APPENDIX

BIODIVERSITY IMPACT ASSESSMENT OF DEVELOPMENT ALTERNATIVE 5 ON THE WETLANDS AND VEGETATION OF ERF 12403, KNYSNA

Prepared for

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by

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Executive summary

This report forms an appendix to the Biodiversity Impact Assessment of the Wetlands and Vegetation of Erf 12403, Knysna (Bornman 2006) report. Following a meeting on Friday 23 March 2007 with regional and national representatives from DWAF, DEA&DP, Knysna Municipality, SANParks and CapeNature, it was decided to include a fifth development alternative into the Environmental Impact Report.

The five development alternatives identified for investigation during the EIA phase were:

- **Alternative 1: No-go:** This option is the alternative with no development and is equal to "do nothing". The land will be left in its current state with current usage.
- **Alternative 2:** As set out in the Background Information Document (BID)
- **Alternative 3:** Similar to the BID option, but with a lower density
- **Alternative 4:** Similar to the BID option, but with a higher density.
- **Alternative 5:** Similar to Alternative 4, but with a smaller development footprint and a larger wetland area.

Development Alternative 5 had the same 15 impacts on the wetlands and vegetation as was identified for the four other development alternatives in Bornman (2006). Most impacts in both the construction and operational phase can be mitigated. The highest negative impact associated with development options 2 – 5 includes the loss of wetlands. The positive impacts related to all the development options can be further enhanced in Options 2 – 5, but the likelihood of beneficiation action being taken in the no-go option is improbable due to the costs involved. Development Options 5 has the lowest overall impact of all the development options (excluding the no-go option).

Development alternative 1 (no-go) will retain the highest wetland area (77% of total property area). Of the development options, Option 2 will have the highest open water area and Option 5 the highest emergent and estuarine wetland area (38.41%). Since most of the property used to consist of estuarine/brackish wetlands with very little open water area, it is apparent that the No-go option will have the least impact followed by Development Alternative 5. The No-go option has the lowest negative impact score, but since the probability of mitigatory action being implemented in this option is very low, it is evident that following mitigation, Option 2 – 5 will have a lower negative impact rating. Positive impacts without mitigation is very low in the No-go option and even after mitigation (which is improbable) the positive impacts in Option 1 is still lower than the positive impacts without beneficiation in Alternatives 2 – 5. Of the development options, Option 5 still remains the best

alternative with the lowest negative and highest positive impact score where over 50% of the present wetland area will be rehabilitated and conserved.

An important mitigation measure that forms part of the proposed development would be the upgrading of the Knysna Sewage treatment plant. At the present the sewage plant is the major contributor of nutrient and bacterial pollution to the groundwater and the Knysna Estuary. Once upgraded, approximately 11 ha additional area will become available for the rehabilitation of wetlands. The oligotrophic (as opposed to eutrophic) groundwater will result in increased freshwater wetland diversity and functioning. The rehabilitated wetland areas that will form part of the proposed development will be more than adequate to attenuate and treat stormwater flows from the adjacent developments. In addition it is recommended that a network of freshwater wetlands be created that form a corridor all along the eastern shore of the Knysna Estuary.

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1. Introduction

1.1. Background

This report is an appendix to the Biodiversity Impact Assessment of the Wetlands and Vegetation of Erf 12403, Knysna (Bornman 2006) report. Following a meeting on Friday 23 March 2007 with regional representatives from DWAF, DEA&DP, Knysna Municipality, SANParks and CapeNature, it was decided to include a fifth development alternative into the Environmental Impact Report. The Appendix was compiled as part of compliance with Section 24.7 of the National Environmental Management Act (NEMA: Act 107 of 1998). In this context the conservation value of each vegetation unit is assessed as objectively as possible using a numerical matrix approach. The matrix assessment is then evaluated together with an assessment of sensitivity of the vegetation to disturbance. In keeping with NEMA, comment is included on ways of maximising the benefits presented for development option 5 and minimising its detriments (mitigation measures). This report was compiled for the independent environmental consultant with ToR as per the Plan of Study for EIA.

1.2. Terms of Reference

The following terms of reference (ToR) are specific to this report and for Alternative 5:

- Identify all aspects that will impact on the vegetation and wetlands of George Rex;
- Assess the impacts (negative & positive) of Alternative 5 that were identified in the Plan of Study for EIA Erf 12403 (using criteria developed by CSIR 2005);
- Identify mitigation measures to reduce the negative impacts as well as measures that would enhance the positive impacts;
- Identify possible future management issues that would be included in the Environmental Management Plan;

1.3. Methodology

The following activities were undertaken in order to meet the objectives listed in the ToR of this Appendix to the Biodiversity Impact Assessment specialist report (Bornman 2006):

1.3.1. Impact Assessment

The impact assessment method used is based on that recommended by the Council for Scientific and Industrial Research (CSIR 2005) as follows:

Nature of the impact: A description of positive or negative effect of the project on the affected environment, or vice versa. Included in this is a description of who or what would be affected, and how.

Extent: the impact could:

- Be site-specific;
- Be limited to the site and its immediate surroundings;
- Have an impact on the region
- Have an impact on a national scale
- Have an impact across international borders

Duration: The lifetime of the impact was indicated as:

- Short term (e.g. during the construction phase);
- Medium term (e.g. during part or all of the operational phase);
- Long term (e.g. beyond the operational phase, but not permanent);
- Permanent (where the impact is for all intents and purposes irreversible) or
- Discontinuous or intermittent (where the impact may only occur during specific climatic conditions or during a particular season of the year).

Intensity or magnitude: The size of the impact (if positive) or its severity (if negative):

- Low, where biodiversity is negligibly affected or where the impact is so low that remedial action is not required;
- Medium, where biodiversity pattern, process and/or ecosystem services are altered, but not severely affected, and the impact can be remedied successfully or
- High, where biodiversity pattern, process and/or ecosystem services would be substantially affected. If a negative impact, could lead to irreplaceable loss of biodiversity and/or unacceptable loss of biodiversity and/or unacceptable consequences for human wellbeing.

Consequence: subjective judgement as to the significance that a particular action on a specific environmental characteristic has for the environment as a whole and is calculated as Extent × Duration × Intensity.

- Low importance, score 1;
- Medium-low importance, score2;
- Medium importance, score 3;
- Medium-high importance, score 4;
- High importance, score 5.

Probability: Describes the likelihood of the impact occurring as:

- Improbable, where the possibility of the impact is very low either because of design or historic experience;
- Probable, where there is a distinct possibility that the impact will occur
- Highly probable, where it is most likely that the impact will occur or
- Definite, where the impact will occur regardless of any prevention measures.

Significance: Can be calculated as Consequence × Probability and described as:

- Low, where it would have negligible effect on biodiversity, and on the decision;
- Medium, where it would have a moderate effect on biodiversity, and should influence the decision;
- High, where it would have a large effect on biodiversity and have a major influence on the decision;
- Very high, where it would have an irreversible negative impact on biodiversity or a major positive effect. Impacts of very high significance should be a central factor in decision making.

Confidence: The level of confidence in predicting the impact can be described as:

- Low, where there is little confidence in the prediction, due to inherent uncertainty about the likely response of the receiving ecosystem , or inadequate information;
- Medium, where there is a moderate level of confidence in the prediction; or
- High, where the impact can be predicted with a high level of confidence.

1.3.2. Mitigation measures

Mitigation measures or management actions are recommended that will minimise or eliminate negative environmental impacts, assist design, enhance project benefits and protect public and individual rights to compensation.

Impacts are rated both with and without the assumed effective implementation of mitigation measures. If appropriate, it is being differentiated between essential mitigation measures which must be implemented (i.e. implicit in the "assuming mitigation" rating) and optional mitigation measures, i.e. "nice-to-haves", but which do not affect the impact rating. Where appropriate monitoring and review programmes that can track the achievement of the mitigation objectives are recommended.

2. Impact assessment

Alternative 5: Additional development option

The additional development option, Alternative 5, is similar to Alternative 4, except that the development area has been decreased and the wetland area increased by 14%. See Chapter 6 for impact assessment tables.

Figure 1. *Alternative 5. – High density with commercial and increased wetland area*

2.1. Increased exotic infestation

Exotic tree species cover at present 5.1 ha (~ 26%) of the property. The three dominant exotic trees on the property are *Acacia melanoxylon*, *Acacia mearnsii* and *Paraserianthus lophantha.* All three produce large quantities of long lived seed that, if not controlled continuously, will remain serious infestations. Disturbing the soil during construction will result in increased germination of exotic plant species. Importing soil from other locations may also potentially import the seedbank of additional exotic species.

2.2. Development on floodplain

The present elevation of Erf 12403 is below the 1:100 year floodline and future expected sea level rise. At present George Rex Drive acts as a seawall, but the development proposes to enlarge the culvert below the road to increase flushing of tidal water and freshwater. This will place the development at greater risk from flooding during exceptionally big flood and high tidal events related to storms at sea. The development option proposes to elevate the development above any future predicted high water levels (including the predicted rise in sea level related to global warming).

2.3. Restrictions to tidal flow

Tidal flow onto Erf 12403 is restricted by a small culvert under George Rex Drive that has resulted in an increase in freshwater wetlands and a decrease in estuarine/brackish wetlands. During the construction phase, the culvert must be closed off to prevent pollution of the Knysna Estuary. Tidal flow onto Erf 12403 will remain restricted in development Option 5 (where a larger culvert has been installed) by the network of conserved wetlands and elevated development islands.

2.4. Loss of estuarine/brackish wetlands

Estuarine wetlands will be lost through the expansion of freshwater wetlands unless the tidal exchange to Erf 12403 is improved. Increased open water areas will reduce the estuarine wetland area. Development in the south-western corner of the property will reduce estuarine wetland area. Increased freshwater flow rates in the canals will dilute the estuarine water.

2.5. Loss of freshwater wetlands

Large areas of freshwater wetlands will be destroyed during the construction phase of Development Alternative 5. In the operational phase approximately 38.5% of the original wetland area will remain.

2.6. Loss of reed & sedge community

Although the reed and sedge community formed as a direct result of past human impacts, it presently serves a useful function in the removal of excess nutrients from the groundwater and as habitat for a variety of birds and other wetland faunal species. The monospecific stands of *Phragmites australis* and *Typha capensis* formed as a result of the eutrophic groundwater. Any additional nutrient input from the development (e.g. grass clippings, fertilisers, etc.) will result in an expansion of this community.

Sufficient space should be made available for this community as part of the rehabilitated emergent wetland.

2.7. Increase in storm water run-off

Clearing of vegetation during the construction phase will result in increased surface run-off from the exposed soil. The increased run-off will impact on the wetland geomorphology and water quality. Increasing the built area will increase stormwater run-off into the remaining wetlands on Erf 12403 and the Knysna Estuary. Increased development on neighbouring higher lying properties will also increase the storm water delivery to Erf 12403.

2.8. Loss of water quality enhancement

Removal of the reed and sedge community as well as other wetland components will increase the nutrient concentration of the groundwater that eventually reaches the Knysna Estuary. The present wetland does not scrub all the pollutants and nutrients from the groundwater and a properly designed artificial wetland will be required to suitably treat the eutrophic water. Alternatively the source of the pollution (i.e. the Knysna Sewage Treatment Works) must be found and the problem rectified (See Section 3.17.).

2.9. Restrictions to groundwater flow

The stockpiling of soil, excavation of foundations and the sealing of the culvert below George Rex Drive will impact on the hydraulic gradient and conductivity of the groundwater. The elevated in-filled areas in the operational phase will act as obstructions to groundwater flow and will attenuate the tidal variation within the groundwater.

2.10. Health & safety issues

The potential of the groundwater to contain unacceptably high levels of harmful bacteria, such as *Escherichia coli*, poses a serious health risk to construction workers labouring on the canals. The open water canals in the operational phase will pose a serious health risk to humans if the source of the pollution is not found and the problem rectified.

2.11. Increase in open water area

Open stagnant water (culvert below George Rex Drive will be closed during the construction phase) is susceptible to various impacts from construction activities. Increasing the open water area from a small choked canal (< 20 m^2 to several hundred m^2 will increase the diversity of wetland habitat, fauna and flora. A variety of habitat will also increase the nutrient and other pollutant scrubbing capacity of the wetland. Creating large open water areas without rectifying the eutrophic state of the groundwater will produce eutrophic surface water bodies. The high nutrient levels in the surface water will result in the bloom of unwanted floating macrophytes, filamentous macroalgae and microalgae. Mixing of the freshwater with the estuarine water can also potentially create conditions suitable to the formation of harmful algal blooms. Mosquitoes and other unwanted insects will be attracted to the open water areas that will in turn attract frogs and consequently snakes and other unwanted fauna.

2.12. Increased flow and water exchange

Increased flow as a result of an increase in impervious surfaces will have a negative impact on the wetlands as well as the construction work. Tidal exchange will be non-existent during the construction phase because of the closing of the culvert below George Rex Drive. The flow of freshwater through the property and tidal exchange from the estuary will be enhanced once the construction phase has been completed and the culvert below George Rex Drive had been enlarged and opened.

2.13. Increased storm water management

During the construction phase the storm water system will be formalised across the property and storm water discharge from Hunters Estate and the road network controlled and managed. Presently storm water is discharged onto the property with no additional conveyance system to transport the storm water to the Knysna Estuary. The storm water that enters Erf 12403 will be managed and monitored to ensure a suitable water quality for the open water canals. If found unsuitable there will be an immediate need to locate the source of the pollution and rectify the problem. Presently there is no control over storm water entering the property and as most of the storm water infiltrate to the groundwater a pollution event will remain invisible.

2.14. Increase in estuarine wetland diversity

Tidal exchange will be non-existent during the construction phase because of the closing of the culvert below George Rex Drive. Construction activities and the closing of the culvert will negatively impact on the existing *Juncus kraussii* stands. Tidal exchange with the estuary will be enhanced once the

construction phase has been completed and the culvert below George Rex Drive had been enlarged and opened. Increased tidal action will increase the diversity of estuarine fauna and flora.

2.15. Rehabilitation of wetlands

The degraded wetlands will be actively rehabilitated during the construction phase. Once established, the rehabilitated estuarine and freshwater wetlands must be maintained in a healthy state.

Summary:

Development Alternative 5 (operational), in the absence of mitigation action, has seven medium to high negative impacts and four low negative impacts. With appropriate mitigation these impacts can all be reduced to low negative impacts and even positive impacts. Overall Option 5 scored 3.08 based on the importance (Consequence in the tables) of the negative impacts without considering mitigation. With mitigation, the negative impacts of Alternative 5 scored 1.13 (low intensity). The positive impacts (five in the operational phase and two in the construction phase) scored 3.85 without mitigation and 4.43 with mitigation (enhancing the positive impacts). The construction phase will have a bigger negative impact than the operational phase (negative impact score of 3.81). Alternative 5 had the lowest score on negative impacts and the highest for positive impacts of all the development options. This was mostly due to the larger wetland conservation area and smaller development footprint.

3. Mitigation

Mitigation measures that will minimise or eliminate negative environmental impacts, assist design, enhance project benefits and protect public and individual rights to compensation are given below for each of the identified impacts:

3.1. Increased exotic infestation

- Remove all alien vegetation from the property and neighbouring land (if possible)

3.2. Development on floodplain

- Elevate property (through infilling) above 1:100 year floodline and expected long term sea level rise.
- No construction should take place during flooding of the Knysna Estuary.
- Wetland conservation areas should remain at present level above MSL.

3.3. Restrictions to tidal flow

- Close culvert during construction phase to prevent pollution of the Knysna Estuary.
- Once major earth works have been completed, increase culvert diameter under George Rex Drive to facilitate tidal exchange between the Knysna Estuary and Erf 12403.
- Clean and maintain tidal canal on the estuary side of George Rex Drive to enhance tidal flow.
- Provide sufficient open space to allow the estuarine wetland to recolonise sections of Erf 12403.
- Ensure sufficient tidal exchange to maintain estuarine biodiversity.

3.4. Loss of estuarine/brackish wetlands

- Increase tidal exchange with the estuary by increasing the culvert diameter under George Rex Drive.
- Demarcate wetland areas and, as far as possible, prevent access to the intact estuarine wetlands during the construction phase.
- Return tidal water to the estuarine/brackish wetland as soon as possible after major construction work had been completed.
- Prevent excessive dilution of estuarine water in the estuarine/brackish wetlands from the freshwater wetlands.
- Reduce freshwater flow rates through the wetlands by ensuring a dense freshwater emergent wetland.
- Prevent trampling of the estuarine wetlands by residents and visitors.
- Allow natural colonisation of the estuarine wetland into the canals.
- Prevent direct stormwater pollution and freshwater input into the estuarine wetland (from development and George Rex Drive).

3.5. Loss of freshwater wetlands

- Open space that is to remain wetland areas should be cordoned off to prevent excessive damage during the construction phase.
- Wetland plant material and topsoil should be rescued from areas earmarked for development and replanted in the conserved and rehabilitated wetland areas.
- Best Management Practices should be employed to prevent pollution of the remaining intact wetlands, e.g. polluted run-off (cement, soil, paint, etc.) should be re-directed off the property or collected in waste water containers on site.
- Rehabilitate all areas that are to remain as freshwater wetlands.
- Restrict access to the freshwater wetlands.

- Maintain a variety of wetland habitats thereby increasing the overall diversity of the freshwater wetlands.
- Employ Best Management Practices in the operation of the development especially as regards storm water management.

3.6. Loss of reed & sedge community

- Treat the source of the eutrophic groundwater (see Section 3.17).
- The reed and sedge community should form an important component of the rehabilitated wetlands.
- Rare sedges should be rescued in the area where construction is taking place and transplanted in the space that will remain wetland area.
- Construction activities should not trespass into the demarcated wetland areas.
- Employ Best Management Practices in the operation of the development especially as regards storm water management, fertilisers, solid waste (grass clippings), etc.
- Restrict access to the reed and sedge wetland.

3.7. Increase in storm water run-off

- Employ Best Management Practices during the construction phase, e.g. silt traps, settling of suspended solids in containers before release of the clean water, removal of polluted water (cement, paint, etc) from the premises, etc.
- The period that the soil is exposed should be kept to a minimum.
- Employ Best Management Practices in the operation of the development, e.g. employ run-off reduction techniques, establish grass swales to facilitate storm water infiltration, capture rainfall from rooftops in reservoirs, etc.

3.8. Loss of water quality enhancement

- Retain as much as possible of the original wetland vegetation in the areas earmarked for wetland rehabilitation and conservation.
- Construction activities should not trespass into these areas.
- The development should not proceed until the source of the eutrophic water is found and the problem rectified (See Section 3.17.)
- Once rectified, there will be no need for large areas of reeds and other wetland plants specifically for the maintenance of the groundwater quality.
- The storm water flowing through the property (either as groundwater or surface water) will contain elevated concentrations of pollutants and nutrients and the rehabilitated wetland areas

must be maintained in a healthy state to ensure an acceptable water quality on Erf 12403 and of the water flowing into the Knysna Estuary.

3.9. Restrictions to groundwater flow

- All earthworks adjacent to the wetland conservation areas should take place first before infilling of the property starts. This will allow conduits for surface and groundwater flow, limiting the impact of the infilling.
- The stockpiling of soil and infilling should only be allowed in the areas designated to be elevated and not in low lying areas earmarked for wetland rehabilitation.
- The culvert below George Rex Drive should be enlarged during the construction phase to facilitate groundwater and surface water flow in the operational phase.
- Construction should preferably take place during the low rainfall months to prevent excessive damming of water behind the closed-off culvert below George Rex Drive.
- Open water and wetland areas should remain free of any obstructions to surface and groundwater flow.

3.10. Health & safety issues

- Prohibit full contact with the groundwater unless tested to be safe (tests should be done once a week and especially after high rainfall events).
- Prohibit unauthorised entry to the construction site during non-working hours.
- Place educational signage in and around the construction site warning people not to come in contact with the polluted water.
- Treat the source of the pollution.
- As it is common practise to allow leaky sewers to flow into the storm water drains it is recommended that the canal water be regularly (quarterly) monitored for *E. coli,* total faecal coliforms and Enterococci.
- Educational signage should be placed along the wetland conservation areas warning residents and visitors that the open water (during the high rainfall period) is unsafe for drinking purposes.

3.11. Increase in open water area

- The construction of the wetland areas should take place first and should be done as quickly as possible.
- Prevent contamination of standing water during construction by employing Best Management Practices in the discharge of contaminated water.

- All bare soil surfaces should be covered with mulch or planted with vegetation as soon as possible to prevent fine suspended solids from entering the open water areas.
- If the water level in the wetland areas increase beyond a safe level because of the closure of the culvert, water should be pumped to a reservoir on a truck and discharged at a suitable location (to be identified by the Knysna Municipality).
- Ensure a variety of habitat in the open water areas, e.g. deep, shallow, sloping, rocky, silty, etc. to maximise wetland faunal and floral diversity.
- Create large and long open water areas to attract water fowl.
- Create small islands within the open water areas to attract breeding birds and other wetland fauna.
- Regulating the water level within the open water areas (maintaining a more or less constant level) will ensure a more permanent wetland community establish rather than predominantly primary colonisers.
- The development should not proceed until the source of the eutrophic water is found and the problem rectified.
- The culvert below George Rex Drive must be increased to facilitate tidal exchange and flushing of freshwater from the property.
- The storm water flowing through the property (either as groundwater or surface water) will contain elevated concentrations of pollutants and nutrients and the rehabilitated wetland areas must be maintained in a healthy state to ensure an acceptable water quality on Erf 12403 and of the water flowing into the Knysna Estuary.

3.12. Increased flow and water exchange

- Employ Best Management Practices during the construction phase, e.g. silt traps, settling of suspended solids in containers before release of the clean water, removal of polluted water (cement, paint, etc) from the premises, etc.
- The period that the soil is exposed should be kept to a minimum.
- All excess water resulting from the construction activities should be collected in a reservoir and removed to a suitable site (to be identified by the Knysna Municipality) for discharge.
- Storm water from Hunter's Estate should be diverted via a canal or pipe to a storm water drain closer to the Knysna Estuary during the construction phase to prevent an excessive build up of storm water on the property.
- The culvert below George Rex Drive must be enlarged to facilitate tidal exchange with the Knysna Estuary and flushing of storm water from Erf 12403.
- The network of wetland conservation areas throughout the property will facilitate surface and groundwater flow.

- The flow must be regulated somehow to prevent excessive flooding by freshwater during large storm events and to stop estuarine/marine water from extending further upstream into the freshwater wetlands during storm events at sea.

3.13. Increased storm water management

- Ensure an adequate storm water system that will be able to convey storm water for a 1:100 year storm.
- The storm water system must have a capacity suitable not only for the development but also be able to handle all the storm water from Hunter's Village and other neighbouring developments. S
- Storm water Best Management Practices must be employed during the construction phase and include the use of silt traps, construction of grassy swales and storm water reservoirs, temporarily diverting storm water flow from neighbouring properties, reducing impermeable surfaces to a minimum, planting vegetation or building on all bare soil as soon as possible, etc.
- It is important that none of the polluted storm water enter the Knysna Estuary during the construction phase and the culvert should be sealed off during this period.
- A storm water system must be installed that can easily divert storm water from the higher lying neighbouring properties either into the canal system of Erf 12403 or into additional storm water drains that bypass the property and discharge elsewhere.
- The water quality in a formal storm water system can easily be monitored and if found unsuitable be diverted away from the rehabilitated wetlands or if the pollution is not severe (no heavy metals) the wetland system on the proposed development can act as a buffer for polluted water before it enters the Knysna Estuary.
- Containing polluted water in the wetlands of the proposed development will provide time to locate the source of the pollution and rectify the problem without threatening the Knysna Estuary.
- Rain water should also be collected from all rooftops and stored in rain water tanks or conveyed to a storm water reservoir on the property from which water can be pumped to irrigate gardens on the development.

3.14. Increase in estuarine wetland diversity

- The culvert below George Rex Drive must be enlarged to facilitate tidal exchange with the Knysna Estuary and flushing of stormwater from Erf 12403.
- Keep the culvert below George Rex Drive closed during the construction phase for as short a period as possible.
- Do not trespass into the estuarine wetland during construction.

- If there is no build up of freshwater behind the culvert (because construction is taking place during the low rainfall months) and there is no pollution threat to the Knysna Estuary, then the culvert may be opened during the spring tidal cycle (a single high and low tide will be sufficient every two weeks).
- The estuarine wetland must be allowed to naturally colonise into the newly created wetland areas.
- Brackish wetlands will establish further along the salinity gradient and will border onto the freshwater wetlands.
- Attempts should not be made to compartmentalise the estuarine wetland as no freshwater wetland species will be able to establish under marine or brackish conditions.
- The more frequent the tidal exchange the higher the diversity of estuarine species will be, e.g. if flushing only takes place during spring tides then only species adapted to the supratidal zone will establish and none of the intertidal and subtidal diversity will be present.

3.15. Rehabilitation of wetlands

- Prevent excessive damage to wetland areas earmarked for rehabilitation.
- All wetland plant species from other areas of the property should be rescued and either stored in a nursery or transplanted in areas designated for wetland rehabilitation.
- Minimal earth works should be attempted in or near the wetlands that will be kept.
- Because of the depauperate diversity of wetland species found on the property, freshwater wetland plant species from natural freshwater wetlands in and around Knysna should be sourced and transplanted into the rehabilitated wetlands to increase the diversity of indigenous and endemic wetland species.
- Regularly monitor the rehabilitated wetlands by determining the vegetation cover abundance, elevation profile, soil physico-chemical characteristics and water quality along fixed transects.
- Once successfully establish changes in faunal and floral community structure and diversity will be an indication of altered hydrodynamics or water quality in the system.
- Certain plant species may be used as indicators of environmental change.
- The rehabilitated wetlands will increase the diversity of faunal and floral species on the property.
- Wetlands are sensitive ecosystems and access to the wetlands should be restricted.

3.16. Hydrological Best Management Practices (BMP's) must be employed

Fundamental hydrological concepts and stormwater management concepts can be applied at the site design phase that are more integrated with natural topography, reinforce the hydrologic cycle, are more aesthetically pleasing, and often less expensive to build. BMPs are used to mitigate the effects of the development on local conditions, in terms of both water quantity and water quality effects. BMPs are used to reduce peak flows, to reduce runoff volumes, to reduce the magnitude and concentrations of constituents in runoff and to increase infiltration of water into the groundwater. Some BMPs are

- Employ run-off reduction practices, e.g. reduced pavement area, porous pavement, vegetated buffers and swales.
- Water conservation landscaping, using indigenous vegetation
- Stabilise drainageways
- Preventing polluted water from entering the wetlands

The increased sediment from areas disturbed during construction can alter habitat and fill in wetland area that previously provided detention and retention of rainfall runoff. After construction, erosion of poorly stabilized land can continue to cause similar problems. The following measures are proposed to mitigate the influx of sediment from the development:

- Vegetated buffers should be created and maintained around construction sites to trap sediment.
- Bund walls could be used, but collection trenches should be avoided as they impact on the geohydrology of the wetlands.
- Cleared areas should be revegetated as the development proceeds and not be left for last.

3.17. Upgrade of the Knysna sewage treatment works

The development should not proceed until the source of the eutrophic water is found and the problem rectified. Once rectified, there will be no need for large areas of reeds and other wetland plants specifically for the maintenance of the groundwater quality. All indications are that the Knysna sewage treatment works is the source of the groundwater pollution on Erf 12403 and the Knysna Estuary. Urgent intervention is required to rectify this problem as the Knysna Estuary is becoming so polluted with bacteria that it poses a serious health risk to all users (P. Joubert, pers. comm.).

The developers of Erf 12403 have proposed to the Knysna Municipality that they will construct a new modern sewage treatment plant for the town of Knysna as part of the development of Erf 12403. The modern plant will be significantly smaller (75%) than the old treatment works and will make a large area of land available for the further rehabilitation and construction of artificial wetlands (Figure 2).

Building a new sewage treatment works will rectify the problem of eutrophic groundwater and the only function of the wetlands on Erf 12403 will then be stormwater attenuation and the maintenance of biodiversity patterns and processes. It will be important to link the wetlands of Erf 12403 to those on the adjacent properties to increase the value and functioning of freshwater wetlands adjacent to the Knysna Estuary.

Figure 2 (adjacent) shows the position of Erf 12403 in relation to the Knysna sewage treatment works. At present the sewage plant covers 13 ha and this area can be reduced to 2 ha if the plant is upgraded. The remaining 11 ha could be rehabilitated back to freshwater wetlands. The position of the new plant as indicated in Figure 2 is important as it allows the creation of wetland corridors both north-south and east-west. The wetland area adjacent to Erf 12403 is approximately 2 ha in size and fulfils an important corridor function that would link the rehabilitated wetlands of Erf 12403 and the sewage treatment works. The corridor should ideally extend south past Erf 12403 and include the Knysna Golf Course.

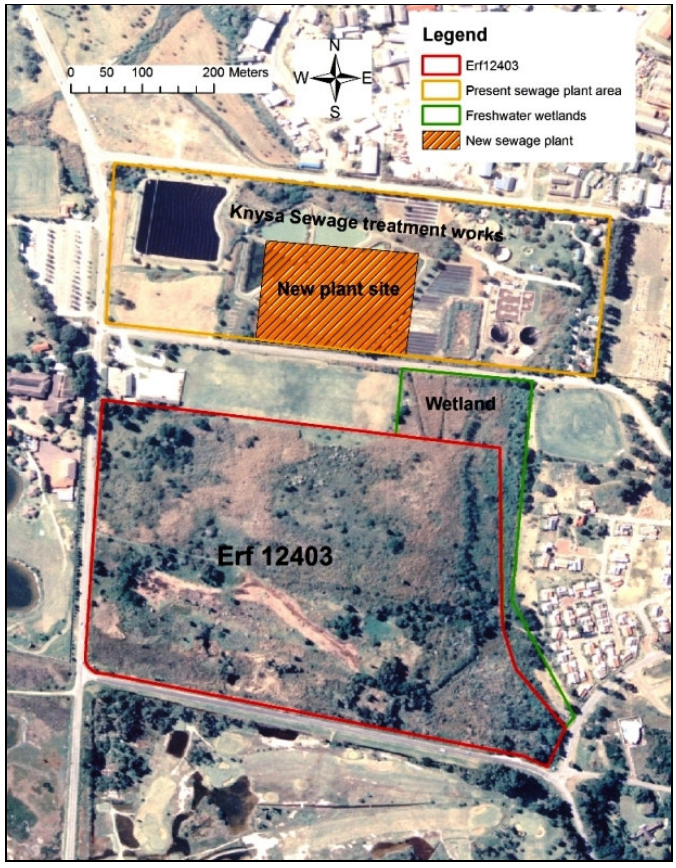

***Figure 2**. Additional wetland area gained if new smaller sewage treatment plant is installed*

4. Discussion

4.1. Management recommendations for construction phase

Construction activities within the boundaries of the intact wetlands should be kept to a minimum. The following are recommended:

- No heavy construction vehicles, dumping of spoil or storage of waste material in the wetland areas that are to be rehabilitated.
- Intact wetlands must be clearly demarcated with danger tape by a suitably qualified person.

- The footprint of any construction or land clearing work must be clearly demarcated with danger tape. No activity will be allowed outside of the demarcated construction areas or within the demarcated sensitive wetlands.
- Stockpiling: All excess material (topsoil) should be removed and stockpiled in designated areas.
- Plant material generated through clearing and excavation must be removed to a designated area for chipping or burial.
- Stormwater:
    - Natural stormwater runoff patterns must be maintained as far as practically possible.
    - Stormwater discharge outlets must be equipped with gabion / reno mattress dissipaters.
    - New artificial wetland areas can be created to improve the water quality of the stormwater before it enters any of the large storage dams/water bodies/wetlands.
    - Regular monitoring of stormwater outlets should take place during and after rain events.
- Waste management: All waste must be suitably contained and removed regularly from site in accordance with municipal waste management procedures.
- Surface and groundwater pollution:
    - The contractor shall prevent all pollution of surface and groundwater as a result of his activities.
    - Cement water runoff must be prevented. All pieces of cement or related material are to be dumped at the approved Municipal site.
- Erosion control:
    - The contractor shall take precautions to prevent soil erosion resulting from a diversion, restriction, or increase in the flow of stormwater or water resulting from its activities.
    - The contractor shall rehabilitate areas where erosion occurs.
- Refuse (all solid waste including construction debris):
    - The contractor shall be responsible for the establishment of a refuse control and removal system that prevents the spread of refuse within and beyond the construction sites.
    - The contractor shall ensure that all refuse is deposited in refuse bins, which he shall supply and arrange to be emptied on a daily basis. Refuse bins shall be conspicuous; water tight, wind-proof and scavenger proof and appropriately placed throughout the site.
    - Refuse shall be disposed of at an approved waste site. Refuse shall not be burned or buried on or near the site.

4.2. Management recommendations for operational phase

The overall management goal for the wetlands on Erf 12403 should be to ensure the long term protection of the rehabilitated wetland's ecological (biodiversity), hydrological (water purification, stream flow regulation and water storage) and erosion control values. Management practices should aim to monitor and protect the hydroperiod characteristics of the wetlands. The strategic advice provided below should be used to inform and guide detailed management planning of the Erf 12403 development.

4.2.1. Drainage

Objectives

- Minimise pollutant input to surface water and groundwater through the use of source control techniques, water sensitive urban design and BMPs (best management practices).
- Harvest stormwater from the development area to minimise top up requirements from other sources, e.g. groundwater and surface water abstraction.

Design Criteria and Guidelines

- Source controls for construction activities and maintenance of landscaped areas including development of site management plans and BMPs for construction sites;
- Implement water sensitive urban design and BMPs where appropriate and design drainage to harvest water from development areas as a mechanism to conserve and manage water;
- Develop and implement a public education campaign to decrease stormwater pollution by household activities;
- Drain marking;
- Encourage planting of indigenous gardens and minimise water use for landscaped areas by adopting landscape water conservation techniques;
- Undertake regular street sweeping; and
- Implement enforcement measures to complement education programs and other management programs

4.2.2. Nutrients

Objectives

- To minimise nutrient application to the development area and
- To minimise nutrient export from the development via runoff and leaching.

Design Criteria and Guidelines

- Minimise fertiliser use for landscaped areas by reducing the extent of exotic vegetation cover and irrigated landscaped areas;

- Determine fertiliser requirements to minimise nutrient applications. Identify areas to be fertilised including quantity, duration, frequency and method of application;
- Eliminate or minimise fertiliser applications adjacent to the estuary;
- Amend soils with phosphorus binding substances where practicable;
- Use slow release fertilisers; and
- Use low fertiliser requirement plants

4.2.3. Irrigation (watering of gardens, lawns, etc)

Objectives

- To conserve and minimise water consumption throughout the development;
- To lower water, power and maintenance requirements and costs;
- To minimise fertiliser leaching;
- To minimise evaporative and leaching water losses.

Design Criteria and Guidelines

- After construction, adopt a target to reduce overall consumption for irrigation by 30% within a 5 year period. This approach will allow the establishment of landscape areas that can then be acclimatised to progressively lower volumes of irrigation waters;
- Reduce extent of irrigated landscaped areas, including irrigated lawns;
- Minimise water use for landscaped areas by adopting landscape water conservation techniques;
- Design irrigation systems to suit climatic, soils and vegetation needs;
- Regularly determine quantity, quality and availability of the water source;
- Aim for a minimum of irrigation water to pass beyond the plant root zone;
- Recapture runoff from irrigated areas for recycling;
- Design frequency, rates and timing of applications to match evapo-transpiration rates;
- Define how irrigation will be scheduled to avoid runoff, excessive groundwater mounding and leaching.
- Consider a fully computerised irrigation system linked to an on-site weather station, together with soil moisture sensors.

4.2.4. Water Quality

Objectives

- To maintain groundwater quality and surface water quality of all streams, wetlands and the Knysna Estuary;
- To avoid water quality condition conducive to episodes of algal blooms and associated problems.

- To avoid altering the water quality of the groundwater, wetlands and estuary.

Design Criteria and Guidelines

- Source controls for construction activities and maintenance targets of landscaped areas including development of site management plans;
- Develop and implement education campaigns to decrease storm water pollution by household activities;
- Implement water sensitive urban design and Best Management Practices where applicable;
- Refinement of local authority management and maintenance activities;
- Planting of indigenous gardens;
- Street sweeping;
- Land use planning to exclude developments with significant risk of stormwater pollution.

4.2.5. Estuarine biota

Objectives

- To maintain and restore the ecology of the estuary and estuarine wetlands within the development;
- Create a functional aquatic ecosystem to improve water quality in the wetlands and maintain biodiversity;

Design criteria and guidelines

- High biotic integrity must be maintained in all wetlands. To ensure the persistence of biodiversity and natural evolution it is essential that all populations, communities or ecosystems that are both viable and of high ecological integrity are protected and that natural ecological processes and disturbance regimes such as floods, droughts and fires are operating within their natural ranges of variability;
- Maintain a suitable vegetated buffer around all the wetlands;
- Manage access to these conservation areas and corridors by providing designated trails and fencing sensitive areas (controlled public access);
- Control and minimise the spread of alien invasive species;
- Control feral and domestic animals;
- Prevent and control vandalism;
- Use plants that are indigenous to the area;

4.3. Response to comments by I&APs

The response to the comments by I&AP's relevant to the wetland baseline study is given in Bornman (2006).

5. Conclusions & recommendations

A synopsis of impacts expected as a result of **construction actions** for each of the five development options is given in Table 1. Table 2 gives a synopsis of impacts expected should all mitigation and beneficiation action be taken. A synopsis of impacts expected as a result of **operation actions** for each of the four development options is given in Table 3. Table 4 gives a synopsis of impacts expected should all mitigation and beneficiation action be taken. The impacts were very similar for development options 2 – 5 because of the small differences between the different alternatives.

5.1. Construction phase

Table 1. Expected impacts (negative; positive) of the **construction** actions of eight development alternative options ***without mitigation*** actions. Positive = green (light = low; midtone = moderate; dark = high); None/Neutral = grey; Negative = red (light = low; midtone = moderate; dark = high)

Alternatives	1	2	3	4	5
Increased exotic infestation					
Development on floodplain					
Restrictions to tidal flow					
Loss of estuarine/brackish wetlands					
Loss of freshwater wetlands					
Loss of reed & sedge community					
Increase in storm water run-off					
Loss of water quality enhancement					
Restrictions to groundwater flow					
Health & safety issues					
Increase in open water area					
Increased flow and water exchange					
Increased storm water management					
Increase in estuarine wetland diversity					
Rehabilitation of wetlands					

Table 2. Expected impacts (negative; positive) of the **construction** actions of eight development alternative options ***with mitigation*** actions. Positive = green (light = low; midtone = moderate; dark = high); None/Neutral = grey; Negative = red (light = low; midtone = moderate; dark = high)

Alternatives	1	2	3	4	5
Increased exotic infestation					
Development on floodplain					
Restrictions to tidal flow					
Loss of estuarine/brackish wetlands					
Loss of freshwater wetlands					
Loss of reed & sedge community					
Increase in storm water run-off					
Loss of water quality enhancement					
Restrictions to groundwater flow					
Health & safety issues					
Increase in open water area					
Increased flow and water exchange					
Increased storm water management					
Increase in estuarine wetland diversity					
Rehabilitation of wetlands					

5.2. Operational phase

Table 3. Expected impacts (negative; positive) of the **operation** actions of eight development alternative options ***without mitigation*** actions. Positive = green (light = low; midtone = moderate; dark = high); None/Neutral = grey; Negative = red (light = low; midtone = moderate; dark = high)

Alternatives	1	2	3	4	5
Increased exotic infestation					
Development on floodplain					
Restrictions to tidal flow					
Loss of estuarine/brackish wetlands					
Loss of freshwater wetlands					
Loss of reed & sedge community					
Increase in storm water run-off					
Loss of water quality enhancement					
Restrictions to groundwater flow					
Health & safety issues					
Increase in open water area					
Increase in open water area					
Increased flow and water exchange					
Increased storm water management					
Increase in estuarine wetland diversity					
Rehabilitation of wetlands					

Table 4. Expected impacts (negative; positive) of the **operation** actions of eight development alternative options ***with mitigation*** actions. Positive = green (light = low; midtone = medium; dark = high); None/Neutral = grey; Negative = red (light = low; midtone = medium; dark = high)

Alternatives	1	2	3	4	5
Increased exotic infestation					
Development on floodplain					
Restrictions to tidal flow					
Loss of estuarine/brackish wetlands					
Loss of freshwater wetlands					
Loss of reed & sedge community					
Increase in storm water run-off					
Loss of water quality enhancement					
Restrictions to groundwater flow					
Health & safety issues					
Increase in open water area					
Increase in open water area					
Increased flow and water exchange					
Increased storm water management					
Increase in estuarine wetland diversity					
Rehabilitation of wetlands					

Most impacts in both the construction and operational phase can be mitigated. The highest negative impact associated with development options 2 – 5 includes the loss of wetlands. The positive impacts related to all the development options can be further enhanced in Options 2 – 5, but the likelihood of beneficiation action being taken in the no-go option is improbable due to the costs involved. Development Options 5 has the lowest overall impact of all the development options (excluding the no-go option).

Table 5 indicates the area of land change proposed for each of the development options. From the table it is clear that Option 1 (no-go) will retain the highest wetland area (77% of total property area). Of the development options, Option 2 will have the highest open water area and Option 5 the highest emergent and estuarine wetland area. Since most of the property used to consist of estuarine/brackish wetlands with very little open water area, it is apparent that the No-go option will have the least impact followed by Development Alternative 5.

Table 5. The development alternatives (top) and area (ha) of land change (bottom) for each development alternative (loss; gain; none) assuming no mitigation actions.

Alternatives	1	2	3	4	5
Open water area	0	3.0391	1.2792	0.8308	0.5
Emergent wetland area	14.3	2.1991	3.5493	3.8587	6.1252
Estuarine wetland area	0.7	0.4092	-	0.8308	0.8308
% of total property (19.41 ha)	77.28 %	26.98 %	24.88 %	24.16 %	38.41%
Total rehabilitated wetland area	-	5.2382	4.8285	4.6895	7.4569

Table 6 shows the impact rating score for the negative and positive impacts before and after mitigation for all five alternatives. The No-go option has the lowest negative impact score, but since the probability of mitigatory action being implemented in this option is very low, it is evident that following mitigation, Option 2 – 5 will have a lower negative impact rating. Positive impacts without mitigation is very low in the No-go option and even after mitigation (which is improbable) the positive impacts in Option 1 is still lower than the positive impacts without beneficiation in Alternatives 2 – 5. Of the development options, Option 5 still remains the best alternative with the lowest negative and highest positive impact score.

Table 6. Impact rating score for negative and positive impacts (construction and operational phase combined) before and after mitigation.

Alternatives	1	2	3	4	5
Negative impact without mitigation	2.6	3.75	3.29	3.25	3.08
Negative impact with mitigation	1	1.16	1.16	1.16	1.13
Positive impact without mitigation	1	3.42	3.57	3.57	3.85
Positive impact with mitigation	3	4	4.29	4.29	4.43

6. Impact Assessment Tables

IMPACT 1	***Increased exotic infestation***
Nature of impact	Negative (impact wetland vegetation through competition and habitat degradation)
Stage	Construction
Extent	Around
Duration	Short
Intensity	Medium
Consequence	4
Probability	Probable
Significance	High
Confidence	High
Legal aspects	CARA (1983), NWA (1998), NEMA (1998), ECA (1989) & NVFFA (1998)
Mitigation measures	Remove all alien vegetation from the property and neighbouring land (if possible)
Significance after mitigation	Low

IMPACT 1	***Increased exotic infestation***
Nature of impact	Negative (impact wetland vegetation through competition and habitat degradation)
Stage	Operational
Extent	Around
Duration	Long term
Intensity	Medium
Consequence	4
Probability	Probable
Significance	Medium
Confidence	High
Legal aspects	CARA (1983), NWA (1998), NEMA (1998), ECA (1989) & NVFFA (1998)
Mitigation measures	Remove all alien vegetation from the property and neighbouring land (if possible)
Significance after mitigation	Low

IMPACT 2	***Development on floodplain***
Nature of impact	Negative (present elevation of Erf 12403 below 1:100 year floodline and expected sea level rise)
Stage	Construction
Extent	Around
Duration	Short
Intensity	Medium
Consequence	3
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Elevate property (through infilling) above 1:100 year floodline and expected long term sea level rise. No construction should take place during flooding of the Knysna Estuary.
Significance after mitigation	Low

IMPACT 2	***Development on floodplain***
Nature of impact	Negative (present elevation of Erf 12403 below 1:100 year floodline and expected sea level rise)
Stage	Operational
Extent	Around
Duration	Long term
Intensity	Medium
Consequence	4
Probability	Highly probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Elevate residential and commercial development (through infilling) above 1:100 year floodline and expected long term sea level rise. Canal system should remain at present level
Significance after mitigation	Low

IMPACT 3	***Restrictions to tidal flow***
Nature of impact	Negative (tidal flow onto Erf 12403 is restricted by a small culvert under George Rex Drive that has resulted in an increase in freshwater wetlands and a decrease in estuarine/brackish wetlands. During the construction phase, the culvert must be closed off to prevent pollution of the Knysna Estuary).
Stage	Construction
Extent	Around
Duration	Short
Intensity	High
Consequence	5
Probability	Highly probable
Significance	High
Confidence	Medium
Legal aspects	
Mitigation measures	Close culvert during construction phase to prevent pollution of the Knysna Estuary. Once major earth works have been completed, increase culvert diameter under George Rex Drive to facilitate tidal exchange between the Knysna Estuary and Erf 12403. Clean and maintain tidal canal on the estuary side of George Rex Drive to enhance tidal flow.
Significance after mitigation	Medium

IMPACT 3	***Restrictions to tidal flow***
Nature of impact	Negative (tidal flow onto Erf 12403 will remain restricted by a small culvert under George Rex Drive in Option 1 and in Options 2 – 4, where a larger culvert has been installed, the tidal flow will be restricted by meandering canals and development).
Stage	Operational
Extent	Around
Duration	Long term
Intensity	Medium
Consequence	4
Probability	Highly probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Provide sufficient open space to allow the estuarine wetland to recolonise sections of Erf 12403. Ensure sufficient tidal exchange to maintain estuarine biodiversity. Clean and maintain tidal canal on the estuary side of George Rex Drive to enhance tidal flow.
Significance after mitigation	Low

IMPACT 4	***Loss of estuarine/brackish wetlands***
Nature of impact	Negative (estuarine wetlands will be lost through the expansion of freshwater wetlands unless the tidal exchange to Erf 12403 is improved.
Stage	Construction
Extent	Around
Duration	Short
Intensity	Medium
Consequence	3
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Increase tidal exchange with the estuary by increasing the culvert diameter under George Rex Drive. Demarcate wetland areas and, as far as possible, prevent access to the intact estuarine wetlands during the construction phase. Return tidal water to the estuarine/brackish wetland as soon as possible after major construction work had been completed.
Significance after mitigation	Low

IMPACT 4	***Loss of estuarine/brackish wetlands***
Nature of impact	Negative (Reduced tidal exchange will result in an increase in freshwater wetlands. Increased open water areas will reduce the estuarine wetland area. Development in the south-western corner of the property will reduce estuarine wetland area. Increased stormwater flow from the development will dilute estuarine water).
Stage	Operational
Extent	Around
Duration	Long term
Intensity	Medium
Consequence	2
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Increase tidal exchange to Erf 12403. Prevent excessive dilution of estuarine water in the estuarine/brackish wetlands from the freshwater canals. Reduce freshwater flow rates in the canals by ensuring a dense freshwater emergent wetland. Prevent trampling of the estuarine wetlands by residents and visitors. Allow natural colonisation of the estuarine wetland into the wetland conservation areas. Prevent direct stormwater pollution and freshwater input into the estuarine wetland (from development and George Rex Drive).
Significance after mitigation	Low

IMPACT 5	***Loss of freshwater wetlands***
Nature of impact	Negative (Approximately 50% of the present freshwater wetland area will be destroyed during the construction phase of development option 5).
Stage	Construction
Extent	Site
Duration	Short
Intensity	High
Consequence	3.5
Probability	Highly probable
Significance	High
Confidence	High
Legal aspects	
Mitigation measures	Open space that is to remain wetland areas should be cordoned off to prevent excessive damage during the construction phase. Wetland plant material and topsoil should be rescued from areas earmarked for development and replanted in the conserved and rehabilitated wetland areas. Best Management Practices should be employed to prevent pollution of the remaining intact wetlands, e.g. polluted

	run-off (cement, soil, paint, etc.) should be re-directed off the property or collected in waste water containers on site.
Significance after mitigation	Low

IMPACT 5	***Loss of freshwater wetlands***
Nature of impact	Negative (Large areas (50%) of freshwater wetlands will be permanently lost in development option 5. The freshwater wetland area in the no-go option will increase over time as the storm water run-off from the nearby built area increases.).
Stage	Operational
Extent	Site
Duration	Long term
Intensity	Medium
Consequence	3.5
Probability	Probable
Significance	High
Confidence	Medium
Legal aspects	
Mitigation measures	Rehabilitate all areas that are to remain as freshwater wetlands. Restrict access to the freshwater wetlands. Maintain a variety of wetland habitats thereby increasing the overall diversity of the freshwater wetlands. Employ Best Management Practices in the operation of the development especially as regards storm water management.
Significance after mitigation	Medium

IMPACT 6	***Loss of reed and sedge community***
Nature of impact	Negative (Although the reed and sedge community formed as a direct result of past human impacts, it presently serves a useful function in the removal of excess nutrients from the groundwater and as habitat for a variety of birds and other wetland faunal species.).
Stage	Construction
Extent	Site
Duration	Short
Intensity	High
Consequence	3
Probability	Highly probable
Significance	Medium
Confidence	High
Legal aspects	
Mitigation measures	Treat the source of the eutrophic groundwater. The reed and sedge community should form an important component of the rehabilitated wetlands. Rare sedges should be rescued in the area where construction is taking place and transplanted in the space that will remain wetland area. Construction activities should not trespass into the demarcated wetland areas.
Significance after mitigation	Low

IMPACT 6	***Loss of reed and sedge community***
Nature of impact	Negative (The monospecific stands of *Phragmites australis* and *Typha capensis* formed as a result of the eutrophic groundwater. Any additional nutrient input from the development (e.g. grass clippings, fertilisers, etc.) will result in a bloom of this community. Sufficient area should be made available for this community as part of the emergent wetland).
Stage	Operational
Extent	Site
Duration	Long term
Intensity	Medium
Consequence	3
Probability	Probable
Significance	Medium
Confidence	Medium

Legal aspects	
Mitigation measures	Ensure that the reed and sedge community form a part of the rehabilitated wetland area. Employ Best Management Practices in the operation of the development especially as regards storm water management, fertilisers, solid waste (grass clippings), etc. Restrict access to the reed and sedge wetland. Treat the source of the polluted water, i.e. the sewage works.
Significance after mitigation	Low

IMPACT 7	***Increase in storm water run-off***
Nature of impact	Negative (Clearing of vegetation during the construction phase will result in increased surface run-off from the exposed soil. The increased run-off will impact on the wetland geomorphology and water quality).
Stage	Construction
Extent	Site
Duration	Short
Intensity	Medium
Consequence	3
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Employ Best Management Practices during the construction phase, e.g. silt traps, settling of suspended solids in containers before release of the clean water, removal of polluted water (cement, paint, etc) from the premises, etc. The period that the soil is exposed should be kept to a minimum.
Significance after mitigation	Low

IMPACT 7	***Increase in storm water run-off***
Nature of impact	Negative (increasing the built area will increase stormwater run-off into the remaining wetlands on Erf 12403 and the Knysna Estuary)
Stage	Operational
Extent	Site
Duration	Long term
Intensity	Medium
Consequence	3.5
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Employ Best Management Practices in the operation of the development, e.g. employ run-off reduction techniques, establish grass swales to facilitate storm water infiltration, capture rainfall from rooftops in reservoirs, etc.
Significance after mitigation	Low

IMPACT 8	***Loss of water quality enhancement***
Nature of impact	Negative (Removal of the reed and sedge community as well as other wetland components will increase the nutrient concentration of the groundwater that eventually reaches the Knysna Estuary).
Stage	Construction
Extent	Site
Duration	Short
Intensity	Medium
Consequence	3
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Retain as much as possible of the original wetland vegetation in the conservation areas and other areas earmarked for wetland rehabilitation and conservation.

	Construction activities should not trespass into these areas. Vegetation should be retained until the source of the eutrophic water is found and the problem rectified.
Significance after mitigation	Low

IMPACT 8	***Loss of water quality enhancement***
Nature of impact	Negative (Decreasing the area covered by deep rooted emergent wetland plants will increase the nutrient concentration of the groundwater that eventually reaches the Knysna Estuary. The present wetland does not scrub all the pollutants and nutrients from the groundwater and a properly designed artificial wetland will be required to suitably treat the eutrophic water).
Stage	Operational
Extent	Site
Duration	Long term
Intensity	Medium
Consequence	2.5
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	The development should not proceed until the source of the eutrophic water is found and the problem rectified. Once rectified, there will be no need for large areas of reeds and other wetland plants specifically for the maintenance of the groundwater quality. The storm water flowing through the property (either as groundwater or surface water) will contain elevated concentrations of pollutants and nutrients and the rehabilitated wetland areas must be maintained in a healthy state to ensure an acceptable water quality on Erf 12403 and of the water flowing into the Knysna Estuary. A water quality monitoring programme should be developed (at least a dry and a wet season sampling period required).
Significance after mitigation	Low

IMPACT 9	***Restrictions to groundwater flow***
Nature of impact	Negative (The stockpiling of soil, excavation of foundations and the sealing of the culvert below George Rex Drive will impact on the hydraulic gradient and conductivity of the groundwater).
Stage	Construction
Extent	Site
Duration	Short
Intensity	Medium
Consequence	3
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	All earthworks adjacent to the conservation areas should take place first before infilling of the property starts. This will allow conduits for surface and groundwater flow, limiting the impact of the infilling. The stockpiling of soil and infilling should only be allowed in the areas designated to be elevated and not in low lying areas earmarked for wetland rehabilitation. The culvert below George Rex Drive should be enlarged during the construction phase to facilitate groundwater and surface water flow in the operational phase. Construction should preferably take place during the low rainfall months to prevent excessive damming of water behind the closed-off culvert below George Rex Drive.
Significance after mitigation	Low

IMPACT 9	***Restrictions to groundwater flow***
Nature of impact	Negative (The elevated in-filled areas will act as obstructions to groundwater flow and will attenuate the tidal variation within the groundwater.
Stage	Operational
Extent	Site
Duration	Long term
Intensity	Medium
Consequence	3
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Open water and wetland areas should remain free of any obstructions to surface and groundwater flow. The culvert below George Rex Drive must be increased to facilitate tidal exchange and flushing of freshwater from the property.
Significance after mitigation	Low

IMPACT 10	***Health and safety issues***
Nature of impact	Negative (The potential of the groundwater to contain unacceptably high levels of harmful bacteria, such as *Escherichia coli*, poses a serious health risk to construction workers labouring on site).
Stage	Construction
Extent	Site
Duration	Short
Intensity	Medium
Consequence	3
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Prohibit full contact with the groundwater unless tested to be safe (tests should be done once a week and especially after high rainfall events). Prohibit unauthorised entry to the construction site during non-working hours. Place educational signage in and around the construction site warning people not to come in contact with the polluted water. Treat the source of the pollution.
Significance after mitigation	Low

IMPACT 10	***Health and safety issues***
Nature of impact	Negative (The open water areas will pose a serious health risk to humans if the source of the pollution is not found and the problem rectified.).
Stage	Operational
Extent	Site
Duration	Long term
Intensity	Medium
Consequence	2
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Locate the source of the faecal pollution and rectify the problem. As it is common practise to allow leaky sewers to flow into the stormwater drains it is recommended that the open water areas be regularly (quarterly) monitored for *E. coli*, total faecal coliforms and Enterococci. Educational signage should be placed along the open water areas warning residents and visitors that the water is unsafe for drinking purposes. Treat the source of the pollution, i.e. sewage treatment works.
Significance after mitigation	Low

IMPACT 11	***Increase in open water area***
Nature of impact	Negative (Open stagnant water (culvert below George Rex Drive is closed) is susceptible to various impacts from construction activities).
Stage	Construction
Extent	Site
Duration	Short
Intensity	Medium
Consequence	2
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	The construction of the open water areas and adjacent to the wetland conservation areas should take place first and should be done as quickly as possible. Prevent contamination of standing water during construction by employing Best Management Practices in the discharge of contaminated water. All bare soil surfaces should be covered with mulch or planted with vegetation as soon as possible to prevent fine suspended solids from entering the open water areas. If the water level in the canals increase beyond a safe level because of the closure of the culvert, water should be pumped to a reservoir on a truck and discharged at a suitable location (to be identified by the Knysna Municipality).
Significance after mitigation	Low

IMPACT 11	***Increase in open water area***
Nature of impact	Positive (Increasing the open water area from a small choked canal (< 20 m^2 to several hundred m^2 will increase the diversity of wetland habitat, fauna and flora. A variety of habitat will also increase the nutrient and other pollutant scrubbing capacity of the wetland.
Stage	Operational
Extent	Site
Duration	Long term
Intensity	Medium
Consequence	3
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Ensure a variety of habitat in the open water areas, e.g. deep, shallow, sloping, rocky, silty, etc. to maximise wetland faunal and floral diversity. Create large and long open water areas to attract water fowl. Create small islands within the open water areas to attract breeding birds and other wetland fauna. Regulating the water level within the open water areas (maintaining a more or less constant level) will ensure a more permanent wetland community establish rather than predominantly primary colonisers.
Significance after mitigation	High

IMPACT 11	***Increase in open water area***
Nature of impact	Negative (Creating large open water areas without doing something about the eutrophic state of the groundwater will produce eutrophic surface water bodies. The high nutrient levels in the surface water will result in the bloom of unwanted floating macrophytes, filamentous macroalgae and microalgae. Mixing of the freshwater with the estuarine water can also potentially create conditions suitable to the formation of harmful algal blooms. Increased storm water run-off from neighbouring properties will create large stagnant water bodies near George Rex Drive in Development Alternative 1. Mosquitoes and other unwanted insects will be attracted to the open water areas that will in turn attract frogs and consequently snakes and other unwanted fauna).
Stage	Operational
Extent	Site
Duration	Long term
Intensity	Medium

Consequence	3
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	The development should not proceed until the source of the eutrophic water is found and the problem rectified. The culvert below George Rex Drive must be increased to facilitate tidal exchange and flushing of freshwater from the property. The storm water flowing through the property (either as groundwater or surface water) will contain elevated concentrations of pollutants and nutrients and the rehabilitated wetland areas must be maintained in a healthy state to ensure an acceptable water quality on Erf 12403 and of the water flowing into the Knysna Estuary. Open water areas must be maintained in a healthy state (containing fish & other predators of insects) to prevent an increase in unwanted insects and other animals. Spraying of insecticide to control mosquitoes should not be allowed because of the impact it has on the rest of the wetland ecosystem.
Significance after mitigation	Low

IMPACT 12	***Increased flow and tidal exchange***
Nature of impact	Negative (Increased flow as a result of an increase in impervious surfaces will have a negative impact on the wetlands as well as the construction work. Tidal exchange will be non-existent during the construction phase because of the closing of the culvert below George Rex Drive.
Stage	Construction
Extent	Site
Duration	Short
Intensity	Medium
Consequence	2
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Employ Best Management Practices during the construction phase, e.g. silt traps, settling of suspended solids in containers before release of the clean water, removal of polluted water (cement, paint, etc) from the premises, etc. The period that the soil is exposed should be kept to a minimum. All excess water resulting from the construction activities should be collected in a reservoir and removed to a suitable site (to be identified by the Knysna Municipality) for discharge. Stormwater from Hunter's Estate should be diverted via a canal or pipe to a stormwater drain closer to the Knysna Estuary during the construction phase to prevent an excessive build up of stormwater on the property.
Significance after mitigation	Low

IMPACT 12	***Increased flow and tidal exchange***
Nature of impact	Positive (The flow of freshwater through the property and tidal exchange from the estuary will be enhanced once the construction phase has been completed and the culvert below George Rex Drive had been enlarged and opened)
Stage	Operational
Extent	Site
Duration	Long term
Intensity	Medium
Consequence	3
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	The culvert below George Rex Drive must be enlarged to facilitate tidal exchange with the Knysna Estuary and flushing of stormwater from Erf 12403. The network of wetland conservation areas throughout the property will facilitate surface and groundwater flow. The flow must be regulated somehow to prevent excessive flooding by freshwater during large storm events and to stop estuarine/marine

	water from extending further upstream into the freshwater wetlands during storm events at sea.
Significance after mitigation	High

IMPACT 13	***Increased storm water management***
Nature of impact	Positive (During the construction phase the storm water system will be formalised across the property and storm water discharge from Hunters Estate and the road network controlled and managed. Presently storm water is discharged onto the property with no additional conveyance system to transport the storm water to the Estuary).
Stage	Construction
Extent	Site
Duration	Short
Intensity	Medium
Consequence	3
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Ensure an adequate storm water system that will be able to convey storm water for a 1:100 year storm. The storm water system must have a capacity suitable not only for the development but also be able to handle all the storm water from Hunter's Village and other neighbouring developments. Storm water Best Management Practices must be employed during the construction phase and include the use of silt traps, construction of grassy swales and storm water reservoirs, temporarily diverting storm water flow from neighbouring properties, reducing impermeable surfaces to a minimum, planting vegetation or building on bare soil as soon as possible, etc. It is important that none of the polluted storm water enter the Knysna Estuary during the construction phase and the culvert should be sealed off during this period.
Significance after mitigation	High

IMPACT 13	***Increased storm water management***
Nature of impact	Positive (The storm water that enters Erf 12403 will be managed and monitored to ensure a suitable water quality for the open water canals. If found unsuitable there will be an immediate need to locate the source of the pollution and rectify the problem. Presently there is no control over storm water entering the property and as most of the storm water infiltrate to the groundwater a pollution event remains invisible.)
Stage	Operational
Extent	Site
Duration	Long term
Intensity	Medium
Consequence	4
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	A storm water system must be installed that can easily divert storm water from the higher lying neighbouring properties either into the rehabilitated wetland system of Erf 12403 or into additional storm water drains that bypass the property and discharge elsewhere. The water quality in a formal storm water system can easily be monitored and if found unsuitable be diverted away from the wetlands of the proposed development or alternatively the wetland system on the proposed development can act as a buffer for polluted water before it enters the Knysna Estuary. Containing polluted water in the wetlands of the proposed development will provide time to locate the source of the pollution and rectify the problem without threatening the Knysna Estuary. Rain water should also be collected from all rooftops and stored in rain water tanks or conveyed to a storm water reservoir on the property from which water can be pumped to irrigate gardens on the development.

Significance after mitigation	High

IMPACT 14	***Increased estuarine diversity***
Nature of impact	Negative (Tidal exchange will be non-existent during the construction phase because of the closing of the culvert below George Rex Drive. Construction activities and the closing of the culvert will negatively impact on the existing *Juncus kraussii* stands.).
Stage	Construction
Extent	Site
Duration	Short
Intensity	Medium
Consequence	2
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	Keep the culvert below George Rex Drive closed for as short a period as possible. Do not trespass into the estuarine wetland during construction. If there is no build up of freshwater behind the culvert (because construction is taking place during the low rainfall months) and there is no pollution threat to the Knysna Estuary, then the culvert may be opened during the spring tidal cycle (a single high and low tide will be sufficient every two weeks).
Significance after mitigation	Low

IMPACT 14	***Increased estuarine diversity***
Nature of impact	Positive (Tidal exchange with the estuary will be enhanced once the construction phase has been completed and the culvert below George Rex Drive had been enlarged and opened. Increased tidal action will increase the diversity of estuarine fauna and flora).
Stage	Operational
Extent	Site
Duration	Long term
Intensity	Medium
Consequence	4
Probability	Probable
Significance	Medium
Confidence	Medium
Legal aspects	
Mitigation measures	The culvert below George Rex Drive must be enlarged to facilitate tidal exchange with the Knysna Estuary and flushing of storm water from Erf 12403. The estuarine wetland must be allowed to naturally colonise into the newly created wetland areas. Brackish wetlands will establish further along the salinity gradient and will border onto the freshwater wetlands. Attempts should not be made to compartmentalise the estuarine wetland as no freshwater wetland species will be able to establish under marine or brackish conditions. The more frequent the tidal exchange the higher the diversity of estuarine species will be, e.g. if flushing only takes place during spring tides then only species adapted to the supratidal zone will establish and none of the intertidal and subtidal diversity will be present.
Significance after mitigation	Very High

IMPACT 15	***Rehabilitation of wetlands***
Nature of impact	Positive (The degraded wetlands will be redesigned and actively rehabilitated during the construction phase)
Stage	Construction
Extent	Site
Duration	Short
Intensity	High
Consequence	5
Probability	Probable
Significance	High
Confidence	Medium
Legal aspects	
Mitigation measures	Prevent excessive damage to wetland areas earmarked for rehabilitation. All wetland plant species from other areas of the property should be rescued and either stored in a nursery or transplanted in areas designated for wetland rehabilitation. Minimal earth works should be attempted in or near the wetlands that will be kept. Digging of the open water areas in the wetlands should be done carefully to avoid unnecessary damage to intact wetland areas. Because of the depauperate diversity of wetland species found on the property, freshwater wetland plant species from natural freshwater wetlands in and around Knysna should be sourced and transplanted into the rehabilitated wetlands to increase the diversity of indigenous and endemic wetland species.
Significance after mitigation	Very high

IMPACT 15	***Rehabilitation of wetlands***
Nature of impact	Positive (Once established, the rehabilitated estuarine and freshwater wetlands must be maintained in a healthy state).
Stage	Operational
Extent	Site
Duration	Long term
Intensity	High
Consequence	5
Probability	Probable
Significance	High
Confidence	Medium
Legal aspects	
Mitigation measures	Regularly monitor the rehabilitated wetlands by determining the vegetation cover abundance, elevation profile, soil physico-chemical characteristics and water quality along fixed transects. Major changes are expected initially as the wetlands adjust to the hydrodynamic regime of the open water areas and increased flushing. Once successfully establish, changes in faunal and floral community structure and diversity will be an indication of altered hydrodynamics or water quality in the system. Certain plant species may be used as indicators of environmental change. The rehabilitated wetlands will increase the diversity of faunal and floral species on the property. Wetlands are sensitive ecosystems and access to the wetlands should be restricted.
Significance after mitigation	Very high

7. References

Bornman, T.G. 2006. Biodiversity Impact Assessment of the wetlands and vegetation of Erf 12403, Knysna. Confidential report prepared for Pieter Badenhorst Professional Services CC. CER Report No. C07/06. 103 pp.

CSIR 2005. DEA&DP guideline for involving biodiversity specialists in EIA Processes. Compiled for the DEADP in June 2005.

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