Christmas Island Waste Management System – Phase 2 Final Report 2011

A report submitted to the School of Engineering and Energy, Murdoch University in partial fulfillment of the requirements for the degree of Bachelor of Environmental Engineering

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Abstract

The Shire of Christmas Island have been in need of an applicable waste management strategy which would reduce the volume of waste entering the landfill and adhere to current environmental legislations. RAUM int. and Murdoch University were appointed to produce a complete waste management strategy. This was completed and produced in the form of a Phase 1 report. This was then submitted to the Shire of Christmas Island, who then reviewed it and decided to proceed onto Phase 2 of the project that was funded by the Federal Government, Australia. This funding will be used to remediate the existing landfill and to begin construction of the facilities. Further funding will have to be applied for during the next financial year to be able to complete the tip site.

Phase 2 of the project involved the development of an overall site plan of the Christmas Island Tip Site as well as the basic construction of structure within the tip site. The site plan would detail the locations, areas and requirements of each of the waste treatment technologies chosen. Phase 2 of the project began by first identifying the facilities which would be within the tip site. The footprints, utility requirements and volume reduction potential were then calculated and consolidated into five tables. These tables were brought to the Shire, along with a draft site layout, where discussions resulted in the alteration of certain facilities and the position of the landfill site.

The finalized set of tables and site layout was then produced in accordance with the constraints, which the shire provided. A total of twenty facilities have been planned to be in the tip site, however the Shire will have the final decision if they chose to proceed with all twenty facilities, a list of which can be found in Table 3.

Disclaimer

I declare the following to be my own work, unless otherwise referenced, as defined by the University’s policy on plagiarism.

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Thanks are extended to Kelvin Matthews, Colin Wheadon and David Nielsen of the Shire of Christmas Island, for allowing me this opportunity to work as an intern on phase 2 of implementing their waste management strategy.

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1 Introduction

Christmas Island is located north west of Western Australia in the Indian Ocean approximately 2300km away from Perth (Gray, 1995). The population of Christmas Island is approximately 3000. This is however subjected to fluctuations with the arrival of boat people and according to the government decisions on the detention center.

The Shire of Christmas Island is in need of an applicable waste management strategy, which will reduce the volume of waste currently entering the landfill site and adhere to current environmental legislation. Activities taking place at the current landfill site do not strictly follow up-to-date environmental policy and recommendations. The state of their waste management system has encouraged the Shire to pursue an innovative waste management strategy to address the current waste management problems (Tan et al, 2011).

RAUM International and Murdoch University were appointed to deliver an innovative complete waste management strategy for the island. The unique social set up, geographical location as well as the crude waste disposal activities of the Island was considered to develop a sustainable and environmentally safe solid waste management plan for the Island.

Taking all these factors into consideration, the team came up with a recommended waste management plan, and the Phase 1 report was submitted to the Shire of Christmas Island for further action. The Shire then approved the recommended waste management strategy and Phase 2 of the project was started. Phase 2 entailed the design of the overall tip site, a detailed list of the needed facilities and lastly the remediation and preparation of the current landfill site. An intern, myself, was tasked to develop the site plan of the tip site, along with the detailed list of facilities that would be located within the tip site, unfortunately the remediation and preparation of the current landfill site will only take place in the year 2012 and cannot be part of this internship. This report will examine the results of phase 2 of the project.

1.1 Literature Review

Various reports were produced in relation to waste management on Christmas Island. Three such reports are shown below, the most important however is the Phase 1 reports.

1. *Christmas Island Waste Management Strategy*, May 2011, by Justin Tan, Brenten Wellington, Daniel Marsh, Albert Yip and Benjamin Ho.

This document was the Phase 1 Report for the proposed Christmas Island Waste Management Strategy. It has provided me with information regarding the chosen waste management technologies, which are essential to Phase 2 of the project. This document was written in 2011 on behalf of the Shire of Christmas Island and as an assessable component of ENG 428.

2. *Christmas Island Waste Management Strategy Funding Submission for Stage II – Landfill Construction and Waste Minimization Plans,* April 2000, by L.K.Reed Pty Ltd.

The report prepared by L.K.Reed Pty Ltd is documentation to support the Shire of Christmas Island's application to the Australian Federal Government for funds to implement and operate Christmas Island's Waste Management System. A lined landfill was agreed however approval was not granted. The report outlines the environmental, legislative and licensing authority requirements that are needed for the landfill site. The report includes letters and application forms to the various departments for approval. A budget is outlined to aid in the application for funds. The report quotes the previous report prepared by the Eastern Metropolitan Regional Council and states the proposed new waste management system as necessary for the future of Christmas Island.

3. *Christmas Island Waste Management*, July 2000, by Gutteridge, Haskins & Davey (GHD) Pty Ltd

The aim of the GHD report is to identify suitable waste management strategies for Christmas Island that are cost effective and satisfy all environmental, regulatory and operational requirements. The report reviewed the current landfill site and outlined the possible solutions to the waste management problem. The report concluded that the proper closure of the current landfill site is a must, followed by the correct siting and construction of a new lined landfill site. This will protect the underground water and environment from harmful leachate. The report suggested potential in in-vessel composting and an interim landfill site while the new landfill site is being built.

Other reports include

- *Solid Waste Management Plan (including budget estimates)* (November 1997) by Eastern Metropolitan Regional Council.
- *Waste Minimization Strategies Christmas Island* (December 1994) by Unimelb Limited.
- *Christmas Island Preliminary Waste management and Pollution Control Study* (January 1992) by Australian Construction Services.

1.2 Objective

A detailed site development plan is to be made up detailing the locations, areas and requirements for organic waste treatment systems such as food waste treatment, in-vessel composting, recyclable material recovery facilities (MRF), community waste acceptance facilities, bulk waste management facilities, the landfill and the overall site management plan, using engineering techniques and risk management plan. This will include necessary illustrations, modeling, specifications and calculations if required. The overall implementation of this waste management system has been estimated at 5 million Australian Dollars. Details of the objectives that have been set by shire for both the tip site and the internship can be found in Table 1. These objectives were written after communications with the shire to realize their desired outcomes of this internship and of the tip site.

Table 1: Table of objectives set by the Shire of Christmas Island

Objectives	Details
Total design of site	This will include a site plan detailing the locations of each of the facilities as well as signage, fencing, gates and other essential structures.
The construction process needs to be economically viable	Sourcing materials, equipment and labour that are available locally to save on importing cost. Researching innovative and cost saving ways of construction
Mitigate all existing problems with the site	The end outcome of the new waste management system facility is to overcome the drawbacks of the current waste disposal system at the current landfill site. And convert the site to a proper waste handling and treatment site.
Area of each facility and total site development area	Calculate the accurate area which each facility will need and hence the area of the total site including roads and buffer zones
Safety requirements of each facility	Research and consolidate the needed safety requirements for each facility
Utility requirements of each facility	Assessing the usage of water, electricity and gas for each facility.
Volume Reduction Capabilities of new facilities	The volume reduction capabilities of each facility will have to be calculated to effectively size the new landfill.
Odour control	Organic waste handling and treatment facilities to be managed and located in such a way that odour

	issues are not raised.
“Ease of use” for the community	Organise the community waste disposal areas with easy access and proper signage that they are able to enter to transfer their bulk rubbish. Make the transferring process a safe and easy one.
Clear signage to direct community to correct areas	Clear signage, entrance and exits for the community so that they may enter the waste facility to transfer any bulk junk they may have in the correct allocated areas
Amount of manpower to manage each facility and total site	The amount of manpower needed to run each facility daily. If there are any allocated days which will require a greater amount of manpower.
The type and amount of training required for any specialized task	Decide the amount of training that is needed for employees that are operating any specialized equipment. If there is a need to fly in specialized skilled workers for the operation of any equipment.
Facilitate continued chalk mining	Council has informed that there is a need to extract chalk from the site for various purposes on the island.
Water and wastewater management with Continued monitoring of groundwater	Investigate the water requirement, sources of water, wastewater treatment system required. Regular monitoring of the existing bore.
New tip site to be further away from road	New tip-site will be constructed further away from the road due to plan housing development opposite the current tip site.

1.3 Constraints

The Shire will face certain constraints when implementing a new waste management strategy. These are shown in Table 2.

Table 2: Table of constraints faced on Christmas Island

Constraints	Description
Monetary	Funding obtained from the Federal Government for Phase 2
Remoteness	Christmas Island being as remote as it is may have financial, technical and resource difficulties.
Human Resource/Labour	Need skilled personal to construct and operate the proposed systems. Workers will need to be trained by skilled personal. Number of employees required operating the system will need to be considered.
Technical Skill	Training program needs to be provided to staff and workers to correctly operate the systems in an efficient, productive and safe manner.
Machine Availability	Currently machines are limited on CI. Right equipment has to be purchased/imported to start the development program
Environmental Protection Act 1986 (WA)(CI)	The Waste Management Systems will need to conform to the Environmental Protection act of 1986 that has been set

	out for Christmas Island.
Department of Water	Design needs to factor in that the drinking water supply and bore/rain water is made available. There needs to be a groundwater protection strategy in-place in accordance to the Australia Drinking Water Guidelines 2004.
Department of Health	The Operation process of the facilities should not be detrimental to the public health. Health Act 1911
Community willingness	Community participation and acceptance of the waste management system is vital, with different socio-economic and ethnic backgrounds that need to be considered. Community education and support need to be developed
Climate	The climate at Christmas Island is tropical. There is high monsoonal rainfall, hot and humid temperatures all year round. The system needs to be designed to effectively operate in such conditions.

1.4 Approach

Once Phase 1 of the project was completed and reviewed, the Shire agreed on starting phase 2 with an intern from the original team, myself, contracted to work on it. Phase 2 started by first identifying the facilities that are to be located within the tip site. Facilities were identified using previous information from phase 1 as well as input from the Shire of Christmas Island and RAUM int. Once all facilities had been identified, the process that would be occurring within each facility, power requirements, area requirements and waste volume reduction potential were calculated and consolidated into a set of easy to understand tables. The process of

forming these sets of tables was done with constant communication with the shire to ensure their approval. The next step was to draft a sketch of the tip-site including the locations of all the facilities, signage and fencing. This draft was brought to the shire during a site visit in October 2011. The feedback that they provided was then used to draft the final overall tip site layout.

1.5 Assumptions

- Population of Christmas Island is to be stable at approximately 5000.
- Shire of Christmas Island will be able to obtain enough funding to complete all recommended construction and operation
- Local community will embrace new waste management strategy.
- All data taken from phase 1 report is accurate and correct.
- Shire of Christmas Island will agree and implement all facilities suggested for the tip site.

2 Considerations

Environmental, Social and Economical consideration must be taken into account when designing the tip site layout and the facilities locations and facilities chosen, as these will have an effect on the final decision made.

2.1 Environmental

Physical – The planned tip site is situated at a high point on Christmas Island. This poses a threat to the island drinking water supply, as their main potable source of water is ground water. Preventions must be taken to ensure the protection of their groundwater resource. . However it was informed that tip site being at a highest point on the island, the groundwater table is at several meters below ground level.

The remoteness of Christmas Island will restrict the availability of machinery on the island. This is not helped by the freight cost of shipping any needed equipment or materials onto the island.

Climate – Christmas Island is located in a humid, tropical climate all year round, with an abundant amount of rainfall. This causes organic waste to decompose quickly and to prevent odour issue, organic waste must be dealt with frequently. Adequate drainage must be installed to prevent the flooding of constructed areas.

Waste Generation – Waste is generated from several locations

- North West Point Detention Center
- Phosphate Hill Detention Center
- Residential and commercial areas of Poon Saan, Silver City, Drumsite, Settlement and Kampong.
- Mining operations
- National Parks Operations

2.2 Social

Population – Currently the total population of Christmas Island is approximately 3000. The population of Christmas Island is largely variable due to the nature of the detention centers. The tip site, facilities and scale of technologies chosen must be able to handle an increase or decrease in the amount of waste produced.

Labor – the availability of labor must be considered in the design of the tip site, it should allow the running of the tip site with minimum work force.

Community – The new waste management strategy relies heavily on the support of the community. The design of the waste transfer station is done to allow the community to enter to dump their waste. The correct placement of signage and fences will help to provide “ease of use” to the community and uphold occupation and health laws.

2.3 Economical

Budget –Funding is exclusively from the Federal Government, and because the Island lack essential machineries to develop the site and construct the facilities, funding is sought in two phases which will be utilized in Phase 2 and Phase 3. Based on that the shire is restricted to what it is able to construct. The tip site design must prove to be both effective and economically viable for the shire.

Labor – As labor cost on the island is high, effective running of the tip site should be done with a minimal workforce.

3 Regulation

The new tip site must conform to environmental and building regulations, which has been set out by the governing body.

3.1 Environmental Regulation

Christmas Island has a unique and sensitive biodiversity that will be impacted if the tip site acts to be detrimental to its surroundings. Current waste management techniques are proving to be not sustainable and due to improper documented, proven hard to manage any potential environmental risk (GHD, 2000). In order to prevent any further environmental risk, all aspects of the tip site design should conform to the Environmental Protection Act 1986 (WA)(CI). This act aims to protect the environment on Christmas Island through the observation of five principles, precautionary, intergenerational equality, conservation of biological diversity and ecological integrity, incentive mechanisms and finally waste minimization. This document provides guidelines as to the role of an Environmental Protection Authority, in this case the shire, lists environmental protection policies, environmental

impact assessments procedure, environmental regulation and enforcement. These guidelines will be used to govern any potential effects that the tip site might have on the environment. Ongoing monitoring will need to be implemented to signal if any characteristics of the tip site are proving to have an environmental, this is in accordance to AS/NZS ISO 14001, environmental management systems. Such procedures should monitor the environmental impacts of both the construction and operation of the tip site.

3.2 Building Regulation

Work approvals will need to be acquired from the shire, before the beginning of the construction of any structures. This is to ensure that the process of construction of the tip site will not have a negative effect on the environment.

Structures that are to be built must conform to the Building Code of Australia to ensure the quality of the work as well as the safety of the building occupants. A guide to the Building Code of Australia is provided in appendix B.

3.3 Health Regulation

In accordance to Section 26 of the Health Act 1911 (WA)(CI) the shire is required to administer the Act, its regulations and local laws within Christmas Island to aid in the reduction in the spread of diseases and the continued maintenance of a safe and healthy population. All elements of the tip-site should act to uphold the laws and regulations that have been set out in Section 26 of the Health Act 1911.

4 Phase 1

Phase 1 of the project involve the planning of a suitable waste management strategy that is cost effective and satisfies all environmental, regulatory and operational requirements. This phase of the project focused mainly on deciding on waste management technologies, collection method and the education of the community.

Four main waste management technologies resulted from phase 1, this are thermal enzymatic treatment (food treatment technology), in-vessel composting, material recovery facility and a lined landfill. This treatment options were deemed to be the most suitable for Christmas Island. A copy of the Phase 1 report can be found in Appendix A

Current waste collection methods were deemed to be unsustainable, as a result new methods have been suggested in phase 1. The biggest change will be to implement a two-bin system, one organic waste and one recyclables (Tan et all, 2011).

Education has also been found, in phase 1, to play an important role in the successful implementation of the waste management system. Education will help the community to understand the importance of source separation and source reduction of waste (Tan et all, 2011).

4.1 Phase 1 Adjustments

A few major changes have been made to the suggested phase 1 waste management strategy due to changing circumstances and the limited budget.

The scale of the food waste treatment unit and in-vessel composting systems has been reduced due to the reduction in the currently population size, from approximately 5000 to 3000. The uncertainty in the future growth of the island has opened the options for an expandable food waste treatment system. This will involve the use of smaller systems depending on the population size and further addition to meet any growing need.

A lined landfill has also been deemed to be uneconomical, as mostly inert waste will be entering the landfill, due to the implementation of waste recovering technologies. Instead an unlined, inert landfill shall be constructed to reduce the cost of the tip site development and allow resources to be diverted elsewhere. The inert landfill will be coupled with the planned monitoring of groundwater bores that will act to help protect the islands groundwater resource.

Signed waste cards upon entry into Christmas Island, at the immigration checkpoint, have been suggested to the shire to help the prevention of unnecessary waste.

5 Facilities

The process of selecting the facilities that are to be located within the tip site was done by taking into account the considerations listed in section 2 and frequent consultations with the shire. The result of this was a table of facilities that detailed the facilities required, proposed workforce, quantity of waste handled, type of facility utilities required and the safety requirements of each facility (as shown in Table 3). Each facility has been given a facility number, in blue, which will be used as a general reference to that facility.

Table 3: Facilities description for the waste management at the tip site

Facility Number	Facilities Needed	Details	Proposed Man hours / Number of Workers	Quantity Waste Handled	Type of Facility	Utilities	Safety	Comments
1	Weigh Bridge	Weight bridge located at the gate of the site next to the main office.	8 Hours 1 Staff For managing both main office and weigh bridge	N/A	Located next to the main office, in an open area on compacted soil.	Electricity (3 Phase)		
2	Main Office	This shall be located near the main access gate and will monitor any trucks and visitors to the site		N/A	A undercover office facility Toilet/kitchenette	Water Electricity	Building must conform to the latest edition of the **Building Code Of Australia.**	
3	Food waste treatment facility	To treat bio-solids and the uncontaminated food waste	Total = 6 Hours Number of Workers = 2	2752 Kg/Day of organic waste	Undercover 'Shed Like' facility	Water	Building's build must conform to the latest	Quantity of waste will depend on the population of

				60 Kg/Day of dewatered Bio-solids Total Input = 2812 Kg/Day Expected Output = 30 - 70% of Input		Electricity (3 Phase Power)	edition of the **Building Code Of Australia.**	the Detention Centre and facility operated accordingly
4	Bio-Solids Facility	Current location in the tip could be developed as a proper drying bed	Total = 1 hour of the bobcat	60 Kg/Day of Bio-solids if the Water Corporation dewaters it.	Dewatering/drying facility should be a covered facility Dried sludge either taken to facility 3 or 5 for further processing	 Hard flooring with roof	All necessary safety precaution to be taken to minimize risk of exposure.	Depending on if bio-solids will be dewatered at the water corporation or at facility
5	In-Vessel Compostin g Facility	This Facility will deal with the contaminated organic waste stream, cardboard and green waste from the township	Total = 4 Hours Number of Workers = 2	1378 Kg/Day of contaminated food waste 870 Kg/Day of shredded Cardboard	Main Process of the facility will be undercover however the Holding and Transportation area will be open air with tarp	Water Electricity (3 Phase) Hard flooring	Building's build must conform to the latest edition of the **Building Code Of**	Area will be confirmed once the amount of waste is confirmed. The product

				190 Kg/Day of shredded or wood chipped Green waste (If needed) Total Input = 2248 Kg/Day Expected Output= 1348 Kg/Day	covering over the compost pile. (Depending on Location) Maturation Bay Bio-Filter unit if required	for equipment, cleaning and mixing	**Australia.**	from facility 3may also be an input in this process. Bio-Filter unit may not be needed – will be build if necessary after plant is open.
6	Maturation Bay and Storage Area	Facility used for the maturation process and storage of compost.	Total: 3 Hours Number of Workers: 1 (from the staff at the composting operation	Total Input: 1348 Kg/Day Total Output: 809 Kg/Day	Undercover Facility with aeration bays	Diesel Electricity	Building's build must conform to the latest edition of the **Building Code Of Australia.**	
7	Green Waste Shredding Area	Green waste shredding area in the waste transfer area	4 hours/week		Open area With wood chipper and cardboard shredding	Diesel		

8	Materials Recovery Facility	This facility deals with the recyclable materials that originate from the yellow top bins	Total = 4Hours/day Number of Workers = 3	792 Kg/Day Plastic Containers 151 Kg/Day Aluminium 67 Kg/Day Steel Cans 558 Kg/Day Glass 365 Kg/Day Plastic Films 132Kg/Day Milk Cartons 346 Kg/Day Textiles 73 Kg/Day Miscellaneous 27 Kg/Day Mixed Metal 312 Kg/Day Mixed Waste Total = 2824 Kg/Day of Recyclables Expected Output = 1568 Kg/Day of Recyclables	Located in an undercover facility Hand picking Or Conveyor Aluminium manual crushing Milk cartons, magazines etc to be baled	Water Electricity (3 Phase)	Building's build must conform to the latest edition of the **Building Code Of Australia.**	.

9	Material Processing facility and storage	Plastic/glass processing and storing	8 hours/week	Plastic shredding and bagging Glass crushing and bagging	Plastic crusher Glass crusher	Electricity (3 Phase)	Safety cage with locks to prevent mishandling	
10	Bulk Storage Area	Storage area for bulk processed recyclables		Storage area for shredded plastic, crushed glass, crushed cans and baled cardboard awaiting processing	Shaded facility	Electricity		
11	Emergency shower/ eye wash	Close to the waste processing area				Mains water supply		
12	Inert Landfill	This landfill will receive any of the waste that was unable to be recovered	Total = 2 Hours of Bobcat Number of Workers = 1	800Kg/Day Mixed and non-recoverable materials	Big open pit, Unlined landfill	Bobcat access facility for occasional covering	Public access prohibited	Size of landfill to be confirmed.

13	Renewable Energy System	This will help to offset the increased energy use due to the implementation of the new facilities	N/A	N/A		Electricity		Solar panels or diesel generator may be investigated.
14	Tyres Transfer Area	Tyres collected at the public transfer station Where public will be able to drop off tyres.	N/A		Open area			Tyres collected will be used on the island as road barriers, steps and other applications.
15	Electronic Equipment Transfer Area	Transfer area for public to dispose or their electronic waste. Shire will then process and dispose/ store this waste	N/A		Open area			Ideally be compacted and shipped of the Island
16	Bulk Metal Transfer Area	Collection area for bulk metal items such as car bodies. Will be located near a compacter	N/A		Open area			

		Public will be able to drop bulk metal items for processing in this area						
17	Hazardous Material Transfer Area	Transfer area for hazardous materials such as asbestos, paint, oils and batteries. There will be an undercover area for battery storage	Important to empty battery liquid Process to manage paint and oils to be established		Mainly open area with a small shed or a shipping container			
18	Tip shop (free)	The tip shop will sell/give away recovered materials from the process	Open one or two days or as per prior notification Number of Workers = 1 (Can be run by employees in the main office)		Undercover building Will receive materials or useable furniture/electronics from the community and the MRF	Water Electricity	Building's build must conform to the latest edition of the **Building Code Of Australia.**	All furniture, electrical goods and materials to be inspected before it can be put into the tip shop

19	Machinery Washing and Storage Area	Designated area where trucks and machinery can be washed by use of a high-pressure hose and stored.	None	Water channelled to the same drain as other facilities cleaning drainage. Wastewater treatment and recycling facility	Open Area with solid foundation	Water Electricity		
20	Landfill Transfer Area	Allocated Area where items that is to be landfilled can first be collected.	N/A		Open Area			
N/A	Waste Water & Drainage	Proper and adequate drainage and filtration systems must be put into place.		N/A	All hard flooring /cleaning surface with runoff drainage, grease and dirt collection traps, water treated onsite through wetlands		N/A	
N/A	Water	All roofs should have water collection facility to collect rainwater for cleaning and					Water	

		process usage. Bore-water to meet the additional requirements as flushing etc. Mains water for drinking. Eyewash/ shower						
N/A	Fencing and Gate	Is required prevent illegal dumping, feral animals and wind blown waste and for restricting access	N/A	N/A	N/A	Fencing using recovered materials	N/A	
N/A	Electricity Supply	Required to power facilities and equipment Electricity to be provided by the Christmas Island Power Authority	N/A	N/A	N/A	Christmas Island Power Plant	N/A	
N/A	Signage	Clearly visible Signs to help direct traffic	N/A	N/A	N/A	Open area	N/A	

Note: The Population of Christmas Island is largely dependent on the number of refugees on the island. This will affect the amount of waste that is entering the landfill site.

Total manpower required to run tip site.

1 Gatekeeper managing Facilities 1, 2, and 18
3 workers for managing organic waste facilities 3, 4, 5
1 bobcat operator for the whole site

5.1 Processes

The treatment /operation process of each facility is different and have been consolidated into a table to foresee the activities undertaken in each facility (shown in Table 4).

Table 4: Table of processes undertaken in the facilities within tip site

Facility	Process	Step Process
1	Weigh Bridge	• Trucks entering will stop on the weighbridge • Truck driver will exit the truck and meet the gatekeeper • Truck drivers will then fill out an entry document listing the weight, type of waste and date • Gatekeeper shall then take the form and compile the data onto an excel document
2	Main Office	• Toilet, Kitchen and Office Areas • Data entry onto a set excel spread sheet • Information counter for the public
3	Food waste treatment	• Food waste transferred from bins to conveyor system • Waste enters input device where it is shredded • Waste pumped to treatment tank • Bio-solids may also be added to treatment tank • Product is mixed with enzymes and heated • After 3-8 hours end product is collected and brought to In-vessel composting facility in provided trays • Process area is then cleaned
4	Bio-Solids Dewatering process	• Bio-Solid Dewatering System or drying bed to reduce the moisture level to 80- 90% if required • Sludge treated in the composting facility or food waste treatment unit depending on the moisture content and treatment required.
5	In-vessel Composting Process	• Shredded cardboard, and shredded green waste if needed, is layered in a $3m^3$ bin along with contaminated organic waste • Contents of bin will then be transferred onto a feed hopper/Mixer • Waste will then be fed onto an enclosed conveyor system, which brings the waste to the composting unit.
6	Maturation Bay and Storage	• Product from In-Vessel Composting process will be mixed with the end-product from facility 3 • Product will then be transported into the undercover maturation bay and left for approximately 2 months.

		• Once matured, compost screened using a trommel to remove contaminants and larger particles • Compost will then be moved to a storage area
7	Green Waste Shredding & Transfer Area	• Green waste brought to transfer area • Wood chipped or shredded then stored into piles for future use • May be used in the In-Vessel Composting process
8	Material Recovery Facility	• Recyclable waste tipped onto tipping floor • Bulk waste handpicked • Remaining waste pushed onto a conveyor system using a bobcat • Recyclables will be recovered through hand sorting into wheelly bins into individual categories (plastics etc) • Hand sorting towards the end to remove any missed recyclables • All remaining waste dumped into a landfill bin • Recyclable bins will then be brought to the Material Processing and Storage Facility
9	Material Processing and Storage Facility	• Plastics will be shredded into small size • Glass will be crushed into granules • Aluminium cans crushed to reduce volume • End product will be brought to the bulk storage facility
10	Bulk Storage Area	• End-product will be kept in this facility awaiting processing
11	Emergency Shower/ Eye wash	• Check if there is clean running water available • Check if all equipment is working well
12	Inert Landfill	• Waste to be landfilled will be brought to the landfill site and dumped into the open pit • A bulldozer will then compact the waste and cover it with a sufficient layer of top soil
13	Renewable Energy System	• Shall be put into place if required
14	Tyres Transfer Area	• Tires collected at the designated tip site transfer area from the public. • Tyres will then be used for road barriers, steps and other applications
15	Electronic Equipment Transfer Area	• Electronic goods shall be brought into the allocated area at the transfer station • It will then be processed for proper disposal or recycling. • Any working electronics will be checked and given to the Tip-Shop
16	Bulk Metal	• Bulk metal shall be brought to the transfer area

	Transfer Area	• It will then be compacted or crushed • Shipped off island or used on island
17	Hazardous Material Transfer Area	• Hazardous materials brought to the transfer area • Material then processed and stored in undercover area • Sorted into their categories (batteries etc) and pre-processing done as required • Await proper disposal
18	Tip Shop	• Bulk material and equipment checked for usability and brought to the tip shop • Those items can be sold or given back to the community through the tip shop
19	Machinery Wash & Storage Area	• High pressure cleaning for Trucks and equipment • Storage shed for trucks and equipment
20	Landfill Transfer Area	• All items that is to be landfilled will first be collected here

5.2 Volume Reduction

The volume reduction potential of each waste recovery technology has to be calculated in order to determine the amount of storage space and transport bins required at selected facilities. Volume reduction calculations were done for the food treatment facility, in-vessel composting facility, maturation bay and storage, material recovery facility, material processing and storage facility as well as the landfill (shown in Table 5). These calculations are based on the total daily input entering each facility, along with data from the waste audit and the reduction in waste due to the causes listed. This results in the final output of each facility, determines the number of bins needed to hold the processed waste can be calculated using the general rule of 150kg of waste/cubic meter (Tiger Waste).

As plastic containers, aluminum cans and glass bottles were calculated by weight during the waste audit in phase 1, calculation had to be done to determine the number of items in each category as well as its volume. Taking the average volume and weight of one plastic container, aluminum can or glass bottle found in Soraka's Fundamentals in Packing Technology, and by using the final output weight from table 5, we are able to calculate the number of items and volume (shown in Table 6).

Table 5: Table of volume calculations at selected facilities

Process	Facility Number	Total Input (Kg/Day)	Process	Volume Reduction	Cause	Final Volume Reduction	Output (Kg/Day)	Final Output (Kg/Day)	Bin Size needed	No. of Bins
Food waste treatment	3	2812	Thermal treatment	70%	Evaporation of Water	30%	844	1968 - 834.6		
In-Vessel Composting	5	2248	Composting Unit	40%	Biological treatment	60%	1349			
Maturation Bay and Storage	6	1348.8	Trommel Screening	40%	Screening of useless waste	60%	809	944		
Material Recovery Facility	8	2824					0	1470		
Plastic Containers		792	Sorting	10%		90%	713		3m^3	4
Aluminium Cans		151	Sorting	10%		90%	136		3m^3	2
Glass Bottles		558	Sorting	10%		90%	502		1m^3	1
Milk Cartons		132	Sorting	10%		90%	119		1m^3	1
Non-recoverable		1190		0%	To Landfill Bin	100%	1190		3m^3	3
Material Processing and Storage Facility		1469.7						270		
Plastic Containers		712.8	Shredding	90%	Shredding	10%	71		1m^3	1
Aluminium Cans		135.9	Compaction	80%	Compaction	20%	27		1m^3	1
Glass Bottles		502.2	Crushing	80%	Crushing	20%	100		1m^3	1
Milk Cartons		118.8	Shredding	40%	Shredding	60%	71		1m^3	1
Landfill - Beginning	12	5636	N/A	N/A	N/A		0	N/A	N/A	N/A
Landfill - (%)	12		N/A	N/A	N/A		0	N/A	N/A	N/A

Table 6: Reference table of calculations for table 5

	Average Volume (litres)	Average Weight (Kg)	Number of Containers	Total Volume (litres)	Cubic Meters
Plastic Container	0.65	0.04	17820	11583	11.6
Aluminium Cans	0.4	0.015	9245	3698	3.7
Glass Bottles	0.35	0.22	2283	799	0.8

5.3 Facility Footprints

Taking into consideration the equipment and handling area required, the footprint of each facility can be estimated. This area estimation is termed as the 'Total Needed' area in Table 7. The actual area to be constructed takes in to consideration the allowance of the needed area as well as a generous amount of additional area; this is termed as the 'Total Actual'. Included in Table 7 is the measurement of each facility in a 1:200 scale, this measurements are made in centimeters (shown in Table 7).

To calculate the size of the maturation bay needed for the maturation of compost in facility 6, compost density of $2m^3$/tonne (Hills-Group) and the average daily input of compost were used to calculate the necessary footprint required in maturing the average daily input of compost. These calculations are shown in Figure 1.

Maturation Bay	**Footprint (m^3)**
Minimum Size (m) (L x W x H) 1 x 1 x 1	1
Maximium Size (m) (L x W x H) 2.4 x 2.4 x 2.4	13.82
Compost Density 1 Tonne = Approx 2m^3	
Input 2.2 Tonnes/Day	
Required Footprint/Day	4.4
Size needed/Day (m) (L x W x H) 1.1 x 2 x 2	4.4

Figure 1: Maturation bay footprint calculations

Table 7: Tip site facility footprint calculations

Facility 1 - Weigh bridge		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Weighbridge	8 x 4	32
Total Needed		32
Total Actual	8 x 4	32
Measurement (1:200) (cm)	4 x 2	

Facility 2 - Main Office		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Office Space	8 x 6	48
Total Needed		48
Total Actual	8 x 6	48
Measurement (1:200) (cm)	4 x 3	

Facility 3 - Food waste treatment	Depends on final volume to be treated	
Process	**Measurements (L x W)**	**Footprint (m^2)**
Machinery	24.4 x 2.44	59.53
Input Conveyor System	5 x 2	10
Handling Area	6 x 3.5	21
Total Needed		90.53
Total Actual	15 x 10	150
Measurement (1:200) (cm)	7.5 x 5	

Facility 4 - Bio-Solids Handling (70%)	Depends on product moisture	
Process	**Measurements (L x W)**	**Footprint (m^2)**
Drying Bed	20 x 14	280
Handling Area	10 x 14	140
Total Needed		420
Total Actual	30 x 14	420
Measurement (1:200) (cm)	15 x 7	

Facility 5 - In-Vessel Composting		
Process	**Measurements (L x W)**	**Footprint**

		(m^2)
Composting Unit	12.8 x 2.2	28.16
Hopper system	3 x 2.5	7.5
Bio - filter - optional	4.4 x 2	8.8
Handling Area	6 x 3.5	21
Total Needed		65.46
Total Actual	20 x 10	200
Measurement (1:200) (cm)	10 x 5	

Facility 6 - Maturation and Storage Area		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Maturation Bay	(1.025 x 2) x 28	57.4
2nd Maturation Bay	(1.025 x 2) x 28	57.4
Back-Up Bay	(1.025 x 2) x 28	57.4
Trommel	2.2 x 1.9	4.18
Handling Area	5 x 10	50
Total Needed		226.38
Total Actual	20 x 25	500
Measurement (1:200) (cm)	10 x 7.5	

Facility 7 - Green Waste Shredding & Transfer Area		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Shredder (AZ460)	3.5 x 1.2	4.2
Storage area	20 x 10	200
Total Needed		204.2
Total Actual	24 x 20	480
Measurement (1:200) (cm)	12 x 10	

Facility 8 - Material Recovery Facility		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Tipping & Handling Area	20 x 15	300
Conveyor System	10 x 1.5	15
Sorting Process	25 x 2	50
Bin Storage Area	10 x 5	50
Total Needed		415
Total Actual	20 x 25	500

Measurement (1:200) (cm)	10 x 12.5	

Facility 9 - Material Processing and Storage		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Shredder (Plastics)	0.76 x 0.79	0.6
Baler (Cardboard)	1 x 0.7	0.7
Crusher (Glass/Cans)	1.27 x 0.94	1.19
Handling & Storage	8 x 8	64
Total Needed		66.49
Total Actual	20 x 5	100
Measurement (1:200) (cm)	10 x 2.5	

Facility 10 - Bulk Storage Area		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Storage Area	13 x10	130
Total Needed		130
Total Actual	13 x 10	130
Measurement (1:200) (cm)	6.5 x 5	

Facility 11 - Emergency Shower/ Eye Wash Area		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Shower Area	1.2 x 1.2	1.44
Toilet	2 x 1	2
Eye Wash	0.5 x 0.5	0.25
Total Needed		3.69
Total Actual	2 x 2	4
Measurement (1:200) (cm)	1 x 1	

Facility 12 - Inert Landfill	Depends on the total WTR process	
Process	**Measurements (L x W)**	**Footprint (m^2)**
LandFill Area	350 x 250	87500
Total Needed		87500
Total Actual	350 x 250	87500
Measurement (1:200) (cm)	175 x 125	

Facility 14 - Tyre Transfer Area		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Storage Area	24 x 10	240
Total Needed		240
Total Actual	24 x 10	240
Measurement (1:200) (cm)	12 x 5	

Facility 15 - Electronic Equipment Transfer Area		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Storage Area	24 x 10	240
Total Needed		240
Total Actual	24 x 10	240
Measurement (1:200) (cm)	12 x 5	

Facility 16 - Bulk Metal Transfer Area		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Storage Area	24 x 14	312
Total Needed		312
Total Actual	24 x 14	312
Measurement (1:200) (cm)	12 x 7	

Facility 17 - Hazardous Material Transfer Area		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Storage Area	15 x 10	150
Undercover Storage	20 x 10	200
Total Needed		350
Total Actual	14 x 31	400
Measurement (1:200) (cm)	7 x 15.5	

Facility 18 - Tip Shop		
Process	**Measurements (L x W)**	**Footprint**

		(m^2)
Materials Area	20 x 10	200
Household Items Area	20 x 10	200
Total Needed		400
Total Actual	20 x 20	400
Measurement (1:200) (cm)	10 x 10	

Facility 19 - Machinery Washing & Storage Area		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Washing Bay	8 x 8	64
Storage Area	8 x 16	128
Total Needed		192
Total Actual	16 x 16	72
Measurement (1:200) (cm)	8 x 8	

Facility 20 - Landfill Transfer Area		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Transfer Area	14 x 23	322
Total Needed		322
Total Actual	14 x 23	322
Measurement (1:200) (cm)	7 x 11.5	

Landscaping & Road Area		
Process	**Measurements (L x W)**	**Footprint (m^2)**
Total Actual	N/A	12442

Summary Table	
Total Constructed Area	16572
Total Landfill Area	87500
Total Area	104072

5.4 Power

Power calculations had to be done to determine the power requirement for the entire tip site. Peak power is the most important power calculation, as it would calculate the maximum power usage the tip site would experience at any time. This power requirement has been passed onto the Christmas Island Power Authority, to ensure that there will be adequate power once the tip site has been constructed. This calculation is shown in Table 8.

Table 8: Power calculation for tip site

Process	Facility Number	Equipment	Power Usage (Kwh/Day)	Equipment	Power Usage (Kwh/Day)	Equipment	Power Usage (Kwh/Day)	Equipment	Power Usage (Kwh/Day)	Total Power Usage (Kwh/Day)	Peak Load (Kw)	Power Type
Weigh Bridge	1	Weigh Bridge (Gendio)	1							1	1	3 Phase
Main Office	2	Computers (Griffith University)	2.7	Lighting /aircon/computer	1.5					4.2	0.5	Single Phase
Food waste treatment	3	Conveyor System (Prodeva)	5	Treatment Unit (Yes-Sun)	160	Depends on waste quantity				165	40	3 Phase
Bio-Solids Handling	4	Pumps	5		Depends on moisture content (no power for dry product)					5	5	3 Phase
In-Vessel Composting	5	Feed Hopper (HotRot Organic Solutions)	14.3	Composting tunnel (HotRot Organic Solutions)	63.8	Trommel -2.5 Tonnes (Brentwood Recycling)	10	Air pump (HotRot Organic Solutions)	5	93.1	20	3 Phase

Green Waste Shredding	6	Shredder (Brentwood Recycling)	5							5	3	Diesel
Resource Recovery Facility (depend on technology)	7	Conveyor system (Provdeva)	8	Trommel (Brentwood Recyling)	10	Sorting Equipment	15			33	10	3 Phase
Material Sorting and Handling	8	Shredder (Provdeva)	5	Granulator (Provdeva)	3.5	Baler (Provdeva)	2.3			10.8	8	3 Phase
Washing Bay	17	High pressure Washers (Karcher)	4.4							4.4	2.2	Single Phase
Site Lighting		15 Street lights (Insitute of Lighting Engineers)	9.6	Dependent on type of streetlights chosen						9.6	1.8	3 Phase
									Total =	**331.1**	**91.5**	

6 Tip Site Design

Taking into consideration the objectives and constraints shown in section 1.2 and 1.3, several tip site designs were draw up. These options were taken to the Shire of Christmas Island for their input of the initial designs. Their feedback was then used to draft the final tip site design that can be seen in Figure 2.

The entire tip site is first going to be remediated before any of the planned construction can begin. Remediation will involve the use of a bulldozer to move and cover any existing waste as well as the leveling of the tip site. This allows a blank canvas for the construction of the tip site.

6.1 Waste Treatment and Transfer Station Design

The final tip site design required the clear segregation of public areas and private areas to prevent the community from entering restricted areas and breaking occupational health and safety regulations. The overall site plan can be seen in Figure 2, we can see that the site design, denoted with blue and red lines, starts away from the current entrance of the site, this is due to the future development of housing estates opposite the tip site. The shire wants to prevent the viewing of the waste handling facility from the housing development, due to the effect it might have on the decision people have to live in the area.

Three roads, one to the north, east and south surround the tip site. However the Christmas Island Recreation Center along with the Construction Camp detention facility is located to the west of the tip site. To prevent any odour from drifting to this area, all organic handing facilities, facilities 3, 4, 5 and 6, has been located at the east side of the station, as seen in Figure 3.

Clear signs will be strategically places around to the tip site to guide both the public and shire staff. Fences will be placed around areas

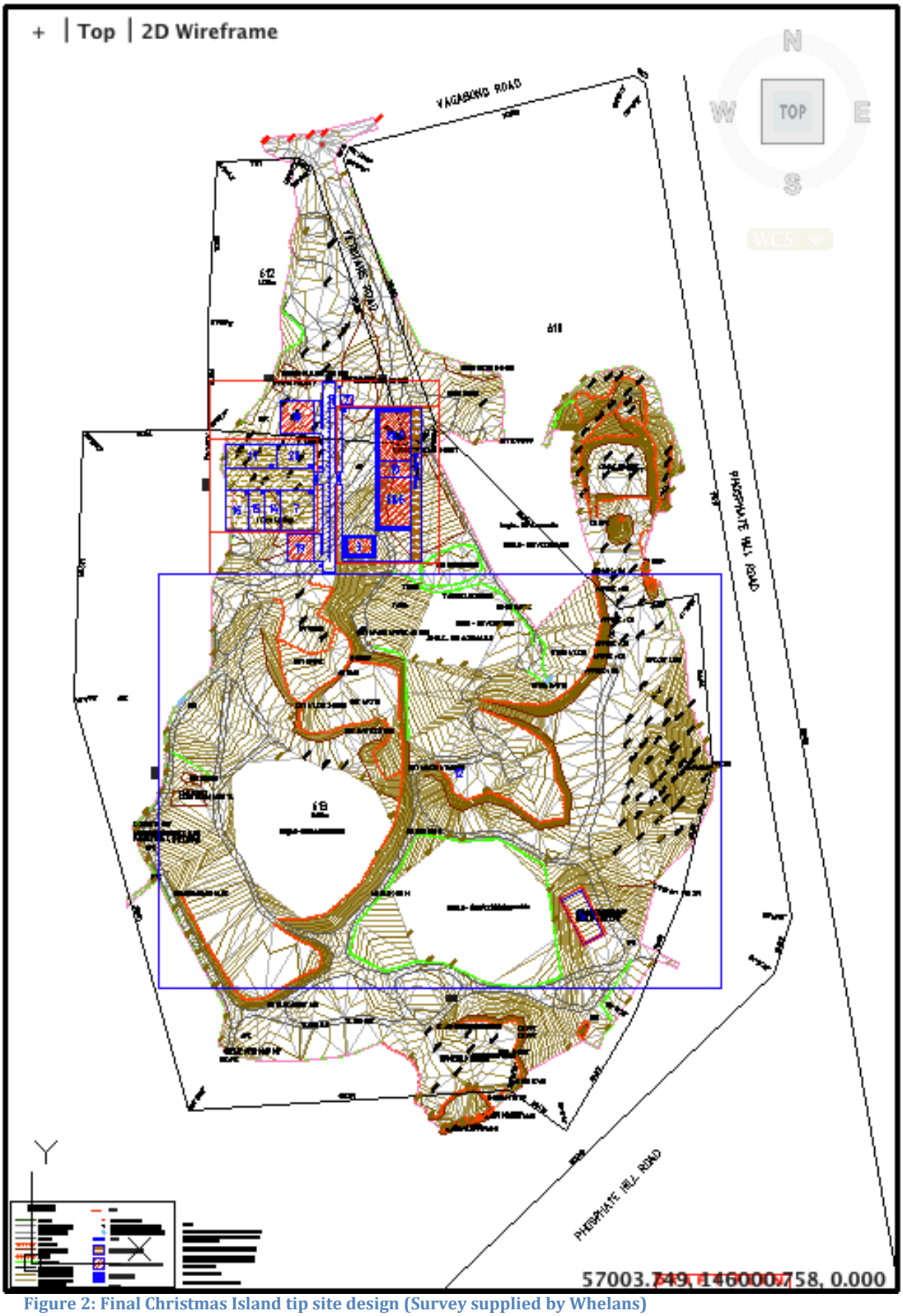

Figure 2: Final Christmas Island tip site design (Survey supplied by Whelans)

A close up on the actual tip site design can be seen in Figure 3. Each facility within the tip site has been given a facility number, which can be found in Table 3, this was done so the design would be more organized. The tip site is divided into two main areas, the constructed area and the landfill area. The main operating area of the site is within the constructed area. For a legend as to the type of areas in the tip site, please refer to Figure 4.

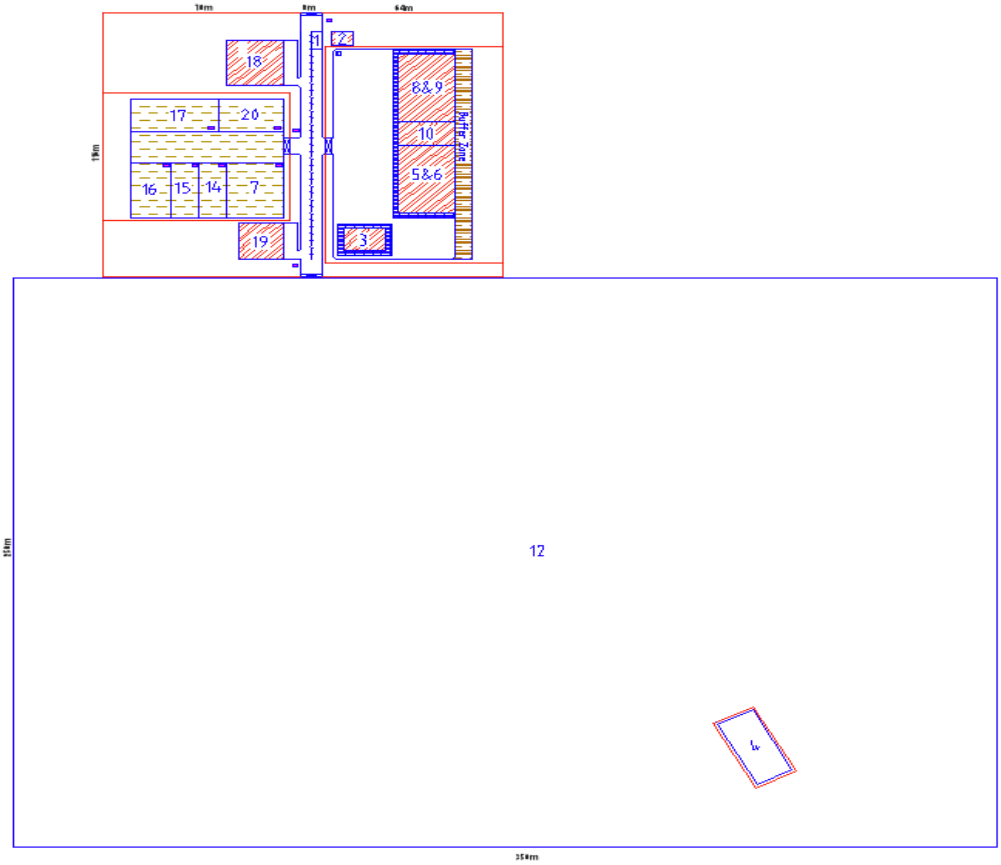

Figure 3: Tip site design without background

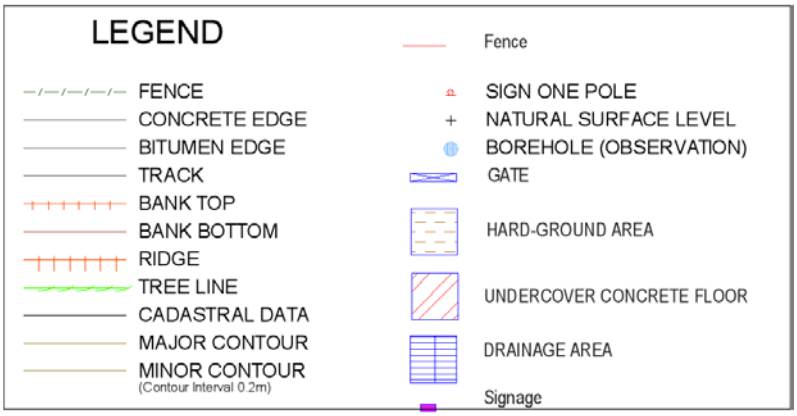

Figure 4: Tip site legend

6.1.1 Constructed Area

The constructed area of the tip site is a fenced and gated area to prevent unauthorized entries as seen in Figure 5. All facilities will be located within this zone except the inert landfill, facility 12, and the bio-solids handling area, facility 4.

The constructed area, Figure 5, is divided into two sections one to the right of the road and one to the left. The area to the right should only be accessible by shire staff . This area shall contain waste treatment facilities 3, 5, 6, 8, 9 and10 along with an emergency eyewash and shower, facility 11. A site office, facility 2, will be located at the main gate to take account of who enters and exits the tip site.

The public access area shall be located to the left of the road with the exceptions of facility 18 and 19, which shall be shire only access areas. The public will be able to access the transfer station to come and drop their waste into the allocated sections, which will be clearly marked out. Once their waste has been placed correctly, tip site staff shall sort and move the waste either into the landfill or into allocated areas around the tip site.

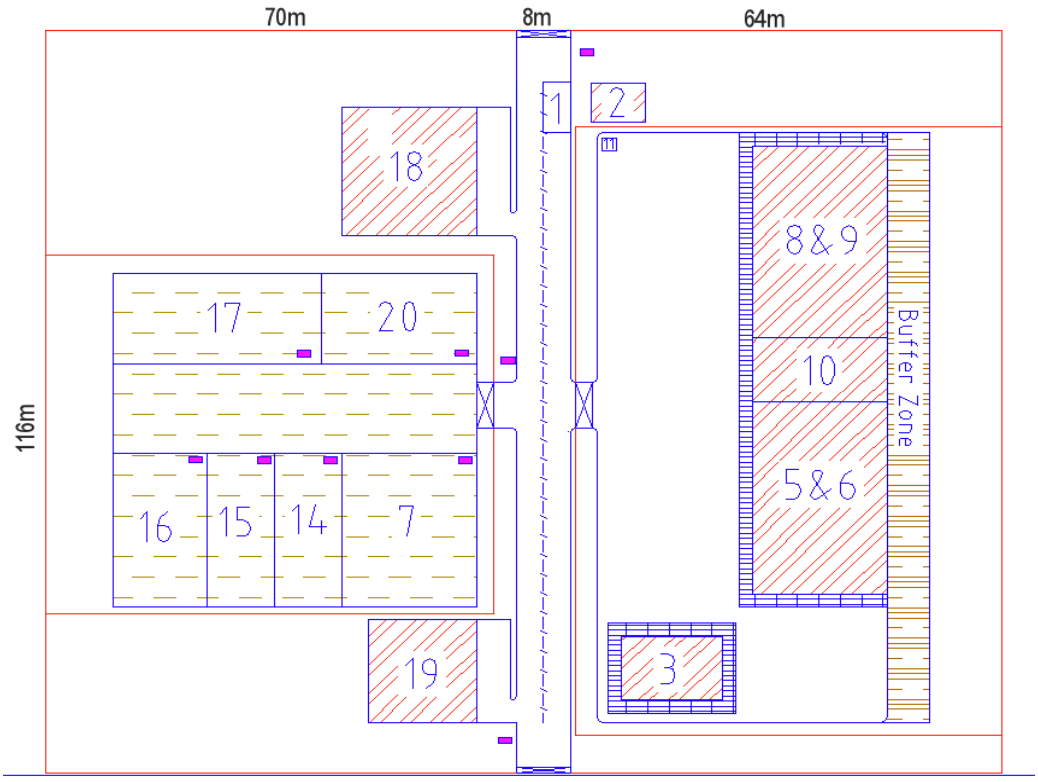

Figure 5: Tip site constructed area

6.1.2 Landfill Area

The landfill area consists of two facilities, the inert landfill, facility 12, and the bio-solids handling area, facility 4, as seen in Figure 6. This area is the allocated area of the landfill and may be used, as the shire desires. Access to these areas is made only through a gate from the constructed area to prevent public access.

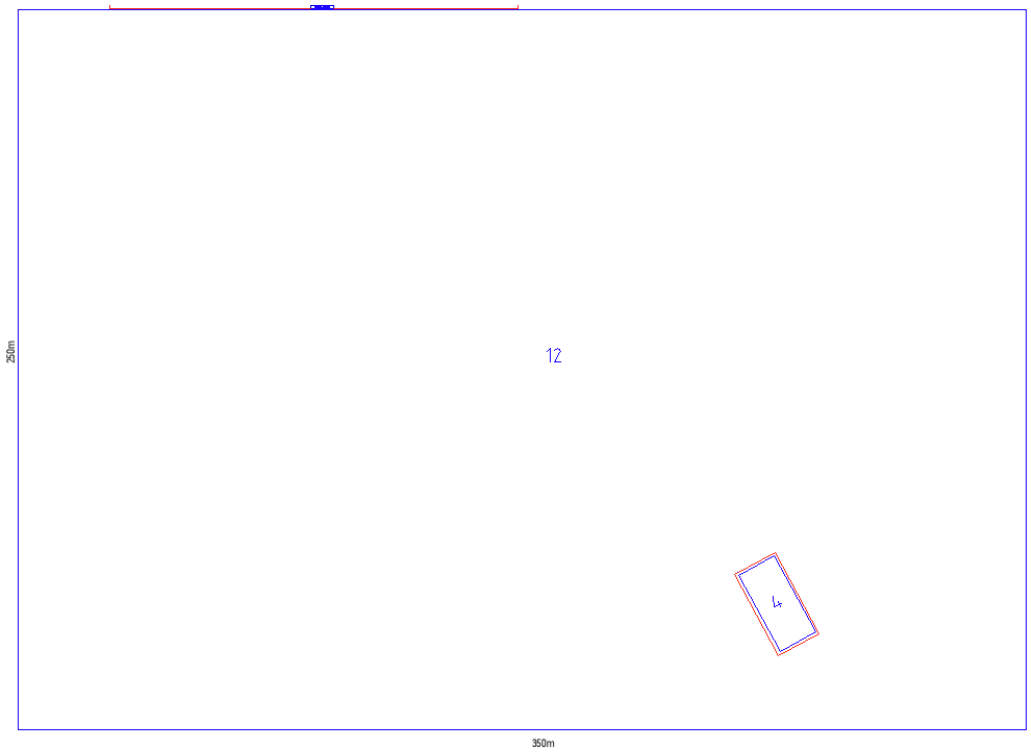

Figure 6: Tip site landfill area

7 Funding

The Shire of Christmas Island has received a total of $1.3 million for the funding of phase 2. This funding has been spent on obtaining the necessary equipment required to begin the construction and remediation of the tip site. A table of present and the known future expenditures can be seen in Table 9, pleases note that these are approximate figures.

Table 9: Table of present and known future expenditures

Expenditure type	Expenditure to acquire	Amount Used	Funding left
Present	Bulldozer, Bobcat and Attachments	$500,000	$800,000
Future	Utility Connections (Water and Electricity)	$200,000	$600,000
Future	Batching Plant	$250,000	$350,000
Future	Remediation Work	$200,000	$150,000

Once phase 2 funding has been depleted, the shire would have to apply for a phase 3 funding of approximately $2 million to complete the tip site.

8 Future Works (Phase 3)

Before any future works can begin, Phase 2 must be first completed, this is scheduled to occur in the middle of 2012. Another intern shall be tasked to complete phase 2 and begin phase 3 of the project. This intern shall begin his internship at the end of February and firstly will oversee the remediation of the currently landfill site on the island. While remediation is occurring the necessary equipment and technologies can be placed on order for delivery to Christmas Island, this shall mark the beginning of phase 3 of the project. However the commencing of phase 3 will largely depend on the acquiring of additional funding from the federal government by the shire. Phase 3 will entail the construction of the physical structures, the employment and training of tip site staff, purchasing of bins and necessary equipment, implementation of education programs and the installation of waste treatment technologies. Phase 3 should be completed in the middle of the year 2013. Once phase 3 has been completed the tip site should be fully functional and work to help the community on Christmas Island effectively and safely manage their municipal waste.

9 Conclusion

The Shire of Christmas Island has received the set of tables detailing the twenty suggested facilities that are to be constructed within the tip site. This list of facilities can be found in Table 3. It is suggested that the shire construct all the listed facilities, however it is entirely up to the shire to do as they see fit. The proposed tip site design has been designed to meet the outlined objected along with taking into consideration the constraints that are faced. The new tip site has been design to fit into the existing landfill once remediation work has occurred. This design has been completed and will be sent to the shire for feedback. The feedback given by the shire will be used to adjust the tip site design accordingly. Once the shire agrees on the finalized Waste management Center/Station, pegs shall mark the area, which the tip site will be located, and remediation work can then begin. Once remediation work has been completed, phase 2 shall be complete.

10 References

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Appendix A

Christmas Island Waste Management Report – Phase 1, by Tan, Justin, Brenten Wellington, Albert Yip, Daniel Marsh, and Benjamin Ho. 2011.

Digital copy is attached in the accompanying compact disc

File name: Appendix A – Christmas Island Waste Management - Phase 1 Report

Appendix B

Guide to Standards - Building and Construction, by Sai Global. 2011.

Digital copy is attached in the accompanying compact disc

File name: Appendix B - Guide to Standards - Building and Construction

Appendix C

Christmas Island Tip Site Design, by Justin Tan (survey supplied by Whelans).2011.

Digital copy is attached in the accompanying compact disc

File name: Appendix C – Christmas Island Tip Site Design