BUFFER ZONES: THE LONG TERM INTERFACE

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SUMMARY

The Plant and Engineering Section of the Department of Cleansing and Solid Waste, DSW, had decided to place emphasis in changing the mindset from "hard engineering to green engineering" on the buffer zone areas. Coupled with this, was the fact that modern landfills have a larger buffer zone area which increases the management and maintenance associated with it. Particular focus was placed on setting up a buffer zone model that would be self sustaining in terms of biodiversity control, forestation of living firebreaks and upgrading the green lung for the eThekwini Municipality. This paper presents the buffer zone management tools and environmental management concepts implemented at the Mariannhill and Buffelsdraai Landfill Sites to achieve sustainable buffer zones with minimal effort over time. The paper further highlights the linking of the buffer zone management into the sites EMP and creating the basis for securing special long term processes e.g. introduction of red data species, indigenous reforestation, Clean Development Mechanisms (CDM) and climate change mitigation etc.

KEYWORDS

Buffer Zone Management, Environmental Management, Landfill Rehabilitation, Green Engineering, Sustainability, Reforestation, PRUNIT (Plant Rescue Unit), Biodiversity.

INTRODUCTION

The Minimum Requirements for Waste Disposal by Landfill was introduced in 1994 by the Department of Water Affairs and Forestry (DWAF) and more recently this responsibility has been handed to the Department of Environmental Affairs and Tourism (DEAT) in order to regulate waste disposal practices and minimise the impacts on the receiving environment. Landfill operators issued with operating permits are continually tasked with ensuring permit compliance to the regulator. Moreover the compliance to the Record of Decision (ROD) and Environmental Management Plan (EMP) for landfill sites further adds to the "compliance stockpile". As such, the operational management and engineering of nowadays landfills referred to as "waste management facilities" become increasingly challenging. One key area of scrutiny by any regulator, neighbouring community, environmental compliance auditor etc tends to zone on the site's buffer zone.

There can be much debate on the above mentioned environmental regulations and permit requirements but the main objective is ensuring a protected environment. Moreover, emphasis is placed on pollution prevention, environmental degradation prevention, preservation of natural assets and protection to ecological sustainable development (Torr, 2009). The Department of Cleansing and Solid Waste, DSW, which is accountable for the waste management within the eThekwini Metropolitan Area (EMA) is renowned both locally and internationally for an innovative approach to landfill management where waste disposal operations are integrated with landfill rehabilitation during the

operational life of the landfill site. DSW uniquely rehabilitates its landfill sites by rescuing indigenous vegetation prior to landfilling from the landfill footprint and buffer zone areas. As a result, an indigenous staging nursery was constructed to stock all indigenous plant sand seedlings not only prior to landfilling but also prior to any earthworks onsite. The rescuing of vegetation approach had led to the creation of the Plant Rescue Unit (PRUNIT) which has shown to be cost effective and environmentally acceptable (Parkin et al., 2006). As a result, DSW is well done the line in mastering the rehabilitation component of the landfill footprint and is now making strides into the long term management of the landfill sites buffer zones.

There has been limited research to date on the proper management of South African landfill buffer zones and therefore limited experiences on the tools and conceptual models that can be used to ensure good practice and sustainable long term buffer zones. The interest of this aspect has initiated the Plant and Engineering team of the Department of Cleansing and Solid Waste, DSW, to change the mindset of how to manage and apply naturalistic engineering concepts at the two new aged landfills namely, the Mariannhill Landfill Site and the Buffelsdraai Landfill Site, Kwa-Zulu Natal. This was identified as a vital component in linking the interface between the landfill footprint and the landfill's buffer zone to avoid future probable pollution into the receiving environment. This paper presents some practical examples of buffer zone management and highlights the start of a long term study of the biodiversity, ecological science, climate change, and reforestation. Therefore comments on preliminary progress achieved through the application of unique management tools and environmental management concepts are highlighted.

SITE DESCRIPTION

The Mariannhill Landfill Site

The Mariannhill Landfill Site is situated outside Pinetown, some 20 kilometres west of Durban and is a permitted GLB^+ landfill where landfill engineering methods have successfully combined to realize South Africa's first landfill conservancy (Conservancy status acquired in August 2002). The Mariannhill Landfill Site, opened in July 1997, was located to text book standards, being well hidden from the public view by the natural topography and well established vegetation (Strachan et al, 2002). The total area of the site covers some 49.5 ha of which 18.5ha is landfill footprint and the remaining *31ha incorporating the buffer zone*.

The landfill presently receives approximately 750tons/day of MSW (Municipal Solid Waste) which serves for the majority of the western areas of the eThekwini Metropolitan Area (EMA). Based on airspace calculations predicting 4.4 million cubic metre capacity, the site will be operational beyond the year 2024.

The Buffelsdraai Landfill Site

The Buffelsdraai Landfill Site is situated in Verulam, approximately 50km north of Durban and is also permitted as a GLB^+ landfill. The site was a successor to the closed La Mercy Landfill and was commissioned in May 2006 and is positioned out of the public eye on a sugar cane farm. The total area of the site is some 887ha of which 100ha is the actual landfill footprint and the remaining *787ha consists of the buffer zone*.

The landfill currently receives some 400tons/day of MSW and services predominately the northern areas of the EMA. This daily tonnage is expected to increase to some 3500tons/day post closure of the city's central landfill i.e. The Bisasar Road Landfill Site by early 2014. Airspace calculations reveal a total of 45 million cubic metre capacity which equates to an operational life of some 70years.

THE BUFFER ZONE MANAGEMENT CONCEPT

Landfill engineering nowadays concentrate significantly on the design, operation and aftercare of the landfill footprint and to some extent neglects the required management and due responsibility of the landfill's surrounding buffer zone. Most landfill operators have a negative perception with regards to the duration of responsibility and size attached the footprint and the buffer zones. Figure 1 below illustrates the conceptual mindset of the interface between the landfill footprint and buffer zone of any landfill as well as duration of responsibility for each area.

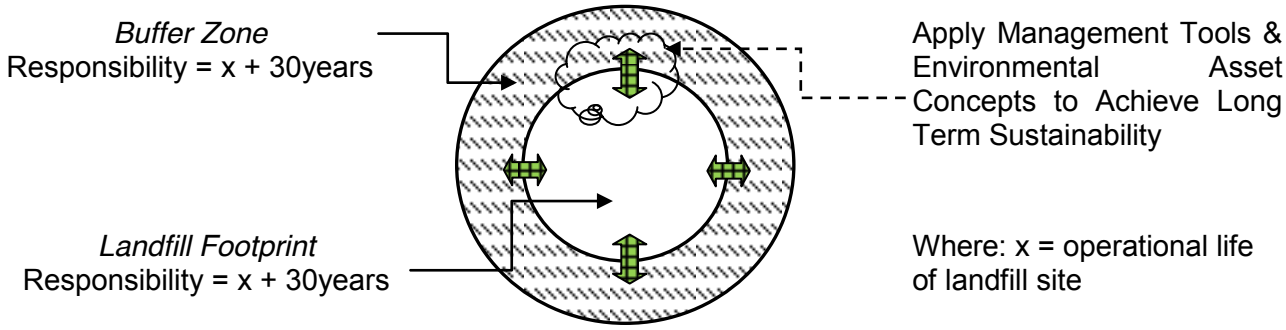

Figure 1: The conceptual mindset of the interface between the landfill footprint and buffer zone

As depicted in figure 1 above, the required duration of responsibility by any permitted landfill operator is given by the operational life (x) years of the landfill plus a 30years after care period. In general a minimum value of x is usually in the order of 20years and as a result the corresponding minimum duration of responsibility is some 50years and varies up 70years which is a lifetime commitment. It is further noted that x is also a function of the available airspace but more importantly with the drive seen in the industry for waste minimisation, recycling etc, would directly increase the duration of responsibility. The reality is that there is some 50~70years responsibility and the mindset change adopted by the Department of Cleansing & Solid Waste – DSW was to accept the long term commitment and apply simple management tools and environmental asset concepts to turn what as previously seen as negatives into positives for a self sustaining system in the long term.

The Legislative Framework

South Africa has compiled a strong legal framework to ensure that all development is biophysically, socially and economically sustainable (Diederichs and Van Nierick, 2009). A legislative management tool in achieving this is the national Environmental Impact Assessment (EIA) Regulations which provide different activities that are known to have a negative effect on the receiving environment if not managed properly. The role of the EIA is to access if the activity can avoid against such detrimental impacts. The EIA is also used to satisfy the constitutional rights as all South African citizens have a right to live in protected environment which is free from harm to human health (DWAF, 2005). The process evaluates both positive and negative impacts which are presented to environmental decision makers regarding the developments sustainability and resulting acceptability or not. The establishment of the Mariannhill and Buffelsdraai Landfill Sites having been subjected to the full scrutiny of the EIA process ensured some 10years "interface" with all registered interested and affected parties and the natural progress thereafter with the EIA approval followed by the issue of the Record of Decision (ROD) by the Department of Agriculture & Environmental Affairs (DAEA) and lastly the operating permit for the landfill (now referred to as waste management facilities).

From this, an Environmental Management Plan (EMP) was compiled using the generic eThekwini's EMP with added peculiarities which were unique to the system and situation. Generally the EIA will investigate the science of the EMP and final compilation will be done by the landfill site's Monitoring Committee. It must be noted that this process is not a fresh/new process as in general the MC is represented by the same interested and affected parties that were registered with the initial EIA process. At the first meeting of the MC, the EMP was expanded and the baseline Terms of Reference (TOR) for the management of the sites was compiled. The most important part of this process is that the EMP and TOR are *living documents* and can be added to improve on the sites management which generally includes for all processes that the buffer zone could help in cementing the above mentioned compliance issues. The Plant and Engineering team that represented the operator on the MC created the vision which was later realised by all on the representatives to move into a conservancy committee.

The understanding is that there could be pressure from external factors to influence the decisions of the buffer zone and emphasis must be placed on attracting the "correct culture" of partners that would work together in achieving long term management goals with adding value. The buffer zone must be deemed as an environmental asset that attracts positive working relations and possible partners. This process had initially started with good intentions and been able to move with the changing times (PRUnit, Rehabilitation, Clean Development Mechanisms, climate change etc).The sooner the management starts, the quicker the onset of the interface.

Waste Management License holders for landfills should ideally own the land within the buffer zone and if not already owned, seek to purchase that land in the near future, or have binding agreements where by the adjoining landowner will not use the land for sensitive land uses within an agreed timeframe. It is from the eThekwini experience, that should the buffer zone not be owned by the license holder then there is too large a risk that any management/investment in this area will have long term sustainability and benefits cannot be enjoyed. As a result, both the buffer zones of the Mariannhill and Buffelsdraai Landfill Sites are owned by the eThekwini Municipality which has ensured controlling interest for long term benefits.

MANAGEMENT TOOLS AND INTERPRETATION

Landfill engineering should factor in selected environmental management tools which are fundamental for environmental acceptance. Such tools may incorporate the use of simple cost effect yet durable tools/systems that form some component of the landfill. The following management tools were identified by the Department of Cleansing & Solid Waste - DSW:

- Rescue and Relocation (Flora & Fauna): All flora and fauna found on the footprint would naturally occur in the buffer zone should be relocated directly to its new long term home in the buffer zone. Emphasis must be placed on moving everything once if possible to guarantee the lowest carbon footprint with minimal disturbance ecologically.
- Rehabilitation Nursery Process: Should plants/flora not be able to be moved once, then a nursery process must be utilized. Specialised hardened off species can thereafter be utilized for rehabilitation of the buffer zone.
- Endemic Indigenous: By definition, all seed sources must be collected with a 50 kilometer zone for international auditing purposes. The DSW approach only uses seed source from its own landfill sites and therefore has always been compliant – As a result there has been no need to change any nursery processes to fulfill the international standard.
- Screening for Aesthetic and Visual: Most ROD's have such a requirement and therefore this rehabilitation/screening process automatically assists in fulfilling the ROD.
- Vegetation for Odour Movement: All landfills have associated odour problems i.e. migration of landfill gas would normally move down the valleys and these drainage lines are rehabilitated as

a priority in all biodiversity management processes. Drainage lines are 32m on both sides (NEMA) and therefore erosion control, leachate movement, gas migration and wind scatter can be mitigated by this rehab approach. Scented species can be utilized for natural odour management e.g. *heteropexis Natalensis* (Natal Lavender).

- Wind breaks for Wind Scatter: Final screening from footprint moving outwards into the buffer zone area. It is a long term guarantee that the footprint does not interfere with the buffer zone but does not preclude internal scatter fences.
- Forestation for Living Fire-Breaks: The mindset is to grow a green firebreak in the form of a forest which cannot burn – long term sustainability (developed within 10years) rather than cutting as conventionally done which is continually for the duration of the landfill commitment. As a result this application becomes sustainable with minimal efforts that are economically viable.
- Closure Rehabilitation: Should the landfill footprint be surrounded by a viable endemic indigenous seed source, would imply that the long term footprint rehabilitation will be enhanced and cost effective. This would ensure enhancement of the buffer zone (best practice in the buffer zone) which would work towards achieving best practice after closure of the footprint.

ENVIRONMENTAL ASSET CONCEPT

All environmental processes associated with the buffer zone must be deemed as an asset to start out with the correct mindset. The following environmental asset concepts were identified and implemented by the Department of Cleansing & Solid Waste - DSW:

- Rescue and Relocate: All fauna within the footprint and buffer zone must be deemed as an asset in creating management tools for the asset. This is seen as an economical viable solution as the only costs attached are labour and time and no external capital costs for the fauna.
    - ✓ *An example of implementation at the Mariannhill Landfill Site is the Boma fire protection i.e. requirement from eThekwini Fire Department which was created using relocation plants/trees from the footprint.*
    - ✓ *All the initial ROD screening for the Osidiswini Hospital was rescued from the Buffelsdraai Landfill entrance road.*

- Seed Source: All endemic indigenous species seed sources must be collected irrespective if the plant/tree cannot be relocated for future use and for fulfilling the requirement off the 50 km zone. Some seeds are propagated directed into the PRUnit process whilst others are stored for future use therefore avoiding purchasing costs and increasing the biodiversity potential.
    - ✓ *Seed sources collected from both the Mariannhill and Buffelsdraai Landfill Sites are not only planted on the sites but also used in rehabilitating inherited "old dumps".*
    - ✓ *The initial seed source and grown on trees for the Reforestation Tree-Preneur process at Buffelsdraai Landfill Site in collaboration with the eThekwini Environmental Planning and Climate Protection Branch, were provided through the PRUnit process. It should be noted that this process provided the opportunity to "kick-start" this process i.e. some 20 000 trees were utilized which saved an 18month lead up time.*

- Topsoil: Where possible this should be utilized for instant rehabilitation – forest base to forest, grassland to grassland. If this is not possible, then it can be used in the nursery mix for potting etc and never be stored in excess of 2m in height so as not to destroy its existing seed source within the stockpile.
    - ✓ *Mariannhill Landfill Conservancy (MLC) red data species grassland was created simply by spreading grassland topsoil some 300mm thick and then doing alien plant control until a high quality grassland was re-established.*

- ✓ *Buffelsdraai Landfill's buffer zone planting and the sites road verges were done using rescued topsoil.*

- Rocks: Rocks salvaged from civil works and blasting can be utilized for road edge protection and creating habitats on the buffer zone interface with the footprint for long term management tools for beneficial wildlife species. Too lessen the potential of rodent increase in this area, snake population should have somewhere to thrive and the habitats created from the rock stockpiles will guarantee a balance in the ecosystem. Further uses could be for landscaping of site entrances, protection of manholes and erosion protection.
  - ✓ *MLC has a natural rock stockpile between the community and the landfill to lessen rodent migration.*
  - ✓ *Electron Road Transfer Station Facility has already had its rocks designated for landscaping set aside at Mariannhill Landfill from blasted rock of Cell 4 Phase 3.*
  - ✓ *The rock in the buffer zone disturbed by the sugar cane farmer has been reinstated to create the same original habitat for rodent control and other habitats. This was placed by the local community under the DSW team's guidance.*

- Groundwater: By enhancing the habitat around the riverrine sections of the buffer zone, there will be an automatic enhancement of the water quality i.e. through filtration, absorption and transpiration. This is not only relevant to the landfill in the footprint in the long term but also for upgrading the original buffer zone use which probably would have had contaminants from "old school" agriculture.
  - ✓ *Buffelsdraai Landfill had been heavily farmed for sugarcane in excess of 60 years and therefore the residues of the fertilizer, herbicides, insecticides and ripening agents all had to be dealt with as they slowly leach into the sites groundwater system. A minimum requirement is the 64m drainage line enhancement and temporary process of plugged all old sugarcane from footprint area into drainage lines had an immediate polishing solution with natural reeds for any initial run off before leachate system was in place.*
  - ✓ *MLC: An upstream man made silt trap and reedbead was created in 2001/2002 for initial desilting and polishing and in 2011 a set of gabion baskets/organic filter have been placed downstream.*

- Leachate: Treated leachate from the site can be utilized for rehabilitation in the footprint but the buffer zone interface is always available for initially for rehabilitation and therefore the fire breaks can be irrigated using this long before final foot rehabilitation.
  - ✓ *MLC: Treated leachate has been used in rehabilitation the buffer zone below the leachate treatment plant and for Boma firebreak.*
  - ✓ *Buffelsdraai Landfill: Treated leachate has been used for dust suppression and for watering the screening plants along the road in the buffer and for irrigation on local community boundaries.*

- Landfill Gas: By nature any landfill gas is heavier than air and as a result migrates down valley lines making the buffer zone drainage lines habitat upgrade even more important. Included in these plantings must be scented plants to assist in odour control and these plants/trees will break up odour plumes before reaching neighbouring communities.
  - ✓ *MLC: Retaining and upgrading forests in the closest community areas on the sites eastern boundary. This is mutually beneficial in also assisting with wind scatter on the landfill. Due to the close proximity of the community the site has an active odour control management system which will probably not be needed at Buffelsdraai as a result of a larger buffer zone.*
  - ✓ *Buffelsdraai Landfill: The reforestration project has focused initially on riverrine areas and therefore minimizes the potential for gas migration.*

- Green Waste: Green waste treatment (mechanically or biologically) will provide end uses within the landfill such as mulching final side slopes, soil amelioration for better rehabilitation and compost for the nursery process. The nursery has provided plants/trees for the buffer zone whilst the mulch is utilized for the understory enhancement of the forest which hasl positively impacted on the biodiversity process.
    - ✓ *MLC: PRUnit nursery has utilized compost for its bagging process and the mulch was used for the creation of PEAT in the upper wetland. This enhances water retention, polishing ability and improves plant growth in a short space of time making the wetland able to fulfill its objective quicker.*
    - ✓ *Buffelsdraai Landfill: All eradicated alien plants are left insitu within the buffer zone to enhance plant growth whilst all seed heads are removed.*

SECURING SPECIAL LONG TERM PROCESSES / RELATIONSHIPS

If best practice is applied to the buffer zone and its interface with the landfill footprint, then opportunities are created for securing long term relationships with various stakeholders of good standing.

- *Biocontrol agents* released on the site which are tested (7years) insect's specific to the degradation of an alien plant in an area which is supplied by the Department of Agriculture only to areas with a long term management plan for the site. These processes demand long term commitment from the site owner/operator who will gain major benefit if best practice is implemented in relationship to the buffer zone. Table 1 below illustrates the biocontrol release at the MLC. This process commenced in 2003/2004 and has shown initial succession and conclusive results will be forthcoming – normally a 10~12 year process. In the interim the MLC has entomological tours when there are local conferences.

Table 1: Biocontrol Release at the Mariannhill Landfill Conservancy, (ARC, 2011)

Weed	Degree of Control*	Biocontrol Agents	Year of Release	Estab-lished	Main Feeding Guild	Damage to weed*
RELEASED IN MARAINNHILL CONSERVANCY IN 2004:	? Science in Progress	*Calycomyza eupatorivora* (Agromyzidae)	2003	Yes	Leaf miner	Moderate
Chromolaena odorata (triffid weed/ paraffienbos)		*Pareuchaetes aurata aurata* (Arctiidae)	1990	No	Leaf chewer	-
		Pareuchaetes insulata (Arctiidae)	1998	Yes	Leaf chewer	Considerable
		Pareuchaetes pseudoinsulata (Arctiidae)	2001	No	Leaf chewer	-

- Red Data Species/Specialised Habitats: Once habitats are be created that the scientific authorities accept as viable for release of endangered species, and then higher authorities such the

International Union of conservation (IUCN) will favour the project as all red data species come with a full international protocol.

- ✓ *MLC has the black headed dwarf chameleon* (*Bradypodion melanocephalum) has been relocated to the grassland surrounding the upper wetland in the buffer zone. The science before and after has been completed and the relocation has been deemed to be highly successful as the population has increased from the original 15 to 47 at the last count. Table 2 below shows the initial release of the 15 black headed dwarf chameleon at the MLC.*

Table 2: Black Headed Dwarf Chameleon Release at the Mariannhill Landfill Conservancy

Black-Headed Dwarf Chameleon rescue/relocation - Hilltop Housing development								
Observation date: 11, 18, July 2007 - Elevation: 75 m ASL								
Weather conditions on the above date: warm, cloudy, moderate East, drizzle								
No.	**Species**	**Male**	**Female**	**Adult**	**Sub-adult**	**WP1 S**	**WP2 E**	**Location**
1	Black-headed				X	29°52.863'	30°57.200'	on *Chromolaena*
2	Black-headed	X		X		29°52.863'	30°57.200'	on *Chromolaena*
3	Black-headed	X		X		29°52.856'	30°57.198'	Turpentine grass
4	Black-headed		X	X		29°52.858'	30°57.203'	Turpentine grass
5	Black-headed	X			X	29°52.858'	30°57.203'	Turpentine grass
6	Black-headed		X	X		29°52.850'	30°57.199'	on *Chromolaena*
7	Black-headed		X	X		29°52.856'	30°57.205'	on *Chromolaena*
8	Black-headed		X	X		29°52.863'	30°57.198'	on creeper
9	Black-headed				X	29°52.863'	30°57.198'	on creeper
10	Black-headed	X			X	29°52.850'	30°57.197'	on creeper
11	Black-headed				X	29°52.850'	30°57.194'	on creeper
12	Black-headed		X	X		29°52.851'	30°57.191'	on creeper
13	Black-headed				X	29°52.852'	30°57.198'	on creeper
14	Black-headed				X	29°52.852'	30°57.198'	on creeper
15	Black-headed		X		X	29°52.852'	30°57.184'	on creeper
		Release co-ordinate				**29°58.749'**	**30°57.951'**	**Mariannhill Conservancy**

By enticing red data relocation onto the site, one would find a new set of allies to concur future pressures on the buffer zone such as land invasion or an EIA for a pipeline (refer to Petronet pipeline on buffer zone – IUCN and KZN Ezemvelo Wildlife assisted in preventing this process from moving forward.

- Reforestation/Tree-Preneur: Is a process to add value to the management process and satisfy the needs of the ROD, EMP and TOR for the site. The process is basically PRUnit being implemented via the surrounding local community and therefore major job creation can be realized without been included in the landfill footprint which demands high skills and safety levels. The project also addresses social upliftment issues through upgrading and maintaining the sites buffer zones with the potential to expedite the rehabilitation for probable "nature reserve status".

  This also leads to the direction of Carbon Sinks, Clean Development Mechanisms (CDM) and Climate Change processes for the future and the DSW teams are always striving to develop a "green lung" from the landfill footprint and buffer zone interface.

CONCULSIONS

There have been limited South African experiences on the tools and conceptual models that can be used on landfills to ensure good practice and sustainable long term buffer zones. The practical examples and preliminary data presented in this paper underline the unique yet simple management tools and environmental management concepts that can be successfully integrated into any landfill facility. The progress made thus far at the Mariannhill and Buffelsdraai Landfills Site has shown that landfill operators/owners need not be apprehensive of management required for landfill buffer zone but instead adopt a change in mindset by creating a beneficial link between the landfills footprint and buffer zone. The much talked about "interface" is merely ensuring the buffer zone can be an asset for the landfill footprint whereby the rehabilitation process would start from buffer zone moving internally towards the footprint i.e. self seeding potential, processes through reforestation, habitat systems etc will ensure restoration of the footprint to natural environment will minimal efforts in the long term. It is recommended that the implementation of environmental asset concepts highlighted in this paper should only be done provided the buffer zones owned by the landfill operator as this guarantees control and vested interest for long term sustainability. Further detailed information on any particular aspect related to this paper can be reviewed on the following website: www.landfillconservancies.com

Plate 1: Release of Black Headed Dwarf Chameleon into the MLC

Plate 2: Rescue & Relocation of a Cussonia Spicata (Indigenous Tree) from footprint to buffer zone at Buffelsdraai Landfill Site

Plate 3: Community Reforestation Project of Buffelsdraai Landfills Buffer Zone

Plate 4: Rhino Award received at the MLC from Ezemvelo KZN Wildlife (2009/2010)

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