Invertebrate survey for the proposed off-channel storage dam: Mzimkhulu Regional Water Supply Scheme

prepared by

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Commissioned by

NEMAI CONSULTING

July 2012

To Nemai Consulting

INVERTEBRATE SURVEY FOR THE PROPOSED OFF-CHANNEL STORAGE DAM: MZIMKHULU REGIONAL WATER SUPPLY SCHEME

We have the pleasure in submitting herewith our report as requested and as per your correspondence and appointment dated 12th July 2012. This study has been carried out in accordance with regulations stated in *DEAT (2005) Guideline 3: General Guide to the Environmental Impact Assessment Regulations, 2005, Integrated Environmental Management Guideline Series, Department of Environmental Affairs and Tourism (DEAT), Pretoria.*

The aim of this report was to provide the client with a description of potential status of Red Data Invertebrate species and habitat that could be potentially suitable for the presence of these species in the Gugamela and Ncwabeni River sites, both of which constitute tributaries of the Mzimkhulu river. We also hoped to ascertain the impact of the proposed construction of the Ncwabeni Off-Channel Storage Dam. Two alternative schemes are being considered for the proposed dam, the Ncwabeni Scheme and the Gugamela Scheme. Results obtained from the assessment are considered sufficient to highlight sensitive habitat types and potential Red Data habitat. However the survey was conducted during a time of the year when invertebrate activity is greatly reduced. Follow up surveys are recommended in late 2012 to confidently confirm the absence of two Myriapod species of conservation concern known to occur in the vicinity of the site, namely *Doratogonus infragili* and *Doratogonus montanus*.

The site was visited on the 13th and 14th of July 2012 by Vincent van der Merwe and Cornel du Toit. The first site visit was carried out to become acquainted with the development area and to put out pitfall traps. The subsequent site visits involved more intensive surveying using both active and passive methods. It is clearly evident that the proposed Gugamela site is considerably more degraded by anthropogenic activities than the Ncwabeni site. This site has been highly degraded by irregular fire regimes, terracing, creation of footpaths, large scale invasion by exotic species and overgrazing by cattle, goats and donkeys. Large areas of this site are consequently heavily eroded. Feral dogs have removed much of the small mammal fauna on the site and the prevalence of chickens has certainly had an impact on invertebrate fauna.

The Ncwabeni River site has also been impacted by the abovementioned anthropogenic activities however on a considerably smaller scale. This is largely due to a lower human population density on this site as it is less conducive to agricultural activities. Much of the Ncwabeni River site remains in a largely natural condition it displays a healthier level of ecosystem functioning. From an invertebrate and a general ecological point of view it is strongly recommended that the proposed off-channel storage dam is constructed on the Gugamela River site.

Should summer surveys confirm the presence of *Doratogonus infragili* and *Doratogonus montanus* on the Gugamela site then large scale relocation of any populations identified could be carried out. This may be a costly and logistically difficult and may tamper with the genetic identity

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INTRODUCTION

Invertebrate diversity and its ecological significance

Biodiversity is the variability among living organisms on earth, including the variability within and between species and within and between ecosystems. The biodiversity of KwaZulu-Natal is under constant threat from human settlement and societal development. Natural land is degraded and transformed by the rapid expansion of human settlements, such as residential areas, mines, manufacturing plants, storage dams, transport and agricultural infrastructure, that have an ever-increasing demand for space. The loss, fragmentation and degradation of natural habitat through urbanisation and an increase in human population numbers, represent the greatest threats to rare and endangered invertebrate species in KwaZulu-Natal.

Sustainable development is an evolving concept, which is continually being redefined and reinterpreted and should form the basis of the planning processes of new developments. Reducing the burden of environmental impacts is necessary if development is to become sustainable. The process of planning new developments should be based on scientific, ecological principles and used as a planning tool to promote sustainable development by integrating environmental considerations into a wide range of proposed actions. Development planning must be intended to ensure that development proposals do not undermine critical resource and ecological functions, by improving the way these environmental resources are utilised, or the well being, lifestyle and livelihood of the communities who depend on them.

Invertebrates dominate terrestrial and freshwater ecosystems, with insects being the most speciose class, comprising more than 75% of all known species in the Animal Kingdom. Insects, myriapods and arachnids form part of the diverse and essential natural processes that sustain biological systems. The insect-plant interaction is the most common biotic interaction on Earth, and indeed, our present ecosystems would not function without these invertebrates. The worldwide Red List of Threatened Species (http://www.iucnredlist.org/) contains approximately 560 insects. This is a meagre 7% of the faunal list, which when one consider that insects make up over 70% of the worlds fauna, is tremendously biased. In a study carried out by Black and Vaughn (2003), it was noted that of the world's insects, very few groups have been assessed on a worldwide scale. Approximately 10% of Swallowtail butterflies, for example, are considered globally threatened. Based on a mathematical model, McKinney (2003), predicted that 10% of all butterflies were threatened strongly contrasting the 1% currently listed. At National levels, figures between 10% and 34% are given for the number of threatened indigenous insect species, suggesting that the overall number of threatened insect species could be in excess of 100, 000. Globally countries such as Australia, France, Spain, the United States and South Africa have among the highest numbers of threatened invertebrates. This is however, more a reflection of the effort made by these countries to assess their biodiversity and hence distinguish those that are threatened rather than a true overall indication.

Invertebrates have an enormous functional value because of the numerous individuals and the great intra- and interspecific variety. The ecological importance of this great variety of invertebrate makes them valuable to assess disturbances or environmental impacts. A sound knowledge of arthropods is crucial to the conservation and management of ecosystems because a skewed focus only on the larger organisms will misrepresent ecosystem dynamics. The lack of human appreciation of the importance of invertebrates and their general disregard and dislike, coupled to the fact that only about 7-10% of insects are scientifically described, must be overcome to realistically conserve biodiversity.

Project background

The Mzimkhulu Regional Water Supply Scheme, which forms part of the KwaZulu Natal's Lower South Coast System, supplies water to the coastal region from Hiberdeen to Margate, including Port Shepstone. The water is presently sourced from non-regulated river flows in the Mzimkhulu River. The water is abstracted at the St. Helen's Rock abstraction works near Port Shepstone and is pumped into the water treatment works. From there the water is distributed to the various user nodes.

In order to provide for the water requirements for all user sectors, including the Reserve, the Department of Water Affairs (DWA) has proposed the construction of an off-channel storage (OCS) dam in one of the tributaries to the Mzimkhulu River. The reservoir can be filled from its incremental catchment, supplemented by pumping from the Mzimkhulu River during times of high river flows. During times of low flows, water can be released back into the Mzimkhulu River for abstraction downstream at the existing St. Helen's Rock abstraction works. The two alternative sites that were identified for the OCS dam are situated in the Ncwabeni River (Alternative 2D) and the Gugamela River (Alternative D3A).

A major objective of the environmental impact assessment process is to select between these two alternative schemes so that the environmental impact of the construction of the off-channel storage dam is minimised. Should the environmental impact of constructing a large off-channel storage dam on both sites be deemed substantial then the no go option may be decided upon.

STUDY AREA

Locality: The project area is located in southern KwaZulu-Natal approximately 25km North West of Port Shepstone (Fig.1). The two off-channel storage dam sites are located close to the southern boundary of Ward 1 of the Umzumbe Local Municipality, which falls under the Ugu District Municipality. Both the Ncwabeni River (D3A site) and the Gugamela River (D2 site) are tributaries of the Mzimkhulu river as indicated in Figure 2.

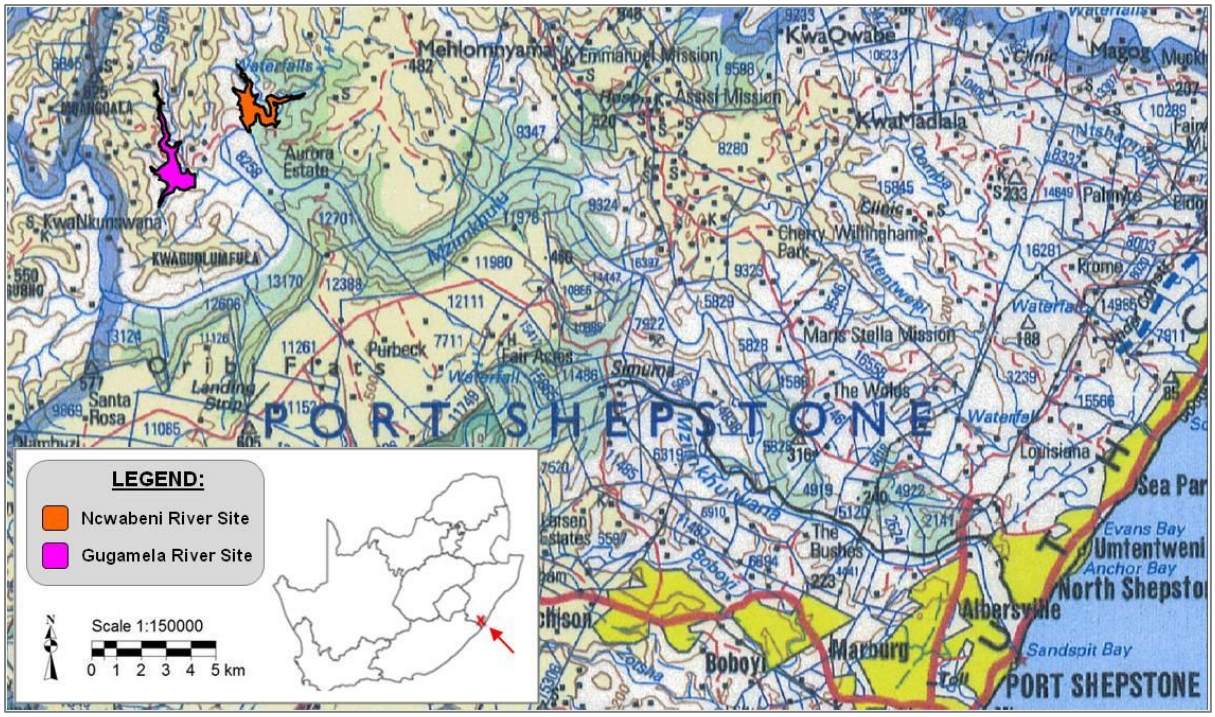

Figure 1. Location of the study area.

Duration of survey: The site was visited on the 14th and 15th of July 2012 as by Vincent van der Merwe and Cornel du Toit. The purpose of these site visits were to become acquainted with the development area and to investigate the possibility of invertebrate species of conservation concern occurring on the site. Pit fall traps were set out on the afternoon of the 14th of July and inspected 24hrs later. Transect sweepnetting was carried out on the following day.

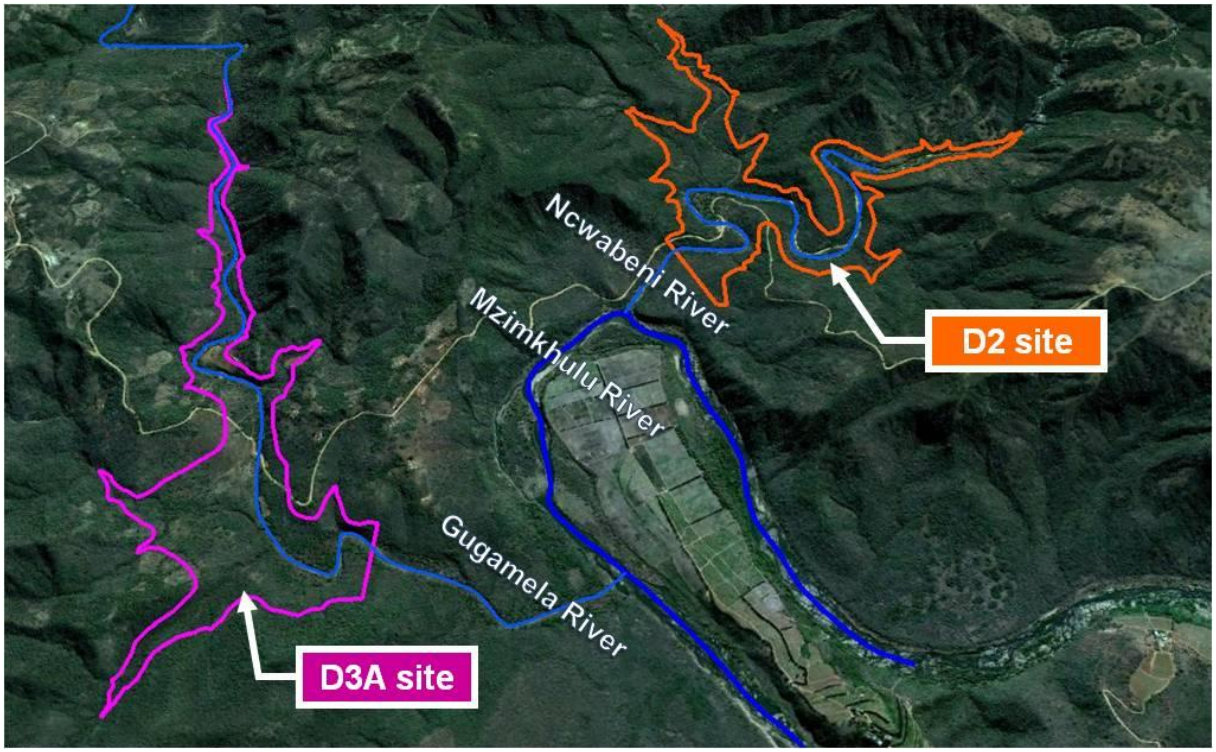

Figure 2. Aerial view of the Gugamela (D3A) and Ncwabeni (D2) River sites.

Conditions during survey: Conditions for invertebrate survey were sub-optimal during both site visits. Although it was sunny and had rained on the 13th July, temperatures did not exceed 23°C. Millipede activity is considerably higher in summer when temperatures are higher and the soil is more moist as a result of higher rainfall.

Geology & Soils: Both the Ncwabeni River Site and the Gugamela River site consist of deeply incised valleys, hence their choice as potential sites for the construction of dams. These valleys are underlain by sediments of the Karoo Supergroup with mudstones and lesser sandstones of the Adelaide and Tarkastad subgroups (Beaufort Group) dominant.

Climate: Both sites fall within a summer rainfall region with some rain recorded in winter. A heavy downpour was recorded on the site on the day before surveying commenced. Mean annual precipitation varies between 550 and 1000 mm. Frost in infrequent. Mean monthly maximum and minimum temperatures are 36.9°C and 4.0°C for December and June, respectively. .

Vegetation

Two distinct vegetation units/invertebrate habitats are located on the Ncwabeni River and Gaugamela River sites (Figure 3), namely:

1. Eastern Valley Bushveld (Savanna Biome)
2. KwaZulu-Natal coastal belt (Indian Ocean Coastal Belt Biome)

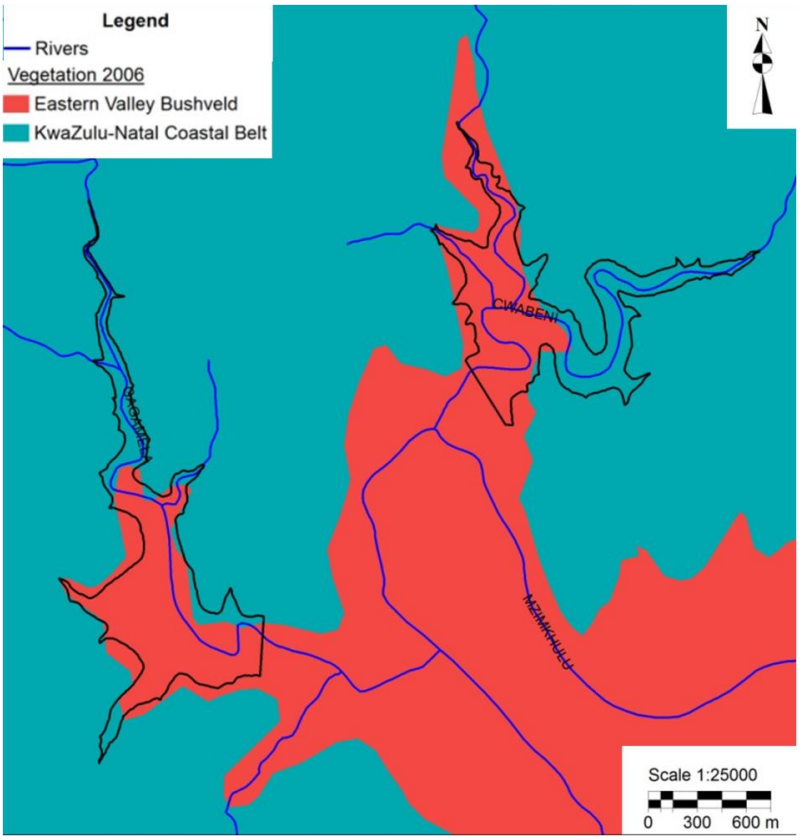

Figure 3. Vegetation map of the Ncwabeni and Gugamela River sites.

Unit 1: Eastern Valley Bushveld

This vegetation unit was dominant on the Gugamela River site before anthropogenic influences transformed much of this area. More than 50% of the Ncwabeni River site is comprised of relatively undisturbed Eastern Valley Bushveld. It is characterised by semideciduous savannah woodlands with pockets of thicket in a mosaic pattern. In some areas these thickets are succulent and dominated by *Euphorbia* and *Aloes*. Prominent alien invasive species observed in this vegetation type include *Chromolaena odorata*, *Lantana camara* and *Caesalpinia decapatela*. All three species were observed on both the sites however they were more prominent on the Gugamela River Site.

- **Ground cover of the Ncwabeni River site:** 65% of which little is transformed.
- **Ground cover of the Gugamela site:** 70% of which the vast majority is transformed.
- **Butterfly foodplants:** No butterfly foodplants of interest were observed in this vegetation unit.
- **Potential invertebrates of conservation concern:** Populations of *Doratogonus infragili* and *Doratogonus montanus* may occur in more wooded portions of this vegetation unit. They are however more likely to occur in subtropical coastal forest within KwaZulu-Natal coastal best vegetation.

Figure 4. The Eastern Valley bushveld on the Ncwabeni River site is largely undisturbed. Rocky areas area in pristine condition. Small areas that are farmed have been heavily invaded by exotic species such as *Eucalyptus camuldensis*.

Unit 2: KwaZulu-Natal coastal belt

This vegetation type occupies the northern and southern tips of the Gugamela site where it has been largely transformed. It also occupies much of the western portion of the Ncwabeni site where is remains in a more natural condition. It is characterised by highly dissected undulating coastal plains which used to be covered largely by various types of subtropical forest. Primary grassland dominated *Themeda triandra* still occurs in hilly, high rainfall areas where pressure from natural fire and grazing regimes prevails. This vegetation type is threatened by sugarcane farming, gum plantations, coastal holiday resorts and secondary *Aristida* grasslands present due to disturbance. These *Aristida* grasslands were prevalent on the Ncwabeni River site. Prominent alien invasive species that threaten this vegetation type include *Chromolaena odorata*, *Lantana camara*, *Melia azedarach* and *Solanum mauritianum*. These invasive were observed in patches in both the Gugamela River and Ncwabeni River site.

- **Ground cover of the Ncwabeni River site:** 35% of which the vast majority remains in a largely natural state.
- **Ground cover on the Gugamela River site:** 30% of which much remains in a natural state.
- **Butterfly foodplants:** No butterfly foodplants of interest were observed in this vegetation unit.
- **Potential invertebrates of conservation concern:** *Doratogonus infragili* and *Doratogonus montanus* may occur in subtropical coastal forest patches of this unit.

Figure 5. Small fragments of subtropical coastal forest in KwaZulu-Natal coastal belt vegetation have been utilised by local communities for natural resources. Grassland areas of this unit have been utilised for grazing by cattle, sheep, donkeys and goats. Large scale erosion is evident. Artificially created wetlands in this unit have provided habitat for various aquatic insects.

MATERIALS & METHODS

Invertebrates were sampled using active and passive methods. Active methods entail collection by an individual using various kinds of equipment, while passive methods involve specialised types of traps at specific sites in the field, which are visited at given time intervals. Our collection effort was hampered by the fact that the farm manager was out of contact and due to access gates being locked up. We nevertheless managed to gain access by unorthodox means and a comprehensive sampling effort was carried out.

Passive collection

Pitfall traps

Ten pitfall traps were placed ten meters apart, in a single transect subtropical coastal forest vegetation most likely to constitute habitat for populations of *Doratogonus infragili* and *Doratogonus montanus*. The pitfall traps were unbaited. The plastic buckets used for traps had a 1000 mL capacity and were 11 cm in diameter and 12 cm deep. All the traps were sunk into the ground so that the buckets' rims were level with the soil surface. Buckets were filled to about one fifth their volumes with a solution of liquid soap and water to immobilise trapped invertebrates. Trap contents were collected 24 hours after the traps had been set. Only insects and arachnids were collected from the traps. Specimens of interest were preserved in absolute ethanol and transported to the laboratory for identification. Morphospecies were identified to order level and family level where possible.

Figure 6. Pit fall traps were placed in patches of subtropical forest, particularly those with plentiful leaf litter. Few invertebrates were caught despite that fact that it rained before site visits were conducted. Summer surveys are recommended.

Active collection

Sweepnetting

Transect sweepnetting was carried out on the 15th of July 2012. An insect net with a diameter of 40 cm were used for collecting insects and arachnids. Three transects were swept along the edges of the pan and for the sake of standardisation, 20 sweeps of 180° constituted one transect (and thus one sample). Insects and arachnids from the samples were preserved in absolute ethanol and transported to the laboratory for identification. Morphospecies were identified to order level and family level where possible.

Beating

This method of collecting was not employed as it is unlikely that this method will retrieve any invertebrates of conservation concern.

Physical searches

Physical ground and rock searches were undertaken in order to identify arachnids, scorpions and various insects which take refuge underground in burrows or under rocks.

Data recorded and red data species

A list of all identifiable insects and arachnids caught or seen on the site was compiled and is included in the report.

A list of invertebrate species of conservation concern that are known to occur in the vicinity of the Ncwabeni River site is included in Appendix A.

A list of invertebrate species of conservation concern that are known to occur in the vicinity of the Gugamela site is included in Appendix B.

Data processing

The conservation priority of each vegetation unit was determined by evaluating:

1. The general condition of the vegetation unit
    a. How much natural vegetation remains
    b. The degree to which the it has been degraded by human activities or invasion by exotic species
2. The invertebrate species composition of the unit
    a. General species diversity
    b. Presence of species of conservation concern
3. The conservation status of the vegetation type in KwaZulu-Natal

INVERTEBRATE DIVERSITY RECORDED FOR THE NCWABENI AND GUGAMELA RIVER SITES

Observations of invertebrate (Insecta, Arachnida, and Diplopoda) activity were infrequent throughout the entire study site (despite a rainfall event the previous day). Data for those that were seen active on the surface, or sampled by any of the passive or active collecting methods are listed in Tables 1 and 2. A total of 43 insects, representing 14 families in 9 orders, were recorded during the survey period. Four arachnids were collected or observed, and diplopod presence was only confirmed by the presence of exoskeleton remains. Representation and numbers of the various arthropod classes caught might not compare favourably to other similar surveys completed in the same vegetation type. All invertebrates sampled were stored in absolute ethanol and positively identified to family (or subfamily) level in the laboratory.

Table 1. Insects that were observed or collected on the site of the proposed development.

Insects			
Order	**Family**	**Specimens**	**Collecting method**
Odonata	Not determined (nymphal stage)	2	Observed
Blattodea	Blattellidae	1	Pitfall trap
Isoptera	Termitidae	4 mounds	Observed
Hemiptera	Pentatomidae	1	Active search
Neuroptera	Myrmeliontidae	7	Observed
Coleoptera	Scarabaeinae	2	Active search
	Tenebrionidae	1	Active search
	Coccinellidae (larval stage)	6	Beating
Diptera	Muscidae	6	Sweepnetting
	Calliphoridae	2	Observed
Lepidoptera	Psychidae	1	Active search
Hymenoptera	Vespidae	5	Active search
	Apidae	3	Sweepnetting
	Formicidae	6	Pitfall trap

Table 2. Arachnids that were collected during the survey on the site of the proposed development.

Arachnida			
Order	**Family**	**Specimens**	**Collecting method**
Araneae	Araneidae	3	Sweepnetting
	Salticidae	1	Beating

The vast majority of arthropods collected were insects. Hymenoptera was the most diverse (3 families) and abundant (14 specimens) order of insects, followed by the Coleoptera.

DISCUSSION

It is usually not feasible to sample invertebrate diversity adequately over a relatively short period of time or during the drier, colder (winter) months. Such conditions are characterised by a general absence of adult insects, when they are present in other life stages. Maximum insect activity is correlated with the onset of the rainy season. Many organisms respond rapidly to rainfall events to complete parts of their life cycle, such as the synchronised mass emergence of secondary reproductives in termites (Isoptera). Furthermore, millipedes (Diplopoda) have a limited tolerance of extended dry periods, leading to a periodicity in their surface activity. Adults aestivate through the dry season and emerge in response to significant rainfall events to remain surface active for several days thereafter. Spider abundance generally follow this same pattern, with maximum activity reached during the wet (summer) season.

Conditions for maximum arthropod activity were sub-optimal during the site visit as it was conducted during mid winter. The soil was dry (although rain was recorded a day prior to the survey) and a strong persisting wind (associated with a passing cold front) compromised sampling efforts. Different species emerge at different times of a season, often depending on the weather. Thus, increased invertebrate abundance (and subsequently increased probabilities of them being collected) is dependent on favourable climatic conditions.

Most sampling devices or techniques target only a single stage of the life cycle. The adult stages of most invertebrates are usually more conspicuous and easier to collect than when individuals are present in egg, juvenile (nymphal or larval), pupal or sub-adult stages. However, some adult insects live for a very limited time and when emergence of a population is synchronised; adults may only be present in the field for a week or less. Due to time constraints, certain sampling methods were not employed. One such method is light trapping, thus excluding various nocturnal species that were not collected from the other sampling methods employed.

It is preferable to identify specimens to the species level, because for nearly all objectives it is better to have specific information on carefully chosen groups than family-level information on many. However, securing reliable identification to the species-level is the greatest single difficulty in invertebrate biodiversity. Except in some of the best known groups, expert knowledge is required to ensure that identifications are accurate. Such expertise is often both extremely limited and in great demand for a great many activities.

Invertebrate Species of conservation concern known to occur in the vicinity of the site

Records indicate that a two Red Data Myriapod species are known to occur in the vicinity of the Gugamela River site, namely *Doratogonus infragili* and *Doratogonus montanus*. Only *Doratogonus infragili* is known to occur in the vicinity of the Ncwabeni site although a concerted effort was made to find both species on both sites.

Doratogonus infrangii is listed as endangered by the IUCN. This species, commonly known as the Strong black millipede, is restricted to the area between Richmond and the Mzimkulwana River in the vicinity of the site. It is well known to occur in Oribi Gorge Nature Reserve that is located approximately 7km to the south of the Ncwabeni River site. It is known to occur in riverine forest even when there is a certain level of invasion by alien invasive plant species. As with most threatened invertebrate species no population data is available. The degree of fragmentation amongst populations of this species is unknown. It is however suspected that surviving populations are fragmented through the loss of habitat.

Doratogonus montanus is listed as a species of least concern by the IUCN. It occurs at localities all along the KwaZulu-Natal Drakensburg that are not heavily transformed and comparatively well protected. There is no evidence that its extent of occurrence or area of occupancy has declined. This species mainly occurs in cooler, higher lying mountainous areas to the north of the study area. The Ingeli forest area, one of the species strongholds, is threatened by road development, invasion by alien plant species and forestry. Although the current population may decline as a result, the extent of occupancy and the area of occurrence are larger than for the IUCN threatened category threshold.

Neither *Doratogonus infrangii nor Doratogonus montanus* were observed during site visits. The survey was however carried out during a time of the year when millipede activity is greatly reduced. Although signs of millipede activity and some millipede remains were observed the presence or absence of these species in the two study areas was not established.

Much of the riverine area on the Gugamela River site is completely dominated by alien invasive species such as *Chromolaena odorata*, *Lantana camara*, *Caesalpinia decapatela, Melia azedarach*, *Solanum mauritianum*, *Jacaranda mimosifolia and Acacia mearnsii.* Some more natural subtropical coastal forest was however present higher up on the slopes of the hilly areas as indicated in Figure 7. These areas are too high to be inundated by the proposed off-channel storage dam. If any populations of *Doratogonus infrangii* do survive in these isolated pockets of forest then they will not be flooded by the proposed storage proposed dam. If approval is obtained for the construction of the storage dam then a concerted effort should be made to subject these isolated pockets of forest to as little disturbance as possible whilst construction is taking place.

Figure 7. Alien invasive vegetation completely dominates the riparian zone around the Gugamela river. Remaining natural pockets of subtropical coastal forest are mainly concentrated on higher lying slopes that will not become submerged by the proposed storage dam. Two IUCN listed millipedes species are known to occur in the general vicinity of the proposed off-channel storage dam sites. *Doratogonus infrangii* (above) is listed as endangered.

RECOMMENDATIONS

Summer surveys are recommended to firmly establish the absence of *Doratogonus infragili* and *Doratogonus montanus* from the two sites. The Gugamela River site (D2) has been considerably more degraded by anthropogenic activities that the Ncwabeni River site (D3A). The Ncwabeni River site is in a much more natural condition and displays a healthier level of ecosystem functioning. The baseline surveys carried out suggests that should approval be obtained for the construction of a off-channel storage dam then this development should take place on the Gugamela River site.

The following standard mitigatory measures are recommended for the site on which construction of the off-channel storage dam will take place:

Large areas of the Gugamela and Ncwabeni sites are ecologically degraded. The Department of Water Affairs should take steps to remove all the alien invasive plant species and employ further restrictions and control, as specified by CARA Regulations. An ecological management plan must be compiled by a suitably qualified specialist for implementation by the appropriate management authority. This ecological management must include a fire management programme and an ongoing monitoring and eradication programme for all non-indigenous species, with specific emphasis on invasive and weedy species. Where removal of alien species may leave soil exposed, alternative indigenous species should be established to prevent any erosion. Plants growing naturally on the site must, as far as possible, be retained and incorporated into landscaping. This should include remnant patches of subtropical coastal forest. When additional plant species are used for landscaping, special emphasis should be focused on forage and host plants required by herbivores and pollinators present in the area and must otherwise only be limited to those indigenous to South Africa (Refer to table 1). The integrity of natural vegetation that falls outside of landscaped areas, such as indigenous grass species and leaf litter, should be preserved as it provides habitat, microclimatic conditions and food sources to many smaller vertebrates and invertebrates. Several of these species may complete their entire life cycles in this specific niche.

Construction activities must be restricted and carefully monitored to keep disturbance to a minimum. Areas impacted by construction activities that will not be submerged by the proposed dam must be appropriately rehabilitated and managed. This entails the removal and proper disposal of all temporary accommodation for construction worker and waste material originating from construction activities. All materials discarded on the site during construction should be relocated to official municipal dumping grounds. Dumping of any materials in undeveloped open areas should not be allowed and this must be actively managed. Construction must preferably take place during the dry season. All construction-related impacts (including service roads) must be contained within the fenced-off development areas" (Pfab, 2006).

Table 1. List of plants and shrubs are recommended for butterflies (nectar plants)

Pentas lanceolata and *Pentas lanceolata*
Buddleja salvifolia
Verbena spp.
Asclepias spp.
Bougainvillea spp. (Varieties such as Killie Campbell)
Plumbago auriculata
Impatiens spp.
Kalanchoe spp.
Lobelia species
Limonium spp.
Asystasia gangetica

It is imperative that adequate erosion preventative mechanisms are implemented throughout the construction phase. Erosion resulting from the development should be appropriately rehabilitated preventing further habitat deterioration. Stormwater runoff must be correctly managed during all phases of the development. Special care needs to be taken during the construction phase to prevent surface stormwater containing sediments and other pollutants from entering the Ncwabeni or Gugamela Rivers. A surface runoff and stormwater management plan must be put in place. The total sealing of walkways, pavements, drive ways and parking lots should not be permitted in the free space system. These should form part of and be contained within the areas earmarked for development. This would aid in the minimising of artificially generated surface stormwater runoff.

The use of insecticides, herbicides and other chemicals should not be permitted close to natural habitat that will not be submerged by the planned storage dam. If chemicals are used to clear invasive vegetation and weedy species, species-specific chemicals should be applied and in the recommended dosages. General spraying should be prohibited and the application of chemicals as part of a control programme should not be permitted to take place on windy days.

Outside lighting should be designed to minimize impacts, both directly on especially rare or endangered invertebrate species and indirectly by impacts on populations of prey species. All outside lighting should be directed away from sensitive areas. No domestic cats should be allowed, and where domestic dogs are kept, the entire development should be fenced to prevent dogs from straying into natural vegetation, particularly remnants of subtropical coastal forest. Dogs threaten the persistence of wild species in these natural areas, particularly small mammals.

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Appendix A

Invertebrates of conservation concern possibly occurring on or in the vicinity of the Gugamela River site (D3A)

Class Diplopoda

Millipedes

Order Spirosteptida

Family Spirostepsidae

Doratogonus infragilis

Doratogonus montanus

Appendix B

Invertebrates of conservation concern possibly occurring on or in the vicinity of the Ncwabeni River site (D2)

Class Diplopoda

Millipedes

Order Spirosteptida

Family Spirostepsidae

Doratogonus infragilis