STORMWATER MANAGEMENT PLAN

Tinley Manor South

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Signed **Date**

EXECUTIVE SUMMARY

Tongaat Hulett Developments intends developing a 480 hectare mixed used development known as Tinley Manor South located within the iLembe District Municipality. SMEC South Africa has been appointed to provide civil engineering input to the EIA phase of this project including the provision of a Stormwater Management Plan.

The Stormwater Management Plan's objectives are to protect all life and property from damage by stormwater and floods, to prevent erosion of soil by wind and water, to conserve the flora and fauna of the natural environment, to protect and enhance water resources in the catchments from pollution and siltation and to protect and enhance the local and downstream water courses.

Based on preliminary Rational Method calculations, it is evident that one of the negative impacts of the development is a substantial increase in the peak stormwater runoff flows for both the 1 in 10 and 1 in 50 year return periods. Dry attenuation ponds are proposed as the primary mitigation to the increased run-off volumes and will be designed to reduce peak flows to pre-development levels.

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1. INTRODUCTION

The proposed Tinley Manor South development is located approximately 10km North East of Ballito (Dolphin Coast) on the Kwa-Zulu Natal North coast. The development is bounded by Sheffield beach to the south, the uMhlali River to the north, the N2 freeway to the west and the Indian ocean to the east (refer to Figure 1).

The project area is approximately 480ha in extent and is currently under sugarcane cultivation with pockets of indigenous vegetation predominantly along the coast. The project area drains to the uMhlali River to the north and the sea to the east.

Tongaat Hulett Developments, intend developing a mixed use development comprising (refer to figure 2):

- Private resorts,
- Semi-private resorts,
- Medium impact mixed use which offers a full range of business, offices, service, light industrial and community facilities,
- Low impact use which offers a range of retail, offices, residential and community facilities and
- Private residential estates

Figure 1: Locality Plan

Figure 2: Land Use Plan (RHDHV)

2. POTENTIAL IMPACTS OF DEVELOPMENT ON EXISTING CATCHMENTS

The impacts of the proposed development on the environment will range from negative to positive depending on the degree of planning, design and methods of implementation. Measures put in place should contribute to the mitigation of the naturally negative impacts of development.

Expected consequences of unmitigated development include an increase in hardened areas, reduced infiltration, loss of vegetation and reduced evapo-transpiration potential. There will be an overall increase in surface runoff, an increase in the speed of runoff and peak flow rates in the watercourses.

3. MITIGATION OF DEVELOPMENT CONSEQUENCES

The recommendations in the specialist studies highlight the importance of adequate attention to the following key issues:

- Improved wetland functionality and zero net-loss approach regarding wetland areas.
- Protection of the natural watercourses to prevent pollution, erosion and retain runoff.
- Promotion of subsoil infiltration where possible.
- Provision of indigenous vegetation along watercourses and stabilisation of banks.
- Provision of in-stream installations at selected sites to trap first-flush pollution and non-soluble trash and litter entering the stormwater system.

- Attention to development of on-site use rainfall attenuation and provisions for reducing runoff by in-catchment and on-site evaporation and evapo-transpiration.

- Local flood risk reduction by selection of appropriate design standards for road bridges, culverts and stormwater attenuation facilities.

- Implementation of adequate on-site and localised stormwater management practices.

- Attenuation of flood peaks to predevelopment levels at the 2% (50-year) and the 10% (10-year) risk level.

- Providing new impermeable areas with sufficient flood attenuation and evaporation provisions.

- Rehabilitation and upgrading of open spaces following conversion from sugarcane.

These issues must be carried through the Stormwater Management Plan to the Parks & Landscaping plan.

The Stormwater Management Plan described below lists many practical on-site controls to address these fundamental issues. However, this does not exclude any technology that can be shown to be effective in controlling runoff whilst supporting the proposed spatial development intensity levels and contributing positively to the environment.

To fully mitigate the negative impacts of development:

- The potential increase in flood peaks must be mitigated to at least pre-development levels by the provision of sufficient stormwater detention facilities at micro and macro levels.
- The potential increase in flood volumes must be mitigated where possible by subsoil infiltration, retention of runoff in on-site facilities for irrigation use and unsaturated wetland areas where evaporation and infiltration can help to reduce flood runoff rates.
- Installations must be provided to contain pollution as close to source as possible and in a practical location for servicing by Department of Solid Wastes.

4. OBJECTIVES

This stormwater management plan has the following objectives:

- To protect all life and property from damage by stormwater and floods
- To prevent erosion of soil by wind and water
- To conserve the flora and fauna of the natural environment
- To protect and enhance water resources in the catchments from pollution and siltation
- To protect and enhance the local and downstream water courses

5. MAJOR RISKS:

5.1 Erosion

(extracted from REPORT TO TONGAAT HULETT DEVELOPMENT ON THE GEOTECHNICAL DESKTOP PHASE 1 ASSESSMENT FOR THE PROPOSED DEVELOPMENT OF TINLEY MANOR ESTATE SOUTH BANK, Ref m 23312, DRENNAN, MAUD AND PARTNERS, DECEMBER 2012)

Erosive Soils

The very loose to loose consistency, low cohesion between individual particles and fine to medium grained particle size of the Recent aeolian Dune sand, sandy Berea Formation and sandy colluvium results in these material being highly prone to erosion via wind and flowing storm water run-off, especially given the sloping nature of the site.

Furthermore, the likelihood of erosion will increase dramatically once the site is cleared of covering vegetation for the purpose of the development, which has a binding action on the underlying soils. As such, strict measures should be in place both during and after construction to control storm water run-off across the site. Post construction all batters and unpaved areas should be vegetated in order to keep the erosion of upper soils to a minimum.

Due to the likely moderately high clay content within the more clayey colluvial and residual materials, these soils are not as susceptible to erosion, however, if subjected to concentrated surface flow, erosion is probable.

5.2 Flooding

The proposed development will tend to reduce the natural rainfall infiltration and increase storm runoff. Downstream flood damage risks will therefore increase unless adequate attenuation of flood runoff is provided. The design of the stormwater system must address this issue as far as possible and must be designed such that the downstream post-development flood risks are no greater than the pre-development flood risks.

As a guide to the degree of runoff attenuation required, pre-development and post development 50-year and 10 year flood estimates are given in the attached appendices.

6. STORMWATER MANAGEMENT PHILOSOPHY

The major stormwater system consists of all natural water ways, including springs, streams, rivers, wetlands and dams. It includes detention dams and other devices constructed to control stormwater. Roadways and their associated drainage structures are also part of the major stormwater system if they result in a significant deflection of stormwater from its natural overland flow path.

The minor stormwater system consists of any measures provided to accommodate stormwater runoff within the development and road reserves and convey the runoff to the major stormwater system. These measures include gutters, conduits, berms, channels, road verges, small watercourses and infiltration constructions.

Stormwater runoff should not be concentrated to an extent that would result in any damage to the environment during storms with a probability frequency more than 1 in 10 years and would result in only minor, repairable damage in storms with a probability frequency of more than 1 in 50 years.

All elements of the built and natural environment must be able to withstand a 1 in 50 year storm event without significant consequential loss and risk to property and life.

Note that a "storm frequency" equates to a "probability of occurrence" of a storm event that should be used to assess the annual budget or insurance provision for remedial works, should the event occur.

Water courses and built stormwater infrastructure must be maintained in a clean state, free of any rubbish, debris and matter likely to pose any pollution threat to the lower reaches of the water courses.

The Stormwater Management Philosophy for the development encourages the owner / developer, the professional teams and contractors to do the following:

- Prevent concentration of stormwater flow at any point where the ground is susceptible to erosion.
- Reduce stormwater flows as much as possible by the effective use of attenuating devices.
- Ensure that development does not increase the rate of stormwater flow above that which the natural ground can safely accommodate at any point.
- Ensure that all stormwater control works are constructed in a safe and aesthetic manner in keeping with the overall development.
- Prevent pollution of water ways and water features by suspended solids and dissolved solids in stormwater discharges.
- Contain soil erosion, whether induced by wind or water forces, by constructing protective works to trap sediment at appropriate locations. This applies particularly during construction.
- Avoid situations where natural or artificial slopes may become saturated and unstable, both during and after the construction process.

7. STORMWATER MANAGEMENT POLICY

The following rules are to be observed by the developer, the professional team, contractors and sub-contractors:

- Designs for the buildings and site development in general must avoid concentration of stormwater runoff both spatially and in time and may be required to provide for on-site attenuation of stormwater runoff to limit peak flows to pre-development levels.
- Detailed plans to control and prevent erosion by water must be agreed prior to the commencement of any works, including site clearance, on any portion of the site.
- Removal of vegetation cover must be carried out with care and attention to the effect, whether temporary or long term, that this removal will have an erosion potential.
- Precautions shall be taken at all times on building sites to contain soil erosion and prevent any eroded material from being removed from the site.
- Landscaping and re-vegetation of areas not occupied by buildings or paving shall be programmed to proceed immediately after building works have been completed, or have reached a stage where newly established ground cover is not at risk from the construction works.

- On-site stormwater control systems, such as swales, berms, soil fences and detention ponds are to be constructed before any construction commences on the site. As construction progresses, the stormwater control measures are to be monitored and adjusted to ensure complete erosion and pollution control at all times.
- Earthworks on sites are to be kept to a minimum. Where embankments have to be formed, stabilization and erosion control measures shall be implemented immediately.
- Stormwater must not be allowed to pond in close proximity to existing building foundations.
- Prior to any physical work proceeding on site, a stormwater control plan (SCP) detailing the proposed stormwater control measures are to be formulated. No work is to be undertaken without an approved SCP.
- The Stormwater Control Plan must describe what control measures are to be implemented before and during the construction period, as well as the final stormwater control measures required for the site on completion of site development. Plans must indicate who is responsible for the design of the control measures and who is, or will be, designated as the responsible person on site during each stage of the implementation of the control measures.
- Stormwater Control Plans must show that all the provisions, regulations and guidelines contained in this document have been taken into account.
- In the event of a failure to adequately implement the approved stormwater control plan, the contractor shall be responsible for making good all consequential environmental damage at his own cost. The developer is therefore advised to ensure that all members of the professional team and contractors are competent to undertake the development work and are adequately insured.

8. MAJOR AND MINOR STORMWATER SYSTEMS

A plan of the delineated sub-catchments (drawing number: DH0002-CATCTHMENTS-01), is attached. In due course, the stormwater systems in each drainage basin will need to be identified and analysed to determine the requirements for new stormwater infrastructure to meet the objectives of this Stormwater Management Plan. The results should be documented in a Stormwater Systems Report that provides the hydraulic capacities of watercourses in the major system and other parameters required for further detailed design at specific locations within the overall development.

The parameters should include:

- Allowable ranges for the impervious percentage for commercial and residential areas.
- Average depression storage values for pervious and impervious areas.
- Initial and final infiltration rates and the appropriate Horton’s decay constant.
- Geotechnical data on infiltration rates for infiltration galleries.
- Equivalent Rational Method coefficients and unit area runoffs for developments on the small sites.

It is important that all building designs provide for maximum on-site stormwater attenuation and that the developers instruct their professional teams accordingly. It is important that level and near-level areas, such as building roofs and parking areas, are used to best advantage to attenuate storm runoff.

Appropriate provision must be made wherever possible for the removal of trash and litter from the major and minor stormwater systems. Stormwater trash collection stations must be conveniently located to facilitate trash collection and regular maintenance of the station.

9. CRITICAL ASPECTS

The Critical Aspects are as follows:

- Stormwater drainage is a crucial aspect and will require careful planning, designing and managing.
- The stormwater detention pond should be designed for the 50-year storm event and should be located at an appropriately selected site. Site selection must take account of the necessary geotechnical, environmental and topographical conditions, including wetland conservation.
- In addition to macro stormwater measures, micro-stormwater measures should be implemented. The form of this attenuation will be dependent on a number of factors such as topography (natural and artificial slopes), the zoning of the site and soil conditions present.
- A limited stormwater pipe network should be provided for stormwater reticulation to safely convey minor stormwater runoff to the attenuation facility.
- To ensure that water quality is not compromised, silt and trash traps will need to be provided within the system. Where conditions permit, open ditches, drains and channels should be used instead of pipes. Attention must be given to the erodibility of channels where flow velocities are high and appropriate lining provided. Forms of lining will vary from natural vegetation to stone pitching and reinforced concrete linings.
- The proposed development should not adversely impact on the environments of the development node and surrounding areas in terms of erosion and sediment deposition, but the frequency of flooding and the total runoff volume will increase unless adequate provision can be made to maintain the current natural rate of stormwater retention and infiltration in the sub-catchments.
- A stormwater systems model should be developed to determine peak flood flow rates and flood levels and assess the collective impacts of development on runoff patterns. The outputs from the modelling will provide the input data required for the design of culverts, channels and other stormwater infrastructure associated with the proposed developments.
- For areas flowing into the development area, potential future development in these sub-catchments should be considered and any requirements for stormwater detention should be identified. Similarly, for stormwater flowing out of the development area may impact on the downstream watercourse and this must be considered and measures taken to ensure any upstream development does not result in an increased flood damage risk downstream.
- Areas within the proposed development that bound on stormwater detention areas, near road crossings, watercourse confluences and water features could be subject to flooding. In these situations no development should take place below the outfall levels of water detention areas, plus an appropriate freeboard allowance.
- Overland flow may be encouraged where possible, but should be avoided in the specific areas identified. These are typically where roads will capture and concentrate cross flows at the local low points in the roads. Plans must take into account probable impact of flow from these points of concentration on the downstream environment.

- Steeper stormwater channels will require protection from erosion through the use of appropriate channel lining, or controlled drops to dissipate flow energy.
- All natural and unlined channels should be inspected for adequate binding of soil by sustainable ground cover. Stone pitching should be used to reinforce channel inverts on steep slopes. Existing wetlands and stormwater detention areas should be protected from encroachment by the development.

10. GUIDELINES FOR DEVELOPERS

Developers will be required to control stormwater runoff in accordance with the stormwater management philosophy and policies of Kwadukuza Municipality. The following guidelines are intended to assist the design of the major and minor stormwater systems infrastructure and to ensure that the objectives of this Stormwater Management Plan are met during the planning, design, construction and operational phases of all developments. Where prescriptive wording is adopted, the guideline shall be accepted and implemented as a rule.

10.1 STORMWATER RUNOFF CONTROL

Formal surface and underground stormwater systems will be provided in the overall development for the acceptance of stormwater drainage, but it is important that the peak runoff rate does not exceed the hydraulic capacities of the elements in the major stormwater system. The following are general guidelines for stormwater control from sites.

10.1.1 Buildings

Any building will inevitably result in some degree of flow concentration, or deflection of flow around the building.

The developer/owner shall ensure that the flow path of the stormwater is adequately protected against erosion and is sufficiently roughened to retard stormwater flow to the same degree, or more, as that found in the natural pre-development state of the site.

Where the construction of a building causes a change in the natural flora of the site that might result in soil erosion, the risk of soil erosion by stormwater must be eliminated by the provision of approved artificial soil stabilisation devices, or alternative flora suited to the changed conditions on the site.

Any inlet to a piped system shall be fitted with a screen, or grating to prevent debris and refuse from entering the stormwater system. This must be done immediately on installation of the piped system.

No building works, earthworks, walls or fences may obstruct or encroach on a watercourse inside or outside the site without approved plans that do not compromise the objectives of the Stormwater Management Plan.

10.1.2 Roof Drainage

Where ground conditions permit, rainwater runoff that is not stored and utilised on site must be connected to infiltration galleries or trenches designed to maximise groundwater recharge.

Infiltration facilities must be large enough to contain at least the first hour of a minor storm's runoff without overflowing.

Infiltration trenches must be aligned along the contour on the downstream side of the property such that any spillage during major storms results in sheet overland flow.

10.1.3 Parking Areas and Yards

Any external parking area, yard or other paved area must be designed to attenuate stormwater runoff from a major storm to an acceptable degree.

Any area described above must discharge rainwater flowing over, or falling onto its surface, in a controlled manner either overland as sheet flow, or into a detention facility, or infiltration gallery suitably sized to accommodate minor storm runoff.

10.1.4 Driveways and Paths

Driveways shall not be constructed to deflect or channel runoff onto a roadway, or to concentrate runoff along a particular path that is not a natural water course, without prior consent.

Driveways and paths should be designed and constructed such that the rate of flow of stormwater across and along the driveway or path is not increased when compared with the pre-development state.

Where the driveway joins the road, the driveway must not obstruct the flow in any open channel, whether lined or unlined, found along the road verge.

10.1.5 Roads

The principle of overland flow should apply to roadways where possible and roads should be designed and graded to avoid concentration of flow along and off the road.

Where flow concentration is unavoidable, measures to incorporate the road into the major stormwater system should be taken, with the provision of detention storage facilities at suitable points.

Inlet structures at culverts must be designed to ensure that the capacity of the culvert does not exceed the pre-development stormwater flow at that point and detention storage should be provided on the road and/or upstream of the stormwater culvert.

Outlet structures at a road culvert or a natural watercourse must be designed to dissipate flow energy and any unlined downstream channel must be adequately protected against soil erosion.

10.1.6 Stormwater Storage Facilities

The sufficiency and effectiveness of on-site detention storage to meet stormwater attenuation requirements within the minor and major stormwater systems is the responsibility of the property owner.

Any detention pond shall be integrated with the landscape on the site.

Detention ponds shall be maintained in good condition and shall not be permitted to become a health hazard or nuisance.

The Municipality shall have the right to inspect any stormwater drainage control facility at any time and issue instructions for repair and maintenance works deemed to be necessary, which instructions must be carried out within the prescribed time period.

10.1.7 Subsurface Disposal of Stormwater

Any construction providing for the subsurface disposal of stormwater should be designed to ensure that such disposal does not cause slope instability, or areas of concentrated saturation or inundation.

Infiltration structures should be integrated into the terrain so as to be unobtrusive and in keeping with the natural surroundings.

10.1.8 Channels

Lined and unlined channels may be constructed to convey stormwater to a natural watercourse where deemed necessary and unavoidable.

Channels must be constructed with rough artificial surfaces, or lined with suitable, hardy vegetation, to be non-erodible and to provide maximum possible energy dissipation to the flow.

10.1.9 Energy Dissipaters

Measures should be taken to dissipate flow energy wherever concentrated stormwater flow is discharged down an embankment or erodible slope and the resulting supercritical flow poses a significant risk to the stability of the waterway.

Attenuation devices should be provided at the head of the energy dissipating structure if possible.

A means of dissipating energy must be provided at the outfall of any drop structure to ensure stormwater flow is returned to a safe sub-critical state, or to disperse the flow.

10.1.10 Flow Retarders

Stormwater flow should be retarded wherever possible through the use of surface roughening or other flow restricting devices, provided these are designed and built to avoid blockages that could result in environmental and structural damage.

All such constructions must be regularly maintained by the owner and may be inspected at any time by the Municipality or their appointed representatives.

10.2 STORMWATER POLLUTION CONTROL

All property owners and developers shall ensure no materials; fluids or substances are allowed to enter the stormwater system that could have a detrimental effect on the flora, fauna and aquatic life in the water courses and wetlands.

Regular monitoring of the sites should be undertaken by the Municipality or their appointed representatives.

Any site that is required to store any substances that could be regarded as hazardous in terms of water pollution shall notify the Municipalities and shall take measures to ensure spillages of the substance(s) can be adequately contained to prevent contamination of the water resources within the development area.

No stormwater, wash water, or waste water may be directed towards any permanent water body or wetland without the installation of a suitable filtration system to prevent pollution, including silt, from entering such water body.

10.3 STORMWATER EROSION CONTROL

The Municipality should inspect the development on a regular basis to:

- Determine the effectiveness of the stormwater management policies and amend policy as and when necessary to meet the objectives of the Stormwater Management Plan.
- Advise the property owner / manager of any repair, maintenance and improvement works required on the stormwater system control elements within their jurisdiction.

10.4 SAFETY

10.4.1 Inundation of Property and Buildings

Any pre-development 1 in 100 year flood line shown on a development plan may not be altered by the development of the site, land-forming or other means, without the approval of the Municipality and confirmation by an appropriately qualified person that the alteration does not diminish the performance of the existing stormwater system and any stormwater management facilities.

All risk of inundation by flood water is carried by the owner of the property. No flood water may be diverted or concentrated such that a risk of flooding or inundation of any property or building is created.

10.4.2 Structural Damage

The diversion or concentration of stormwater, whether on the surface or underground, must not increase the risk of structural damage to any development within the Tinley Manor South.

The above includes the undermining of structures due to erosion of soil and/or the subsidence of structures due to saturation of the foundations by stormwater.

11. STORMWATER PLAN IMPLEMENTATION PROCEDURES

The following procedures are to be followed by owners, developers, appointed agents, professional teams and contractors:

11.1 Application for Permission to Build

A copy of the Stormwater Management Plan shall be obtained from Tongaat Hulett Developments or the Municipality.

11.2 Site Survey and Investigations

Anyone involved in site survey and investigation work shall be familiar with the contents of this Stormwater Management Plan.

11.3 Design Stage

The professional team shall take into account the Stormwater Management requirements contained in this document and shall clearly indicate on all plans and in any contract document where and how measures have been provided in the design to ensure the Stormwater Management requirements are implemented. Approval from the Municipality must be obtained before commencing construction.

11.4 Construction

The contractor shall prepare a Stormwater Control Plan to ensure that all construction methods adopted on site and within the Tinley Manor South do not cause, or precipitate, soil erosion and shall take adequate steps to ensure that the requirements of the Stormwater Management Plan are met before, during and after construction. The designated responsible person on site, as indicated in the Stormwater Control Plan (usually the contractor) shall ensure that no construction work takes place before the Stormwater Control measures are in place.

11.5 Certificate of Occupation

On completion of the works, the Municipality, or their appointed professional person will inspect the site for compliance with the Stormwater Management requirements, prior to the issuing of a Certificate of Occupation by the Municipality.

11.6 Occupation Period

During occupation of any property, the Municipality may undertake periodic inspections, to ensure the Stormwater Management Policy is being correctly implemented, and may serve notice on occupants to undertake remedial work, which is deemed necessary in the opinion of the Municipality.

12. COMPLIANCE WITH STORMWATER MANAGEMENT POLICY

Within Tinley Manor South in general, the owner and his professional team, including the contractor, shall be responsible for ensuring that the requirements of this Stormwater Management Plan are met.

The owner and his professional team shall be responsible for the performance of all stormwater control measures implemented on a site under their jurisdiction and the impact such works may have on downstream property within the Tinley Manor South.

Approval of any plan or document, whether verbally or in writing, by the Municipality shall not be construed as absolving the owner or the professional team of this responsibility.

13. HYDROLOGY AND HYDRAULICS

13.1 Rational Method

The DWA Rational Method was used to estimate the peak stormwater runoff as a result of this development. The results of these calculations indicate that attenuation is required to accommodate the increase in stormwater runoff in a 1:50 year storm.

Rainfall data obtained from “Rainfall Statistics for Design Flood Estimation in South Africa" for the 1 in 10 and 1 in 50 year return periods was used in these calculations. A time of concentration (Tc) of 15 minutes was used to select a storm duration.

In the DWA Rational Method, the pre-development C-factors are influenced by the steepness of the sub-catchment, the permeability of the soil and type of vegetal cover. The permeability of the soil is assumed to be semi-permeable and currently cultivated.

The post development C-factors were determined by measuring the area of each land use within a sub-catchment and then weighting the appropriate C-factors according to the ratio of land use versus overall area.

13.2 Stormwater Management System

The following key aspects will be implemented in doing the detailed design plan:

- All internal storm water reticulation will be designed with due cognizance accordance of the relevant guidelines.
- The use of the proposed road network will act as the primary storm water collector with controlled discharge to attenuation ponds.
- The secondary system (pipe network) will be designed to accommodate the 1:3 and 1:10 year peak flow at critical points.
- Dry attenuation ponds will be used to reduce runoff into the natural drainage system to the pre-development 1:10 and 1:50 year flood. Excess storm water will be attenuated on site and attenuation ponds will be sized to accommodate the difference in volume between 1:50 pre and post development runoff volumes.

13.2.1 Proposed Water Retaining facilities

[Refer to APPENDIX E Drawing No. *DH0002-POND-01*]

Proposed dry attenuation ponds may be used as storage facilities for the anticipated stormwater runoff. There are a total of seventeen proposed ponds, which have varying areas and an indicative depth of 2m. The combined attenuation volume of these proposed ponds is approximately 41 500 m^3 which meets the required attenuation volume required from based on the Rational Method calculations.

14. CONCLUSION

It is evident from the Rational Method results that one of the negative impacts of the development is a substantial increase in the peak stormwater runoff flows for both the 1 in 10 and 1 in 50 year return periods.

The increase in peak runoff will primarily be mitigated by the introduction of stormwater attenuation devices as part of the stormwater network. These devices will be attenuation dams.

These attenuation structures will be required to reduce the post-development peak runoffs for the 1 in 10 and 1 in 50 year storms to pre-development levels. With this in mind, it is recommended that the hydraulic characteristics of the stormwater network is analyzed (using EPASWMM or similar software) during the detail design part of the project. This analysis will accurately determine the attenuation volumes required and the outlet configuration in order to reduce the peak outflows to pre-development levels.

ANNEXURE A
STORMWATER RUNOFF ESTIMATES
(RATIONAL METHOD)

Rational Method for 1 in 50 years

	PRE DEVELOPMENT						POST DEVELOPMENT						Attenuation Required (m3)	Att. Vol. Check @ 1m3 per 40m2
Catchment	C	I (mm/hr)	A (ha)	Q (m3/s)	Tc (min.)	Volume (m3)	C	I (mm/hr)	A (ha)	Q (m3/s)	Tc (min.)	Volume (m3)		
1a	0.46	169	5.2550	1.127	30	3044	0.47	216	5.2550	1.481	24	3136	92	698
2a	0.46	189	9.8179	2.347	24	5069	0.52	261	9.8179	3.678	17	5730	661	555
3	0.38	185	5.2832	1.035	25	2328	0.45	250	5.2832	1.649	18	2740	413	232
4a	0.38	121	24.6472	3.159	42	11942	0.44	242	24.6472	7.362	21	13869	1928	1701
5b	0.38	172	22.7588	4.148	29	10827	0.46	217	22.7588	6.295	23	13024	2197	472
6a	0.46	169	14.7737	3.170	30	8558	0.50	217	14.7737	4.505	23	9465	906	1680
7	0.38	185	24.2366	4.746	25	10679	0.45	245	24.2366	7.391	19	12508	1830	1291
8	0.38	169	22.5075	4.039	30	10905	0.45	215	22.5075	6.001	24	12734	1829	2063
9a	0.38	98	41.0525	4.250	52	19890	0.45	116	41.0525	5.909	44	23241	3351	8883
10	0.38	172	18.5351	3.378	29	8818	0.44	222	18.5351	5.040	22	10204	1387	1461
11	0.38	145	30.0088	4.616	35	14539	0.45	186	30.0088	7.001	27	17197	2658	3878
12	0.38	178	4.5740	0.862	27	2096	0.45	233	4.5740	1.328	21	2459	364	271
13	0.38	130	24.9010	3.437	39	12065	0.45	167	24.9010	5.229	30	14324	2260	2481
14	0.38	134	22.5622	3.196	38	10932	0.48	483	22.5622	14.555	11	13781	2849	2745
15	0.46	193	7.1570	1.749	23	3620	0.51	268	7.1570	2.713	17	4045	425	727
16a	0.38	98	91.3104	9.453	52	44240	0.47	252	91.3104	30.301	20	54839	10599	8165
17a	0.46	189	5.1468	1.230	24	2657	0.56	252	5.1468	2.025	18	3266	608	35
18a	0.46	193	1.6805	0.411	23	850	0.63	271	1.6805	0.793	16	1166	316	417
18c	0.38	169	0.6508	0.117	30	315	0.55	250	0.6508	0.248	20	453	138	103
19a	0.46	178	15.2160	3.430	27	8335	0.58	231	15.2160	5.637	21	10549	2214	865
20a	0.38	149	9.6131	1.522	34	4658	0.50	196	9.6131	2.598	26	6050	1392	998
21a	0.38	134	9.5957	1.359	38	4649	0.47	171	9.5957	2.143	30	5730	1081	456
22a	0.38	181	7.4174	1.424	26	3333	0.45	250	7.4174	2.341	19	3969	636	395
	SUB-TOTALS:		**418.70**	**64.21**		**204348.48**				**126.22**		**244480.53**	**40132.05**	**40572.78**

2015/03/04

Rational Method for 1 in 10 years

	RATIONAL METHOD CALCULATION (1:10 YEAR RP)							
	PRE DEVELOPMENT				POST DEVELOPMENT			
Catchment	**C**	**I (mm/hr)**	**A (ha)**	**Q (m3/s)**	**C**	**I (mm/hr)**	**A (ha)**	**Q (m3/s)**
1a	0.33	108	5.2550	0.522	0.47	123	5.2550	0.845
2a	0.33	121	9.8179	1.086	0.52	143	9.8179	2.018
3	0.28	118	5.2832	0.479	0.45	138	5.2832	0.908
4a	0.28	77	24.6472	1.463	0.44	181	24.6472	5.504
5b	0.28	110	22.7588	1.921	0.46	189	22.7588	5.493
6a	0.33	108	14.7737	1.468	0.50	189	14.7737	3.919
7	0.28	118	24.2366	2.197	0.45	173	24.2366	5.220
8	0.28	108	22.5075	1.871	0.45	193	22.5075	5.383
9a	0.28	63	41.0525	1.968	0.45	217	41.0525	11.029
10	0.28	110	18.5351	1.565	0.44	185	18.5351	4.214
11	0.28	93	30.0088	2.138	0.45	205	30.0088	7.715
12	0.28	114	4.5740	0.399	0.45	181	4.5740	1.032
13	0.28	83	24.9010	1.592	0.45	217	24.9010	6.798
14	0.28	86	22.5622	1.480	0.48	158	22.5622	4.754
15	0.33	123	7.1570	0.809	0.51	165	7.1570	1.678
16a	0.28	63	91.3104	4.378	0.47	177	91.3104	21.287
17a	0.33	121	5.1468	0.569	0.56	169	5.1468	1.359
18a	0.33	123	1.6805	0.190	0.63	162	1.6805	0.472
18c	0.28	108	0.6508	0.054	0.55	185	0.6508	0.184
19a	0.33	114	15.2160	1.588	0.58	181	15.2160	4.427
20a	0.28	96	9.6131	0.705	0.50	201	9.6131	2.662
21a	0.28	86	9.5957	0.630	0.47	217	9.5957	2.719
22a	0.28	116	7.4174	0.659	0.45	173	7.4174	1.624
	SUB-TOTALS:		**418.70**	**29.73**				**101.24**

ANNEXURE B
CALCULATIONS FOR TIME OF CONCENTRATION

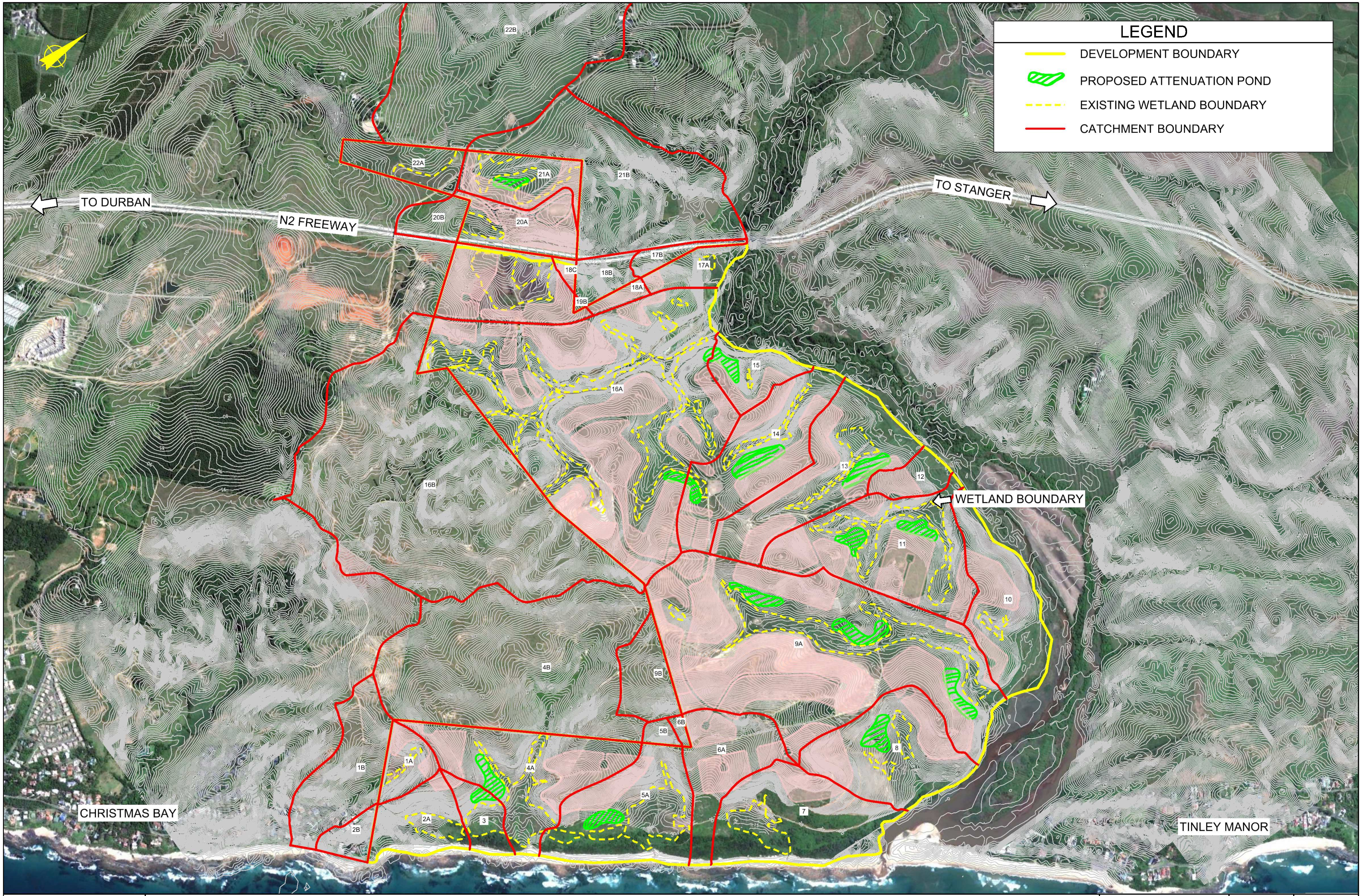
Calculations for Time Concentration for Pre Development

	PRE DEVELOPMENT														
	Overland Flow						Streamflow						Rainfall Depth (mm)		
	r factor	L (m)	Z_1	Z_2	Slope (m/m)	Tc_{OF} (min.)	L (m)	Z_1	Z_2	Slope (m/m)	Tc_{SF} (min.)	Tc_{TOTAL} (min.)	1:10 year	1:50 year	1:100 year
Catchments															
1a	0.8	200	70	44.0914	0.130	24.653	463.34	44.0914	4.8941	0.085	5.696	30	54.2	84.6	100.4
2a	0.8	200	39.9724	3.6855	0.181	22.788	19.37	3.6855	3.2526	0.022	0.825	24	48.3	75.4	89.4
3	0.8	200	33.9875	5.8098	0.141	24.175	43.83	5.8098	2.5163	0.075	0.970	25	49.3	76.9	91.3
4a	0.8	200	68.5961	55.5466	0.065	28.935	1032.77	55.5466	0.5	0.053	12.614	42	54.2	84.6	100.4
5b	0.8	200	55	19.331	0.178	22.880	389.71	19.331	2.3411	0.044	6.435	29	53.2	83.1	98.6
6a	0.8	200	65	38.5	0.133	24.524	451.77	38.5	0.5	0.084	5.599	30	54.2	84.6	100.4
7	0.8	200	70	18	0.260	20.952	239.67	18	0.7	0.072	3.645	25	49.3	76.9	91.3
8	0.8	200	40	15.06	0.125	24.874	289.42	15.06	5	0.035	5.584	30	54.2	84.6	100.4
9a	0.8	200	58.6	47.1	0.058	29.802	1588.90	47.1	0.6	0.029	22.139	52	54.2	84.6	100.4
10	0.8	200	26.8645	1.744	0.126	24.832	133.93	1.744	0.0299	0.013	4.532	29	53.2	83.1	98.6
11	0.8	200	37.9641	22.0145	0.080	27.611	449.37	22.0145	3.3536	0.042	7.317	35	54.2	84.6	100.4
12	0.8	200	36.1509	7.6939	0.142	24.119	136.07	7.6939	2.978	0.035	3.126	27	51.2	80.0	94.9
13	0.8	200	50	38.8873	0.056	30.041	639.10	38.8873	4.6907	0.054	8.704	39	54.2	84.6	100.4
14	0.8	200	62	46.1	0.080	27.631	808.37	46.1	3.8	0.052	10.520	38	54.2	84.6	100.4
15	0.8	200	43.5404	6.5968	0.185	22.693	7.11	6.5968	4.6	0.281	0.144	23	47.3	73.9	87.6
16a	0.8	200	78	62.5	0.078	27.796	1780.88	62.5	8.5	0.030	23.844	52	54.2	84.6	100.4
17a	0.8	200	57.5501	26.1006	0.157	23.563	73.57	26.1006	5.7776	0.276	0.876	24	48.3	75.4	89.4
18a	0.8	176.4266	60.0028	34.1697	0.146	22.595						23	47.3	73.9	87.6
18c	0.8	200	65	50.0523	0.075	28.032	100.00	50.0523	44.052	0.060	1.996	30	54.2	84.6	100.4
19a	0.8	200	85.0013	54.7986	0.151	23.786	121.39	54.7986	52.4538	0.019	3.586	27	51.2	80.0	94.9
20a	0.8	200	65.0029	49.7507	0.076	27.900	132.83	49.7507	48.8256	0.007	5.692	34	54.2	84.6	100.4
21a	0.8	200	60.0121	49.4015	0.053	30.367	594.58	49.4015	12.0505	0.063	7.740	38	54.2	84.6	100.4
22a	0.8	166.2278	70	58.223	0.071	26.035						26	50.3	78.5	93.1

Calculations for Time Concentration for Post Development

	POST DEVELOPMENT															
	Overland Flow						Streamflow							Rainfall Depth (mm)		
	r factor	L (m)	Z_1	Z_2	Slope (m/m)	Tc $_{OF}$ (min.)	L (m)	Z_1	Z_2	Slope (m/m)	Tc $_{SF}$ (min.)	Tc $_{TOTAL}$ (min.)	Tc min. (15 mins.)	1:10 year	1:50 year	1:100 year
Catchments																
1a	0.4	200	70	44.0914	0.130	17.836	463.3353	44.0914	4.8941	0.085	5.696	24	24	48.3	75.4	89.4
2a	0.4	200	39.9724	3.6855	0.181	16.487	19.3718	3.6855	3.2526	0.022	0.825	17	17	41.4	64.7	76.7
3	0.4	200	33.9875	5.8098	0.141	17.490	43.8293	5.8098	2.5163	0.075	0.970	18	18	42.4	66.2	78.5
4a	0.4	200	68.5961	55.5466	0.065	20.934	1032.767	55.5466	0.5	0.000	0.000	21	21	45.3	70.8	84.0
5b	0.4	200	55	19.331	0.178	16.553	389.7051	19.331	2.3411	0.044	6.435	23	23	47.3	73.9	87.6
6a	0.4	200	65	38.5	0.133	17.742	451.7663	38.5	0.5	0.084	5.599	23	23	47.3	73.9	87.6
7	0.4	200	70	18	0.260	15.158	239.67	18	0.7	0.072	3.645	19	19	43.3	67.7	80.3
8	0.4	200	40	15.06	0.125	17.995	289.4166	15.06	5	0.035	5.584	24	24	48.3	75.4	89.4
9a	0.4	200	58.6	47.1	0.058	21.561	1588.901	47.1	0.6	0.029	22.139	44	44	54.2	84.6	100.4
10	0.4	200	26.8645	1.744	0.126	17.965	133.9308	1.744	0.0299	0.013	4.532	22	22	46.3	72.3	85.8
11	0.4	200	37.9641	22.0145	0.080	19.975	449.3721	22.0145	3.3536	0.042	7.317	27	27	51.2	80.0	94.9
12	0.4	200	36.1509	7.6939	0.142	17.449	136.0665	7.6939	2.978	0.035	3.126	21	21	45.3	70.8	84.0
13	0.4	200	50	38.8873	0.056	21.734	639.0978	38.8873	4.6907	0.054	8.704	30	30	54.2	84.6	100.4
14	0.4	200	62	46.1	0.000	0.000	808.3738	46.1	3.8	0.052	10.520	11	15	39.4	61.6	73.0
15	0.4	200	43.5404	6.5968	0.185	16.418	7.1127	6.5968	4.6	0.281	0.144	17	17	41.4	64.7	76.7
16a	0.4	200	78	62.5	0.078	20.109	1780.884	62.5	8.5	0.000	0.000	20	20	44.3	69.3	82.1
17a	0.4	200	57.5501	26.1006	0.157	17.047	73.5667	26.1006	5.7776	0.276	0.876	18	18	42.4	66.2	78.5
18a	0.4	176.4266	60.0028	34.1697	0.146	16.347						16	16	40.4	63.1	74.8
18c	0.4	200	65	50.0523	0.075	20.280	99.999	50.0523	44.052	0.060	1.996	22	22	46.3	72.3	85.8
19a	0.4	200	85.0013	54.7986	0.151	17.209	121.3855	54.7986	52.4538	0.019	3.586	21	21	45.3	70.8	84.0
20a	0.4	200	65.0029	49.7507	0.076	20.185	132.8257	49.7507	48.8256	0.007	5.692	26	26	50.3	78.5	93.1
21a	0.4	200	60.0121	49.4015	0.053	21.970	594.5813	49.4015	12.0505	0.063	7.740	30	30	54.2	84.6	100.4
22a	0.4	166.2278	70	58.223	0.071	18.836						19	19	43.3	67.7	80.3

ANNEXURE C
PROPOSED PONDS LAYOUT



SMEC
Local People. Global Experience.

TINLEY MANOR SOUTH

PROPOSED PONDS LAYOUT

Scale	Sheet	Date
1: 5000 (A0)	1	MAR 2015
Drawing No DH0002-POND-01 (APPENDIX C)		