5. DESCRIPTION OF THE AFFECTED ENVIRONMENT

5.1 RESULTS OF ECOREGIONS LITERATURE REVIEW

When assessing the ecology of any area (aquatic or terrestrial), it is important to know which ecoregion the area is located within. This knowledge allows for improved interpretation of data to be made, since reference information and representative species lists are often available on this level of assessment, which aids in guiding the assessment.

The study area falls within the South Eastern Uplands Aquatic Ecoregion and the Mzimvubu to Kieskamma Management Area (WMA). Quaternary catchment database (Kleynhans 1999) was used as reference for the catchment of concern in order to define the EIS, PEMC and DEMC. **Figures 6 to 8** indicate the aquatic ecoregion and quaternary catchments of the different developments of the study area.

The Lalini Dam is located within the T35L and T35K Quaternary Catchments **(Figure 6)**, whilst the Ntabelanga Dam and road upgrades are located within the T35E quaternary catchment and the particular river resource in the area is the Upper Ntata, Mzimvubu River (**Figure 7**). The pipelines traverse over several quaternary catchments, namely T20B, T34H, T34 J, T35E, T35H and T35K (**Figure 8**).

The ecological status of these quaternary catchments are summarised in **Table 13**. From the table, it is apparent that the PES Category of the various river systems varies between PES B and PES C. Specifically, the Tsitsa River is classified as a PES Category B river, whilst the Inxu is considered to be in a PES Category C. All systems are considered to have a 'moderate' Ecological Importance (EI) whilst the Ecological Sensitivity (ES) varies between High to Medium sensitivity. The Tsitsa River is considered to be of moderate sensitivity whilst the Inxu River is deemed to be highly sensitive. The default Ecological Class (EC) of the river systems in these quaternary catchments, based on the median PES and highest of EI or ES means is considered to be either a Class B or a Class C. The Tsitsa River is deemed to be a Class C, and the Inxu is deemed to be a Class B system.

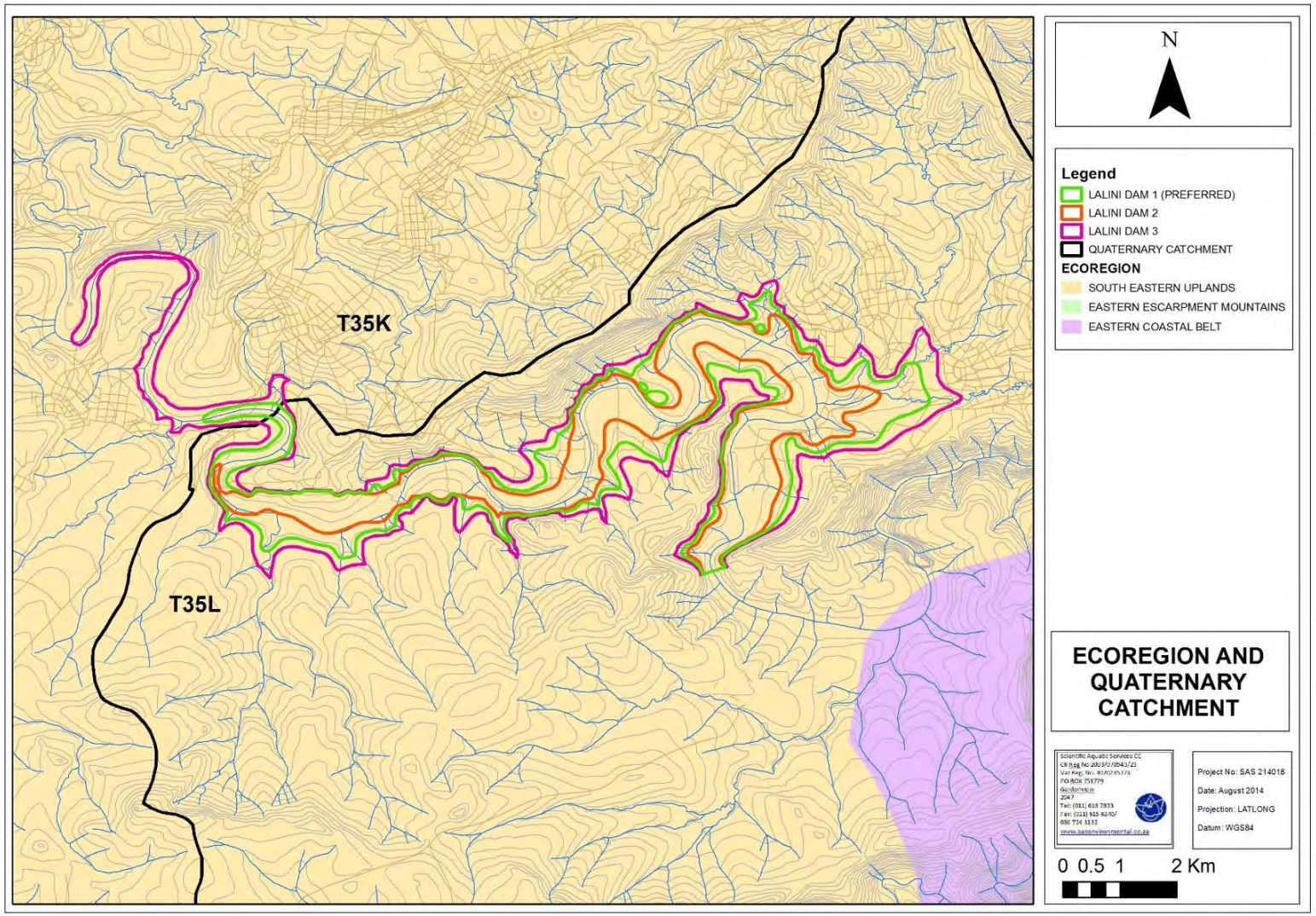

Figure 6: Aquatic Ecoregion and quaternary catchment associated with the Lalini Dam.

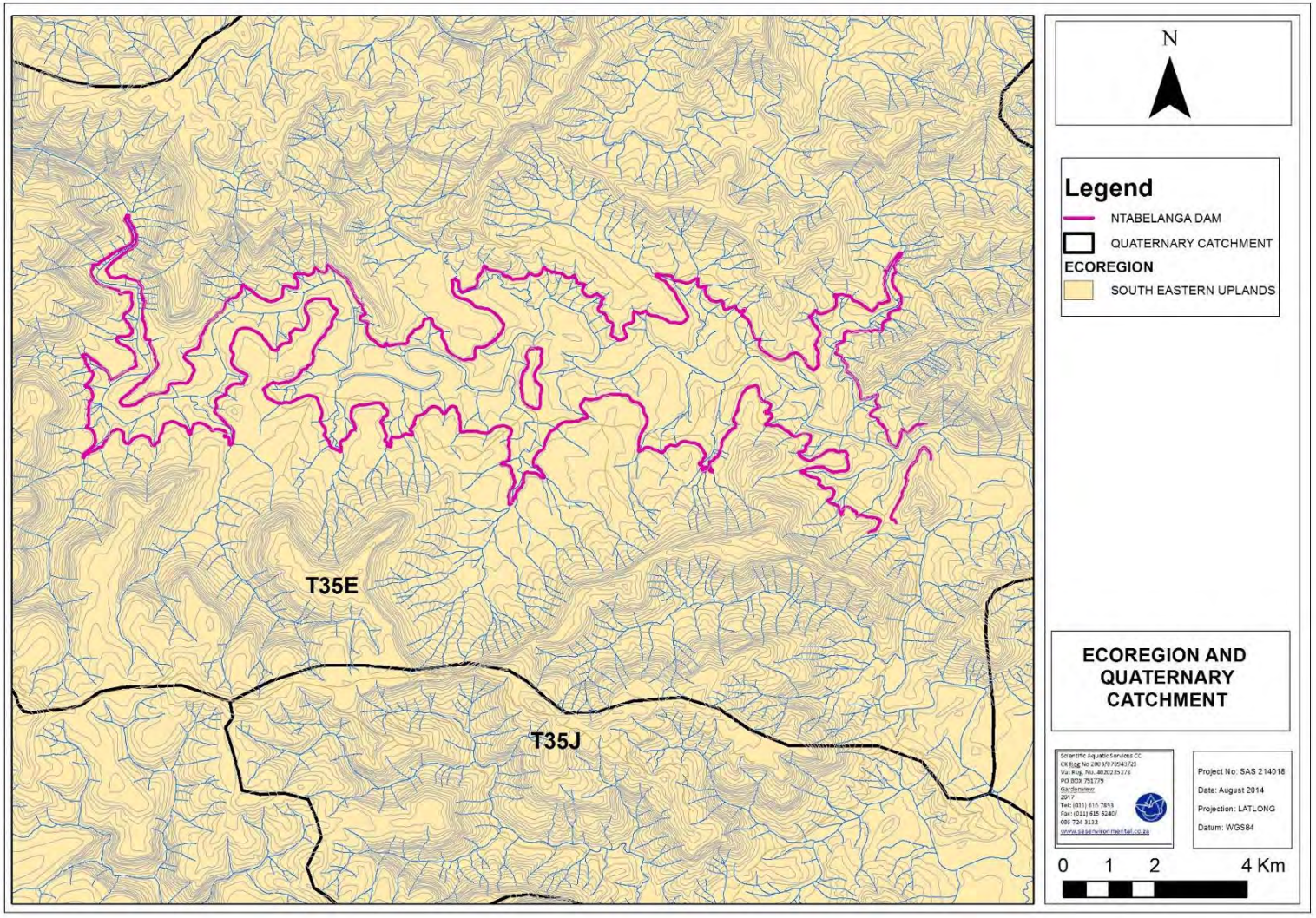

Figure 7: Ecoregion and quaternary catchment associated with the Ntabelanga Dam and the road upgrades.

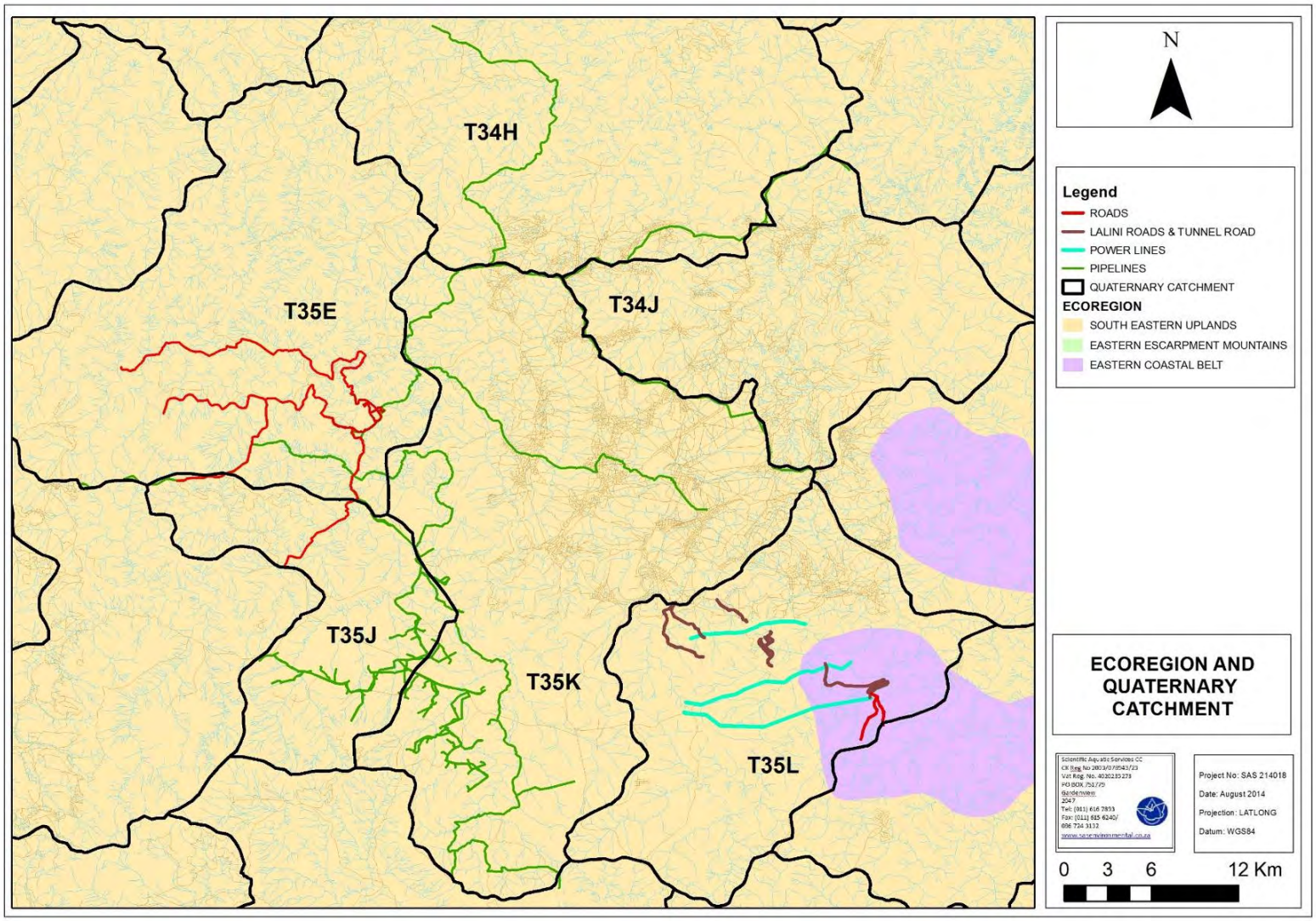

Figure 8: Ecoregion and quaternary catchment associated with the pipelines

Table 13: Summary of the Ecological Status of the quaternary catchments associated with the study area (Kleynhans *et al*. 2007)

SQ REACH	SQR NAME	PES ASSESSED BY XPERTS? (IF TRUE="Y")	PES CATEGORY MEDIAN	MEAN EI CLASS	MEAN ES CLASS	STREAM ORDER	DEFAULT EC (BASED ON MEDIAN PES AND HIGHEST OF EI OR ES MEANS)
T34H-05598	Thina	Y	C	MODERATE	MODERATE	3,0	C
T34H-05699	Mvuzi	Y	C	MODERATE	MODERATE	1,0	C
T34H-05714	Qhanqu	Y	C	MODERATE	MODERATE	1,0	C
T34H-05738	Ngcibira	Y	B	MODERATE	MODERATE	2,0	C
T34H-05769	Tsilithwa	Y	B	MODERATE	MODERATE	2,0	C
T34H-05772	Thina	Y	B	MODERATE	MODERATE	3,0	C
T34H-05791	Tsilithwa	Y	B	MODERATE	MODERATE	1,0	C
T34H-05809	Mvumvu	Y	B	MODERATE	HIGH	1,0	B
T34H-05826	Ngcothi	Y	B	MODERATE	MODERATE	1,0	C
T34H-05838	Thina	Y	C	MODERATE	MODERATE	3,0	C
T35E-05780	Gqukunqa	Y	B	MODERATE	MODERATE	1,0	C
T35E-05908	Tsitsa	Y	B	MODERATE	MODERATE	3,0	C
T35E-05977	Tsitsa	Y	B	MODERATE	MODERATE	3,0	C
T35H-06024	Inxu	Y	C	MODERATE	HIGH	3,0	B
T35H-06053	Inxu	Y	C	MODERATE	HIGH	3,0	B
T35H-06158	Qwakele	Y	C	MODERATE	HIGH	1,0	B
T35H-06186	Umnga	Y	C	MODERATE	MODERATE	2,0	C
T35H-06240	KuNgindi	Y	B	MODERATE	MODERATE	1,0	C
T35H-06282	Umnga	Y	B	MODERATE	MODERATE	1,0	C
T35J-06088	Inxu	Y	C	MODERATE	HIGH	3,0	B
T35J-06106	Ncolosi	Y	C	MODERATE	HIGH	1,0	B
T35K-05897	Culunca	Y	B	MODERATE	HIGH	1,0	B
T35K-05904	Tyira	Y	C	MODERATE	MODERATE	1,0	C
T35K-06037	Tsitsa	Y	B	MODERATE	MODERATE	4,0	C
T35K-06098	Tsitsa	Y	B	MODERATE	MODERATE	4,0	C
T35K-06167	Xokonxa	Y	C	MODERATE	MODERATE	1,0	C
T35L-05976	Tsitsa	Y	B	MODERATE	MODERATE	4,0	C
T35L-06190	Tsitsa	Y	B	MODERATE	MODERATE	4,0	C
T35L-06226	Ngcolora	Y	C	MODERATE	MODERATE	1,0	C

5.2 AQUATIC ECOLOGICAL ASSESSMENT RESULTS FOR THE TSITSA RIVER

5.2.1 Visual Assessment – April 2014

Figure 9: Upstream view of the TS1 site on the Tsitsa River showing the rocky substrate at this point, as assessed April 2014.

Figure 10: Downstream view of the TS1 site showing the diversity of flow types present, as assessed April 2014.

Figure 11: Upstream view of the Tsitsa River (TS4) showing the diversity of depth and flow profiles at this point, as assessed April 2014.

Figure 12: A downstream view of the TS4 site in the vicinity of the proposed Ntabelanga Dam wall, as assessed April 2014.

Figure 13: Upstream view of the TS7 site on the Tsitsa River showing the excellent rocky substrate at this point, as assessed April 2014.

Figure 14: Downstream view of the TS7 site showing the diversity of flows at this point, as assessed April 2014.

Figure 15: Upstream view of the TS8 site on the excellent rocky riffles and rapids at this point, as assessed April 2014.

Figure 16: Downstream view of the TS8 site showing the deeper pools, providing cover for fish, as assessed April 2014.

Table 14: Visual description of the sites selected on the Tsitsa River as assessed during April 2014

ASPECT	TS1	TS4	TS7	TS8
Significance of the point	This site serves as a future spatial reference point for all sites further downstream in the catchment. The point also serves to indicate the condition of the Tsitsa River prior to any effects as a result of the activities of the proposed construction and flooding of the Ntabelanga Dam.	Photographs are representative of the Tsitsa River approximately 500m upstream of the proposed Ntabelanga Dam wall. The point also serves to indicate the condition of the Tsitsa River prior to any effects as a result of the activities of the proposed construction and flooding of the Ntabelanga Dam.	The site is situated on the lower reaches of the Tsitsa River near to the upper flooding point of the proposed Lalini Dam. The point also serves to indicate the condition of the Tsitsa River prior to any effects as a result of the activities of the proposed construction and flooding of the Lalini Dam.	Photographs are representative of the Tsitsa River approximately 1000m upstream of the proposed Lalini Dam wall. The point also serves to indicate the condition of the Tsitsa River prior to any effects as a result of the activities of the proposed construction and flooding of the Lalini Dam.
Surrounding features	This section of the river is located a short distance downstream of the escarpment. Upstream of this area the land is rugged and remote with relatively limited rural occupation. In the immediate vicinity of the point the area is more populated and the area consists of a typical rural setting with rural settlements and agriculture dominating the landscape.	In the immediate vicinity of the point and stretching to the TS1 point the area is relatively densely populated and the area consists of a typical rural setting with rural settlements and agriculture dominating the landscape. Some larger scale commercial agriculture occurs in this area	Areas upstream of this point are relatively densely populated and the area consists of a typical rural setting with rural settlements and agriculture dominating the landscape. The N2 roadway also crosses the Tsitsa river a short distance upstream of this point as well as a DWS gauging weir	Areas upstream of this point are relatively densely populated and the area consists of a typical rural setting with rural settlements and agriculture dominating the landscape. In the immediate vicinity of the point the area is less densely populated due to limitation on accessibility of the valley and with the Tsitsa falls lower downstream in the valley.
Riparian zone characteristics	The riparian zone along the length of this section of the Tsitsa River is generally steep and narrow due to topography of the area although in some areas the floodplain is wider. Some vegetation removal has occurred as a result of firewood collection and livestock grazing. The riparian zone at this point has not been significantly affected by alien vegetation encroachment.	The riparian zone along the length of this section of the Tsitsa River is generally steep and narrow due to topography of the area. Some vegetation removal has occurred as a result of crop cultivation and livestock grazing. The riparian zone at this point has not been significantly affected by alien vegetation encroachment.	The riparian zone along the length of this section of the Tsitsa River is generally steep and narrow due to topography of the area although in some areas the floodplain is wider. Some vegetation removal has occurred as a result of firewood collection and livestock grazing. The riparian zone at this point has not been significantly affected by alien vegetation encroachment.	The riparian zone along the length of this section of the Tsitsa River is generally steep and narrow due to topography of the area although in some areas the floodplain is wider. Little vegetation removal has occurred due to the more remote nature of this area. The riparian zone at this point has not been significantly affected by alien vegetation encroachment.

ASPECT	TS1	TS4	TS7	TS8
Depth and flow characteristics	The Tsitsa River was flowing strongly at this point at the time of assessment. A diversity of flow was evident with very fast, fast and slow flow areas present. The river consisted mostly of shallow rapids and deeper pools and glides.	The Tsitsa River was flowing strongly at this point at the time of assessment. A diversity of flow was evident with very fast, fast and slow flow areas present. The river consisted mostly of shallow rapids and deeper pools and glides.	The Tsitsa River was flowing strongly at this point at the time of assessment. A diversity of flow was evident with very fast, fast and slow flow areas present. The river consisted mostly of shallow rapids runs and glides.	The Tsitsa River was flowing strongly at this point at the time of assessment. A diversity of flow was evident with very fast, fast and slow flow areas present. The river consisted mostly of shallow rapids and deeper pools and glides.
Water clarity	Water was very clear.	Water was very clear.	Water was very clear.	Water was very clear.
Impacts and signs of pollution	At the time of assessment no significant impacts on the instream ecology were visually evident.	At the time of assessment no significant impacts on the instream ecology were visually evident	At the time of assessment limited impacts on the instream ecology were visually evident.	At the time of assessment limited impacts on the instream ecology were visually evident.

5.2.2 Visual Assessment – June 2014

Figure 17: Upstream view of the TS1 site on the Tsitsa River as assessed June 2014, showing the rocky substrate at this point and slightly lower flow compared to April 2014.

Figure 18: Downstream view of the TS1 site at the time of assessment in June 2014.

Figure 19: Upstream view of the Tsitsa River (TS4) as assessed in June 2014, showing the decrease in diversity of depth and flow profiles at this point, when compared to the April 2014 assessment.

Figure 20: A downstream view of the TS4 site in the vicinity of the proposed Ntabelanga dam wall, as assessed in June 2014.

Figure 21: Upstream view of the TS7 site on the Tsitsa River showing the excellent rocky substrate at this point, as assessed in June 2014.

Figure 22: Downstream view of the TS7 site as assessed in June 2014, showing the decrease in diversity of flows at this point when compared to the April 2014 assessment.

Figure 23: Upstream view of the TS8 site on the excellent rocky riffles at this point, as assessed in June 2014.

Figure 24: Downstream view of the TS8 site showing slightly deeper habitat providing cover for fish, as assessed in June 2014.

Table 15: Visual description of the sites selected on the Tsitsa River as assessed during June 2014

ASPECT	TS1	TS4	TS7	TS8
Depth and flow characteristics	The Tsitsa River exhibited lower flow at this point at the time of assessment, compared to that observed during the April 2014 assessment. Lower flow also resulted in a reduction in the diversity of flow types. Limited diversity of flow was evident with fast and slow flow areas present. The river consisted mostly of shallow rapids and glides/runs and small, shallow pools.	The Tsitsa River exhibited lower flow at this point at the time of assessment, compared to that observed during the April 2014 assessment. Lower flow also resulted in a reduction in the diversity of flow types. However, a diversity of flow was still evident with very fast, fast and slow flow areas present. The river consisted mostly of shallow rapids and deeper pools and glides.	The Tsitsa River exhibited lower flow at this point at the time of assessment, compared to that observed during the April 2014 assessment. Lower flow also resulted in a reduction in the diversity of flow types. However, a diversity of flow was evident with very fast, fast and slow flow areas present. The river consisted mostly of shallow runs and glides with interspersed rapids.	The Tsitsa River exhibited lower flow at this point at the time of assessment, compared to that observed during the April 2014 assessment. Lower flow also resulted in a reduction in the diversity of flow types. A diversity of flow was evident with very fast, fast and slow flow areas present. The river consisted mostly of shallow rapids and deeper pools and glides.
Water clarity	Water was very clear.	Water was very clear.	Water was very clear.	Water was very clear.
Impacts and signs of pollution	At the time of assessment no significant impacts on the instream ecology were visually evident.	At the time of assessment no significant impacts on the instream ecology were visually evident	At the time of assessment limited impacts on the instream ecology were visually evident.	At the time of assessment limited impacts on the instream ecology were visually evident.

5.2.3 Physico-Chemical Water Quality

Water quality variables were measured at the four points on the Tsitsa River (**Table 16, Figures 25 and 26**). TS1 represents the most upstream point and acts as upstream reference for the other sites downstream.

Table 16: Biota specific water quality data for the assessed Tsitsa River sites

Site	Description	Month	Conductivity (mS/m)	pH (pH units)	Temp (ºC)
TS1	Most upstream point on the system on the upper boundary of the project area, just prior to the location of the proposed Ntabelanga Dam and road upgrades Tsitsa River – spatial reference point	April 2014	9.0	8.78	18.6
		June 2014	5.2	7.10	14.4
TS4	Downstream site on the system at a point just above the proposed dam wall.	April 2014	14.0	8.57	20.8
		June 2014	14.2	8.10	17.3
TS7	Downstream site on the system at a point just upstream of the location of the proposed Lalini Dam full supply level.	April 2014	14.0	8.81	22.8
		June 2014	12.1	7.80	12.1
TS8	Downstream site on the system at a point just after the planned development mentioned above.	April 2014	13.0	8.79	22.8
		June 2014	12.3	7.60	20.1

The following key points on the water quality of the Tsitsa River system both upstream and in the vicinity of the proposed Mzimvubu Water Project were observed:

- The overall water quality conditions in the Tsitsa River is very good, with recorded water quality parameters similar for the two assessments;
- Between April 2014 and June 2014, EC values decreased by 42.2% at site TS1, by 10.0% at site TS7 and by 5.4% at site TS8. There was a 1.4% increase in EC between assessments at site TS4;
- Spatially there was an increase in conductivity in a downstream direction in April 2014, with electrical conductivity (EC) being 44.4% higher at site TS8 compared to TS1. For the June 2014 assessment spatial comparison between the same two points yielded an increase of 136.5% in a downstream direction;
- The increase in EC may indicate salt loading from surrounding rural settlements and agricultural activities, that may have been compounded by lower flow conditions during June 2014;

- EC recorded at the three downstream sites on the Tsitsa River (TS4, TS7 and TS8) were thus very similar, ranging between 13.0 and 14.0 in April 2014 and between 12.3 and 14.2 in June 2014. EC values at site TS1 were lower (9.0 and 5.2 respectively), which can be expected as this is the reference point located upstream of the other points assessed;
- The water quality guideline for aquatic ecosystems (DWA 1997) states that: 1) Total dissolved salts (TDS) concentrations (i.e. as indicated by the EC measurements) should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year; and 2) the amplitude and frequency of natural cycles in TDS concentrations should not be changed;
- When viewing upstream site TS1 as reference site, the spatial change in a downstream direction during both April 2014 and June 2014 thus exceeds the above recommendation;
- From a temporal perspective, the percentage change between April 2014 and June 2014 ranged between 1.4% and 42.2% for the various sites. The guideline recommendation was exceeded only at site TS1 (42.2% change), with percentage change at the remaining three sites varying between 1.4% and 10.0%;
- These observations indicate that seasonal variation in dissolved salt concentrations in the system vary seasonally and based on rainfall in the catchment, however dissolved salt concentrations in the system can generally be considered low;
- The construction of the dams may lead to some changes in the dissolved salts in the system with temporal cycles as well as spatial changes in salt loading being altered due to altered chemical and biological processes;
- Spatially there was a 0.1% increase in pH value in a downstream direction between sites TS1 and TS8 during April 2014. During June 2014 pH increased by 7.0% between these two points;
- The water quality guideline for aquatic ecosystems (DWA 1997) states that pH values should not be allowed to vary from the range of the background pH values for a specific site by > 5 %;
- If the upstream site TS1 pH value is considered a reference value for the downstream site TS8, the observed spatial changes in pH value are in compliance the recommended guideline for April 2014, but the change exceeded the guideline in June 2014;
- From a temporal perspective, pH decreased by between 5.5% and 19.1% at the various sites between April 2014 and June 2014, exceeding the guideline recommendation in all cases;
- The results therefore indicate that pH is variable in the system over time and some changes in pH occur along the length of the system which may be related to surrounding activities;
- The proposed dams are likely to lead to additional changes in pH due to altered biological processes in the system;
- The temperatures observed at each of the points are deemed natural for the time of year and the nature of the systems. The observed variations between the points can be attributed to diurnal variation between sampling times, altitude variation between

the points and the variation in the volume of water in the river. The observed variation between the autumn and winter assessments could be expected and is considered natural seasonal variation.

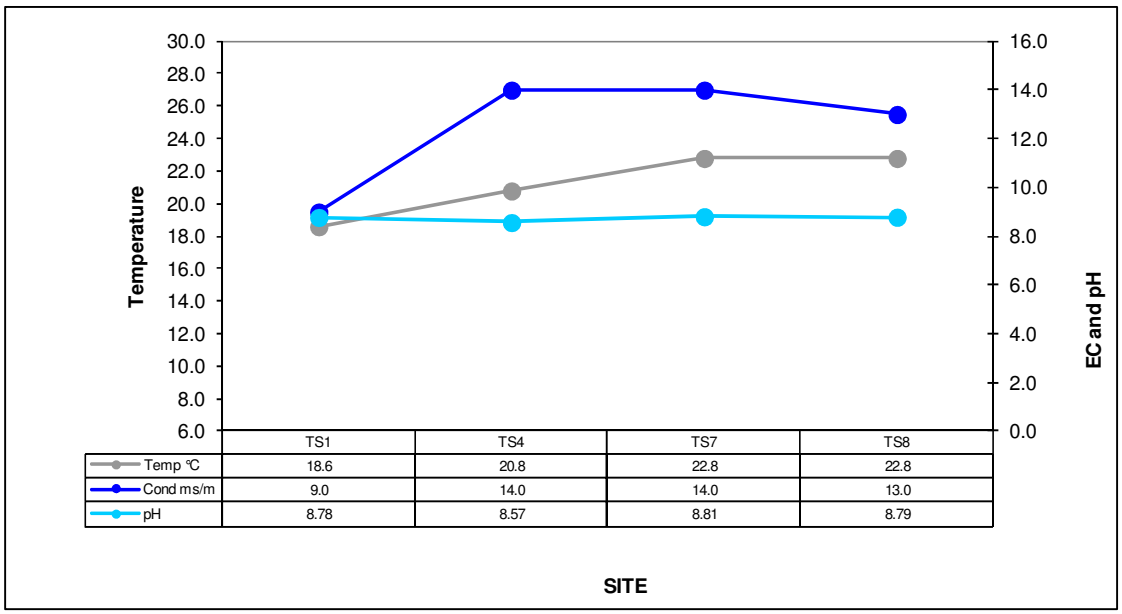

Figure 25: Physico-chemical water quality measured during April 2014 showing spatial trends

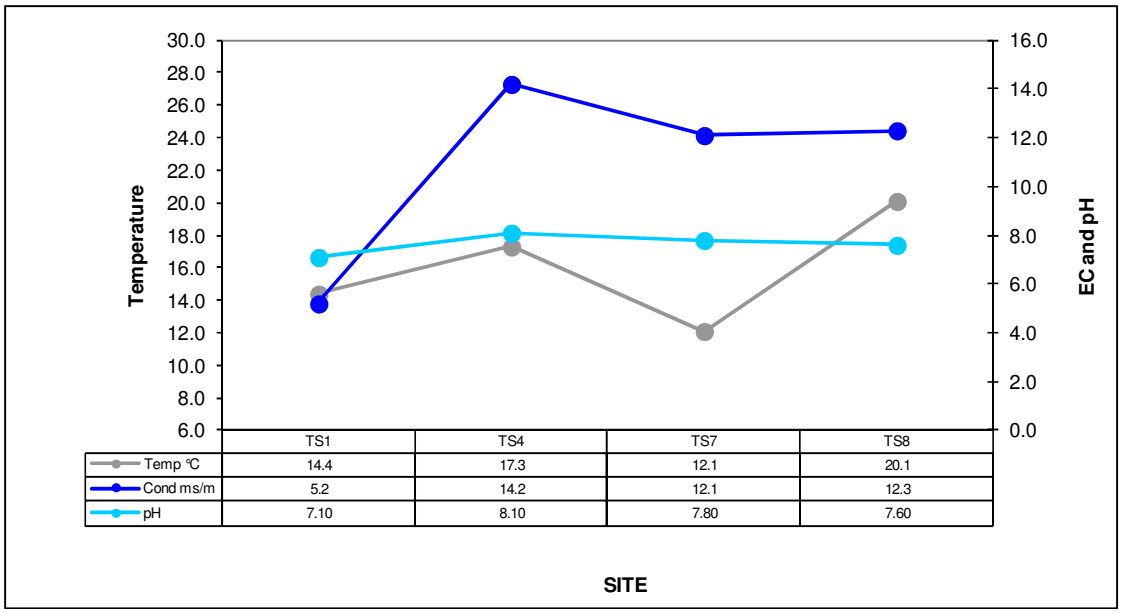

Figure 26: Physico-chemical water quality measured during June 2014 showing spatial trends

5.2.4 Intermediate Habitat Integrity Assessment (IHIA)

The full results following the application of this index are presented in **Appendix B.** This assessment was only performed during April 2014, as the index is not sensitive to small short-term changes but rather assesses longer term changes in habitat integrity.

For Tsitsa River assessment sites, small to moderate impacts were recorded for the instream zone habitat. The former relates to water abstraction (all sites), flow modification (all sites), channel modification (TS7), bed modification (all sites), water quality (all sites), exotic fauna (TS1, TS4 and TS8) and solid waste disposal (all sites).

The exotic fauna category presented with moderate impacts in all three cases. Site TS7 is most impacted in terms of instream habitat integrity. Site TS1 obtained a Class A (unmodified/natural) classification, site TS4 a Class B (largely natural) classification and sites TS7 and TS8 both obtained a C (moderately modified). The results therefore show an increasing trend of general impact on instream habitat in a downstream direction on the system.

Small to large impacts were recorded for the riparian zone. These included vegetation removal (all sites), alien encroachment (all sites) and bank erosion (all sites). Large impacts were reported for vegetation removal, alien encroachment and bank erosion. The most significant riparian zone impact at all sites was vegetation removal. Site TS1 obtained a Class B (largely natural) classification whilst the remaining three sites (TS4, TS7 and TS8) obtained a Class C (moderately modified) classification with regard to riparian habitat integrity.

Overall, sites TS1 and TS4 presented with a Class B (largely natural) classification, whilst a Class C (moderately modified) classification was obtained for sites TS7 and TS8 indicating a general deterioration in riverine habitat integrity in a downstream direction on the system.

5.2.5 Invertebrate Habitat Assessment System (IHAS)

Tables 17 and 18 are summaries of the results obtained from the application of the Invertebrate Habitat Integrity Assessment (IHAS) Index to the four river assessment sites on the Tsitsa River during April 2014 and June 2014 respectively. This index determines habitat suitability, with particular reference to the requirements of aquatic macro-invertebrates. The results obtained from this assessment will aid in interpreting the SASS5 results. IHAS scores (McMillan, 1998) are presented in **Appendix 4**.

Table 17: A summary of the results obtained from the application of and IHAS indices to the assessment sites on the Tsitsa River during April 2014.

SITE	TS1	TS4	TS7	TS8
IHAS score	77	66	71	75
IHAS Adjustment score (illustrative purposes only)	+14	+19	+15	+10
McMillan, 1998 IHAS description	Habitat diversity and structure is highly suited for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is highly suited for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.
Stones habitat characteristics	Adequate loose cobbles and rocks in current present. Stones out of current present.	Stone habitat in current present but suitably sized cobbles limited. Stones out of current absent.	Adequate loose cobbles and rocks in current present. Stones out of current absent. .	Adequate loose cobbles and rocks in current present. Stones out of current present.
Vegetation habitat characteristics	Bank/riparian vegetation (mix of reeds and shrubs) and fringing vegetation were present. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	Bank/riparian vegetation (mix of reeds and shrubs) and fringing vegetation were present. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	Bank/riparian vegetation (reeds/grass) and fringing vegetation were present. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	Bank/riparian vegetation (mix of reeds and shrubs) and fringing vegetation were present. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.
Other habitat characteristics	No sand, gravel or mud habitats available. No algae or bedrock substrate present.	Some sand habitat available and sampled, no gravel or mud habitats available. No algae present but some bedrock substrate present.	Some sand habitat available and sampled, no gravel or mud habitats available. No algae present but some bedrock substrate present.	Some sand and gravel habitat available and sampled, no mud habitats available. No algae or bedrock.
IHAS general stream characteristics	The stream at this point has a good diversity of flow, is wide and of average depth under the current conditions. Water is clear and bank cover is good, thus limiting the potential for erosion at this point.	The stream at this point has a good diversity of flow, is wide and of average depth under the current conditions. Water is clear and bank cover is fair, thus limiting the potential for erosion at this point.	The stream at this point has a good diversity of flow, is wide and of average depth under the current conditions. Water is clear and bank cover is fair, thus limiting the potential for erosion at this point to some degree.	The stream at this point has a good diversity of flow, is wide and of average depth under the current conditions. Water is clear and bank cover is fair, thus limiting the potential for erosion at this point. However, some signs of erosion were evident.

Table 18: A summary of the results obtained from the application of and IHAS indices to the assessment sites on the Tsitsa River during June 2014.

SITE	TS1	TS4	TS7	TS8
IHAS score	71	65	71	76
IHAS Adjustment score (illustrative purposes only)	+11	+20	+15	+9
McMillan, 1998 IHAS description	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is highly suited for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.
Stones habitat characteristics	Adequate loose cobbles and rocks in current present. Stones out of current present.	Stone habitat in current present but suitably sized cobbles limited. Stones out of current absent.	Adequate loose cobbles and rocks in current present. Stones out of current absent. .	Adequate loose cobbles and rocks in current present. Stones out of current present.
Vegetation habitat characteristics	Bank/riparian vegetation (predominantly shrubs) and fringing vegetation were present. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	Bank/riparian vegetation (mix of reeds and shrubs) and fringing vegetation were present. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	Bank/riparian vegetation (reeds/grass) and fringing vegetation were present. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	Bank/riparian vegetation (mix of reeds and shrubs) and fringing vegetation were present. Limited leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.
Other habitat characteristics	Some sand, gravel and bedrock sampled but no mud habitats available. No algae present.	Some sand habitat available and sampled, no gravel or mud habitats available. No algae present but some bedrock substrate present.	Some sand habitat available and sampled, no gravel or mud habitats available. No algae present but some bedrock substrate present.	Some sand and gravel habitat available and sampled, no mud habitats available. No algae or bedrock.
IHAS general stream characteristics	The stream at this point has a good diversity of flow, is wide and of average depth under the current conditions. Water is clear but bank cover is poor, increasing potential for erosion at this point under current flow and environmental (winter) conditions.	The stream at this point has a good diversity of flow, is wide and of average depth under the current conditions. Water is clear and bank cover is fair, thus limiting the potential for erosion at this point.	The stream at this point has a good diversity of flow, is wide and of average depth under the current conditions. Water is clear and bank cover is fair, thus limiting the potential for erosion at this point.	The stream at this point has a good diversity of flow, is wide and of average depth under the current conditions. Water is clear and bank cover is fair, thus limiting the potential for erosion at this point. However, some signs of erosion were evident.

The following points are evident with reference to the IHAS assessments:

- Habitat limitations that may negatively impact the diversity, abundance and sensitivity of the aquatic community to some degree, include absence of aquatic vegetation, mud and gravel substrate at the majority of sites;

- However, suitable habitat in the form of ample rocky substrate indicates suitable macro-invertebrate habitat conditions at the Tsitsa River points sampled;
- The variety of flow and depth conditions present at the sites is also conducive to an increased diversity of macro-invertebrate species;
- The habitat conditions at the remaining sites on the Tsitsa River is considered to be adequate to support a diverse aquatic macro-invertebrate community.

From a temporal perspective, the IHAS score decreased slightly at sites TS1 (7.8%) and TS4 (1.5%), which can be attributed to lower flow conditions in June 2014. However, IHAS score remained unchanged at site TS7 and increased by 1.3% at site TS8.

At site TS1 lower flow conditions resulted in sand and gravel substrate becoming available for sampling in June 2014. Furthermore a lower percentage leafy material and less bank cover was observed in June 2014 compared to April 2014. This can be expected under the dry winter conditions. Lower percentage leaf cover was recorded at the majority of the other sites sampled for the same reason. Apart from the latter the IHAS variables recorded remained similar between assessments at sites TS4, TS7 and TS8.

5.2.6 Aquatic Macro-Invertebrates: South African Scoring System (SASS5)

Table 19 indicates the results obtained per biotope sampled whilst SASS5 scores are tabulated in **Tables 20 and 21**. SASS5 and ASPT score sheets (Dickens and Graham, 2001) are presented in **Appendix D**.

Table 19: Biotope specific summary of the results obtained from the application of the SASS5 index to the assessment sites on the Tsitsa River during both April 2014 and June 2014

PARAMETER	SITE	MONTH	STONES	VEGETATION	GRAVEL, SAND AND MUD	TOTAL
SASS5 Score	TS1	April 2014	85	37	0	115
Number of taxa			10	7	0	15
ASPT			9.0	5.3	0	7.7
SASS5 Score		June 2014	71	12	67	88
Number of taxa			8	2	9	12
ASPT			9.0	6.0	7.0	7.3
SASS5 Score	TS4	April 2014	85	22	36	85
Number of taxa			12	3	5	13
ASPT			7.0	7.3	7.0	6.5
SASS5 Score		June 2014	76	11	19	89
Number of taxa			11	2	4	14
ASPT			7.0	5.5	5.0	6.4
SASS5 Score	TS7	April 2014	107	21	22	116
Number of taxa			12	3	5	13
ASPT			9.0	7.0	4.0	8.9
SASS5 Score		June 2014	36	12	54	67
Number of taxa			6	3	9	12
ASPT			6.0	4.0	6.0	5.6
SASS5 Score	TS8	April 2014	87	6	14	87
Number of taxa			11	1	3	11
ASPT			8.0	6.0	5.0	7.9
SASS5 Score		June 2014	79	21	99	114
Number of taxa			10	3	13	16
ASPT			8.0	7.0	8.0	7.1

- Because of the very similar habitat, flow and water quality conditions at the sites, there is little variation in SASS5 results from a spatial perspective. During April 2014 sites T1 and T7 presented with similar SASS5 scores whilst sites TS4 and TS8 had similar SASS5 scores (**Figure 27**).
- Because of the lower flow conditions in June 2014, there were more variation between sites compared to April 2014 results. During June 2014 sites T1 and T4 presented with similar SASS5 scores. TS8 had the highest SASS5 score whilst sites TS7 had the lowest SASS5 score (**Figure 28**).

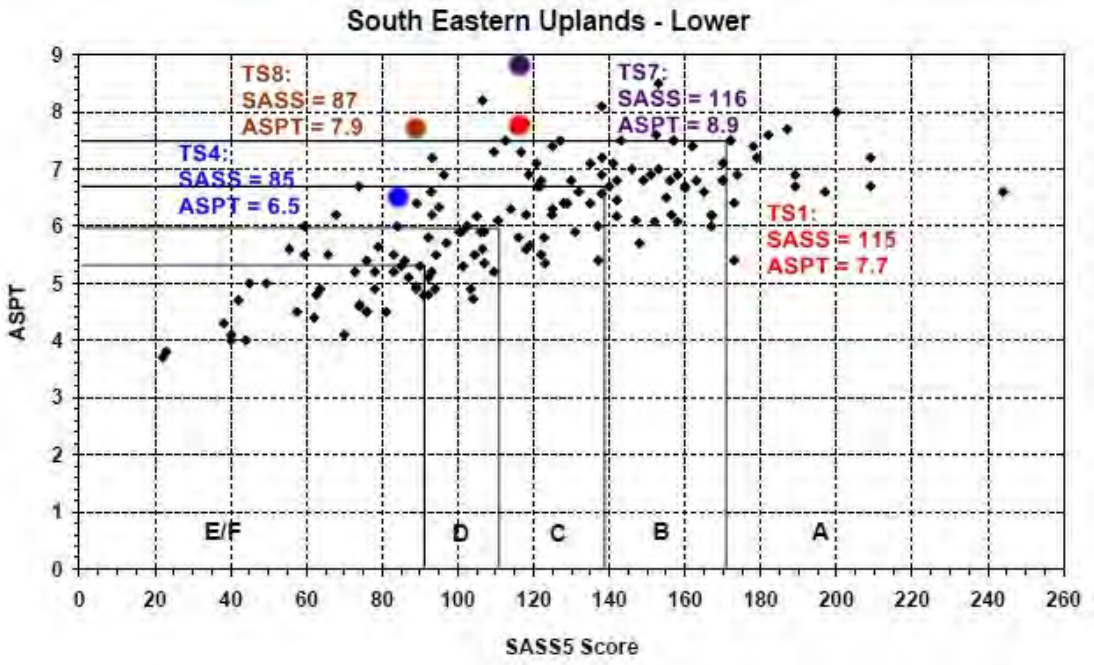

Figure 27: Visual depiction of SASS5 and ASPT scores for sites on the Tsitsa River based on the Dallas (2007) classification as recorded during April 2014.

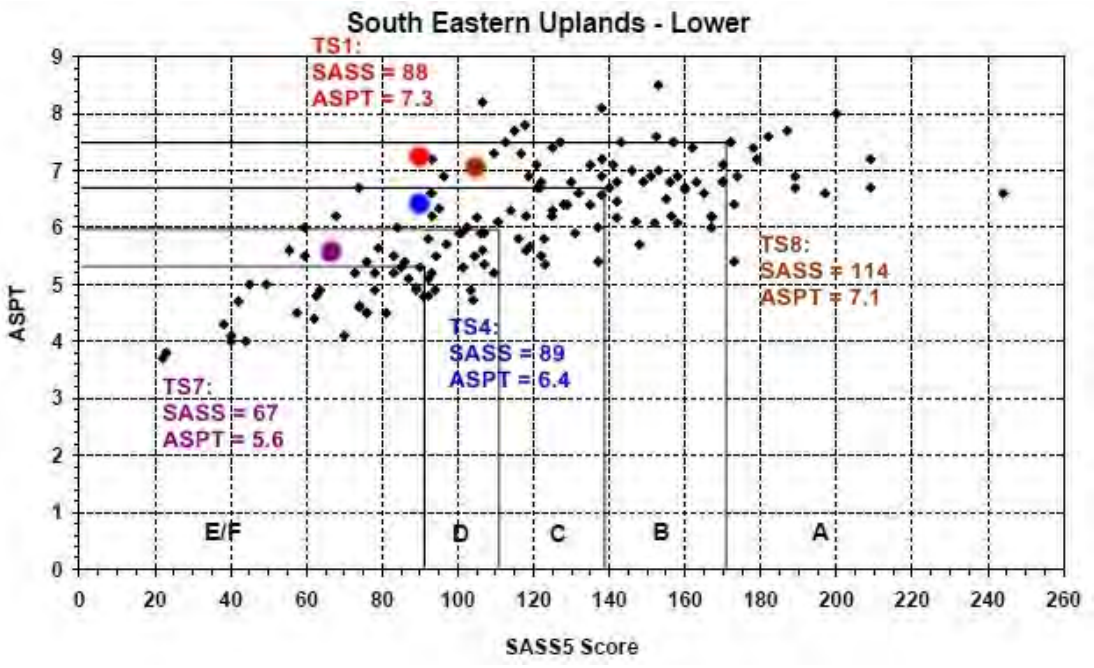

Figure 28: Visual depiction of SASS5 and ASPT scores for sites on the Tsitsa River based on the Dallas (2007) classification as recorded during June 2014.

Table 20: Summary of the results obtained from the application of the SASS5 index to the assessment sites on the Tsitsa River during April 2014

Type of Result	TS1	TS4	TS7	TS8
Biotopes sampled	Stones in current; Fringing vegetation; Stones out of current; Bedrock.	Stones in current; Fringing vegetation; Sand; Bedrock.	Stones in current; Fringing vegetation; Sand.	Stones in current; Fringing vegetation; Stones out of current; Sand; Gravel.
Sensitive taxa present	*Hydracarina; Perlidae; Heptageniidae; Oligoneuridae; Tricorythidae; Elmidae; Psephenidae.*	*Perlidae; Caenidae; Oligoneuridae; Elmidae; Psephenidae; Aeshnidae; Gomphidae.*	*Perlidae; Oligoneuridae; Prosopistomatidae; Gomphidae; Pyralidae; Elmidae; Psephenidae.*	*Perlidae; Caenidae; Oligoneuridae; Gomphidae; Elmidae; Psephenidae; Ancylidae.*
Sensitive taxa absent	*Caenidae; Aeshnidae; Gomphidae; Prosopistomatidae; Pyralidae; Leptophlebiidae; Hydraenidae.*	*Hydracarina; Heptageniidae; Tricorythidae; Prosopistomatidae; Pyralidae; Leptophlebiidae; Hydraenidae.*	*Caenidae; Aeshnidae; Hydracarina; Heptageniidae; Tricorythidae; Leptophlebiidae; Hydraenidae.*	*Prosopistomatidae; Pyralidae; Aeshnidae; Hydracarina; Heptageniidae; Tricorythidae; Leptophlebiidae; Hydraenidae.*
SASS5 score	115	85	116	87
Adjusted SASS5 score	129	104	131	97
SASS5 % of theoretical reference score*	67.6	50.0	68.2	51.2
ASPT score	7.7	6.5	8.9	7.9
ASPT % of theoretical reference score**	102.7	86.7	118.7	105.3
Dickens & Graham, 2001 SASS5 classification	C (Moderately impaired)	C (Moderately impaired)	C (Moderately impaired)	C (Moderately impaired)
Dallas 2007 classification	A	C	A	A

Table 21: Summary of the results obtained from the application of the SASS5 index to the assessment sites on the Tsitsa River during June 2014

Type of Result	TS1	TS4	TS7	TS8
Biotopes sampled	Stones in current; Fringing vegetation; Stones out of current; Sand; Gravel; Bedrock.	Stones in current; Fringing vegetation; Sand; Bedrock.	Stones in current; Fringing vegetation; Sand.	Stones in current; Fringing vegetation; Stones out of current; Sand; Gravel.
Sensitive taxa present	*Leptophlebiidae; Oligoneuridae; Tricorythidae; Aeshnidae; Caenidae.*	*Perlidae; Caenidae; Heptageniidae; Gomphidae; Psephenidae.*	*Caenidae; Prosopistomatidae; Gomphidae.*	*Heptageniidae; Oligoneuridae; Prosopistomatidae; Tricorythidae; Gomphidae.*
Sensitive taxa absent	*Hydracarina; Perlidae; Heptageniidae; Elmidae; Psephenidae; Gomphidae; Prosopistomatidae; Pyralidae; Hydraenidae.*	*Hydracarina; Oligoneuridae; Tricorythidae; Elmidae; Aeshnidae; Prosopistomatidae; Pyralidae; Leptophlebiidae; Hydraenidae.*	*Hydracarina; Perlidae; Heptageniidae; Oligoneuridae; Tricorythidae; Elmidae; Psephenidae; Aeshnidae; Pyralidae; Leptophlebiidae; Hydraenidae.*	*Hydracarina; Perlidae; Elmidae; Psephenidae; Caenidae; Aeshnidae; Pyralidae; Leptophlebiidae; Hydraenidae.*
SASS5 score	88	89	67	114
Adjusted SASS5 score	99	109	82	123
SASS5 % of theoretical reference score*	51.8	52.4	39.4	67.1
ASPT score	7.3	6.4	5.6	7.1
ASPT % of theoretical reference score**	97.3	85.3	74.7	94.7
Dickens & Graham, 2001 SASS5 classification	C (Moderately impaired)	C (Moderately impaired)	Borderline D/E (Largely to severely impaired)	C (Moderately impaired)
Dallas 2007 classification	B	C	D	B

- During the April 2014 assessment all sites could be considered to be in a Class C (moderately impaired) condition according the Dickens & Graham (2001) classification system. According to the Dallas (2007) classification system, the site TS4 was classified as Class C whilst the remaining three sites were classified as Class A (natural);
- This apparent discrepancy can be explained by the lower ASPT score recorded at site TS4;
- During the June 2014 assessment sites TS1, TS4 and TS8 can be considered to be in a Class C (moderately impaired) condition according the Dickens & Graham (2001) classification system. According to the same classification site TS7 is classified as borderline D/E (largely to severely impaired). According to the Dallas (2007) classification system, sites TS1 and TS8 were classified as Class B, site TS4 was classified as Class C whilst site TS7 was classified as Class D;
- As could be expected based on seasonal changes in flow (lower in winter), seasonal changes in SASS5 score classifications appear evident;
- This appears to have particularly impacted site TS7, where a significant decrease in ecological classification appear to have occurred between April 2014 and June 2014. This is considered to be the result of change in habitat availability resulting from lower flow. Previous riffle areas with very fast flow were no longer available, as is also shown by the percentage preference by habitat type (**Table 22**) discussed in the MIRAI section that is to follow;
- The results indicate that there is substantial spatial and temporal variation in the system, however all the variation in the system can be considered to be natural variation. No highly significant impacts are deemed likely to occur in this segment of the Tsitsa river which will lead to a fundamental change in the aquatic macro-invertebrate community integrity of the system;
- Because of the largely natural conditions evident at these sites, special care should be taken during the construction phase, but also during design and operational procedures to limit the impact on the Tsitsa River;
- Due to the natural conditions in the system the aquatic macro-invertebrate community is reliant on fast flowing, turbulent, well oxygenated, clear water flowing over a rocky substrate. The proposed impoundments will lead to the complete loss of this habitat over extensive lengths of the Tsitsa River and will therefore have a very significant impact on the aquatic macro-invertebrate community in this segment of the system;
- The significance of the impact on the areas below the two dams will depend on how water is released from the systems and how instream flows within the system are maintained, but some level of impact on the aquatic macro-invertebrate community is deemed definite.

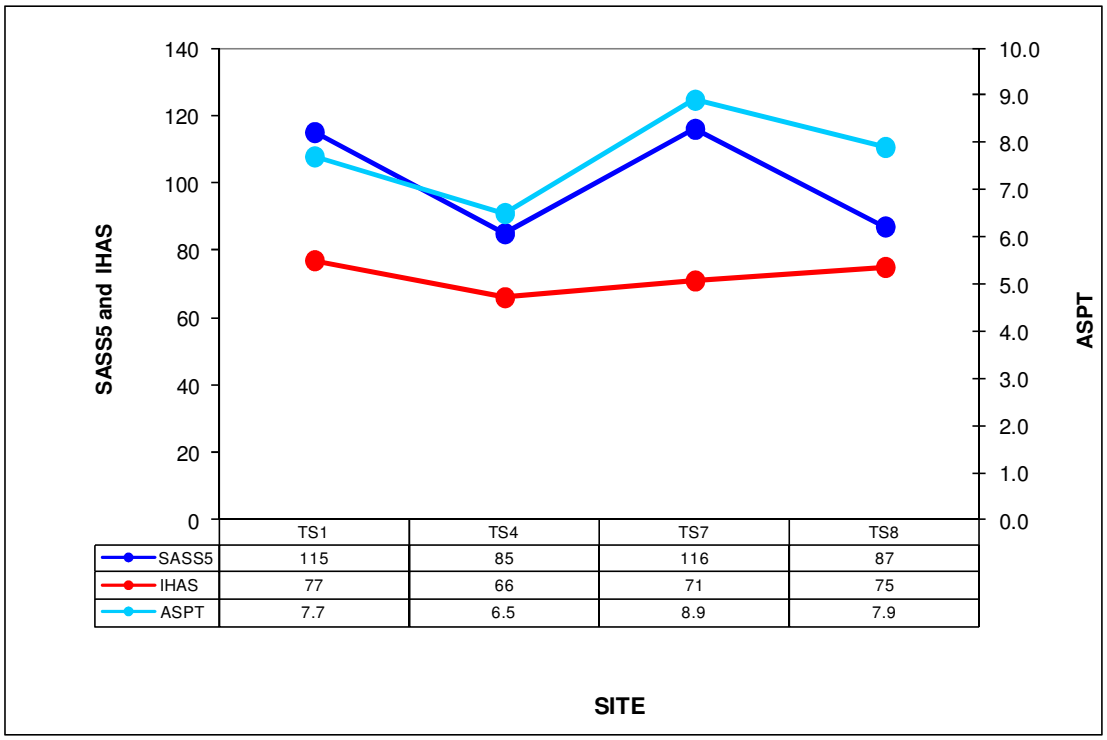

Figure 29: Visual depiction of SASS5 and ASPT scores for sites on the Tsitsa River showing spatial trends during April 2014.

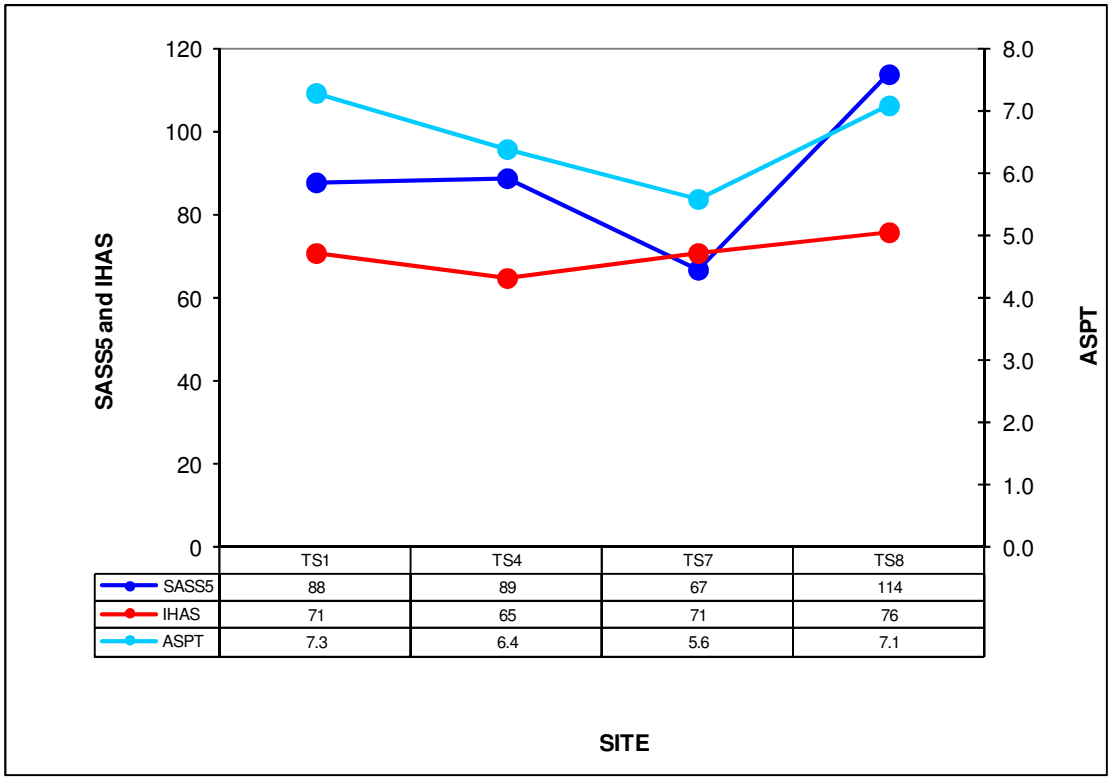

Figure 30: Visual depiction of SASS5 and ASPT scores for sites on the Tsitsa River showing spatial trends during June 2014.

5.2.7 Aquatic Macro-Invertebrates: Macro-Invertebrate Response Assessment Index (MIRAI)

During MIRAI preparation the percentage taxa occurrence per preference criteria was calculated and is summarised in **Table 22** for the **April 2014** assessment and **Table 23** for the **June 2014** assessment. This was determined by divided the number of taxa by the number of taxa expected and expressing it as a percentage.

Table 22: Percentage taxa occurrence per preference criteria for the Tsitsa River sites assessed during April 2014.

Variable	Criteria	Percentage occurrence of taxa showing preferences at each of the sites			
		TS1	TS4	TS7	TS8
Flow	Very Fast (>0.6 m/s)	75.00	62.50	75.00	62.50
	Moderately Fast (0.3-0.6 m/s)	50.00	25.00	50.00	50.00
	Slow (0.1-0.3 m/s)	66.67	33.33	33.33	33.33
	Very Slow (<0.1 m/s)	50.00	33.33	33.33	16.67
Habitat	Bedrock	0.00	0.00	0.00	100.00
	Cobbles	69.23	38.46	53.85	46.15
	Vegetation	50.00	0.00	25.00	0.00
	Gravel, Sand, Mud	25.00	50.00	50.00	50.00
	Water	50.00	33.33	16.67	16.67
Water quality	High	71.43	42.86	71.43	42.86
	Moderate	55.56	22.22	33.33	22.22
	Low	33.33	50.00	50.00	50.00
	Very Low	50.00	16.67	16.67	16.67

The preference pattern as determined during April 2014 is in agreement with the other assessments performed. Because of the very suitable rocky substrate within the system, a preference for cobbles features strongly. Whilst a variety of flow types are represented at the sites assessed, preference for moderately to very fast water features strongly. The water quality of this system is good and is reflected in the high preference exhibited for high water quality at sites TS1 and TS7. This is also reflected in the higher SASS5 scores reported from these two sites.

Table 23: Percentage taxa occurrence per preference criteria for the Tsitsa River sites assessed during June 2014.

Variable	Criteria	Percentage occurrence of taxa showing preferences at each of the sites			
		TS1	TS4	TS7	TS8
Flow	Very Fast (>0.6 m/s)	37.50	50.00	12.50	75.00
	Moderately Fast (0.3-0.6 m/s)	12.50	25.00	25.00	37.50
	Slow (0.1-0.3 m/s)	50.00	50.00	50.00	50.00
	Very Slow (<0.1 m/s)	25.00	12.50	37.50	12.50
Habitat	Bedrock	0.00	0.00	0.00	0.00
	Cobbles	38.46	30.77	7.69	53.85
	Vegetation	0.00	0.00	40.00	0.00
	Gravel, Sand, Mud	60.00	60.00	60.00	40.00
	Water	0.00	33.33	33.33	33.33
Water quality	High	37.50	25.00	25.00	50.00
	Moderate	22.22	11.11	11.11	22.22
	Low	28.57	64.29	35.71	50.00
	Very Low	28.57	14.29	57.14	42.86

The preference pattern as determined during June 2014 is in agreement with the other assessments performed. Because of the lower flow conditions in winter, the preference for slow water was higher in June compared to April. Despite the fact that very suitable rocky substrate predominates the system, a preference for less prevalent sand, mud and gravel habitats features strongly. With lower flow fewer riffle habitats would be present which explains this apparent change in preference. Whilst the water quality of this system is considered to be good, preference shifted towards lower water quality. Once again this can be largely attributed to seasonal variation relating to flow conditions and the volume of water within the system.

MIRAI scores are presented in **Table 24**, together with SASS5 scores for ease of comparison.

Table 24: Summary of the results (ecological categories) obtained from the application of the MIRAI to the assessment sites on the Tsitsa River, compared to classes awarded using SASS5.

Variable / Index	Month	TS1	TS4	TS7	TS8
Ecological category (MIRAI)	April 2014	B	C	B	C
	June 2014	C	C	C	C
Dickens and Graham (SASS5)	April 2014	C	C	C	C
	June 2014	C	C	Borderline D/E	C
Dallas (SASS5)	April 2014	A	C	A	A
	June 2014	B	C	D	B

Habitat conditions and ecological drivers at all the Tsitsa River sites were very similar. The fact that MIRAI scores at these sites were also very similar (borderline C/B in April 2014

and C in June 2014) was expected, considering that these sites are all subject to the same ecological drivers.

5.2.8 Fish Biota: Habitat Cover Rating (HCR) and Fish Habitat Assessment (FHA)

The HCR (Habitat Cover Rating) results for the Tsitsa River sites as assessed during April 2014 are provided in **Figure 31**.

Based on the depauperate fish fauna in this quaternary catchment and results obtained during the April 2014 fish sampling efforts, assessments pertaining to fish were not repeated during the June 2014 assessment. Furthermore visual assessment/observation indicated that, apart from lower water levels and slightly reduced flow, habitat cover did not change and hence the April 204 assessment results are also considered to be relevant to June 2014 conditions.

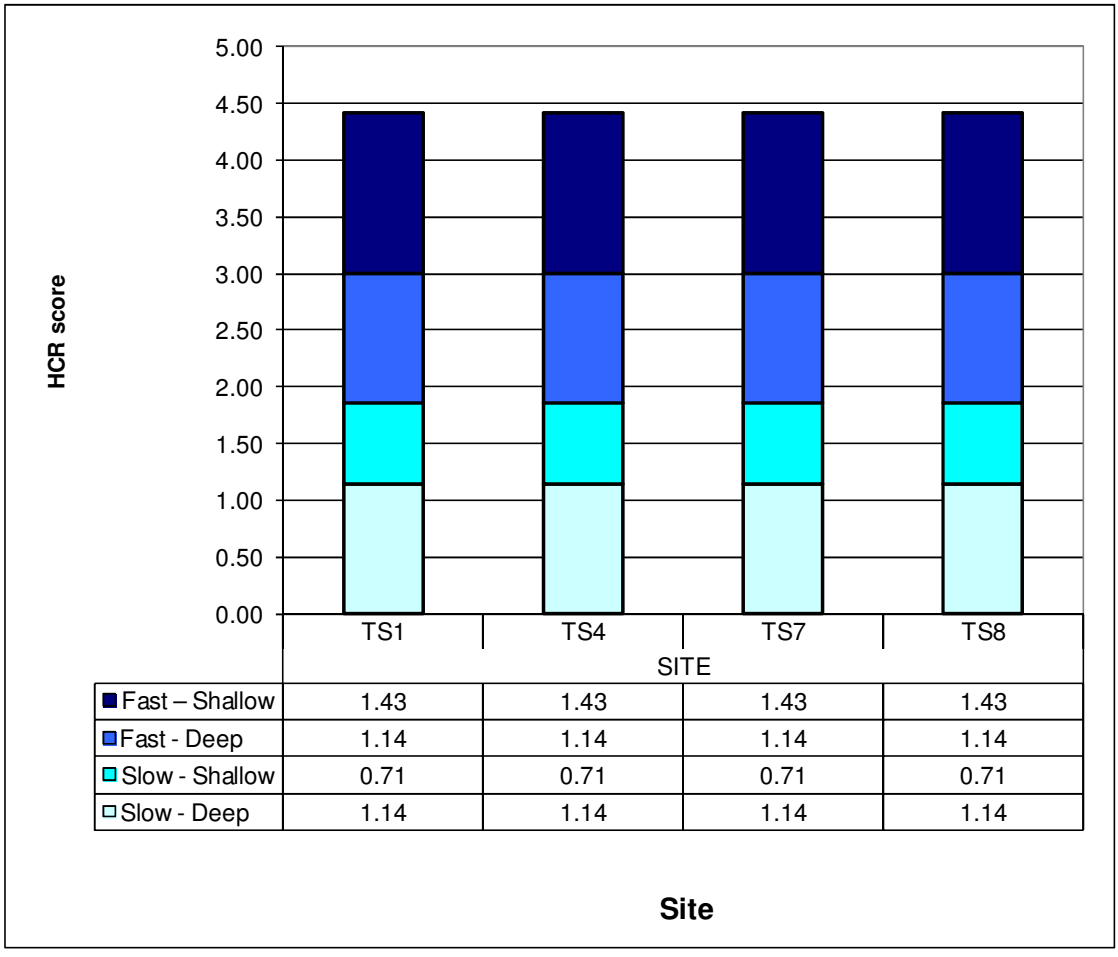

Figure 31: HCR scores for the sites assessed on the Tsitsa River as assessed during April 2014.

The sites on the Tsitsa River were all very uniform with regard to flow and depth conditions during April 2014.

During June 2014 lower flow was experienced as illustrated by the visual assessment presented previously. In the Tsitsa River this resulted in lower and slower flow as well as reduced depth at the sites assessed.

5.2.9 Fish Biota: Fish Response Assessment Index (FRAI)

The fish species expected to occur and frequency of occurrence (FROC) scores employed in the FRAI assessment were provided in **Table 5**. From this table it is clear that the fish fauna is depauperate with a naturally low diversity of fish species present.

No fish specimens were collected during sampling efforts but carp (*Cyprinus carpio*) were observed in the Tsitsa River during the April 2014 assessment. This fish species would occur at all sites assessed. Furthermore, although not collected, the longfin eel (*Anguilla mossambica*) is most likely also present at all sites (**Table 25**) and a dead specimen was observed in the vicinity of the Ntabelanga dam, caught by a local fisherman.

Table 25: Fish species observed during collections or known to occur at the various sites on the Tsitsa River as assessed during April 2014.

SPECIES NAME	Number of fish collected at sites TS1, TS4, TS7 and TS8	Frequency of occurrence score (FROC)
Cyprinus carpio	Observed only	**1**
Anguilla mossambica	Known to occur in system, observed at the Ntabelanga dam area (**Figure 32**) and sites conducive to them being present	**1**

Figure 32: Local fisherman with an *Anguilla mossambica* specimen caught in the proposed Ntabelanga Dam development area.

Table 26 summarises the EC obtained using the FRAI. For ease of comparison the EC values obtained by using the MIRAI have again been included.

Table 26: Summary of the results (ecological categories) obtained from the application of the FRAI to the GSP9 assessment site on the one site on the Mutamba River, compared to that obtained using MIRAI during the April 2014 assessment.

River assessed in April 2014	Tsitsa River
Variable / Index	**Sites TS1, TS4, TS7 and TS8**
Automated FRAI (%)	30.5
Automated EC (FRAI)	E
Refined EC (FRAI)	D/E
Ecological category (EC) (MIRAI)	C/B borderline

EC = Ecological category

From the above it is clear that the EC calculated for the FRAI does not correspond to that obtained for the MIRAI, even though changes in fish community composition would be subject to the same ecological drivers. This is firstly because of the naturally depauperate fish diversity in the quaternary catchment, but also due to the fact that no fish were collected. Only longfin eel was considered to be present in the FRAI assessment reference versus observed sheet, as carp is an alien/invasive species.

Based on the depauperate fish fauna in this quaternary catchment and results obtained during the April 2014 fish sampling efforts, sampling assessments pertaining to fish were not repeated during the June 2014 assessment.

Based on the observations of the study it is evident that the two large waterfalls on the system occurring upstream and downstream of the project area, this segment of the Tsitsa River is considered to be geographically isolated. For this reason the fish community in the system shows low diversity and sensitivity. The only fish species occurring in the system are those introduced to the system such as the exotic species *Cyprinus carpio, Micropterus Salmoides* and possibly *Onychorhynchus mykiss* and *Salmo trutta* as well as widely occurring species such as *Barbus anoplus*. None of these species except for *Cyprinus carpio* were observed in the system but the probability of these species occurring in the system is high.

The only other fish species occurring in the system was *Anguilla mossambica* which is a catadromous fish species that is known to ascend sheer waterfalls and cliffs, especially as elvers and therefore eels are the only species deemed likely to be able to colonise this segment of the Tsitsa River, except for introduction by other dispersal agents such as waterfowl.

Based on these observations it is evident that this segment of the Tsitsa River is of limited ecological importance to fish and is of limited importance to fish migration, except eels.

The proposed construction of the dams will lead to increased availability of slow deep water types which favour alien fish species such as *Cyprinus carpio* and *Micropterus Salmoides*. It is deemed highly likely that with the proposed construction of the dams the abundance of these two species will increase significantly in the area which will lead to localised impacts on aquatic community structures, fish population structures and potentially water quality regimes in the systems.

5.3 THE INXU RIVER (TS6) AND THE SMALLER UNNAMED TRIBUTARIES OF THE TSITSA RIVER (TS2, TS3, TS5 AND TS9)

A photographic record of each site was made in order to provide a visual record of the condition of each assessment site as observed during the field assessment.

The photographs taken are presented (**Figures 33 to 52**), followed by tables (**Table 27 and 28**) summarising the observations for the various criteria made during the visual assessment undertaken at each point.

5.3.1 Visual Assessment – April 2014

Figure 33: Upstream view of the TS2 site on an unnamed tributary of the Tsitsa River showing the good habitat available of the site during April 2014.

Figure 34: Downstream view of the TS2 site showing the sandy substrate present at the site as assessed April 2014.

Figure 35: Upstream view of the TS3 site on an unnamed tributary of the Tsitsa River, showing the limited habitat and cover in the system at this point as assessed in April 2014.

Figure 36: Downstream view of the TS3 site on an unnamed tributary of the Tsitsa River assessed April 2014

Figure 37: Upstream view of the TS5 site on an unnamed tributary of the Tsitsa River showing the diversity of habitat and cover at the point.

Figure 38: Downstream view of the TS5 site on an unnamed tributary of the Tsitsa River showing the good flow in the system at the time of assessment.

Figure 39: Upstream view of the TS6 site on the Inxu River showing the dominance of sandy substrate at the point.

Figure 40: Downstream view of the TS6 site on the Inxu River showing the slow laminar flow at the point.

Figure 41: Upstream view of the TS9 site on an unnamed tributary of the Tsitsa River showing the good rocky substrate at this point.

Figure 42: Downstream view of the TS9 site on an unnamed tributary of the Tsitsa River showing the limited flow at the point.

5.3.2 Visual Assessment – June 2014

Figure 43: Upstream view of the TS2 site on an unnamed tributary of the Tsitsa River showing the good habitat available despite slightly lower flow conditions during June 2014.

Figure 44: Downstream view of the TS2 site showing the sandy substrate present at the site as assessed June 2014.

Figure 45: Upstream view of the TS3 site on an unnamed tributary of the Tsitsa River showing the rocky substrate at this point. With lower flow conditions more sand and gravel substrate were also available for sampling in June 2014.

Figure 46: Downstream view of the TS3 site on an unnamed tributary of the Tsitsa River, showing lower water levels as assessed in June 2014.

Figure 47: Upstream view of the TS5 site on an unnamed tributary of the Tsitsa River showing the largely unchanged conditions (compared to April 2013) as assessed during June 2014.

Figure 48: Downstream view of the TS5 site on an unnamed tributary of the Tsitsa River showing slightly slower (compared to April 2014 assessment) flow in the system at the time of the June 2014 assessment.

Figure 49: Upstream view of the TS6 site on the Inxu River showing the dominance of sandy substrate at the point, even more pronounced during the June 2014 assessment (pictured above) when compared to April 2014, due to the lower flow conditions in winter.

Figure 50: Downstream view of the TS6 site on the Inxu River showing the lower water level and slightly slower laminar flow at the point when compared to April 2014, as assessed during June 2014.

Figure 51: Upstream view of the TS9 site on an unnamed tributary of the Tsitsa River showing the good rocky substrate but limited flow at this point, as assessed in June 2014.

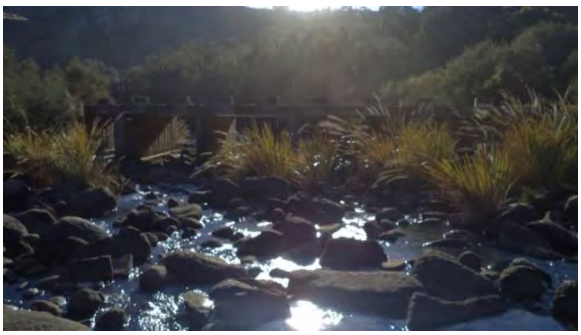

Figure 52: Downstream view of the TS9 site on an unnamed tributary of the Tsitsa.

Table 27: Visual description of the sites selected on the Inxu River (TS6) and smaller unnamed tributaries of the Tsitsa River as assessed during April 2014

ASPECT	TS2	TS3	TS5	TS6	TS9
Significance of the point	The site is located on an unnamed tributary of the Tsitsa River in the upper reaches of the Ntabelanga Dam. This site serves as a future monitoring point and the current data serves to present temporal data prior to any effects as a result of the construction activities associated with the proposed dam construction with special mention of roadway construction.	The site is located on an unnamed tributary of the Tsitsa River in the middle reaches of the Ntabelanga Dam. This site serves as a future monitoring point and the current data serves to present temporal data prior to any effects as a result of the construction activities associated with the proposed dam construction with special mention of roadway construction.	The site is located on an unnamed tributary of the Tsitsa River in the vicinity of the Ntabelanga Dam. This site serves as a future monitoring point and the current data serves to present temporal data prior to any effects as a result of the construction activities associated with the proposed road upgrade to transport equipment and material to the dam construction site.	The site is located on the Inxu River, a tributary of the Tsitsa River which confluences with the Tsitsa River between the Ntabelanga and Lalini Dams. This site serves to indicate the aquatic ecology of this important system occurring between the two proposed dams.	The site is located on an unnamed tributary of the Tsitsa River in the vicinity of the town of Tsolo. This site serves as a future monitoring point and the current data serves to present temporal data prior to any effects as a result of the construction activities associated with the proposed pipeline construction and water supply network within this systems catchment.
Surrounding features	This section of the river is located in an area dominated by rural dwellings along with use of the veld for livestock grazing purposes.	This section of the river is located downstream of rural settlements at a low water bridge crossing. Some impacts on water quality from the rural settlements on this system are likely.	This section of the river is located in a rural area with some forestry and agriculture occurring in the catchment.	The Ncu River is a large River flowing through a remote rural area. In the immediate vicinity of the sampling site sand winning is taking place which is significantly affecting the riparian zone of this system	This section of the river is located downstream of several rural settlements at a bridge crossing. Some impacts on water quality from the rural settlements on this system are likely.
Riparian zone characteristics	The riparian zone along the length of this section of the stream is narrow due to the incised nature of the stream. Some vegetation removal has occurred and a loss of the woody vegetation component is evident. The riparian zone at this point is affected by erosion.	The riparian zone along the length of this section of the stream is narrow due to the incised nature of the stream. Some vegetation removal has occurred.	The riparian zone along the length of this section of the stream has been severely affected by alien vegetation encroachment. The riparian zone is narrow due to the incised nature of the system.	The riparian zone along the length of this section of the stream has been severely affected by alien vegetation encroachment and smaller impacts from livestock grazing and watering are evident. The riparian zone is narrow due to the incised nature of the system.	The riparian zone along the length of this section of the stream has been severely affected by alien vegetation encroachment. The riparian zone is narrow due to the relatively steep banks of the valley in which the system is located.
Depth and flow characteristics	The unnamed tributary River was flowing at this point and displayed some moderately fast flowing rapids but was dominated by slow flowing sections. The river alternated	The unnamed tributary River had limited flow at this point and was dominated by slow shallow flowing sections and slightly deeper pools.	The unnamed tributary River had limited flow at this point and was dominated by slow glides and runs. The river was generally shallow with limited depth and flow diversity.	The Ncu River had a low level of flow at the time of assessment and was dominated by shallow flowing glides. Flow was generally slow with limited flow variation	The unnamed tributary River had limited flow at this point and was dominated by slow glides and runs. The river was generally shallow with limited depth and flow diversity.

ASPECT	TS2	TS3	TS5	TS6	TS9
	between rapids and glides.				
Water clarity	Water was clear.	Water was slightly discoloured, most likely as a result of algal proliferation.	Water was clear.	Water was clear.	Water was clear.
Impacts and signs of pollution	At the time of assessment no significant impacts on the in-stream ecology were visually evident	At the time of assessment no significant impacts on the in-stream ecology were visually evident although the discolouration of the water serves as a potential indication of eutrophication of the system.	At the time of assessment the most significant impact on the system observed was riparian vegetation removal. Some impact on water quality may be present leading to algal proliferation.	At the time of assessment the most significant impact on the system observed was sand winning from the river followed by impacts from alien vegetation encroachment.	At the time of assessment the most significant impact on the system observed was impacts from alien vegetation encroachment. Some impacts from impaired water quality are also deemed possible

Table 28: Visual description of the sites selected on the Inxu River (TS6) and smaller unnamed tributaries of the Tsitsa River as assessed during June 2014

ASPECT	TS2	TS3	TS5	TS6	TS9
Depth and flow characteristics	The unnamed tributary River was flowing at this point and displayed some moderately fast flowing rapids but was dominated by slow flowing sections. Water levels were lower compared to April 2014, resulting in a reduction of faster flowing rapid sections.	The unnamed tributary River had very limited flow at this point and was dominated by slow shallow flowing sections and only slightly deeper pools.	The unnamed tributary River had limited flow at this point and was dominated by slow glides and runs. The river was generally shallow with even more limited depth and flow diversity (compared to April 2014), due to lower flow conditions during June 2014.	The Inxu River had a low level of flow at the time of assessment and was dominated by shallow flowing glides. Flow was generally slow with limited flow variation, compounded by the lower water levels experienced in June 2014 compared to April 2014.	The unnamed tributary River had limited flow at this point and was dominated by slow glides and runs. The river was generally shallow with limited depth and flow diversity.
Water clarity	Water was clear.	Water was clear.	Water was clear.	Water was clear.	Water was clear.
Impacts and signs of pollution	At the time of assessment no significant impacts on the in-stream ecology were visually evident	At the time of assessment no significant impacts on the in-stream ecology were visually evident.	At the time of assessment the most significant impact on the system observed was riparian vegetation removal.	At the time of assessment the most significant impact on the system observed was sand winning from the river, compounded by low flow conditions in winter, followed by impacts from alien vegetation encroachment.	At the time of assessment the most significant impact on the system observed was impacts from alien vegetation encroachment.

As is evident from the tabulated descriptions the only difference in terms of visual assessment pertains to lower flow conditions experienced in June 2014 when compared to April 2014.

5.3.3 Physico-Chemical Water Quality

Water quality variables were measured at one point on the Inxu River (TS6) as well as four other points on smaller unnamed tributaries of the Tsitsa River (**Table 29**).

Table 29: Biota specific water quality data for the assessed Inxu River (TS6) and other smaller unnamed tributaries of the Tsitsa River (TS2, TS3, TS5 and TS9) sites

Site	Description	Month	Conductivity (mS/m)	pH (pH units)	Temp (ºC)
TS2	Unnamed tributary of the Tsitsa River upstream of the proposed Ntabelanga Dam and road upgrade developments.	April 2014	8.0	8.75	17.2
		June 2014	18.1	7.30	14.6
TS3	Unnamed tributary of the Tsitsa River upstream of the proposed developments described above.	April 2014	13.0	9.08	24.2
		June 2014	22.3	7.20	18.2
TS5	Unnamed tributary of the Tsitsa River in the vicinity of the proposed road upgrade crossing.	April 2014	10.0	8.68	23.3
		June 2014	14.3	7.70	20.6
TS6	Inxu River upstream of the proposed road upgrade developments and a major tributary of the Tsitsa River.	April 2014	8.0	8.49	24.2
		June 2014	9.2	7.10	20.1
TS9	Unnamed tributary of the Tsitsa River directly associated with the proposed pipeline development.	April 2014	10.0	8.78	19.4
		June 2014	11.7	7.8	8.8

The following key points on the water quality of the various sites both upstream and in the vicinity of the proposed Mzimvubu Water Project were observed:

- The overall water quality conditions in the Inxu River and smaller unnamed tributaries of the Tsitsa River is very good;
- As was the case with the Tsitsa River sites, EC values were consistently low at all sites assessed. However, EC values were generally higher in June 2014 when compared to April 2014. This can be attributed to lower flow conditions during winter, as represented by the June 2014 assessment), resulting in concentration of the salt load in the systems. However, potential additional salt loading from sources such as agricultural activities and rural settlements cannot be completely excluded;
- The water quality guideline for aquatic ecosystems (DWA 1997) states that: 1) Total dissolved salts (TDS) concentrations (i.e. as indicated by the EC measurements) should not be changed by > 15 % from the normal cycles of the water body under unimpacted conditions at any time of the year; and 2) the amplitude and frequency of natural cycles in TDS concentrations should not be changed;

- From a temporal perspective the recommended guideline was exceeded at all sites, with percentage increase between April 2014 and June 2014 ranging between 15% (site TS6) and 126% (site TS2);
- These results indicate that significant seasonal variation in salt concentrations in the system are evident prior to the proposed projects. Dissolved salt concentrations in the systems are however generally low and there is significant risk that the proposed irrigation activities in some of the catchments could lead to increased salinization of the systems in the nearby area
- At all sites pH values were slightly alkaline (April 2014) with a shift towards neutrality (June 2014) and once again corresponds well with that reported from the Tsitsa River;
- The water quality guideline for aquatic ecosystems (DWA 1997) states that pH values should not be allowed to vary from the range of the background pH values for a specific site by > 5 %;
- Temporally there was a decrease in pH at all sites between April 2014 and June 2014, ranging between 11.2% (site TS9) and 20.7%, exceeding the guideline recommendation in all instances indicating that there is significant seasonal variation in pH;
- The temperatures observed at each of the points are deemed natural for the time of year and the nature of the systems. The observed variations can again be attributed to diurnal variation between sampling times, the variation in the volume of water in the water bodies sampled and some level of seasonal variation in sampling times.

A graphic presentation of results is depicted in **Figures 53 and 54**.

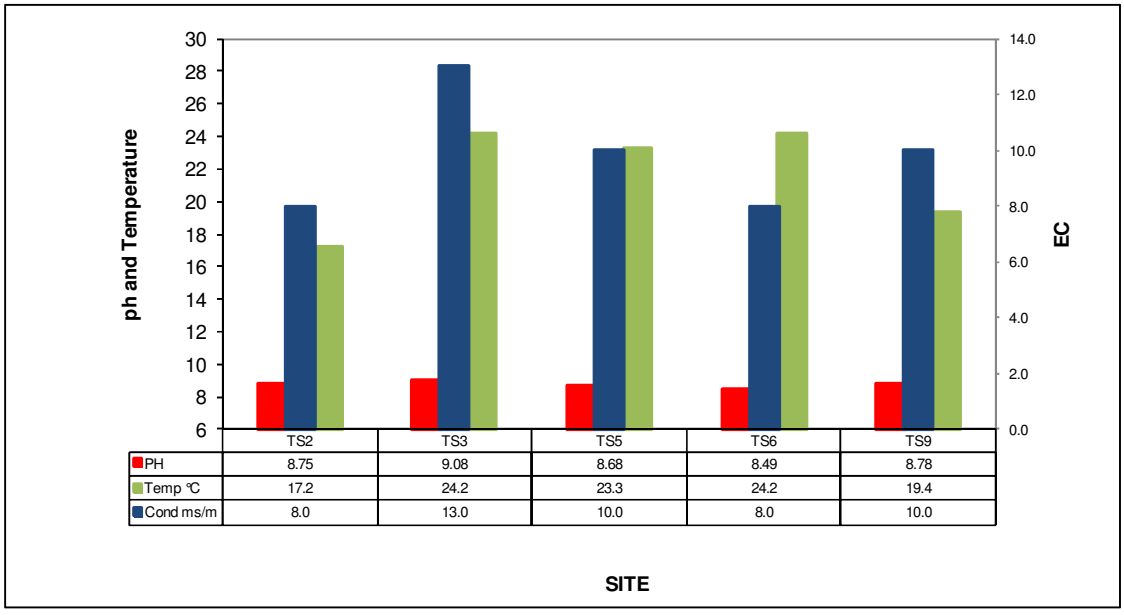

Figure 53: Physico-chemical water quality variables as measured at the respective Inxu River and smaller Tsitsa River tributary sites during the April 2014 assessment.

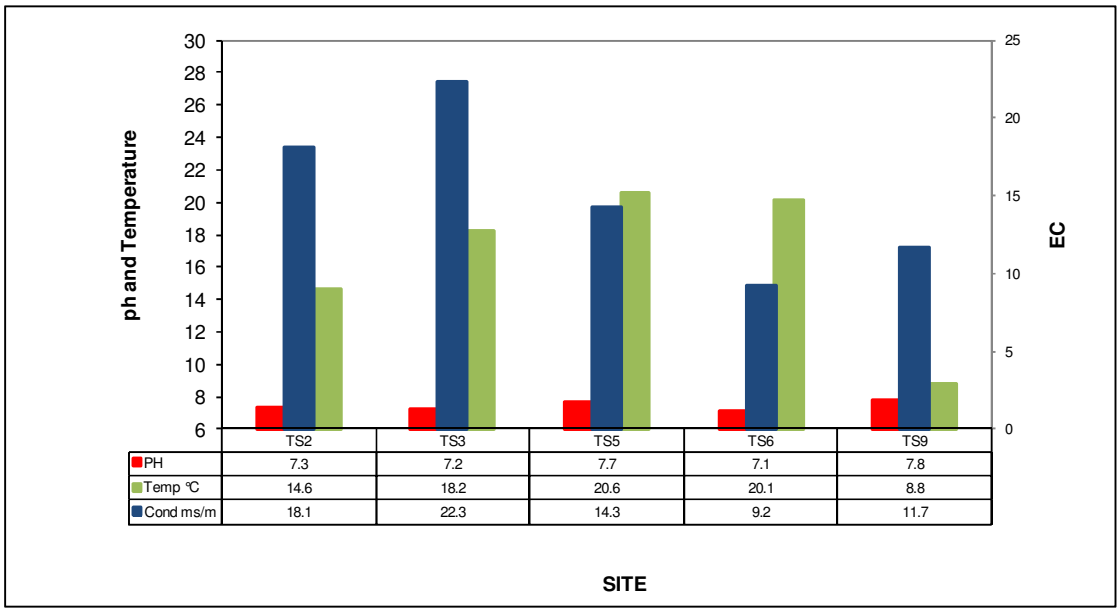

Figure 54: Physico-chemical water quality variables as measured at the respective Inxu River and smaller Tsitsa River tributary sites during June 2014.

5.3.4 Intermediate Habitat Integrity Assessment (IHIA)

The full results following the application of this index are presented in **Appendix B**. This assessment was only performed during April 2014, as the index is not sensitive to small short-term changes but rather assesses longer term changes in habitat integrity.

For Tsitsa River tributary assessment sites, small to large impacts were recorded for the in-stream zone habitat. The latter relates to channel and bed modification (TS6). At sites TS3 and TS9 moderate impacts were recorded for the same two assessment criteria. Inundation and exotic macrophytes were the only two criteria for which no impacts were recorded at any of the sites. Sites TS2 and TS3 obtained Class B (largely natural) classifications whilst the remaining sites (TS5, TS6 and TS9) obtained a Class C (moderately modified) classification.

Small to large impacts were recorded for the riparian zone. Large impacts were recorded for vegetation removal at all sites assessed. At sites TS6 and TS 9 large impacts were recorded for alien encroachment with moderate impacts recorded for the same criteria at the other sites. At sites TS2, TS3 and TS 6 large impacts were recorded for bank erosion. Moderate impact was recorded for the same criteria at site TS9 and small impact at TS5. No impacts were recorded for water abstraction, water quality or inundation at any of the sites. All sites obtained a Class C (moderately modified) classification.

Overall, sites TS3 presented with a Class B (largely natural) classification, whilst a Class C (moderately modified) classification was obtained for sites TS2, TS5, TS6 and TS9.

5.3.5 Invertebrate Habitat Assessment System (IHAS)

Table 30 and 31 summarises the results obtained from the application of the Invertebrate Habitat Integrity Assessment (IHAS) Index to the five river assessment sites on the Tsitsa River tributaries. This index determines habitat suitability, with particular reference to the requirements of aquatic macro-invertebrates. The results obtained from this assessment will aid in interpreting the SASS5 results. IHAS (McMillan, 1998) score sheets are presented in **Appendix D.**

Table 30: A summary of the results obtained from the application of and IHAS indices to the assessment sites on the Inxu River and smaller unnamed Tsitsa River tributaries during April 2014

SITE	TS2	TS3	TS5	TS6	TS9
IHAS score	67	52	44	70	66
IHAS Adjustment score (illustrative purposes only)	+23	+29	+32	+15	+25
McMillan, 1998 IHAS description	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.
Stones habitat characteristics	Adequate loose cobbles and rocks in current present. Stones out of current not present.	Stone habitat present in current. No stone habitat out of current	Stone habitat present in current. No stone habitat out of current	Adequate loose cobbles and rocks in current present. Stones out of current not present.	Adequate loose cobbles and rocks in current present. Stones out of current present.
Vegetation habitat characteristics	Bank/riparian vegetation (mix of reeds and shrubs) present. Fringing vegetation absent. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	Bank/riparian vegetation (reeds/grass) present but fringing vegetation absent. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	Bank/riparian vegetation (reeds/grass) present but fringing vegetation absent. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	Bank/riparian vegetation (mix of reeds and shrubs) as well as fringing vegetation present. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	Bank/riparian vegetation (reeds/grass) present but fringing vegetation absent. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.
Other habitat characteristics	No mud habitat available but sand and gravel substrate available. No algae or bedrock substrate present.	Some sand and gravel habitat available and sampled, no mud habitat available. No algae present but some bedrock substrate present.	Some sand and gravel habitat available and sampled, no mud habitats available. No algae or bedrock substrate present.	Some sand and gravel habitat available and sampled, no mud habitats available. Isolated patches of algae but no bedrock present.	Some sand, gravel and bedrock habitat available and sampled, no mud habitats available. No algae present.
IHAS general	The stream at this	The stream at this	The stream at this	The stream at this	The stream at this

SITE	TS2	TS3	TS5	TS6	TS9
stream characteristics	point has a fair (mixed) diversity of flow, is of medium width and shallow under the current conditions. Water is clear and bank cover is fair. Signs of erosion were evident.	point has poor diversity of flow (slow), is of medium width and shallow under the current conditions. Water is clear and bank cover is fair. Signs of erosion were evident	point has a poor diversity of flow (slow) and is wide but shallow under the current conditions. Water is clear and bank cover is poor with signs of erosion evident.	point has a poor diversity of flow (slow), of medium width but shallow under the current conditions. Water is clear and bank cover is fair (left bank) to poor (right bank) with signs of erosion evident.	point has a poor diversity of flow (slow), of medium width but shallow under the current conditions. Water is clear and bank cover is fair (left bank) to poor (right bank) with signs of erosion evident.

During April 2014 (**Table 30**), the habitat diversity and structure of the Inxu River (TS6) as well as two of the other smaller Tsitsa River tributaries (TS2 and TS9) were found to be adequate for supporting a diverse macro-invertebrate community. Conditions at sites TS3 and TS5 were found to be inadequate to do the same. The lack of mud habitat and absent or reduced leaf cover on vegetation at all sites may further negatively affect diversity of invertebrate fauna

During June 2014 (**Table 31**), the exact same trend was observed as for the April 2014 assessment: habitat diversity and structure of the Inxu River (TS6) as well as two of the other smaller Tsitsa River tributaries (TS2 and TS9) were found to be adequate for supporting a diverse macro-invertebrate community. Conditions at sites TS3 and TS5 were found to be inadequate to do the same. As for April 2014 the lack of mud habitat and absent or reduced leaf cover on vegetation at all sites may further negatively affect diversity of invertebrate fauna.

Table 31: A summary of the results obtained from the application of and IHAS indices to the assessment sites on the Inxu River and smaller unnamed Tsitsa River tributaries during June 2014

SITE	TS2	TS3	TS5	TS6	TS9
IHAS score	65	52	51	69	68
IHAS Adjustment score (illustrative purposes only)	+23	+29	+27	+15	+22
McMillan, 1998 IHAS description	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is inadequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.	Habitat diversity and structure is adequate for supporting a diverse aquatic macro-invertebrate community under the current flow conditions.
Stones habitat characteristics	Adequate loose cobbles and rocks in current present. Stones out of current not present.	Stone habitat present in current. No stone habitat out of current	Stone habitat present in current. No stone habitat out of current	Adequate loose cobbles and rocks in current present. Stones out of current not present.	Adequate loose cobbles and rocks in current present. Stones out of current present.
Vegetation habitat	Bank/riparian vegetation (mix of	Bank/riparian vegetation	Bank/riparian vegetation	Bank/riparian vegetation (mix of	Bank/riparian vegetation

SITE	TS2	TS3	TS5	TS6	TS9
characteristics	reeds and shrubs) present. Fringing vegetation absent. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	(reeds/grass) present but fringing vegetation absent. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	(reeds/grass) present but limited fringing vegetation sampled. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	reeds and shrubs) as well as fringing vegetation present. However, the lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.	(reeds/grass and shrubs) present and limited fringing vegetation sampled. The lack of leafy material is likely to negatively affect the diversity of the macro-invertebrate community. Aquatic vegetation was absent.
Other habitat characteristics	No mud habitat available but sand and gravel substrate available. No algae or bedrock substrate present.	Some sand and gravel habitat available and sampled, no mud habitat available. No algae or bedrock substrate available for sampling.	Some sand and gravel habitat available and sampled, no mud habitats available. No algae or bedrock substrate present.	Some sand and gravel habitat available and sampled, no mud habitats available. Isolated patches of algae but no bedrock present.	Some sand, gravel and bedrock habitat available and sampled, no mud habitats available. No algae present.
IHAS general stream characteristics	The stream at this point has medium, is of medium width and shallow under the current lower flow conditions. Water is clear and bank cover is fair. Signs of erosion were evident.	The stream at this point has poor diversity of flow (slow), is of medium width and shallow under the current lower flow conditions. Water is clear and bank cover is poor (left bank) to fair (right bank). Signs of erosion were evident	The stream at this point has a poor diversity of flow (slow) and is wide but shallow under the current conditions. Water is clear and bank cover is poor with signs of erosion evident.	The stream at this point has a poor diversity of flow (slow), of medium width but shallow under the current conditions. Water is clear and bank cover is poor with signs of erosion evident.	The stream at this point has a poor diversity of flow (slow), of medium width but shallow under the current conditions. Water is clear and bank cover is fair with signs of erosion evident.

Comparing the April 2014 IHAS assessment to that performed in June 2014, the only changes pertain to lower water level and flow rates during June 2014. In many cases flow rates decreased from “mixed” to “medium” or “slow”, resulting in seasonal loss of fast flowing riffle/rapid habitat within the system during winter. Lower water levels may also impact availability of other habitat types, an example being site TS3 where bedrock was not available for sampling during the June 2014 assessment. The reduction in availability of riffle habitats with very fast to fast flowing water is expected to impact on macro-invertebrate habitat preference patterns, with associated changes in family taxa composition and prevalence. A seasonal shift toward a preference for lower, slower flow can be expected with the preference for sand, mud and gravel also increasing during winter.

The IHAS score remained unchanged at site TS3, decreased at sites TS2 by 3.0% and TS6 by 1.4% respectively, but increased at sites TS5 by 15.9% and TS9 by 3.0% respectively. Whilst habitat scores increased in some cases, the changes in habitat

preferences described above may negatively impact SASS5 scores during winter as riffle areas with fast to very fast flow predominate in summer during higher flow conditions.

5.3.6 Aquatic Macro-Invertebrates: South African Scoring System (SASS5)

Table 32 indicates the results obtained per biotope sampled whilst SASS5 scores are tabulated in **Table 33** and visually represented in **Figures 55 and 56**. SASS5 and ASPT score sheets (Dickens and Graham, 2001) are presented in **Appendix D**.

Table 32: Biotope specific summary of the results obtained from the application of the SASS5 index to the assessment sites on the Tsitsa River tributaries

PARAMETER	SITE	MONTH	STONES	VEGETATION	GRAVEL, SAND AND MUD	TOTAL
SASS5 Score	TS2	April 2014	59	0	55	70
Number of taxa			9	0	8	12
ASPT			7.0	0	7.0	5.8
SASS5 Score		June 2014	49	0	38	63
Number of taxa			6	0	6	9
ASPT			8.0	0	6.0	7.0
SASS5 Score	TS3	April 2014	75	0	35	79
Number of taxa			14	0	7	15
ASPT			5.0	0	5.0	5.3
SASS5 Score		June 2014	50	0	52	77
Number of taxa			7	0	10	13
ASPT			7.0	0	5.0	5.9
SASS5 Score	TS5	April 2014	42	20	6	53
Number of taxa			8	3	2	9
ASPT			5.0	6.7	3.0	5.9
SASS5 Score		June 2014	14	9	14	25
Number of taxa			2	2	3	5
ASPT			7.0	4.5	5.0	5.0
SASS5 Score	TS6	April 2014	71	49	26	86
Number of taxa			12	7	6	15
ASPT			6.0	7.0	4.0	5.7
SASS5 Score		June 2014	66	11	42	71
Number of taxa			11	2	7	12
ASPT			6.0	5.5	6.0	5.9
SASS5 Score	TS9	April 2014	71	49	26	86
Number of taxa			12	7	6	15
ASPT			6.0	7.0	4.0	5.7
SASS5 Score		June 2014	41	11	29	53
Number of taxa			7	2	6	10
ASPT			6.0	5.5	5.0	5.3

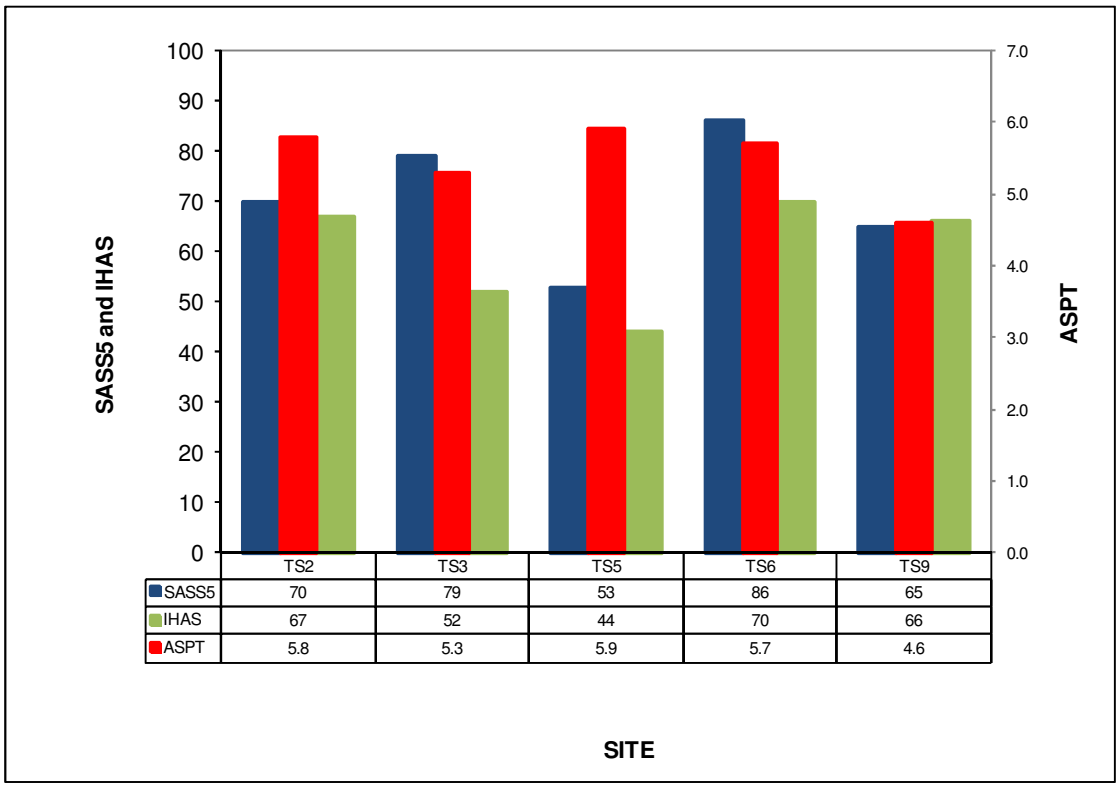

Figure 55: Visual depiction of SASS5 and ASPT scores for sites on the Tsitsa River tributaries as assessed April 2014.

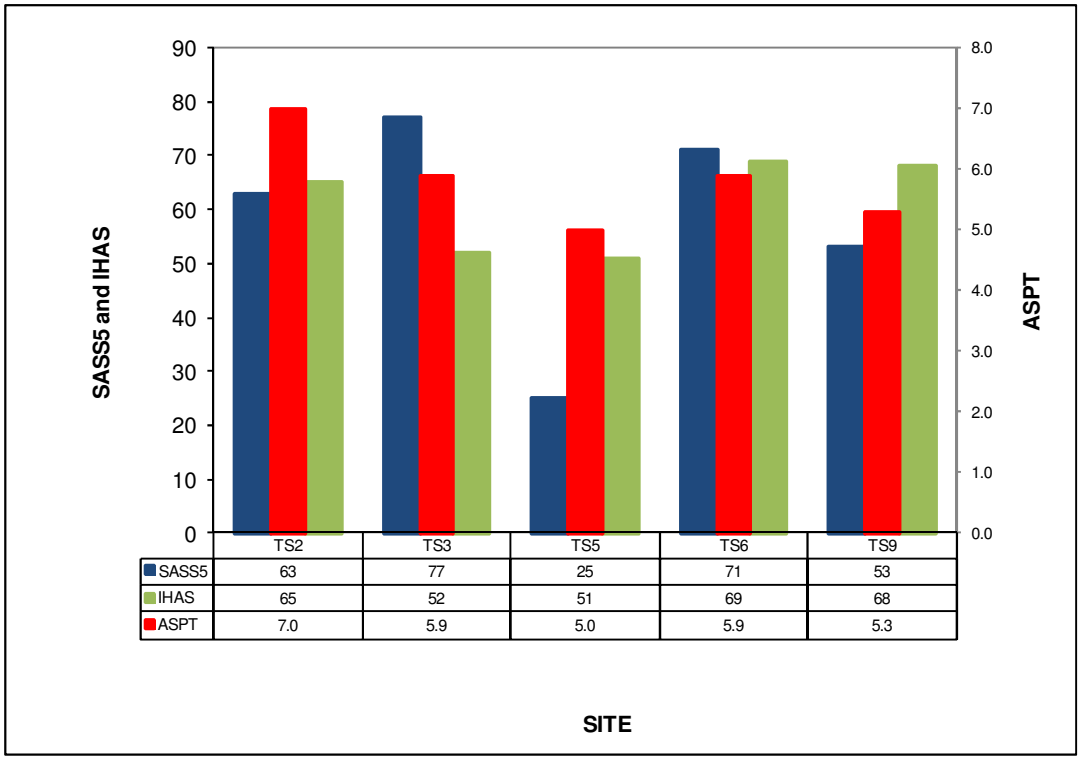

Figure 56: Visual depiction of SASS5 and ASPT scores for sites on the Tsitsa River tributaries as assessed June 2014.

Table 33: Summary of the results obtained from the application of the SASS5 index to the assessment sites on the Tsitsa River tributaries, as assessed during April 2014.

Type of Result	TS2	TS3	TS5	TS6	TS9
Biotopes sampled	Stones in current; Sand; Gravel.	Stones in current; Sand; Gravel.	Stones in current; Sand; Gravel.	Stones in current; Fringing vegetation; Sand; Gravel.	Stones in current; Stones out of current; Sand; Gravel; Bedrock.
Sensitive taxa present	*Leptophlebiidae; Tricorythidae; Aeshnidae; Gomphidae.*	*Hydracarina; Leptophlebiidae; Tricorythidae; Aeshnidae; Gomphidae; Elmidae.*	*Perlidae; Caenidae; Aeshnidae.*	*Caenidae; Leptophlebiidae; Tricorythidae; Aeshnidae; Gomphidae; Hydraenidae;*	*Leptophlebiidae; Tricorythidae; Aeshnidae;*
Sensitive taxa absent	*Hydracarina; Perlidae; Caenidae; Heptageniidae; Oligoneuridae; Prosopistomatidae; Pyralidae; Elmidae; Hydraenidae; Psephenidae.*	*Perlidae; Caenidae; Heptageniidae; Oligoneuridae; Prosopistomatidae; Pyralidae; Hydraenidae; Psephenidae.*	*Hydracarina; Heptageniidae; Leptophlebiidae; Oligoneuridae; Prosopistomatidae; Tricorythidae; Gomphidae; Pyralidae; Elmidae; Hydraenidae; Psephenidae.*	*Hydracarina; Perlidae; Heptageniidae; Oligoneuridae; Prosopistomatidae; Pyralidae; Elmidae; Psephenidae.*	*Hydracarina; Perlidae; Caenidae; Heptageniidae; Oligoneuridae; Prosopistomatidae; Gomphidae; Pyralidae; Elmidae; Psephenidae.*
SASS5 score	70	79	53	86	65
Adjusted SASS5 score	93	108	85	101	90
SASS5 % of theoretical reference score	46.5	54.0	42.5	50.5	45.0
ASPT score	5.8	5.3	5.9	5.7	4.6
ASPT % of theoretical reference score	80.6	73.6	81.9	79.2	63.9
Dickens & Graham, 2001 SASS5 classification	D (Largely impaired)	C (Moderately impaired)	D (Largely impaired)	C (Moderately impaired)	D (Largely impaired)
Dallas 2007 classification	Borderline D and E/F	E/F	D	E/F	Borderline D and E/F

Table 34: Summary of the results obtained from the application of the SASS5 index to the assessment sites on the Tsitsa River tributaries, as assessed during June 2014.

Type of Result	TS2	TS3	TS5	TS6	TS9
Biotopes sampled	Stones in current; Sand; Gravel.	Stones in current; Sand; Gravel.	Stones in current; Fringing vegetation; Sand; Gravel.	Stones in current; Fringing vegetation; Sand; Gravel.	Stones in and out of current; Fringing vegetation; Sand; Gravel; Bedrock.
Sensitive taxa present	*Caenidae; Tricorythidae; Gomphidae.*	*Tricorythidae; Aeshnidae; Gomphidae; Psephenidae.*	*Caenidae; Aeshnidae.*	*Caenidae; Tricorythidae; Aeshnidae; Gomphidae; Psephenidae.*	*Caenidae; Tricorythidae; Aeshnidae; Gomphidae.*
Sensitive taxa absent	*Hydracarina; Perlidae; Heptageniidae; Oligoneuridae; Prosopistomatidae; Pyralidae; Elmidae; Hydraenidae; Psephenidae; Leptophlebiidae; Aeshnidae.*	*Hydracarina; Perlidae; Caenidae; Heptageniidae; Oligoneuridae; Prosopistomatidae; Pyralidae; Elmidae; Hydraenidae; Leptophlebiidae.*	*Hydracarina; Perlidae; Heptageniidae; Oligoneuridae; Prosopistomatidae; Pyralidae; Elmidae; Hydraenidae; Psephenidae; Leptophlebiidae; Tricorythidae; Gomphidae.*	*Hydracarina; Perlidae; Heptageniidae; Oligoneuridae; Prosopistomatidae; Pyralidae; Elmidae; Hydraenidae; Leptophlebiidae.*	*Hydracarina; Perlidae; Heptageniidae; Oligoneuridae; Prosopistomatidae; Pyralidae; Elmidae; Hydraenidae; Psephenidae; Leptophlebiidae.*
SASS5 score	63	77	25	71	53
Adjusted SASS5 score	86	106	52	86	75
SASS5 % of theoretical reference score	43.0	53.0	26.0	43.0	37.5
ASPT score	7.0	5.9	5.0	5.9	5.3
ASPT % of theoretical reference score	97.2	81.9	69.4	81.9	73.6
Dickens & Graham, 2001 SASS5 classification	D (Largely impaired)	C (Moderately impaired)	E (Severely impaired)	D (Largely impaired)	E (Severely impaired)
Dallas 2007 classification	B	Borderline D and E/F	E/F	Borderline D and E/F	E/F

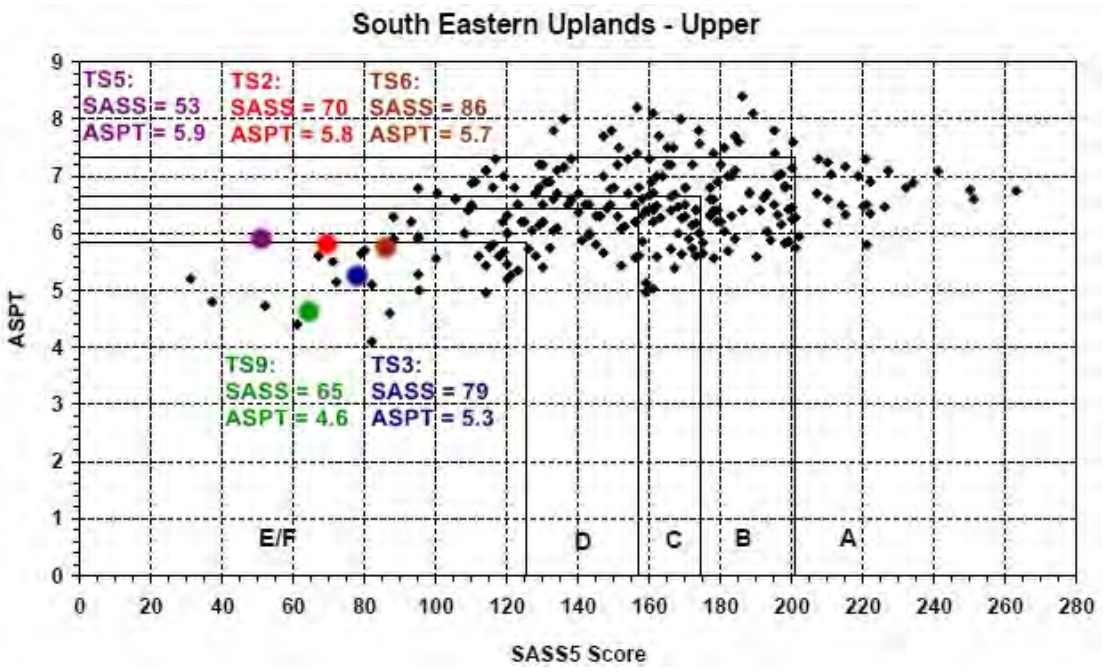

Figure 57: Visual depiction of SASS5 and ASPT scores for sites on the Tsitsa River tributaries based on the Dallas (2007) classification, as assessed during April 2014.

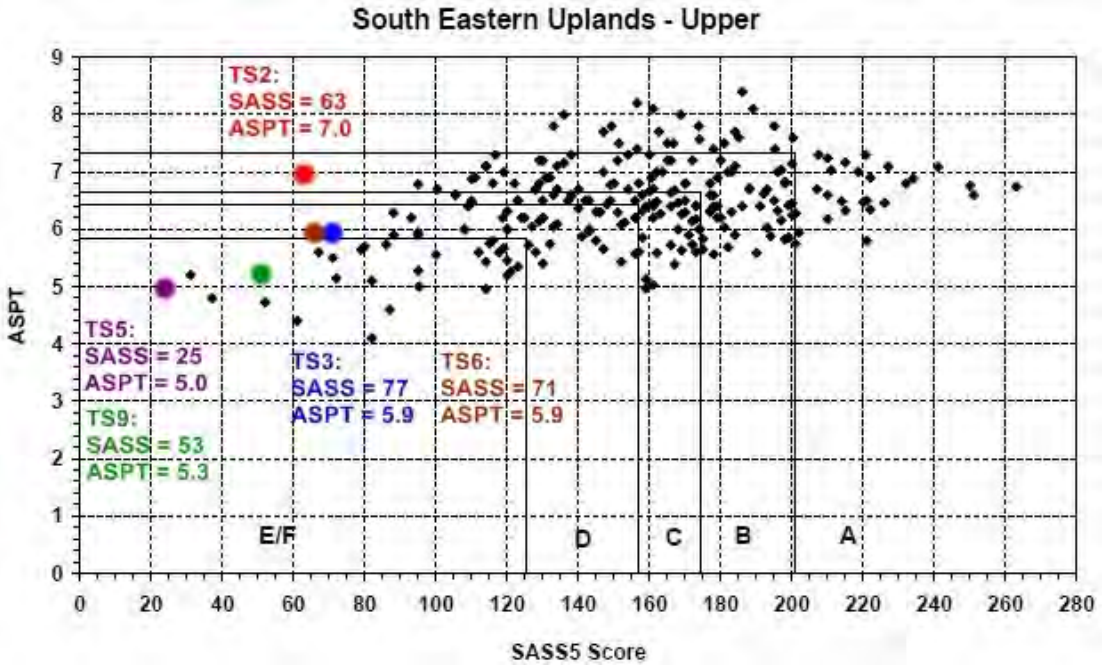

Figure 58: Visual depiction of SASS5 and ASPT scores for sites on the Tsitsa River tributaries based on the Dallas (2007) classification, as assessed during June 2014.

- Habitat limitations are likely to limit the diversity, abundance and sensitivity of the aquatic community to some degree, considering the absence of aquatic vegetation, leafy material, mud and gravel substrate at the majority of sites;

- The lack of variety of flow and depth conditions present (mostly slow and shallow) at the sites is also conducive to a decreased diversity of macro-invertebrate species. This is especially relevant to the June 2014 assessment, where lower flow conditions were encountered when compared to April 2014;
- Suitable habitat in the form of rocky substrate was present at the majority of the Tsitsa River tributaries sampled in April 2014. Exceptions were sites TS5 and TS6. The same habitat was still available during June 2014, but lower flow resulted in a reduction of available riffle habitat with fast flowing water;
- Based on the above it is clear that the lower SASS scores correlate with lower IHAS scores, when compared to that recorded for the sites on the Tsitsa River itself, especially with reference to April 2014;
- However, when comparing IHAS scores between the tributary sites, such a correlation is less evident. A point in case is site TS5, where the SASS5 score decreased by 52.8% but IHAS score actually increased by 15.9%;
- SASS 5 scores at all sites decreased by between 2.5% (site TS3) and 52.8% (site TS5). ASPT scores increased by between 3.5% and 20.7% at sites TS2, TS3, TS6 and TS9 but decreased by 15.3% at site TS5 between April 2014 and June 2014;
- Whilst seasonal changes in flow and habitat availability did contribute to the lower SASS5 scores recorded in June 2014 compared to April 2014, the effects of reduced water quality (concentration of pollutants/salt load under conditions of low flow) and negative effects from other diffuse sources (agriculture and rural settlements) cannot be completely ruled out;
- Despite the lower SASS5 scores obtained in June 2014, the generally higher ASPT scores either resulted in higher classifications (for example site TS2) or very similar classifications when compared to that obtained in April 2014;
- The Dallas (2007) classification indicated D (site TS5) or E/F (remainder of sites) conditions at all sites (**Table 33** and **Figure 57**) for April 2014. Corresponding classification in June 2014 ranged between B (site TS2) and E/F (remainder of sites) (**Table 34** and **Figure 58**).
- According to the Dickens and Graham (2001) classification, conditions at the sites in April 2014 were either impaired (classification C as recorded for sites TS3 and TS6) or largely impaired (classification D as recorded for sites TS2, TS5 and TS9) (**Tables 33 and 34**). The classifications for June 2014 were C (site TS3), D (sites TS2 and TS6) and E (sites TS5 and TS9), thus ranging from impaired to severely impaired.

5.3.7 Aquatic Macro-Invertebrates: Macro-Invertebrate Response Assessment Index (MIRAI)

During MIRAI preparation the percentage taxa occurrence per preference criteria was calculated and is summarised in **Table 35 and 36**. This was determined by divided the number of taxa by the number of taxa expected and expressing it as a percentage.

Table 35: Percentage taxa occurrence per preference criteria for the Tsitsa River tributary sites assessed during April 2014.

Variable	Criteria	Percentage occurrence of taxa showing preferences at each of the sites				
		TS2	TS3	TS5	TS6	TS9
Flow	Very Fast (>0.6 m/s)	37.50	37.50	12.50	25.00	37.50
	Moderately Fast (0.3-0.6 m/s)	25.00	37.50	0.00	62.50	25.00
	Slow (0.1-0.3 m/s)	66.67	66.67	66.67	66.67	66.67
	Very Slow (<0.1 m/s)	33.33	33.33	50.00	33.33	50.00
Habitat	Bedrock	0.00	0.00	0.00	0.00	0.00
	Cobbles	30.77	30.77	7.69	30.77	38.46
	Vegetation	0.00	0.00	0.00	50.00	0.00
	Gravel, Sand, Mud	25.00	75.00	25.00	75.00	25.00
	Water	50.00	50.00	50.00	33.33	66.67
Water quality	High	14.29	0.00	28.57	14.29	0.00
	Moderate	22.22	44.44	11.11	33.33	33.33
	Low	41.67	41.67	33.33	50.00	41.67
	Very Low	50.00	83.33	50.00	66.67	83.33

Table 36: Percentage taxa occurrence per preference criteria for the Tsitsa River tributary sites assessed during June 2014.

Variable	Criteria	Percentage occurrence of taxa showing preferences at each of the sites				
		TS2	TS3	TS5	TS6	TS9
Flow	Very Fast (>0.6 m/s)	25.00	50.00	0.00	50.00	12.50
	Moderately Fast (0.3-0.6 m/s)	25.00	25.00	0.00	25.00	25.00
	Slow (0.1-0.3 m/s)	25.00	50.00	50.00	50.00	25.00
	Very Slow (<0.1 m/s)	16.67	0.00	16.67	16.67	33.33
Habitat	Bedrock	0.00	0.00	0.00	0.00	0.00
	Cobbles	23.08	30.77	0.00	30.77	15.38
	Vegetation	0.00	0.00	0.00	0.00	0.00
	Gravel, Sand, Mud	60.00	40.00	20.00	80.00	60.00
	Water	0.00	16.67	16.67	16.67	16.67
Water quality	High	25.00	12.50	0.00	0.00	0.00
	Moderate	11.11	22.22	0.00	22.22	22.22
	Low	46.15	46.15	15.38	53.85	38.46
	Very Low	0.00	33.33	33.33	50.00	16.67

The preference patterns are in agreement with the other assessments performed. Slow conditions predominate at the majority of tributary sites, as is also indicated by observed macro-invertebrate flow preference percentage. As a result the low flow and reduced availability of fast-moving riffles did not significantly affect preference for fast water in June 2014. Habitat types between sites are more variable compared to that observed between sites on the Tsitsa River itself. For the tributaries sand and water column habitat exhibited the highest preference percentages. Whilst the water quality of the Tsitsa River tributaries considered fair, a high preference was exhibited for low water quality, with special reference to sites TS3, TS6 and TS9.
This is also reflected in the lower SASS5 scores reported from sites TS3 and TS9 in April 2014 and for all three sites in June 2014. Site TS3 also presented with the highest EC value in both April 2014 and June 2014.

MIRAI scores are presented in **Table 37,** together with SASS5 scores for ease of comparison.

Table 37: Summary of the results (ecological categories) obtained from the application of the MIRAI to the assessment sites on the Tsitsa River, compared to classes awarded using SASS5.

Variable / Index	Month	TS2	TS3	TS5	TS6	TS9
Ecological category (MIRAI)	April 2014	D	C	D	C	D
	June 2014	C	C	D	C	D
Dickens and Graham (SASS5)	April 2014	D	C	D	C	D
	June 2014	D	C	E	D	E
Dallas (SASS5)	April 2014	Borderline D and E/F	E/F	D	E/F	Borderline D and E/F
	June 2014	B	Borderline D and E/F	E/F	Borderline D and E/F	E/F

Despite the fact that habitat and flow conditions differed between the Tsitsa River tributary sites, MIRAI scores and hence ecological drivers within the larger system were very similar. The MIRAI score classifications largely corresponded with the results obtained using the SASS assessment, especially with reference to the April 2014 assessment, with either C or D classifications obtained.

With the potential developments in some of these catchments some impact on habitat, due to sedimentation and reduced water quality impacts may occur which will lead to changes in aquatic macro-invertebrate community structure. Some systems may be locally affected by proposed infrastructure upgrades with special mention of roadways and the associated bridges and therefore specific care must be applied in the design and construction of these features.

5.3.8 Fish Biota: Habitat Cover Rating (HCR) and Fish Habitat Assessment (FHA)

The HCR (Habitat Cover Rating) results for the Inxu River and smaller unnamed Tsitsa River tributary sites as assessed during April 2014 are provided in **Figure 59**.

Based on the depauperate fish fauna in this quaternary catchment and results obtained during the April 2014 fish sampling efforts, assessments pertaining to fish were not repeated during the June 2014 assessment. Furthermore visual assessment/observation indicated that, apart from lower water levels and slightly reduced flow, habitat cover did not change and hence the April 204 assessment results are also considered to be relevant to June 2014 conditions.

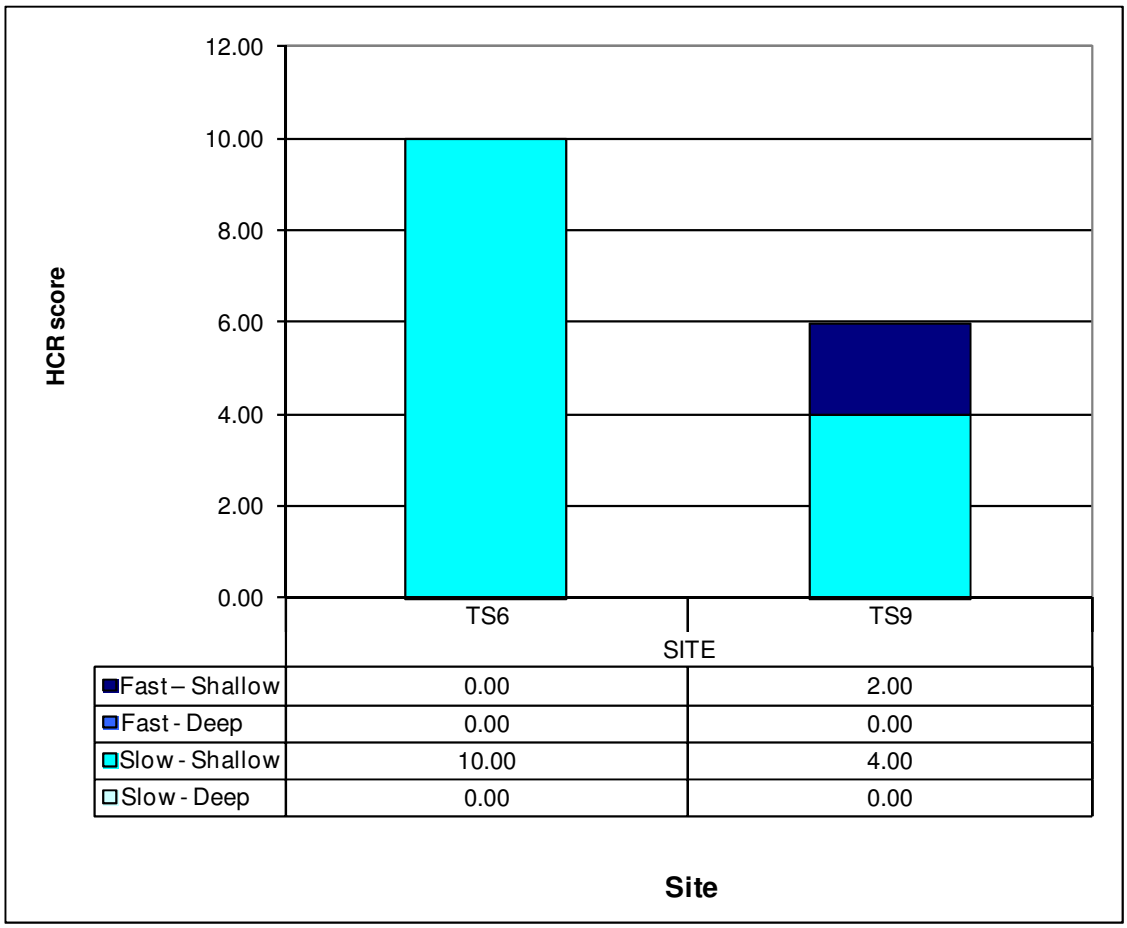

Figure 59: HCR scores for Tsitsa River tributary sites TS6 and TS9.

Assessment and sampling resulted in no fish being collected at any of the tributary sites. Because of the depauperate fish species diversity in the area, fish are not expected to occur in the small and shallow sites TS2, TS3 and TS5. However, as fish are expected to occur at sites TS6 and TS9 only HCR ratings for these two sites were provided in **Table 35**. Site TS6 presented with slow flow conditions only, whilst the latter was combined with some fast flow in riffle areas at siteTS9.

5.3.9 Fish Biota: Fish Response Assessment Index (FRAI)

The fish species expected to occur and frequency of occurrence (FROC) scores employed in the FRAI assessment were provided in **Table 5**. From this table it is clear that the fish fauna in the quaternary catchment is depauperate with a naturally low diversity of fish species present.

No fish specimens were collected during sampling efforts but as previously indicated carp (*Cyprinus carpio*) was observed in the Tsitsa River. It can be assumed that this fish species will also occur in the Tsitsa River tributaries where conditions permit. This fish species is thus likely to occur at sites TS6 and TS9.

Furthermore, although not collected, the longfin eel (*Anguilla mossambica*) is also likely to be present at these two sites (**Table 38**).

Table 38: Fish species observed during collections or known to occur at the various sites on the Tsitsa River.

SPECIES NAME	Number of fish collected at sites TS1, TS4, TS7 and TS8	Frequency of occurrence score (FROC)
Cyprinus carpio	Known to occur in system and sites conducive to them being present	1
Anguilla mossambica		1

The table below (**Table 39**) summarises the EC obtained using the FRAI. For ease of comparison the EC values obtained by using the MIRAI have again been included.

Table 39: Summary of the results (ecological categories) obtained from the application of the FRAI to the TS6 (Inxu River) and TS9 (unnamed tributary of the Tsitsa River) assessment sites, compared to that obtained using MIRAI as well as that obtained for the Tsitsa River.

River assessed	Inxu River (TS6), unnamed tributary of the Tsitsa River (TS9) and Tsitsa River (TS1, TS4, TS7 and TS8)		
Variable / Index	TS6	TS9	TS1, TS4, TS7 and TS8
Automated FRAI (%)	30.5	30.2	30.5
Automated EC (FRAI)	E	E	E
Refined EC (FRAI)	D/E*	D/E*	D/E*
Ecological category (EC) (MIRAI)	Borderline D and E/F	E/F	C/D

EC = Ecological category; * = No species expected/collected during assessments and habitat not conducive to known species being present based on sampling at the other sites.

The EC calculated for the FRAI corresponds to that obtained for the MIRAI for the Inxu River and to a lesser extend the Tsitsa River unnamed tributary and Tsitsa River sites. However, the naturally depauperate fish diversity in the quaternary catchment combined with the fact that no fish were collected during the sampling effort in April 2014, confounds any direct comparisons in terms of the effects of common/shared ecological drivers that may affect both the MIRAI and FRAI indices.

Based on the findings of the fish community assessments of the Tsitsa River tributaries, the proposed project is deemed likely to have a very limited impact on the fish ecology of the region.

5.4 SYNOPTIC OVERVIEW OF CURRENT AQUATIC ECOLOGICAL CONDITIONS AND POTENTIAL IMPACTS

To facilitate detailed assessment of potential impacts and suggest mitigation measures, the quaternary catchment ecological importance of the development areas and outcome of

the aquatic assessment is summarised in **Tables 40** and **41** respectively, followed by an overview discussion on potential impacts anticipated.

Table 40: Summary of site relevance to proposed developments and quaternary catchment ecological states

Development	Relevant sites	EIS	PES	DEMC
Ntabelanga Dam development	TS1 and TS4	High	C	B
Roads associated with Ntabelanga Dam construction	TS2, TS3 and TS5	Moderate to high	C	C/B
Area between Ntabelanga Dam and Lalini Dam	TS6	Moderate to high	C	C/B
Lalini Dam development	TS7 and TS8	Moderate	C	C
Pipeline development	TS9	Moderate to high	C	C/B
EIS = Ecological importance and sensitivity; PES = Present ecological state; DEMC = Desired ecological management class.				

The greater study area can thus be said to be of moderate to high ecological importance.

Table 41: Summary of the results (ecological categories) obtained from the application of the various indices to the Tsitsa River and tributaries

Assessment	Month	Sites								
		Tsitsa River				Inxu River (TS6) and other unnamed tributaries of the Tsitsa River				
		TS1	TS4	TS7	TS8	TS2	TS3	TS5	TS6	TS9
IHIA	April 2014*	B	B	C	C	C	B	C	C	C
IHAS	April 2014	Highly suited	Ade-quite.	Ade-quite.	Ade-quite.	Ade-quite.	Inade-quite.	Inade-quite.	Ade-quite.	Ade-quite.
	June 2014	Ade-quite.	Ade-quite.	Ade-quite.	Highly suited	Ade-quite.	Inade-quite.	Inade-quite.	Ade-quite.	Ade-quite.
Dickens and Graham (SASS5)	April 2014	C	C	C	C	D	C	D	C	D
	June 2014	C	C	D/E	C	D	C	E	D	E
Dallas (SASS5)	April 2014	A	C	A	A	D/E/F	E/F	D	E/F	D/E/F
	June 2014	B	C	D	B	B	D/E/F	E/F	D/E/F	E/F
MIRAI	April 2014	B	C	B	C	D	C	D	C	D
	June 2014	C	C	C	C	C	C	D	C	D
FRAI	April 2014*	D	D	D	D	**	**	**	E	E

Abbreviations and footnotes:
IHIA = Invertebrate habitat integrity assessment; IHAS = Invertebrate habitat assessment; SASS5 = South African scoring system; MIRAI = Macro-invertebrate response assessment index; FRAI = Fish response assessment index; NA = Not assessed.
*April 2014 conditions also representative of June 2014 conditions with reference to IHIA and FRAI;
** Conditions not suitable for habitation by fishes.

The ecological importance of the greater study area is reflected in the aquatic assessment results obtained, particularly with reference to the four sites on the larger Tsitsa River (classifications ranging between A to C for assessments pertaining to invertebrates and invertebrate habitat). Fish fauna diversity was, however, depauperate as was also

indicated in literature sources consulted. Smaller streams are thought to be less resilient to environmental change and more sensitive to disturbances, simply because of the smaller spatial scale in terms of potential areas of refugia and associated faunal and floral diversity to act as "buffer" to change. This is also reflected in the assessment results, with the tributary assessments generally yielding lower classifications. Seasonal changes in terms of the macro-invertebrate assessments are evident, with lower classifications being recorded during the lower flow period in June 2014. However, the contributions of lower flow and hence also potentially poorer water quality, as well as potential diffuse and point sources (agriculture activities and existing rural settlements) cannot be quantified at present.

Table 42: Summary of site relevance to proposed projects and general potential impacts associated with such development

Development	Relevant sites	General potential impacts
Ntabelanga Dam development	TS1 and TS4	Both sites are located on the larger Tsitsa River. During the construction phase restriction of flow, further destruction of bank cover and release of silt/sediment particles possibly resulting in discoloration and inundation is considered to be the most important potential impacts. After construction disruption of flow, also in terms of seasonal flow patterns, is considered the most significant impact along with the extensive loss of natural riverine habitat due to the inundation of the valley and the associated loss of aquatic community structure sensitivity and function. This impact is particularly pertinent as the system is reliant on clear fast flowing water to support the aquatic macro-invertebrate community of the area (as deduced from the MIRAI habitat preference tables discussed previously). Impacts on the Tsitsa River may thus impact the system on a much larger scale. Given the depauperate fish species diversity, potential impact on macro-invertebrates communities are expected to be far more significant throughout the system than on the fish community. However, the still deep impoundments created are likely to lead to a very significant increase in the population of the alien fish species *Cyprinus carpio* and increased impacts on the migratory connectivity of eels.
Roads associated with Ntabelanga Dam construction	TS2, TS3 and TS5	Anticipated impacts resulting from construction and use of roads include vegetation removal, increased risk of erosion, sediment loading into the system and inhibition of water flow. if not designed correctly roads can severely impact on instream habitat as well as bankside stability and riparian habitat
Area between Ntabelanga Dam and Lalini Dam	TS6	The Inxu River is the largest tributary and may also potentially act as "refugia" from where smaller tributaries can be populated. However, with limited diversity of flow and habitat types (very little rocky habitat) the potential to do so is also limited. Potential impacts may be the same as for the Tsitsa River sites, but being a tributary impacts resulting from changed flow rates may be less severe.
Lalini Dam development	TS7 and TS8	As for sites TS1 and TS4 and the Ntabelanga dam site
Pipeline development	TS9	Impact resulting from construction and use of roads as well as extensive digging are considered the greatest risk. Impacts as for TS2, TS3 and TS5.

The potential impacts will be discussed in terms of specific phases in the sections that follow.