5 PROJECT DESCRIPTION

5.1 PROJECT LOCATION

The LAMP site which covers an area of 100 hectares is located within the GIE, an industrial estate dedicated for the establishment of medium and heavy industries in the chemical and petrochemical sectors. The GIE which was developed in the mid 1990s is strategically located 4 km west of Kuantan Port and approximately 30 km north of the Sultan Ahmad Shah Airport. Kuantan Town is located 35 km south of the site.

The proposed secure landfill is located within the eastern sector of the LAMP plant whilst the western sector houses the rare earths processing plant. The landfill occupies a footprint of 39 hectares (89 acres) or 39% of the LAMP site (100 hectares or 247.1 acres). The onsite secure landfill will be used for the storage of the NUF whilst awaiting export offsite for purposes of commercialisation.

The coordinates of the proposed secure landfill facilities and the existing LAMP site are outlined in **Table 5.1** and presented in **Figure 5.1**

Table 5.1 : Coordinates of proposed Project and existing LAMP site

Location	Points	Coordinates
	LAMP Site	
NE	A	4 00’ 30.1” N 103 22’ 59.2” E
NW	B	4 00’ 18.2” N 103 22’ 15.4” E
SW	C	3 59’ 53.9” N 103 22’ 25.1” E
SE	D	4 00’ 5.9” N 103 22’ 57.3” E
	Proposed Secure Landfill	
NE	1	4 00’ 30.1” N 103 22’ 59.2” E
NW	2	4 00’ 23.5” N 103 22’ 36.4” E
SW	3	4 00’ 0.2” N 103 22’ 44.5” E
SE	4	4 00’ 5.9” N 103 22’ 57.3” E

5.2 EXISTING OPERATION

5.2.1 Introduction

As discussed previously, the main feedstock, lanthanide (rare earths) concentrate, is imported from the Mt Weld mine in Western Australia operated by Lynas Corporation Ltd. (Australia). At the mine site in Australia, lanthanide ore is mined, stockpiled, crushed and concentrated (via the flotation process) to produce the lanthanide concentrate. The concentrate is then placed in bulk bags and transported in containers by sea from Fremantle Ports (Western Australia) to Kuantan Port in Malaysia. Upon arrival at the Kuantan Port, the containers are transferred onto trucks for transportation by road to the LAMP site within the Gebeng Industrial Estate in Kuantan.

At the LAMP site, the lanthanide concentrate which is the primary feedstock undergoes various stages of refining (or processing) to produce a suite of high purity lanthanide products comprising individual lanthanide elements or mixed lanthanide elements. The current approval limit (as imposed by DOE) for the processing of the concentrate is 95,000 wet tonnes per annum. The following are the products formed from the LAMP process:

- SEG-HRE Carbonate
- LaCe Carbonate
- Cerium Carbonate
- Cerium oxide
- Lanthanum Carbonate
- Lanthanum Oxide
- LaCe oxide, LaCePr oxide, LaCeNd oxide
- PrNd (Didymium) oxide
- Pr oxide
- Nd oxide

5.2.2 Main Components of the LAMP

The main buildings/structures presently onsite include:

- Cracking and Separation Plants;
- Waste Gas Treatment Plants;
- Lanthanide Concentrate Storage Building;
- RSFs and DSFs WLP storage, DSFs and Geotubes for NUF storage area (secured landfill)
- Chemical Store;
- Aboveground storage tanks (for the storage of sulphuric acid, hydrochloric acid, sodium hydroxide, kerosene, firefighting foam, water and diesel);

- Stormwater Retention Ponds;
- Biological water treatment plant
- Water Treatment Plant surge ponds
- Generators;
- Scheduled / Hazardous wastes store;
- Industrial Effluent Treatment Plant;
- Administration Building;
- Training building
- Laboratory; and
- Maintenance Workshop and Store.

The list of major equipment installed at the plant is listed in **Table 5.2.**

Table 5.2: List of Major Equipment at the LAMP Site

Description	Number of Units
Pressure filters	41
Rotary kilns	4
Solvent extraction cells	922
Centrifuges	53
Tunnel furnaces	8
Boilers	2
Water treatment bio-reactors	3
Cooling towers	2
Compressors	7
Pumps	>500
Tanks (FRP, concrete, steel) and agitators	Multiple

The LAMP site layout plan is as shown in **Figure 5.2a**

5.2.3 LAMP Process Description

At the LAMP, the lanthanide concentrate imported from Mt. Weld, Australia undergoes three (3) main stages of processing:

- Cracking and Separation (houses the Waste Gas Treatment Plant)
- Solvent Extraction (SX)
- Product Finishing (PF)

A high-level block flow diagram of existing LAMP processes will be shown in **Figure 5.2b.** The mass balance for the process is presented in **Figure 5.2 c**.

The processing of the lanthanide concentrate into the final products results in the generation of two main process residue steams, namely the NUF and WLP. NUF is produced at an average monthly rate of 32,790.83 metric tonnes and the total quantity of NUF produced since commencement of operations in 2013 to 31st of August 2018 is 1.44 million metric tonnes (wet weight) and 0.867 million metric tonnes (dry weight). And this number will continue to increase in the following years.
In the first stage, the concentrate is roasted with sulphuric acid in rotary kilns at high temperatures and atmospheric pressure with water leached through to produce a lanthanide sulphate solution, which will then be sent to the Solvent Extraction process. Solid cake (WLP residue) produced from the filtration process will be sent to an existing RSF.

The key information involved in the Cracking and Separation Plant are summarised in **Table 5.3** and block flow diagram presented in **Figure 5.3**:

Table 5.3 : Key Information of Cracking and Separation Plant

Key Area	Key Information
Operations	Mt. Weld Rare Earth Concentrate to produce Rare earth Sulphate solution feed for SX separation: • Operation: 24/7 (365 days) • Production Areas: Concentrate Handling Rotary Kiln Acid Cracking Waste Gas Treatment (Block flow diagram graphically shown in **Figure 5.4**) Primary Leaching MgO Neutralisation Secondary Leaching and Filtration
Staff	Rare Earth Processing Capability developed at Lynas Malaysia – Total 105 employees (all Malaysian, no expats) • Management Team (2) • Process Engineers (2) • Supervisors (6) • Technicians (95)
Standards	Accredited to International Standards: • Quality ISO 9001 (2015) • Safety OHSAS 18001 (2007) • Environmental ISO 14001 (2015)
Safety, Health and Environment	Key Safety and Environmental Risks - Stack Emissions, High temperature, Chemicals • Control of Waste Gas Emissions to meet regulatory limits: • Venturi Scrubbers, Spray Towers, Wet Electrostatic Precipitators • On-line monitoring and regular stack sampling • Engineered Controls and Procedures for safe management of safety, health and environmental hazards • Operations in compliance with Radiation Management Plan • Maintenance Management System and Programmes
Main Equipment	• 60 meter Gas Fired Rotary Kilns • Multi Stage Waste Gas Treatment Plant • Leaching and Neutralisation Circuit

Solvent extraction process will be used to purify, separate and concentrate the lanthanides before their precipitation into products. The lanthanide elements will be selectively extracted from the aqueous phase into an organic phase using a battery of mixer-settlers. The aim of each stage of extraction is different, the conditions within the mixer-settlers will be controlled to remove part of, or all lanthanide elements to the organic phase from aqueous phase.

Key information on the solvent extraction process is presented in **Table 5.4** and a schematic block flow diagram will be illustrated in **Figure 5.5.**

Table 5.4 : Key Information of Solvent Extraction Plant

Key Area	Key Information

Operations	Using Solvent Extraction (liquid – liquid extraction process) to separating Rare Earth in solution and remove non-Rare Earth impurities.
	Separation of Rare Earths is difficult and complex. IP and expertise is not widely available (predominantly in China)
	• Operation : 24/7 (365 days)
	• Production Processes:
	  • Removing non-Rare Earth Impurities (Fe, Al, Zn, Ca, S, P)
	  • Separating Rare Earths to produce:
	    ▪ NdPr Chloride
	    ▪ SEG Chloride
	    ▪ Ce Chloride
	    ▪ La Chloride
	    ▪ LaCe Chloride

Staff	Rare Earth Processing Capability developed at Lynas Malaysia - Total 76 employees (74 Malaysian, 2 expat) • SX Technical and Management Team (8) • Supervisors, Coordinators and Panel man (4 + 2 + 13) • Technicians (49)
Standards	Accredited to International Standards • Quality ISO 9001 (2015) • Safety OHSAS 18001 (2007) • Environmental ISO 14001 (2015)
Safety, Health and Environment	Key Safety and Environmental Risks • Fire Protection, engineering containment and strict operational controls to manage flammable liquids (organic used in SX) • Engineered Controls and Procedures for safe management of chemicals including hydrochloric acid and caustic • Operations in compliance with Radiation Management Plan
Main Equipment	• Upstream Separation • Downstream Separation • Impurities Removal

In the product finishing stage (post-treatment stage), lanthanide chloride strip solutions are purified to remove impurities, precipitated into carbonate or oxalate forms, and in some cases calcined to oxides, resulting in the production of various products, namely:

- SEG-HRE Carbonate
- LaCe Carbonate
- Cerium Carbonate
- Cerium oxide
- Lanthanum Carbonate
- Lanthanum Oxide
- LaCe oxide, LaCePr oxide, LaCeNd oxide
- PrNd (Didymium) oxide
- Pr oxide
- Nd oxide

The key information involved in the Product Finishing plant are summarised in **Table 5.5** and the block flow diagram is presented in **Figure 5.6**:

Table 5.5 : Key Information of Product Finishing Plant.

Key Area	Key Information
Operations	Precipitation, Washing, Dewatering, Calcination, Packaging and Sampling of Rare Earth Products Production of high quality Rare Earths products is difficult and complex. IP and expertise is not widely available. • Operation : 24/7 (365 days) • Production Areas: Impurity removal (Zn) Rare earth carbonate precipitation Rare earth oxalate precipitation PrNd oxalate calcination La carbonate calcination Speciality product calcination (SEG, LaCe, Ce oxides)
Staff	Rare Earth Processing Capability developed at Lynas Malaysia - Total 130 (128 Malaysian and 2 Expat) • Management Team (2) • Process Engineers (2) • Technicians (126)
Standards	Accredited to International Standards • Quality ISO 9001 (2015) • Safety OHSAS 18001 (2007) • Environmental ISO 14001 (2015)
SHE	Key Safety and Environmental Risks - Stack Emissions, High temperature, Chemicals • Engineered Controls and Procedures for safe management of safety, health and environmental hazards • Operation in compliance with Radiation Management Plan • Maintenance Management System and Programs
Main Equipment	• 6 pre-treatment/neutralisation vessels • 37 Precipitation Vessels • 53 high speed centrifuges • 8 High Temperature Tunnel Furnaces (80-88m long)

5.3 NUF PHYSICAL AND CHEMICAL PROPERTIES

5.3.1 Safety Data Sheet

The NUF Safety Data Sheet is appended in **Appendix 5.1.** A description of its physical properties and measures are provided in the subsections below.

5.3.1.1 Composition / Information on Ingredients

The NUF residue consist of 75 – 85 % of Calcium Sulphate (Dihydrate) and 15 – 20 % of Magnesum Hydroxide, which makes it a magnesium rich gypsum.

5.3.1.2 First Aid Measures

The following are the description of NUF's first aid measures:

Ingestion : Rinse mouth with water. Give plenty of water to drink. If vomiting occurs give further water. Seek medical advice.

Eye Contact : Irrigate with copious quantities of water for 15 minutes. In all cases of eye contamination, it is a sensible precaution to seek medical advice, especially if irritation persists.

Skin Contact : If skin contact occurs, wash affected skin thoroughly with soap and water.

Inhalation : If excess dust is inhaled, move patient to a fresh air location and allow patient to assume more comfortable position and keep warm. Keep at rest until fully recovered. Seek medical advice.

5.3.1.3 Fire-Fighting Measures

Extinguishing media : Non-flammable. Water fog, foam, carbon dioxide or dry agent will be used to cool intact containers and nearby storage areas and/or fight fire

Specific Hazards : Non-flammable solid

Advise for firefighters : Non-combustible solid. Fire fighters should wear approved, positive pressure, self-contained breathing apparatus and full protective clothing when appropriate.

More information of preventive measures and exposure control of the NUF residue is presented the SDS.

5.3.2 Particle Size

The NUF residue contains 69% silt-sized particles (3.9 to 62.5 μm) and 26% clay-sized particles (0.98 to 3.9μm) with 5% sand-sized (>62.5μm) particles and classified as an inorganic silt.

5.3.3 Atterberg Limit

The Atterberg limits are a basic measure of the critical water contents of a fine-grained soil: its shrinkage limit (SL), plastic limit (PL), and liquid limit (LL). The Atterberg limits can be used to distinguish between silt and clay, and to distinguish between different types of silts and clays.

NUF has a liquid limit of 105.3%, a plastic limit of 48.3% and a shrinkage limit of 33%. NUF is pressure-filtered to an average moisture content of 46%. It is then transported by truck to the DSF where over time, it drains to a moisture content of around 30%. At this point it has reached its shrinkage limit, and can be compacted and shaped with excavator.

5.3.4 Slope Stability

The embankment slopes of the current DSF which is in operation; DSF 1, is based on the various ANCOLD (Australian National Committee on Large Dams) guidelines pertaining to the construction of large-scale dam structures similar to the DSF. Lynas will ensure that the final detailed design of the proposed secure landfill will also comply with the Malaysian slope design standards specified by the Department of Works and other local technical agencies. This same design will be employed for future DSFs to be constructed within the LAMP site.

The slope stability analysis conducted showed that the NUF material has sufficient strength to support a 1:1.5 (Vertical (V) to Horizontal (H) ratio) slope with a 3 m berm for every 5 m of height. This recommendation delivers a safety factor of 1.39:1 (the slope will only fail at 1.39 times of the design load).

For embankments that may become permanent, Lynas will target a slope of 1V:2.5H with 5 m embankments. This delivers a safety factor in excess of 1.7 and makes allowance for potential slippage of the capping material.

5.3.5 NUF Chemical Properties

The following test were conducted by SIRIM on three (3) NUF samples to establish if any hazardous characteristics existed:

- Characteristic of Corrosivity
- Character of Ignitability
- Characteristic of Reactivity
- Characteristic of Toxicity

The following inferences on the characteristics of three (3) NUF were obtained from the laboratory findings of SIRIM (**ETRC 257/16/965,R247/17)** appended in **Appendix 5.2**. It is important to highlight that based on the tests conducted in laboratory, all three (3) NUF samples were:

1. Not inherent of physical hazards such as corrosivity, explosivity, ignitability and flammability
2. No toxic chemicals were identified in the composition as major constituents. The dioxin and furan analysed were below the total threshold limit concentration set by the DOE.
3. The absence of microorganism such as Total Coliform, Fecal Coliform (E.coli), *Pseudomonas aeruginosa, Salmonella sp., Shigella sp., Vibro sp., Feacal streptococci* and *Enterococi sp.* infers the sample is not infectious according to the DOE's classification of hazard.

5.3.5.1 Characteristics of Corrosivity

The characteristics of corrosivity is designed to identify wastes that might pose a hazard to human health and the environment through their ability to mobilise toxic metals, corrode handling or storage equipment and destroy human tissue on accidental contact.

The pH of NUF samples was tested on paste of 10% solid sample. pH values were more than 2 and less than 12.5 ($2 < pH < 12.5$ are limits set to indicate potential corrosivity of a waste). Thus, it can be inferred that the NUF samples are not corrosive.

5.3.5.2 Characteristic on Ignitability

The characteristic of ignitability is intended to identify wastes that may either present a fire hazard or intensify a fire once started. No combustion occurred when the NUF samples were ignited to 1000˚C within 2 minutes with a bunsen burner flame.

5.3.5.3 Characteristic of Reactivity

The NUF samples were not miscible in water. No reactions in the form of heat release or effervescence were observed when the samples were immersed in simulated rainwater. The concentration of cyanide and sulphide for the samples are as follows:

- NUF 1 : Cyanide (< 0.01 ppm) and Sulphide (6.9 ppm)
- NUF 2 : Cyanide (< 0.01 ppm) and Sulphide (6.2 ppm)
- NUF 3 : Cyanide (< 0.01 ppm) and Sulphide (5.0 ppm)

Hence, there will be no significant emission of hydrogen cyanide and hydrogen sulphide should the samples come in contact with an acidic medium. The NUF 1,2 and 3 samples are considered as not reactive and are not expected to present danger to human health.

5.3.5.4 Characteristic of Toxicity

All three (3) NUF samples were subjected to the Toxicity Characteristic Leaching Procedure (TCLP) and the results **(Table 5.6)** show that none of the organics and inorganics analysed exceeded the limits specified under the Special Management of Scheduled Waste Guidelines for Regulation 7 of the Environmental Quality (Scheduled Waste) Regulations, 2005.

Table 5.6 : Results of the NUF TCLP Analysis

No.	Contaminants (Organics)	Concentration (mg/L)			
		NUF 1	NUF 2	NUF 3	Regulation 7 (1) Maximum Level
1	Benzene	<0.005	<0.005	<0.005	0.5
2	Carbon Tetrachloride	<0.005	<0.005	<0.005	0.5
3	Chlordane	<0.005	<0.005	<0.005	0.03
4	Chlorobenzene	<0.005	<0.005	<0.005	100
5	Chloroform	<0.02	<0.02	<0.02	6.0
6	o – Cresol	<0.005	<0.005	<0.005	200
7	M – Cresol	<0.005	<0.005	<0.005	200
8	P – Cresol	<0.005	<0.005	<0.005	200
9	Cresol	<0.005	<0.005	<0.005	200
10	2,4 – D	<0.01	<0.01	<0.01	10
11	1,4 – Dicholorobenzene	<0.005	<0.005	<0.005	7.5
12	1,2 – Dicholoroethane	<0.005	<0.005	<0.005	0.5
13	1,1 – Dichloroethylene	<0.005	<0.005	<0.005	0.7
14	2,4 – Dinitrotoluene	<0.005	<0.005	<0.005	0.13
15	Endrin	<0.005	<0.005	<0.005	0.02
16	Heptachlor	<0.005	<0.005	<0.005	0.008
17	Hexachlorobenzene	<0.005	<0.005	<0.005	0.13
18	Hexachlorobutadiane	<0.005	<0.005	<0.005	0.5
19	Hexachloroethane	<0.005	<0.005	<0.005	3.0
20	Lindane	<0.005	<0.005	<0.005	0.4
21	Methoxychlor	<0.005	<0.005	<0.005	10
22	Metyl ethyl Ketone	<0.05	<0.05	<0.05	200
23	Nitrobenzene	<0.005	<0.005	<0.005	2.0
24	Pentachlorophenol	<0.05	<0.05	<0.05	100
25	Pyridine	<0.05	<0.05	<0.05	5.0
26	Tetrachloroethylene	<0.005	<0.005	<0.005	0.5
27	Toxaphene	<0.005	<0.005	<0.005	0.5
28	Trichloroethylene	<0.005	<0.005	<0.005	0.5
29	2,4,5 – Trichlorophenol	<0.005	<0.005	<0.005	400
30	2,4,6 – Tricholorophenol	<0.005	<0.005	<0.005	2.0
31	2,4,5 – TP (Silvex)	<0.01	<0.01	<0.01	1.0
32	Vinyl Chloride	<0.05	<0.05	<0.05	0.2
No.	**Elements (Inorganics)**	**Concentration (mg/L)**			
		NUF 1	**NUF 2**	**NUF 3**	**Regulation 7 (1) Maximum Level**
1	Arsenic	<0.01	<0.01	<0.01	5.0
2	Barium	0.04	0.05	0.05	100

No.	Contaminants (Organics)	Concentration (mg/L)			
		NUF 1	NUF 2	NUF 3	Regulation 7 (1) Maximum Level
3	Silver	<0.0001	<0.0001	<0.0001	5
4	Cadmium	0.0008	<0.0008	<0.001	1.0
5	Chromium	0.003	0.03	0.04	5.0
6	Lead	0.002	0.02	0.02	5.0
7	Selenium	<0.02	<0.02	<0.02	1.0
8	Mercury	<0.00007	<0.00007	<0.00007	0.2

Source: Technical Evaluation Report on NUF 1,NUF 2 and NUF 3

The three NUF samples were also subjected to the Total Threshold Limits Concentration (TTLC) testing procedure and the data presented in **Table 5.7.**

Table 5.7 : Results of NUF TTLC Analysis

No	Analyte	Concentration (mg/kg)			
		NUF 1	NUF 2	NUF 3	Regulation 7 (1) TTLC
1	Antimony	<4.3	<4.0	<4.3	500
2	Arsenic	<6.2	<5.8	<6.2	500
3	Barium	22	26	21	10000 (1%)
4	Berrylium	2.3	2.0	1.5	75
5	Cadmium	5.3	0.6	<0.3	100
6	Cobalt	8.9	9.1	7.4	8000
7	Chromium	7.2	7.6	7.0	2500
8	Chromium Hexavalent	<0.3	<0.3	0.4	500
9	Copper	8.7	8.7	6.9	2500
10	Molybdenum	<3.2	<0.5	<0.5	3500
11	Nickel	26	27	20	2000
12	Selenium	<8.9	<8.4	<8.9	100
13	Silver	6.9	<0.3	<0.3	500
14	Thallium	<4.7	<4.5	<4.7	700
15	Vanadium	2.8	3.2	2.1	2400
16	Zinc	178	167	134	5000
17	Mercury	0.03	0.03	0.02	20
18	Lead	54	27	18	1000
19	Penthacholorophenol	< 1.0	<1.0	<10.	17
20	2,4 Dicholorophenoxy acetic acid	< 0.05	< 0.05	< 0.05	100
21	2,4,5 Trichlorophenoxypropionic acid (Silver)	< 0.05	< 0.05	< 0.05	10
22	Trichloroethylene	< 0.5	< 0.5	< 0.5	2040
23	Aldrin	< 0.5	< 0.5	< 0.5	1.4
24	Chlordane	< 0.5	< 0.5	< 0.5	2.5
25	DDT, DDE, DDD	< 0.5	< 0.5	< 0.5	1.0
26	Dieldrin	< 0.5	< 0.5	< 0.5	8.0
27	Endrin	< 0.2	< 0.2	< 0.2	0.2
28	Heptachlor	< 0.5	< 0.5	< 0.5	4.7
29	Kepone	< 0.5	< 0.5	< 0.5	21

No	Analyte	Concentration (mg/kg)			
		NUF 1	NUF 2	NUF 3	Regulation 7 (1) TTLC
30	Lindane	< 0.5	< 0.5	< 0.5	4.0
31	Methoxychlor	< 0.5	< 0.5	< 0.5	100
32	Mirex	< 0.5	< 0.5	< 0.5	21.0
33	PCBs	< 0.1	< 0.1	< 0.1	50.0
34	Toxaphene	<5.0	<5.0	<5.0	5.0
35	Asbestos	ND	ND	ND	1%
36	Fluoride Salts	35	32	33	18000
37	Organic Lead	<10	<10	<10	13
38	Dioxins	<0.0009 – <0.02	<0.001 – <0.2	<0.001 – <0.3	<0.1
39	Furan	<0.001 – <0.01	<0.001 – <0.002	<0.001 – <0.002	<0.1

Source: Technical Evaluation Report on NUF 1,NUF 2 and NUF

5.4 CONSTRUCTION OF THE SECURE LANDFILL

The description provided below is for secure landfill NUF DSF 2 as it is the next facility to be constructed as DSF 1 approaches its maximum storage capacity. Similar method will be employed for the construction of the subsequent NUF DSF 3, 4 and 5 over a 10 – year period (2019 – 2029).

5.4.1 Engineering Design, Phasing and Construction Philosophy

The main objectives for the design and construction of the DSF are to meet both regulatory requirements of the DOE and the operational requirements of Lynas in terms of its storage and subsequent removal (for commercialisation) from the LAMP site.

5.4.2 Best Practice in Residue Storage

The majority of the world's storage facility for gypsum generated from chemical processing industry involve the use of impoundments (also referred to as dams). The impoundments store the gypsum residue in the form of slurry with a solid content of 25% to 60%, depending upon whether any thickening is carried out prior to deposition. This conventional system remains as the lowest cost storage solution. However, the structural integrity of these impoundments needs to be sound to contain the solids stored and prevent failure of the embankments. The large volume of water in the impoundment also needs to be managed as well. Upon cessation of operation of the processing plant, the closure of these impoundments also poses significant challenges due to the unstable nature of the slurries that are stored within.

For the proposed secure landfill Project, Lynas has invested in a costlier yet more effective solution which is the dry stacking method. For this method, large filters have been procured (in turn requiring many pumps, power infrastructure and structures to house these filters).

The filtration and dry stacking method are recognised as a world's best practice for storage of gypsum residues for the following reasons:

- The dry stacked solids provide a far more stable and robust platform for long-term storage;
- As the residues are in solid form, they provide their own structural integrity. Therefore, the construction of large storage structures is not required for containment; resulting in less area required for a given volume of residues;
- The dry stacking method results in less water loss; and
- In the event the residues can be commercialised and used as alternative raw material for other industrial applications, the removal of the gypsum residue (in dry solid form) is more effective.

5.4.3 Design of the NUF DSF

It must be noted that, NUF residue does not inherit any physical hazards such as corrosivity, explosivity, ignitability and flammability although it is classified as a scheduled waste (SW 205). This secure landfill will be designed using a combination of two different liners, with an engineered leakage detection system that provides high safety standards. The NUF DSF 2 and its subsequent secure landfill will have the following cross-sectional engineering design:

The cross-section of the DSF 2 is presented in **Figure 5.9** and a description of the 7 layers is presented in **Table 5.8**. The other DSFs to be constructed will employ the same design concept.

Table 5.8 : Cross Section Area of DSF 2 and Subsequent Secure Landfill

Layer No	Description	Purpose
1	300 mm thick sand	Protection from machinery (dissipate machinery vibration) when the NUF is placed into the. The sand layer's permeability coefficient is 1 x 10^{-4} m/s
2	2.0 mm HDPE liner coated with UV protected polymer)	Primary liner for the DSF and acts as a barrier to prevent leachate from entering the groundwater system. The coating has been proven to be resistant to all aggressive chemicals. This liner has a permeability coefficient of 1 x 10^{-14} m/s
3	Layer of geosynthetic clay liner (5 mm)	Made from bentonite base clay known for its consistency and sealing properties, this secondary liner will prevent leachate from entering the groundwater system – in case there is a breach in the primary liner. This liner has a permeability coefficient of 1 x 10^{-11} m/s
4	High tensile woven geotextile PET 400 – 50	Ensures the stability of the base of the DSF

Layer No	Description	Purpose
5	ULLD (300 mm)(Underline leak detection system) which refers to a high permeability network drainage system constructed in a herring bone pattern and placed below the 2 liners.	This is a high permeability system that channels any leachate that may seep from the DSF to collection sump.
6	Geonet drainage liner (8 mm)	The geonet drainage liner forms the base layer of ULLD system. It is designed to strengthen the base of the ULLD system as well as to prevent clogging.
7	Compacted soil (nominal 300 mm)	Ensures the stability of the base of the DSF

5.4.4 Secure Landfill Phasing Plan

The storage of the NUF residue within the secure landfill will be confined within a continuous area within the eastern sector of LAMP over a 10 – year period (2019 – 2029). This is to maximise the efficiency of the secure landfill through the elimination of voids between stockpile embankments. **Figures 5.7a to 5.7e** shows the phasing plan of the proposed secure landfill.

DSF 1

DSF 1 which is currently in operation is located in the southern boundary of the site. This cell is expected to reach its maximum capacity around late June 2019. Please refer to **Figure 5.7a.**

DSF 2

DSF 2 will be built as an extension of DSF 1 and will comprise the void space between GT 1 and GT 2 as well as the areas in between DSF 1 and the WLP lagoon / WLP RSF 2 and the Surge Lagoon (refer to **Figure 5.7b**). This secure landfill will be capable of handling 874,000 m^3 of NUF residue and is expected to be operational until January 2022. Construction of DSF 2 is expected to commence in June 2019.

DSF 3

DSF 3 will be located in the north-east corner of the LAMP site and ultimately is intended to form a continuous contour with DSF 1 and 2 by merging the three (3) facilities together **(Figure 5.7c)**. This DSF will generate an initial storage volume of 412,990 m^3 and progressively, this volume is expected to double as the adjoining facilities fill up and the surrounding land contours increase.

DSF 4

The existing two surge lagoons will be converted to DSF 4 and two new surge lagoons will replace these. Construction of the new lagoons are anticipated to kick-off in the dry season of Year 2020 allowing sufficient time for the lagoons to fill up and proceed with the next step of construction. Once the new lagoons are in operational, the existing surge lagoons will be dug out and relined to be used as DSF 4 (**Figure 5.7d**). This generates an additional storage volume of approximately 824,697 m^3 that is expected to operate until October 2025.

DSF 5

DSF 5 is not meant as a discreet storage area but rather refers to the remaining area at height that needs to be establish to achieve the final contour (34 m) (**Figure 5.7 e**). In order to execute this, a total volume of 1.3 million cubic meter is needed so as to allow the facility to last until late 2029. As each section is covered and reaches its final contour, the process of final capping can begin. This process will progress over four years of operation (2025 – 2029).

5.4.5 Pre – Construction Preparation

The proposed NUF DSF 2 site will include the current Geotube 1 and Geotube 2 areas **(Figure 5.8)** and the new available space is currently occupied with a network of pipes, racks, drains, construction debris and crushed rock. As part of the pre-construction activities, these obstacles will be removed.

5.4.6 DSF Construction Methodology

The description provided below is for the construction of the NUF DSF 2; the first to be constructed as DSF 1 has almost reached it maximum storage capacity. This same method will be employed for the subsequent DSFs 3, 4 and 5.

5.4.6.1 Construction of NUF DSF 2

During the early stages of construction, trenches will be dug for the installation of under-liner leak detection (ULLD) system after the site clearing works. The ULLD trench measuring 2 m in width and 0.3 m (depth) will be excavated at locations shown in **Figure 5.10a**. The base of the trench will be graded to a gradient of 1V:400H towards a collection sump. The sump, measuring 9 m (width) x 9 m (length) x 0.5 m (depth) will be filled with 50 mm aggregates as graphically shown in **Figure 5.10b**.

The ULLD system will be covered by a layer of high strength woven geotextile PET 200 and a secondary liner in the form of a geosynthetic clay liner (GCL). Above the GCL, a layer of HDPE liner is laid which acts as the primary lining system. The HDPE liner is double-textured and has a thickness of 2mm as shown in **Figure 5.9**.

Both the primary and secondary liners will be anchored in a 0.5 m (width) x 0.5 m (depth) trench, located 0.5 meter away from the edge of the southern and eastern crest of Surge Lagoon A, southern crest of WLP RSF 4, southern crest of WLP Lagoon and the southern and eastern crest of WLP RSF 2 as shown in **Figures 5.11a and Figure 5.11b**.

The NUF DSF 2 will be contained by three (3) bunds in locations shown in **Figures 5.12a, 5.12b and 5.12c**. Two types of bund will be constructed to the height of 2 m and 1.5 m respectively. The bunds will be constructed using silty gravelly sandy soil with a slope gradient of 1V:2H.

Although the NUF DSF 2 will share the bund walls with the WLP lagoon and WLP RSF, it is important to highlight that an efficient pumping system will be deployed. The 150 m^3/hour capacity pump ensures that the WLP Lagoon remains with a minimum 500 mm freeboard even during the wettest recorded rainfall of 300 mm/day. As a secondary precaution, a 0.5 m high bund will be placed on the crest area between the WLP Lagoon and the NUF DSF 2. This will act as a buffer whenever the pump malfunctions and prevents spill over from the WLP Lagoon into NUF DSF 2.

Access road into the NUF DSF 2 area will be built to enable trucks to safely transport NUF material for storage. The access road will be built with a 1V:10H gradient using silty gravelly sand material. A layer of protective geotextile will be placed underneath the access road whenever it comes in contact with the HDPE liner. The top 400 mm of the access road will be filled with a layer of compacted crusher-run material **(Figure 5.13)**. This ensures the integrity of the access road.

5.4.6.2 Management of the NUF Residue

The secure landfill will have a comprehensive stockpile management plan created by Lynas to ensure allocated space along the eastern sector is well managed and enable drying of the NUF residue for commercialisation will take place with ease. Geotubes 1 and 2 will merge with the new NUF DSF 2 secure landfill. The stacking of NUF residue will begin at the embankment's inner toe. NUF will be stored on top of the Geotubes and will be contoured at a slope geometry ratio of 1V:2.5H.

The following inner slopes geometry will be contoured at a gradient of 1V:2H. At every 5 – meter high contour embankment, a 5 – meter wide berm will be constructed for operational and movement of machineries such as the roller compactor and excavator. The contour design will bury the Geotubes as graphically shown in **Figure 5.14**.

Even with such storage consideration accorded to NUF which is classified as SW205, it must be emphasised that NUF is not ecotoxic and is environmentally benign.

5.4.7 Safety Provisions Considered in the Design of the Secure Landfill

The geotechnical design of embankments of the DSFs complies with the following minimum factors of safety requirements stipulated in the ANCOLD guidelines (**Table 5.9).**

Table 5.9: Minimum Factor of Safety (FoS) Specified by the ANCOLD Guidelines

Case Analysed	Remark	Minimum FOS
Construction Phase	Applicable during initial construction prior to commissioning	1.2
Short-Term Static Loading	Post-initial construction, operating conditions.	1.3
Long-Term Static Loading	Post operating conditions, closure	1.5
Pseudo-Static (Earthquake Loading)	Applicable at any time	1.1

Tables 5.10 and 5.11 list out the test that will be carried out in line with the Malaysia standards and guidelines and international best practices (in the absence of Malaysian standards) to ensure the structural stability of the DSF.

Table 5.10: Testing Methods to be Employed for DSF Structural Design

Item	Tests	Test Method	Remarks
A	**NUF Material**		
i	Moisture content	BS1377:Part 2:1990, Method 2	Tests to identify material characteristics
ii	Atterberg limits • Liquid limits • Plastic limits • Plastic Index	BS1377:Part 2:1990, Method 4 BS1377:Part 2:1990, Method 5 BS1377:Part 2:1990, Method 5	
iii	Particle size distribution tests	BS1377:Part 2:1990, Method 9	
iv	Proctor tests	BS1377:Part 4:1990, Method 3.5	Specify minimum density and moisture of NUF when stored in landfill
v	Direct shear tests	BS1377:Part 7:1990, Method 4	Shear strength parameters used in stability analysis / modelling
B	**Earthfill Material**		
i	Moisture content	BS1377:Part 2:1990, Method 2	Tests to identify material characteristics
ii	Atterberg limits • Liquid limits • Plastic limits • Plastic Index	BS1377:Part 2:1990, Method 4 BS1377:Part 2:1990, Method 5 BS1377:Part 2:1990, Method 5	
iii	Particle size distribution tests	BS1377:Part 2:1990, Method 9	
iv	Proctor tests and field density tests	BS1377:Part 4:1990, Method 3.5 & BS1377:Part 9:1990	Specify minimum density and moisture of earth when building the embankment.

Item	Tests	Test Method	Remarks
C	**Soil samples from the Soil Investigation**		
i	Consolidation properties	BS1377: Part 5: 1990, Method 3	Settlement prediction
ii	Triaxial tests (UU / CU)	BS1377:Part 8:1990	Shear strength parameters of subsoil layers
D	**HDPE Liner; GCL Liners; Geotextiles (High strength; Cushion; Separator)**		
i	Material properties required for the construction is tabulated in the project specification	Listed in the Specifications	Properties of material delivered must achieve the minimum specified
E	**Road base and Sub-base for access road**		
i	Physical properties (Similar to item Ai to Aiii)	i	Physical properties (Similar to item Ai to Aiii)
ii	CBR tests	ii	CBR tests
iii	Proctor tests	iii	Proctor tests

Table 5.11: Compliance to Slope Stability in the DSF Structural Design

Item	Tests	Standards / Guidelines Adopted	Remarks
1	Slope stability analysis (Static Loading)	Guidelines for Slope Design by Jabatan Kerja Raya	Minimum safety factor = 1.4 (short term) FOS = 1.2 (long term)
2	Slope stability analysis (Seismic Loading)	Guidelines for Slope Design by Jabatan Kerja Raya MS EN 1998-1:2015 (National Annex:2017) – Part 1 – Design of Structures for Earthquake Resistance	
3	Maximum settlement Caused By Consolidation of Subsoil Layers	One dimensional consolidation theory used. Adopted in Geotechnical software	Limits of settlement is the maximum strain of the liners
4	Surface water management	Rational Method JPS Manual	100 years flood and 72 hours rainfall volume. All water storage cells designed with a 700mm free-board
5	Erosion control	JPS Manual on Erosion and	Erosion and rainfall management are elements that will erode the stability of the design and must be in place and maintained through-out the post closure stages
6	Access Road	JKR Road Manual	
Notes			

Item	Tests	Standards / Guidelines Adopted	Remarks
1.Slope Stability analysis are based on ANCOLD, as follows: - Minimum safety factor during construction: 1.2 - Minimum safety factor for short term static loading: 1.3 - Minimum safety factor for long term static loading: 1.5 - Minimum safety factor considering earthquake load: 1.1 (Earthquake load parameters based on MS EN 1998-1:2015 (NA 2017)) 2. Settlement and long term stability analysis are calculated using a finite element software, plaxis and static stability analysis using FINE5 and / or GEOSLOPES's SlopeW. In the stability analyses, all possible localized and global slip surfaces were checked using Bishop and Spenser methods for circular and wedge type failures respectively			

5.4.8 Access Road and Transportation of NUF Residue

The current road access to NUF Geotube 1 will be used to access the NUF DSF 2 area with an access ramp into the DSF area. Traffic route for the transportation of NUF from the filter press area to the NUF DSF 2 is shown in **Figure 5.15**. Transportation of NUF residue from the process area to the secure landfill (NUF DSF 2) will use the same route currently used for NUF DSF 1.

Transport of the NUF residue to the new DSF secure landfill will be made via dedicated open top tipper trucks. The feeding process of NUF inside the trucks will be strictly monitored and controlled in order to avoid overloading and spillage. The trucks will make trips to the secure landfill as per the standard operating procedure currently in place.

The proposed secure landfill site is an open space and previous NUF handling by Lynas has shown that NUF residue amalgamate rather than forming an aggregate. However, aggregates are still expected to be generated due to the movement of vehicles in the DSF area. Therefore, under normal operating conditions, the moisture of the NUF will be maintained so as to minimise the generation of fugitive dust. Should an emergency take place, the existing ERP (elaborated in Chapter 9) will be implemented.

5.4.9 Secure Landfill Surface Water Management

As mentioned previously, the NUF DSF 2 will be equipped with three (3) bunds (**Figures 5.12a, 5.12b and 5.12c)**, allowing all surface water collected in the NUF DSF to be managed and treated as one source. The schematics of surface water management at the secure landfill is presented in **Figure 5.16.**

Surface water that accumulates in the secure landfill is mostly rainwater that had come into contact with the NUF residue. As the NUF residue has very low permeability, rainwater will generally flow over the residue rather than infiltrate through. Following this, the runoff and to a lesser extent, the leachate, following the contouring of the NUF DSF 2, will then be directed to the sump pit.

The contents of the sump pit will be sampled and analysed on a daily basis for selected key parameters (Mn, TSS and pH) and compared against the Standard B limits stipulated in the Environmental Quality (Industrial Effluents) Regulations 2009. If the constituent complies with the limits, it will be conveyed to the Clear Well prior to being released at the Final Discharge Point (FDP). The discharge from the FDP will be released into LAMP's stormwater retention pond which overflows into an unlined earth drain that flows along the southern boundary of the LAMP site. In the event the results of the analysis do not comply with the prescribed Standard B limits, the discharge will be pumped back to the Surge Lagoon and subsequently into LAMP's High-Density Sludge (HDS) area (3T1101) (Industrial Effluent Treatment Plant (IETS)).

The BFD and mass balance of the IETS in **Figure 5.17**

Based on the 100-year rainfall record of 850 mm rainfall in 72 hours, the proposed secure landfill (NUF DSF 2) will be able to manage a total of 35,803 m^3 of storm water. The proposed secure landfill will have a water ponding capacity of 13,022m^3 while the remaining 22,781m^3 will be channelled to the surge lagoons (if storm water doesn't comply to Standard B) or clear wells (if storm water complies to Standard B).

The secure landfill will be employed with a sump pump with a capacity of 250m^3/hr which is sufficient to handle storm water during normal raining season. However, during monsoon season (worst-case scenario), Lynas will install portable diesel pumps with a capacity of 300 m^3/hr to manage the storm water generated by 850 mm rainfall for 72 hours. This will ensure that no overflow of storm water from inside secure landfill. The locations of the pumps are presented in **Figure 5.18.**

5.4.9.1 Waste Water Control and Monitoring

The IETS technicians will carry out water sampling from the surge lagoon to analyse the water quality during each work shift. Summarised below **(Table 5.12)** are the control points, sampling frequency and responsible parties to manage the waste water. It is important to note that, industrial effluent will be tightly controlled and monitored to ensure compliance to the stipulated limits.

Table 5.12 : Wastewater Control and Monitoring Plan

No	Control point	Sampling frequency	Responsible person	Remark
1	NUF DSF 1 Sump pit	Before pumping	OUR Prod Technician	Analyse for pH and Mn
2	3T1106/3T1156 (HDS area)	Every shift	OUR Prod Technician	If NUF DSF 1 sump not meet standard B – Abnormal condition

No	Control point	Sampling frequency	Responsible person	Remark
3	Surge Lagoon	Every shift	IETS Prod Technician	Take sample at mixing chamber.
4	Sequential Batch Reactor (SBR)	Every shift	IETS Prod Technician	IETS lab testing
5	Clear Well	Every shift	IETS Prod Technician	IETS lab testing
6	FDP 3T4403	Once / day	IETS Prod Technician	Central lab testing
7	FDP 3T4403	Every shift	OUR Prod Technician	Check for Na, Mg, Ca, Cl, SO_4, Si, TDS, Mn, Fe, COD, TSS, pH
8	FDP 3T4403	Once a week: Saturday	OUR Prod Technician	Analyse for all 31 parameters standard B
9	FDP 3T4403	Daily	Third party contractor-Under SHES team	Check for Cod, TSS, Temp, pH
10	FDP 3T4403	Weekly	Third party contractor-Under SHES team	Analyse for Standard B parameter
11	SRP	Every shift	OUR Prod Technician	Check pH at several points at entire SRP
12	SRP – Outfall	Daily	Third party contractor-Under SHES team	Check for Cod, TSS, Temp, pH
13	SRP– Outfall	Weekly	Third party contractor-Under SHES team	Analyse for Standard B parameter

5.4.10 Environmental Monitoring System

The current LAMP site has a comprehensive environmental monitoring system approved by the DOE Pahang. The addition and operation of a NUF DSF 2 area is not expected to incorporate significant changes to the environmental monitoring system currently being implemented on-site.

5.4.10.1 Fugitive Dust Management

The NUF residue will have 45-50% moisture content during its placement in the secure landfill. Drying using natural airflow will not cause the residue to become airborne. NUF cake with moisture content of 35% to 45% will harden over time and will have a low probability to create any dust.

5.4.10.2 Environmental Monitoring Program

5.4.10.2.1 Ambient Air Quality

The existing ambient air monitoring program is deemed sufficient and remains applicable with the execution of this proposed Project. The monitoring program is carried out on a monthly basis and conducted in four (4) sampling locations at the boundary of the Project site. The sampling and analysis methodology will be described in detail in Chapter 6.

5.4.10.2.2 Groundwater Quality

The existing groundwater monitoring program will remain applicable with the execution of the proposed Project. The monitoring program consists of seven (7) sampling locations and sampling is carried out on a monthly basis, and the methodology will be further elaborated in Chapter 6.

5.4.10.2.3 Noise Level Monitoring

No abnormality in noise level is expected during the construction and operation of the new NUF DSF 2. However, the existing noise level monitoring program currently in place at the LAMP remains applicable with the execution of this Project. The monitoring program consists of four (4) sampling locations, similar to ambient air quality stations. Sampling is carried out on a monthly basis, and the methodology will be further elaborated in Chapter 6.

5.4.10.2.4 Surface Water Monitoring Program

The existing water quality monitoring program along Sg Balok remains applicable with the execution of this Project. The monitoring program consists of eleven (11) sampling locations and sampling is carried out on a monthly basis, and the methodology will be further elaborated in Chapter 6.

5.4.10.2.5 Effluent Final Discharge Point Monitoring Program

The existing monitoring program developed and implemented for the OUR Section (as per Document No. SP-330-001, Rev. No. 01) remains applicable with the execution of this Project. The monitoring program covers the effluent of Final Discharge Point (FDP) and is carried out as per schedule.

5.4.11 Research and Development Towards NUF Commercialisation

It is important to note that, Lynas has always been committed to prevent and minimise sources of pollution and waste. Through diligent research and development efforts, Lynas has developed two major products using LAMP process residue:

1. Road base material (RB10, RB10SA)
   - These road base materials have been proven to be suitable substitutes for aggregates and sand. They will be used in road construction and as landfill material to reclaim and rehabilitate land.

2. Soil Conditioner (CondiSoil)
   - CondiSoil contains WLP, NUF and filler material in a ratio of 1 : 2 : 7 respectively. NUF residues are magnesium rich synthetic gypsum. It provides nutrient sources to soil in the form of magnesium, sulphide, calcium and phosphorus. CondiSoil

acts aa a great limiting agent as well as soil conditioner. The presence of calcium sulphate also helps reduce aluminium toxicity.

A diagrammatic representation of the different product trials carried out on NUF and CondiSoil is as shown in **Figure 5.19**. Lynas has carried out lab tests, pilot trials and upscaled studies on crops such as paddy, corn, kenaf, teak, palm oil, coconut and napier grass.

Mining of bauxite in Kuantan in the past had caused detrimental impacts on the environment, health and quality of life for people living in the vicinity. To prevent recurrence of similar post–mining practice, Lynas in collaboration with University of Malaysia Pahang and Malaysia Nuclear Agency carried out a study on the applicability of CondiSoil as alternative backfill engineered buffer material for post–mining bauxite land.

In summary, the R&D to commercialise the use of WLP and NUF has grown and diversified from being products for road-base material in road construction to soil conditioners that will ameliorate poor soil for agriculture, as well as alternative backfill engineered and buffer material to rehabilitate bauxite-mined areas for civil construction.

Lynas' commercialisation R&D has clearly provided an opportunity for the adoption of best practicable means to use and reduce its residues safely. This is in line with the important principle in waste management of from cradle to cradle encouraged by the DOE and world environmental bodies.

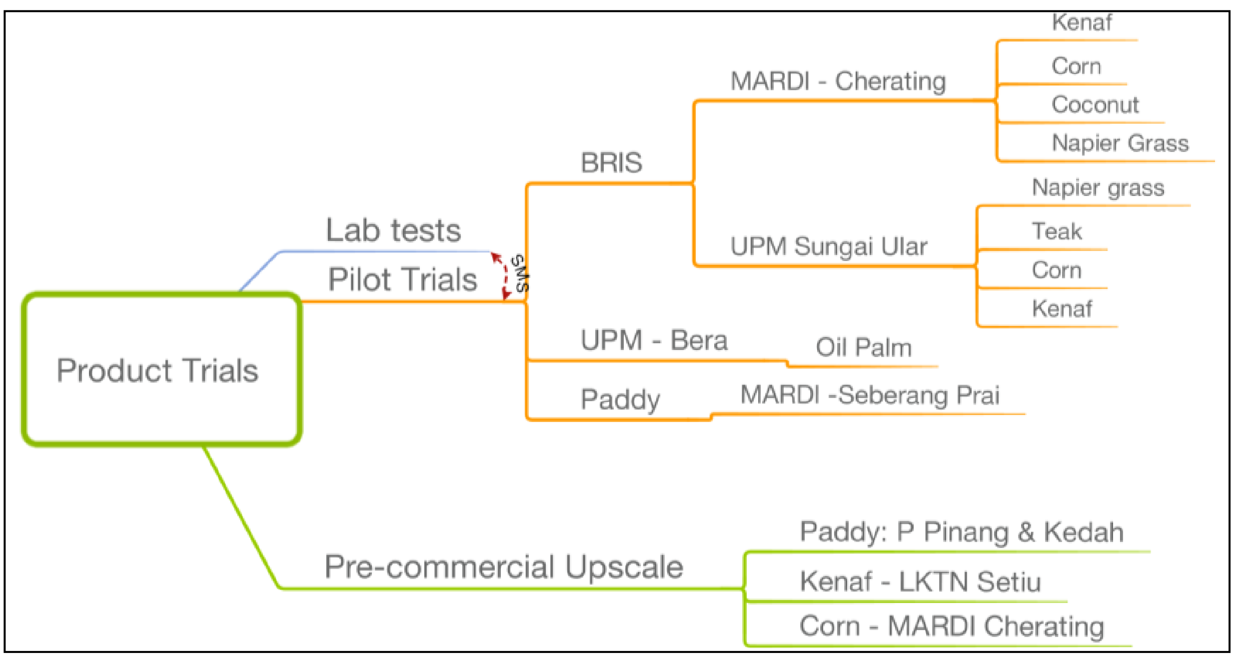

Figure 5.19: Product trials involving CondiSoil as ameliorant of poor soil condition in agriculture

5.4.11.1 Research and Development Outcome for NUF CondiSoil

Lynas had collaborated with five (5) universities, four (4) research institutes, four (4) accredited laboratories and several toxicological and engineering consulting firms to carry out nine (9) research projects to prove that the WLP and the NUF can be used commercially instead of being disposed of as waste. The engagement of subject-matter experts and facilities ensure the much-needed confidence to back the research outcomes.

Research on formulations containing a mixed ratio of WLP to NUF as well as NUF on its own demonstrated its suitability and applicability as construction materials, soil conditioners and even as an alternative to engineered buffer material.

Table 5.13 summarises all the research carried out by Lynas up to the time of reporting. It summarises the research collaborators and institutions involved, locations and outcome of studies as well as the impact of applying the residues on the environment.

It is important to highlight that:

a. All research projects were pre – approved by the DOE and the AELB before being implemented.
b. The research projects were carried out by experts and accredited research institutions and facilities.
c. Every research project involved a potential client who may benefit from NUF’s commercialisation.
d. The R&D outcome confirmed that CondiSoil and NUF are soil conditioners that can be used to ameliorate poor soils which is important for local agriculture.
e. The R&D outcome confirmed that CondiSoil and NUF are not radioactive, non-toxic, non-ecotoxic, non-carcinogenic and met all chemical tests specified under Regulation 7 of the Special Management of Scheduled Wastes
f. NUF and CondiSoil can be commercially used as soil conditioners and alternative engineered buffer material for use to rehabilitate bauxite mined areas (filling up the mining pit)

Table 5.13 : Summary of Research Carried Out by Lynas for Commercialisation

No.	Topic	Status	Study Duration	Collaborators	Project Location	Project Outcome		
						Heavy Metal	Radioactivity	Yield
1	RB10 and RB10SA as road base material	Completed 12th of Feb 2012	8 months	KL Integrated Consultant (IKRAM), Asia Lab and ERA Lab	Lab Study at IKRAM	• Conforms to JKR criteria for road – base material • Non-toxic, test below TTLC and TCLP limits	Not a radioactive material	RB10SA is suitable as road – base material
2	Testing Lynas' residue (NUF and WLP) in glasshouse trials by University of Western Australia (Plants: Wheat and Canola)	Completed February 2014	1 year	University of Western Australia	Greenhouse study at the University of Western Australia	Leaching of elements and rare earths from the residue were within the expected range	-	• Increase in soil pH • NUF complements guano or carbon for greater effect on wheat growth.
3	Evaluation of CondiSoil as soil ameliorant	Completed 08th of January 2018	2.5 years	MARDI and UKM	MARDI Cherating, Pahang	Below the permissible limit or lower than other reported studies	Below the permissible limit or lower than other reported studies	Positive yield
4	Evaluation on the Efficiency of CondiSoil Application on paddy	Completed July 2018	2 years	MARDI and UKM	Alor Pudak, Pendang, Kedah	Below the permissible limit or lower than other reported studies	Below the permissible limit or lower than other reported studies	Positive yield and increase in soil strength (high resistivity towards soil erosion)
5	Effects of CondiSoil on Growth and Yield of Oil Palm Planted on Mineral Soil	Completed August 2018	4 years	UPM and UKM	Bera, Pahang	Below the permissible limit or lower than other reported studies	Below the permissible limit or lower than other reported studies	Positive yield

No.	Topic	Status	Study Duration	Collaborators	Project Location	Project Outcome		
						Heavy Metal	Radioactivity	Yield
6	An Upscaled Study on Grain Corn Production using CondiSoil	**On – Going** Project Expected Feb 2019	2 years	MARDI and UKM	35 acres. MARDI Cherating, Pahang.	Not available	Not available	Not available
7	An Upscaled Study on Kenaf Production Grown using CondiSoil	**On – Going** Project Expected Feb 2019	2 years	UPM, LTKN and UKM	50 acres. Lembaga Kenaf dan Tembakau Negara, Setiu, Terengganu.	Not available	Not available	Not available
8	Evaluation on the Applicability of CondiSoil as Alternative Backfill and Buffer Material	**Completed** 25th of May 2018	9 months	UMP and Malaysian Nuclear Agency	Bukit Goh, Kuantan, Pahang	Below the permissible limit or lower than other studies	Below the permissible limit or lower than other studies	• Positive rehabilitation of soil (as alternative backfill material • Good for Agriculture.
9	Enhancing the Fertility of an Acidic Malaysian Soil for Sustainable Oil Palm Cultivation using NUF Residue	**Completed** 25th of May 2018	3 years	UPM and UKM	• Bera, Pahang • UKM and UPM (Nursery Stage)	Below the permissible limit or lower as compared with other studies	Not Applicable	Equal or above average. NUF can be alternative to kieserite

Source: Lynas Malaysia Sdn. Bhd.

The commercialisation of products derived from NUF will commence once approval for Special Management of Scheduled Wastes from DOE is received. Upon receival, Lynas will implement the construction of all the necessary plants and facility required to commercially produce the approved products. Concurrently, Lynas will also resume all business negotiations with potential clients for the sale of the products.

5.4.12 Secure Landfill Closure Plan

The proposed Lynas capping design uses a combination of several cover systems, with an engineered system. The following points encapsulate the NUF DSF capping design:

- The proposed capping design will include a double liner system to prevent escape of residue to external environment. In addition, the dry stacking method used by Lynas results in a far more stable contour compared to slurry-based tailings dams.
- The proposed capping design will include a double liner system preventing leakage, as well as a capillary break to inhibit the development of a hydraulic gradient.
- The proposed capping design will include erosion controlling measures (rock mulch, plant species), gradients for surface run off, infiltrated water collection and drainage, and slopes designed with recommended safety factors.
- The proposed capping design will include drainage and surface run off controls.
- Materials required for the closure plan are not exotic and are available in close proximity to the plant.

For the closure of the DSF once it has reached its storage capacity, the proposed capping is as follows:

- The total height of the cap will be nominally 1000 mm.
- The vertical cross section of layers for the cap will be:
  - 0.7 mm (or similar) HDPE liner
  - 200 mm drainage layer (coarse river sand) with drainage pipe at 50m spacings
  - 300 mm bio-barrier (cobble-stones), eliminating burrowing animals
  - 400 mm top-soil
  - 100 mm layer of rock mulch, planted with Vetiver grass at 2m spacings. Natives are expected to naturally infiltrate once the vetiver establishes sufficient shade to promote germination.
- Drainage pipe will be used at 50 m intervals to assist in movement of water through the drainage layer.
- The drainage pipe will drain to stormwater drains surrounding the facility, with the stormwater drains draining to the Balok River through existing stormwater drainage infrastructure on site.

5.4.13 Abandonment Plan

The LAMP is built within an established industrial estate where land prices are typically around MYR 15 – 20 per ft^2. One of the key issues with building a permanent onsite secure landfill (in case of LAMP unexpected shutdown) is that it consumes industrial land.

With the final height of the secure landfill being 34 m, there will be a relatively flat top measuring 14 hectares in area. There is an option to revitalise the top flat section of the secure landfill into a solar farm. Solar panels itself are light in weight and provide a good amount of renewable, clean energy to Lynas plant and reduce its electricity bill during daylight hours. This will definitely preserve the economic value of the land and gain some positive public perception throughout Malaysia.

Besides that, it is proposed that the east end of the stormwater retention pond will be converted into a natural wetland biofilter, to provide an extra level of treatment and protection prior to discharge.

5.5 PROJECT REQUIREMENT

5.5.1 Road Network

The GIE is linked to the major town of Kuantan, regional port and airport by main coastal trunk road, Jalan Kuantan – Kemanan (FR 3) and the East Coast Highway. These links also provide access to the southern part of Malaysian Peninsular (Johor Bahru), whilst the East – West Highway to the north of Project site, provides direct access to the West Coast of Peninsular Malaysia (Penang and Ipoh). The existing road network is presented in **Figure 5.20.**

Jalan Kuantan – Kemanan which is part of FR 3 is a single lane dual carriageway road. Gebeng Bypass passes through the area of Kuantan Port and is a 2 – lane dual carriageway. Currently, there is only one road that connects the Gebeng Bypass to the GIE.

The proposed secure landfill Project is connected to the Kuantan Port through Jalan Kuantan – Kemaman and Jalan Gebeng Bypass. Jalan Kuantan – Kemaman is located at the south of the development site, whilst Jalan Gebeng Bypass is located at the north of the plant site. The plant site is connected to Jalan Kuantan – Kemaman through three roads i.e. Jalan Gebeng 1/1, Jalan Gebeng 1/11 and Jalan Gebeng 2/5, whilst the plant site is connected to the Gebeng Bypass through an existing road located at the west of the plant site.

5.5.2 Utilities

5.5.2.1 Electricity

Total electricity consumption during construction period will be 31536kWh

Total Daily Electricity Consumption during operational phase will be 350.4kWh :

i. Pump 3P3602 = 264kwh
ii. Others (lighting etc) = 86.4kwh

5.6 PROJECT IMPLEMENTATION SCHEDULE

Tentatively, the construction of the four (4) newly proposed NUF DSF will take an approximated 10 years, with the first to be constructed; DSF 2, was just recently approved for construction in February 2019. Currently, clearing of piping structures and pipe racks are ongoing in its proposed location. Civil works for these structures are expected to be minimal as majority of the bund walls are already in place.

Following this will either first be DSF 3 or DSF 4 in 2021 or 2020 respectively, depending on the financial situation of the company. DSF 5, the last in line, is expected to initiate construction in November 2025 and rather than being a discreet storage area itself, it is rather the area at height that remains in order to establish the final contour of the facility.

The tentative Project implementation schedule is outlined in **Figure 5.21**