MARIANNHILL LANDFILL CONSERVANCY – A "CLOSED LOOP" DESIGN

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1. MOTIVATION

The Mariannhill Landfill, in the eThekwini Municipality of Kwazulu-Natal, presents a landfill development where landfill-engineering methods have successfully combined with the daily-operation to realise South Africa's first landfill site conservancy. The application of naturalistic engineering to landfill development is crucial to environmental acceptance of the landfill site – specifically where a conservation site is to be created and sustained! Naturalistic engineering encompasses many landfill facets for example: the provision of landfill capping layers that would stimulate vegetation growth; the use of simple and low-cost, yet robust, natural systems to treat landfill leachate; and the installation of wetlands to reduce stormwater energy and to simultaneously re-introduce valuable bird life into the site. In addition, the recent availability of carbon finance since South Africa's recent signing of the Host Country agreement, landfill-gas-to-electricity-generation is financially viable. Methane gas is a distinctly serious greenhouse gas and such projects will assist towards global emission reductions (ER's) of carbon.

2. CELL CONSTRUCTION

Natural biodegradation processes within waste bodies give rise to landfill leachate (produced as a result of rainfall passing through the waste body) and landfill gas. The protection of the receiving environment from these potentially harmful landfill emissions is addressed in the form of a barrier system (so-called because it incorporates a number of engineered layers). Two types of barrier systems are currently adopted at the Mariannhill Landfill Site, depending on the grade of the natural ground. On valley slopes, the barrier system consists of a stabilised sand layer onto which a geomembrane (FPP – Flexible Poly Propylene) liner and geogrid is placed. A stabilised sand protection layer is then constructed on the liner/geogrid. Crushed dump rock aggregate is then placed on this protection layer to facilitate the collection and removal of leachate.

In the valley basal areas, an additional component is added to the barrier system described above. As the inflow of leachate into the strata below the landfill is critical in the valley base, two low permeability clay layers, between which a layer of 19mm stone is placed, are constructed below the system described previously. The 'sandwiched' stone layer serves as a leachate leakage detection system, and provides further environmental protection.

3. "CLOSED LOOP" LANDFILL DESIGN

3.1 The Plant Rescue Unit (PRUNIT)

A typical item in civil engineering contract documents of "Clear and Grubb" is indicative of environmental engineering ignorance. The value of the original soil profile at the Mariannhill Landfill was identified from the onset of a Conservancy creation plan, as a vital component to environmental equation that must be rescued for effective rehabilitation to be realised. This lead to the creation of a large holding nursery for the

storage of all indigenous vegetation, along with the surrounding soil profile, rescued from within the landfill footprint development area. This rescue operation to the holding nursery is referred to by DSW as "PRUNIT" (Plant Rescue Unit). PRUNIT has proven to be both environmentally and economically successful. PRUNIT has provided indigenous vegetation for the remediation of the peripheral "buffer-zone" areas of Mariannhill, as well as the ongoing rehabilitation of the Bisasar Road Landfill Site. In fact, the PRUNIT growth has realised the low cost remediation of several defunct "dumps" throughout the eThekwini Municipality.

3.2 The Landfill Conservancy

The Mariannhill Landfill Site is an excellent example of an ecosystem restoration project, which has become an increasingly important part of biodiversity conservation. Continuing human population growth ultimately results in the loss of natural ecosystems, either directly through the development of land, or indirectly through inappropriate land use practice. Restoration has become an essential tool for improving ecosystem functioning, minimising biodiversity losses and increasing the connectivity in nature reserve networks. Some of the results achieved through the landfill conservancy are:

- Mariannhill was the first landfill site, arguably worldwide to be incorporated into an ecosystem restoration site and be a registered National Conservancy site.
- The maintenance of the indigenous ecosystem minimises biodiversity loss in the area
- The landfill site serves as an important natural corridor for species migration
- Significant near and long term cost savings are realized to the City for landfill rehabilitation
- Numerous job opportunities and skills development have been realized
- Education of learners, students and general public is effective and ongoing. Some 2 000 people have learnt of the landfill conservancy, the PRUNIT concept and of DSW's waste management principles.

4. TREATMENT AND RE-USE OF LANDFILL EMISSIONS

The construction of the barrier system at the Mariannhill Landfill Site not only provides environmental protection, but also facilitates the collection and treatment of landfill emissions – again this is in keeping with the "closed-loop" concept.

4.1 Mariannhill Leachate Treatment Plant

The disposal of leachate prior to the construction of the treatment plant was to the municipal sewer, an approximate distance of one kilometre away. The disposal of leachate to sewer is not a treatment method, but rather one of dilution. Raw (untreated) leachate does potentially pose a risk of corrosion and elevated methane gas levels to the municipal sewer systems.

Leachate treatability trials began in 1998 by DSW, in collaboration with Enviros UK (previously Enviros Aspinwall). The trials demonstrated that the Mariannhill Landfill leachate can be treated to high standards, within the limits of the discharge standards required by the Department of Water Affairs and Forestry for discharge of wastewater by irrigation. The findings of the treatability trials thus allowed DSW, in association with Enviros (UK), to design a full-scale treatment plant.

The overall treatment philosophy of the treatment plant is the use of "natural, low cost and robust" treatment processes. This plant, therefore, adopts biological primary treatment processes (aligned to the activated sludge process), and secondary "polishing treatment" by reedbed.

The treatment plant comprises one Sequencing Batch Reactor (SBR) unit, constructed of reinforced concrete 10 metres in diameter and 6 metres deep. This capacity allows for the treatment of up to 50 cubic meters of leachate daily. The plant also comprises a lined reedbed of some 280 square metres, which provides 'polishing treatment' for the removal of specifically residual BOD, COD and solids. All treated effluent from the SBR is fed into a balance tank, which is level controlled to supply a portion of the effluent to a standpoint for the site water tanker (dust suppression) and a portion to the reedbed. The effluent from the reedbed is used for irrigation of the vegetated areas within the conservancy area. The treatment processes are controlled by computer systems, which relay information via a visual display on a computer screen.

4.2 Landfill Gas to Electricity

It is widely known that landfill sites, with wastes undergoing a methanogenic stage of biodecomposition, produce large volumes of landfill gas (LFG). The recent availability of carbon finance, since South Africa's recent signing of the Host Country agreement, has created the possibility that landfill-gas-to-electricity-generation can be financially viable on the African continent.

The Kyoto Protocol, in broad terms, paves a way to address global environmental problems through the financial "top-up" of projects in developing countries that will realise carbon emission reductions (ER's). In this way, funding is generated by industrialised countries so as to meet their obligations for ER's through such projects. Article 12 of the Kyoto Protocol provides for the application of Clean Development Mechanisms (CDM's) under which an entity in an industrialised country finances or purchases ER's from a project in a developing country. The purpose here being to transfer cleaner technology and financial resources for specific projects while at the same time achieving the objective of lowering carbon emissions on a global scale. However, countries wishing to enter into such transactions have to sign as "host countries" to receive such CDM's. South Africa is a most recent signatory.

The eThekwini Municipality has a proposed project (in the EIA process) that will combat the serious issue of global warming and will find a financially viable use for the amazing power potential of landfill gas. The project is made possible through "Carbon Finance", which is channelled through the World Bank's Prototype Carbon Fund (PCF) – a Public Private Partnership with participants from several countries worldwide.

A landfill gas extraction scheme, comprising six gas wells, linked to a 500Nm3/hr flare unit, has been operational for some three and a half years. The gas collection system for the flaring as installed at the Mariannhill landfill site could prove an adequate starting place as a pre-injection treatment system for the engine-generators. As is typical to several other projects worldwide, LFG will be drawn from the wells through pipe work systems by extraction equipment and fed to electricity generation units, with any surplus gas being flared.