s set by NEMC (a condition which sets the ideal EF).
c. The final cropping plan determined by Digby (2015), maximum abstraction during the low season will be 2.11m^3/s, 9% lower than estimated in the ESIA, and an insignificant low 1.3% of the average low season flows of the total Kilombero floodplain.
d. The new cropping plan means the abstraction will peak for a ten-day period, and remain above 2m^3/s for less than 2 weeks, thus minimizing the stress period of low river flows downstream.
e. The lower Mngeta wetland ecology and that of the Kibasira wetlands is powered by the hydrology of 6 rivers and influenced by groundwater. The combined impact of this combination therefore determines the low season wetland ecology, and the wetland system is not entirely dependent on the flows from the Mngeta.
f. The Mngeta catchment and total river flows are a low <1% of the total Kilombero valley and therefore the Mngeta River contribution of Kilombero flows to maintain the ecology of the Ramsar site, are minimal by comparison to the other 41 river systems.
g. As the KPL abstraction pattern of maximum off take is mostly in the dry season, it will not have an impact on the EF required for the flood season spawning behavior of potamodromous Kilombero floodplain fish species.
h. Likewise, those fish species that migrate up the Mngeta River to breed in the peak flood season, will equally not be affected by KPL abstraction rates, which is an insignificant low of between 1-5% of high river flows.
i. All Kilombero fish and wading birds are floodplain species. They make use of the high flood waters during wet season inundation of the valley floor, to breed and feed. This again is a time when KPL water requirements are well below 5% of the minimum high season Mngeta river flows. This off-take is insignificant compared to the vastness of the Kilombero floods at this time.
j. Domestic needs for water are minimal as there are very few resident populations and no settlement or institutional infrastructure downstream of the pump site nor in the lower Kilombero Floodplains. In the dry season, most residents, for safety against crocodile attacks, draw water from shallow, ground water wells, and are not dependent on Mngeta flows. There is no recorded use of Mngeta water for small scale irrigation or of major domestic abstraction downstream of the KPL pumps.
k. Those few communities that do farm in the floodplain area around the Mngeta and Kibasira, except for illegal livestock herders in the Kilombero floodplains, do so mostly in the wet season. They grow traditional, rainfed and recession rice, in the higher flooded ground, independent of the Mngeta flows.
l. Historically, Kibasira wetlands were independent of the Mngeta, until the 1990's floods changed the river course. Kibasira wetlands aquatic flora and fauna have therefore evolved and have adapted to dry season conditions, pre-Mngeta inflows. They would be tolerant of local floods and river inflow fluctuations.
m. The Kibasira Wetlands is almost a marshland. Located in waterlogged soils, the wetland is effectively an overgrown lake formed by the exposed groundwater table and is a floodwater buffer zone for 6 rivers.

n. The groundwater in the area is considered to be vast and copious, with potential to supplement upto 33% of the irrigation. This offers KPL an alternative strategy during the wet season of increasing the EF, if required.
o. Through crop pattern management, KPL has demonstrated a further reduction in 9% of water requirement, and this offers scope for future mitigation consideration, if needed to sustain EF.

Therefore, according to the Tenant Method, the KPL scheme current off take requirement of 2.11m^3/s allows for an EF that is 30% of the average monthly flow in the low season. This meets the minimum required for:

a. The Tenant Classification that a 30% of average flows will maintain "*a satisfactory quality of habitat and aquatic species survival",* and
b. The Project is classified as an Environment Management Class B, of *"Slightly Modified"* leaving a "*largely intact habitat and biodiversity, despite the water extraction"*.

In conclusion, proposed is that:

a. The NEMC value of 3.4m^3/s, or 40% of lowest season flow, be taken as the ideal EF to be observed by KPL at all times.
b. KPL should experiment with cropping patterns to further reduce the potential stress on the system to find ways to increase EF at critical low season periods.
c. KPL could consider use of groundwater for supplemental irrigation in the low season should the environmental monitoring plan suggest the need to further reduce abstraction rates.
d. KPL should never, under any circumstance, allow Mngeta flows to go below an EF of 1 m^3/s.

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Digby, R. (2015) Mngeta Farm, Preliminary Irrigation Design Report: 02/02/2015: 22p.

Jailos, F (2104) Water Table Readings from Mngeta Farm Through Kibasira Wetlands. KPL Report.

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Annex 1: 30 Year Mean Monthly Flows of Mngeta River, Ministry of Water, (Halcrow, 1994)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann Avg
1960		13.6		90.4	33.5	17.0	12.6	10.5	8.8	7.2	6.9	6.2	
1961	14.7	20.6	21.5	31.3	41.7	18.1	17.4	12.9	10.5	9.5	17.1	17.5	19.4
1962	18.1	21.9	20.8	40.2	34.5	17.8	13.6	11.6	9.0	8.1	6.9	8.6	17.6
1963	10.5	9.4	17.7	66.8	27.2	15.5	12.0	9.8	8.2	7.0	10.6	11.5	17.2
1964	21.6	18.9		57.7	31.6	16.0	12.0	10.0	8.0	6.9	6.2	7.4	
1965		7.4	8.9		16.7		10.2	9.7	8.6	8.3	9.6	14.4	
1966			43.2		33.7	17.8	12.3	9.7	8.4	7.4	7.0	8.1	
1967	11.6	8.3	12.7	17.3		24.4	14.7	11.2	9.0		15.8	22.8	
1968	16.8	15.0	25.5	55.4	36.3	29.5	16.5	12.1	9.7	8.3	10.3	19.0	21.2
1969	8.8	9.2	30.2	62.5	38.9	20.7	13.1		8.2	8.8	9.6	8.0	
1970	11.4	17.0	16.8		20.9	13.4	9.7	8.4	7.9	6.4	5.7	9.0	
1971	6.6	7.2	15.9	51.9	30.5	15.4	13.9	10.6	8.8	10.7	9.3	9.7	15.9
1972		13.7		12.0	8.0	11.0	14.6	11.1	9.6	8.4	7.9	32.4	
1973	18.9	21.0	23.2	71.6	52.9	19.4	13.1	10.3	8.7			6.7	
1974	14.1		8.4	81.2	70.7	30.1	17.7	11.9	9.4	7.5	6.9	6.8	24.1
1975	10.6	8.5	12.8	45.2	47.0	20.5	13.4	10.8	9.5	8.2	7.1	7.8	16.8
1976	15.3	11.1	40.7	63.5	38.5	24.5	14.4	11.6	9.7	8.4	7.2	6.7	21.0
1977	9.4	7.6	17.6	49.4	47.3	23.8		11.0	10.0		14.9	24.1	
1978	21.5	15.1	23.9	54.4	34.8	17.8	13.5	11.1	9.9	8.9	14.9	28.7	21.2
1979	27.6	24.8	54.3	88.7	70.1	46.7	21.1	14.3	13.5	9.8	9.9	11.9	32.7
1980	13.0	20.6	18.6	36.3	42.9	20.7	31.8	11.2	9.6	9.6	9.3		
1981		13.7	13.6	40.4	38.3	20.5	13.1	10.9	9.4	8.7	7.9	8.6	
1982	8.0	8.9	15.1	46.2	49.1	89.6	90.1	18.8		13.6	19.7	32.1	
1983	39.3	66.9	60.0	49.4	70.7	76.9	25.9	16.1	12.2	10.5	9.5	10.5	37.3
1984	11.2	11.8	30.2	46.7	45.1	27.4	19.7	15.2	12.6	11.5	12.9	33.9	23.2
1985	32.8	20.9	28.7		45.4	24.0	18.3	13.1	11.2	9.4	14.7	27.9	
1986	29.8	30.2	40.4		61.0	39.2	20.4	15.5	12.6	10.6	11.8	21.0	
1987	18.2	23.9	22.2	35.1	35.6	22.1	15.6	13.0	10.9	10.0	9.6	9.3	18.8
1988	17.2	19.0	18.9	32.0	24.8	18.3	14.4	13.9	12.3	10.6	22.5	19.9	18.6
1989	28.5	23.6	33.3	80.3	83.0	48.6	24.1	17.5	14.1	11.8			
1990	12.1	14.6	23.9	47.1	31.1	16.6							
Mean	17.2	17.4	25.0	52.0	41.4	26.8	18.6	12.2	10.0	9.1	10.8	15.4	21.8[1]
Max	39.3	66.9	60.0	90.4	83.0	89.6	90.1	18.8	14.1	13.6	22.5	33.9	37.3
Min	6.6	7.2	8.4	12.0	8.0	11.0	9.7	8.4	7.9	6.4	5.7	6.2	15.9
Std Dev	8.4	11.4	12.9	20.0	16.8	17.8	14.6	2.5	1.7	1.7	4.3	9.1	6.2
Coeff Var	0.49	0.65	0.52	0.38	0.41	0.66	0.79	0.20	0.17	0.18	0.40	0.59	0.28

Annex 2. 34 Year Mean Monthly Flows, 1960-90 Ministry of Water & 2011-14 RBWB/KPL

Year, MC/s	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Ann Avg*	
1960		*13.6*		*90.4*	*33.5*	*17.0*	*12.6*	*10.5*	*8.8*	*7.2*	*6.9*	*6.2*		
1961	*14.7*	*20.6*	*21.5*	*31.3*	*41.7*	*18.1*	*17.4*	*12.9*	*10.5*	*9.5*	*17.1*	*17.5*	*19.4*	
1962	*18.1*	*21.9*	*20.8*	*40.2*	*34.5*	*17.8*	*13.6*	*11.6*	*9*	*8.1*	*6.9*	*8.6*	*17.6*	
1963	*10.5*	*9.4*	*17.7*	*66.8*	*27.2*	*15.5*	*12*	*9.8*	*8.2*	*7*	*10.6*	*11.5*	*17.2*	
1964	*21.6*	*18.9*		*57.7*	*31.6*	*16*	*12*	*10*	*8*	*6.9*	*6.2*	*7.4*		
1965		*7.4*	*8.9*		*16.7*		*10.2*	*9.7*	*8.6*	*8.3*	*9.6*	*14.4*		
1966			*43.2*		*33.7*	*17.8*	*12.3*	*9.7*	*8.4*	*7.4*	*7*	*8.1*		
1967	*11.6*	*8.3*	*12.7*	*17.3*		*24.4*	*14.7*	*11.2*	*9*		*15.8*	*22.8*		
1968	*16.8*	*15*	*25.5*	*55.4*	*36.3*	*29.5*	*16.5*	*12.1*	*9.7*	*8.3*	*10.3*	*19*	*21.2*	
1969	*8.8*	*9.2*	*30.2*	*62.5*	*38.9*	*20.7*	*13.1*		*8.2*	*8.8*	*9.6*	*8*		
1970	*11.4*	*17*	*16.8*		*20.9*	*13.4*	*9.7*	*8.4*	*7.9*	*6.4*	*5.7*	*9*		
1971	*6.6*	*7.2*	*15.9*	*51.9*	*30.5*	*15.4*	*13.9*	*10.6*	*8.8*	*10.7*	*9.3*	*9.7*	*15.9*	
1972		*13.7*		*12*	*8*	*11*	*14.6*	*11.1*	*9.6*	*8.4*	*7.9*	*32.4*		
1973	*18.9*	*21*	*23.2*	*71.6*	*52.9*	*19.4*	*13.1*	*10.3*	*8.7*			*6.7*		
1974	*14.1*		*8.4*	*81.2*	*70.7*	*30.1*	*17.7*	*11.9*	*9.4*	*7.5*	*6.9*	*6.8*		
1975	*10.6*	*8.5*	*12.8*	*45.2*	*47*	*20.5*	*13.4*	*10.8*	*9.5*	*8.2*	*7.1*	*7.8*	*16.8*	
1976	*15.3*	*11.1*	*40.7*	*63.5*	*38.5*	*24.5*	*14.4*	*11.6*	*9.7*	*8.4*	*7.2*	*6.7*	*21.0*	
1977	*9.4*	*7.6*	*17.6*	*49.4*	*47.3*	*23.8*		*11*	*10*		*14.9*	*24.1*		
1978	*21.5*	*15.1*	*23.9*	*54.4*	*34.8*	*17.8*	*13.5*	*11.1*	*9.9*	*8.9*	*14.9*	*28.7*	*21.2*	
1979	*27.6*	*24.8*	*54.3*	*88.7*	*70.1*	*46.7*	*21.1*	*14.3*	*13.5*	*9.8*	*9.9*	*11.9*	*32.7*	
1980	*13*	*20.6*	*18.6*	*36.3*	*42.9*	*20.7*	*31.8*	*11.2*	*9.6*	*9.6*	*9.3*			
1981		*13.7*	*13.6*	*40.4*	*38.3*	*20.5*	*13.1*	*10.9*	*9.4*	*8.7*	*7.9*	*8.6*		
1982	*8*	*8.9*	*15.1*	*46.2*	*49.1*	*89.6*	*90.1*	*18.8*		*13.6*	*19.7*	*32.1*		
1983	*39.3*	*66.9*	*60*	*49.4*	*70.7*	*76.9*	*25.9*	*16.1*	*12.2*	*10.5*	*9.5*	*10.5*	*37.3*	
1984	*11.2*	*11.8*	*30.2*	*46.7*	*45.1*	*27.4*	*19.7*	*15.2*	*12.6*	*11.5*	*12.9*	*33.9*	*23.2*	
1985	*32.8*	*20.9*	*28.7*		*45.4*	*24*	*18.3*	*13.1*	*11.2*	*9.4*	*14.7*	*27.9*		
1986	*29.8*	*30.2*	*40.4*		*61*	*39.2*	*20.4*	*15.5*	*12.6*	*10.6*	*11.8*	*21*		
1987	*18.2*	*23.9*	*22.2*	*35.1*	*35.6*	*22.1*	*15.6*	*13*	*10.9*	*10*	*9.6*	*9.3*	*18.8*	
1988	*17.2*	*19*	*18.9*	*32*	*24.8*	*18.3*	*14.4*	*13.9*	*12.3*	*10.6*	*22.5*	*19.9*	*18.7*	
1989	*28.5*	*23.6*	*33.3*	*80.3*	*83*	*48.6*	*24.1*	*17.5*	*14.1*	*11.8*				
1990	*12.1*	*14.6*	*23.9*	*47.1*	*31.1*	*16.6*								
2011	5.7	6.1	11.8	53.4	39.9	22.6	12.9	10.8	8.5	8.4	5.8	7.5	16.1	
2012	8.7	6.4	10.2	19.4	24	14.4	10.8	9.1	5.9					
2013	8.8	6.8	38.8	38.2	36.9	20	13.4	10.4	7.5	7.7	6.9	9.2	17.1	
2014	12.1	10.7	28.5	79.6	68.8	31.1	21.6	17.1	14.2	15.1	10.4	12.4	26.8	
2105	12.5	13.5												
Mean	16.0	16.1	24.6	51.5	41.5	26.2	18.1	12.2	9.9	9.2	10.5	14.8	*21.3* [1]	*20.9* [2]
Max	39.3	66.9	60.0	90.4	83.0	89.6	90.1	18.8	14.2	15.1	22.5	33.9		
Min	5.7	6.1	8.4	12.0	8.0	11.0	9.7	8.4	5.9	6.4	5.7	6.2		
Std Dev	8.2	11.0	12.8	20.3	16.8	16.9	13.8	2.6	2.0	2.0	4.2	8.8		
Coeff Var	0.51	0.68	0.52	0.39	0.40	0.64	0.76	0.21	0.20	0.21	0.40	0.60		

1. Average annual mean or 80% probable flow
2. Average of montly means or 80% probable flows

1960-1990 data complied by MAJI at Dar -Es -Salaam
2011-2014 data compiled by RBWB/KPL

MINISTRY OF WATER

RUFIJI BASIN WATER BOARD

Telegrams: "MAJI"
Telephone: 026-2720951-3
Fax: 026-2720952

Rufiji Basin Water Board,
P.O. Box 1798,
IRINGA.

RBWB

RUFIJI BASIN

In reply please quote:

Ref: No. RBWO/

Date: 20th March 2015

To: Managing Director,
Kilombero Plantations Ltd,
PO Box 23294,
Dar es Salaam

Att: Carter Coleman

Ref: Re-calibration of Mngeta River Flows Gauge Station 1KB15A

Dear Mr. Carter Coleman,

The Rufiji River Basin Office hereby encloses our report on re-calibration and estimates of the water flow of the Mngeta from October 2010 to May 2014.

The Rufiji River Basin Office has

a. Since December 2010 to October 2012 has taken 45 monthly river flow readings.
b. Since October 2013 to May 2014 taken 21 bi-monthly river flow readings.
c. In total 66 river flow readings were used to estimate the river flow rating curve.
d. This new curve was applied to KPL daily gauge readings from October 2010 to May 2014, and
e. New daily and monthly average river flows were estimated.

According to our estimates, the lowest flow occurs in the month of November, estimated at 6.39 m3/s, and taking in to consideration the requirements to maintain and environmental flow of at least 40-50%, we estimate that an allowable maximum abstraction during the low water flow periods would be in the magnitude of a range of somewhere between 3.2-3.8 m3/sec.

We trust this information will be useful to your Environmental Impact Assessment

Yours Sincerely

Idris A. Msuya