November 2016

Bangka-Belitung Site Reclamation Plan

Final Conceptual Design Report

PREPARED FOR

The Sustainable Trade Initiative
Utrecht, the Netherlands

PT Bangka-Belitung Timah Sejahtera
Bangka-Belitung Island, Indonesia

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- Tin Working Group (TWG)
- Southeast Asian Regional Centre for Tropical Biology (SEAMEO-BIOTROP)
- Institut Pertanian Bogor (IPB)
- Provincial and regent governments for Bangka-Belitung

NOVEMBER 7, 2016

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Preface

This conceptual design report provides information on the restoration and reclamation of a 10-hectare artisanal tin mining site found on the island of Bangka-Belitung. The design approach is based on existing site information and on successful reclamation projects and approaches from the surrounding region. The proposed design uses reforestation and wetland restoration to restore the ecological health of the site, addressing soils, biodiversity, and water quality in its approach. By restoring native forests and wetlands, important ecological processes that were impacted by mining can be re-established, allowing the local community to develop additional business opportunities at the site through agriculture, ecotourism, recreation, and forestry. Methods for establishing these areas are described within this document; including information on site grading, soil preparation, plant species specifications, and maintenance recommendations. Additional information on community organization and engagement is also included along with estimated costs for implementation. This design approach ultimately seeks to develop a replicable restoration methodology that can be applied to similar artisanal mining sites in the region, in an effort to restore native habitats and develop alternative economic opportunities.

This report was developed through the combined efforts of Fred Phillips Consulting, LLC, Oxbow Ecological Engineer, LLC, Telapak, Michael Barkley Agriculture, and Veduto Designs.

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1. Introduction

Project Goals and Objectives

1. Provide economic opportunities such that artisanal small miners (ASM) miners can choose an alternative livelihood.
2. Design a viable reclamation project where implementation can begin immediately and replicated across Bangka Island.
3. Reclaim degraded mining land into productive forests.
4. Provide sound Good Management Practices (GMP) for implementation of reclamation projects that can be replicated throughout Indonesia.
5. Establish early action projects that can begin immediately (nursery, compost, community trash, clean-up, etc.). Determine the level of funding available for these projects.
6. Establish meaningful metrics so that reclamation process can be optimized for future projects.
7. Determine the budget for project construction and identify what the other companies are willing to pay.
8. Provide successful and replicable example of large-scale reclamation on degraded tin-mined lands on Bangka Island.
9. Use site data including depth to groundwater, soil texture/salinity, topography, and existing infrastructure information to guide restoration designs and create healthy riparian habitats that require minimal long-term maintenance after initial establishment.
10. Strive for 80% survivorship in all plantings of restoration habitats.
11. Achieve government success criteria within 3 years of implementation.

Licensing Status

Status IUP

Company Name: PT. Bangka Belitung Timah Sejahtera
Contact Person: Ir. H. Ernawan Rebuin
Position: Director
Address: Jl. Ketapang City Industrial Zone
Pangkalpinang, Kep Province. Bangka-Belitung

Location: Village Belilik Village. Namang District, Central Bangka, Kep Province. Bangka, Belitung

Licensing Status

Tin mining sites, as described in this plan and managed by PT. Bangka Belitung Timah Sejahtera, are located in the Village District Belilik Namang, Central Bangka regency, province of Kep. Bangka Belitung. This activity is based on the Decree of Regent middle, Number 188.45 / 605 / DPE / 2014, dated 14 June 2014 on the Granting of Licenses Mining Production Operation to PT. Bangka Belitung Timah Sejahtera for the 10 hectares proposed for reclamation.

Permit Area

PT. Bangka Belitung Timah Sejahtera has a license for 10 hectares of Mining Production area in the Village District of Belilik, Namang, in Central Bangka. The planned reclamation area will cover the 10 hectares described by the mining license agreement.

Project Area and Existing Conditions

Regional Mining Permit (Permit Area) Production Operations PT. BBTS is located in the Village District Belilik Namang, in Central Bangka on the Island Province Bangka Belitung. Access to the location of the town is via the road south from Pangkal Pinang. Road conditions between the two towns are relatively good due to the hotmix asphalt. The distance between Pangkal Pinang and Village Belilik Namang is about 45 km. Figure 1 and Figure 2 illustrate the location of the proposed project site.

Climate

As a tropical climate, weather variability for Bangka-Belitung is based on rainfall, with seasonal variations related to the monsoon season. Temperatures average 27.5°C throughout the year, with annual rainfall averaging 3,218mm. The drier season (June through September) brings hotter daily temperatures, averaging a high of 30.5°C and a low of 23°C. Rainfall is still present but diminished, with the driest month, August, averaging 186mm of monthly rainfall. The wet season (December to March) brings more cloud cover and rain with lower daily temperatures and highs averaging 29°C and lows averaging 24°C. Rainfall reaches its peak around November, averaging 405mm (Meteoblue 2016, Climatedata.org, 2016). Typhoons are common between September and December, resulting in periods of heavy wind and rain outside of the annual wet season.

Figure 1-1. Location of the proposed project site on the island province of Bangka-Belitung relative to Village District Belilik Namang

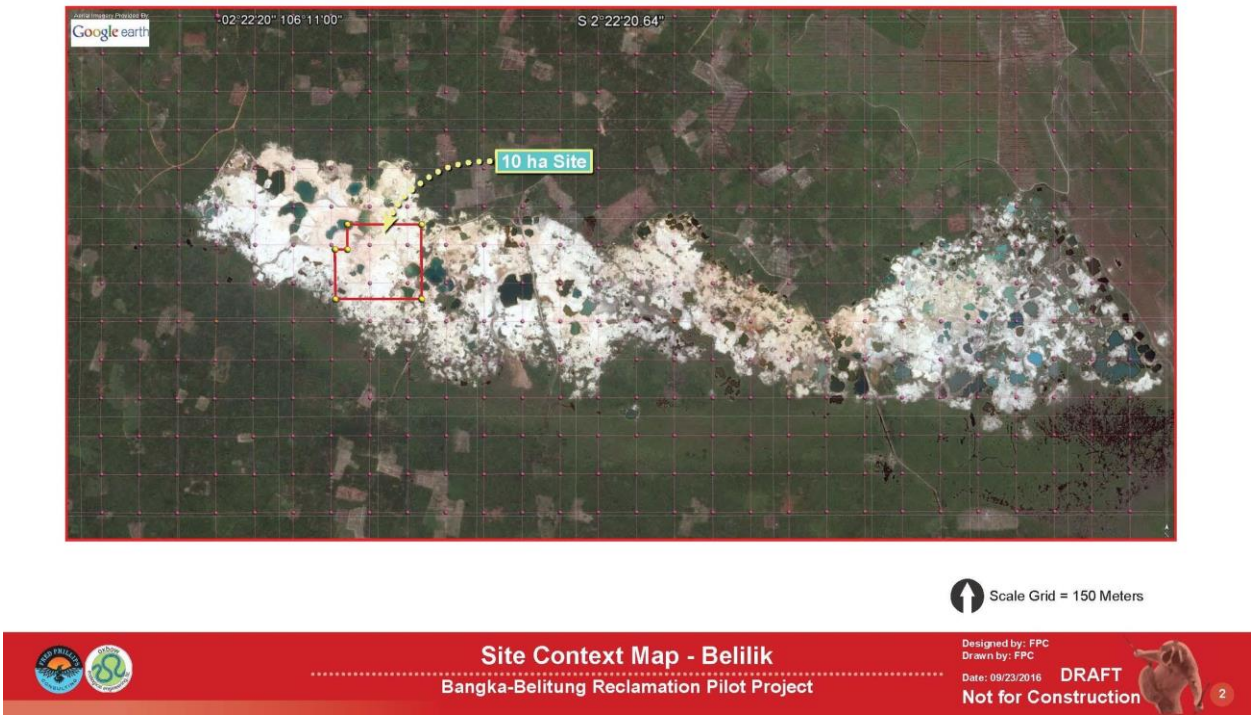

Figure 1-2. Proposed project site within the larger mining area at the project site location

Water Quality

Mining activities at the project area have resulted in the formation of several ponds throughout the site. Waste materials and tailings left at the site from mining activities present a risk to these water sources as they can facilitate the formation of sulfuric acid and the mobilization of trace metals into solution. This chemical process can occur for hundreds to thousands of years after mining operations have ceased, depending on the amount of waste and tailings left at a reclaimed site. Over time this process can lead to acidified water and a reduction in the availability of trace metals for plant growth in adjacent areas.

To assess current water quality, water samples from the project site were taken from four of the ponds found at the site (Figure 3). Each sample was tested for total dissolved solids, pH, and dissolved oxygen. This preliminary analysis provides an initial measure of how water at Bangka-Belitung has been impacted by mining at the site. Mine drainage with a pH value of 4 or below requires more aggressive remediation measures (Banks 1997), as lower pH values can facilitate mobilization of a wide variety of trace metals, including iron, manganese, copper, zinc, lead, arsenic, and aluminum. As pH levels become closer to neutral values (pH 6.5-7.5), the concentrations of these dissolved metals is reduced (Balintova et al. 2012), resulting in chemical forms of these metals that are more available for plant use.

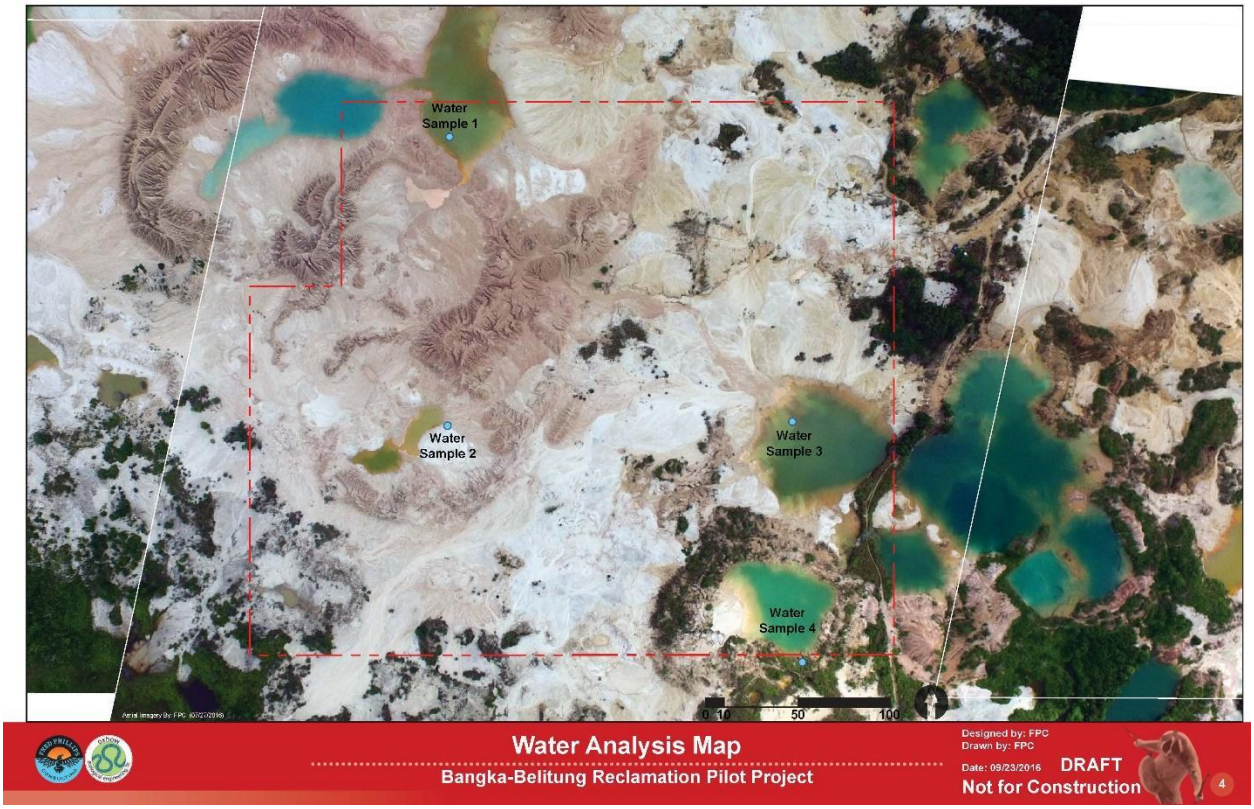

Figure 1-3. Map showing the locations of the water samples tested at the project site.

Table 1-1. Water quality results for ponds at the reclamation site in Bangka-Belitung, Indonesia.

Sample ID	Temp (°C)	TDS (mg/L)	pH	DO (mg/L)
1	31.1	13.7	5.98	3.96
2	31.4	16.5	5.52	4.23
3	30.5	9.34	5.19	4.05
4	32.7	7.33	6.32	4.37

The preliminary water quality results for the site (Table 1) indicate that the pH of water in the region, while acidic, is likely to have relatively lower concentration of mobilized trace metals than more acidic mine drainage. Dissolved metals may include copper and zinc, with higher than normal amounts of manganese and iron. Cadmium is also a concern as acidic mine drainage can transport and allow the metal to accumulate in some areas. If plants are grown in these areas, it can accumulate in different plant tissues, which can be harmful if consumed by animals or humans. Heavy metal testing is recommended to determine how mine drainage at the site has impacted water quality and to identify specific metals that should be remediated at the site. One method for treating contaminated water uses constructed wetlands to passively remove metals and decrease water acidity. Constructed wetlands utilize a variety of biochemical processes to treat waters with high concentrations of dissolved metals and low pH. These processes are facilitated by microbial activity, phytoremediation, and other naturally occurring chemical interactions.

Soil Conditions

Soils in the area are typical of tropical systems. Warmer temperatures and frequent precipitation result in accelerated rates of bedrock weathering, mineral loss, and decomposition. This results in soils that are highly depleted of minerals and organic matter. Tropical soils also tend to have lower pH values, which can further accelerate mineral loss and lower nutrient availability for plants. Some topsoil is available at the site, which should be re-applied to the site as part of the soil preparation process.

Sample ID	pH		Cation Content (cmol$_c$/kg)		Soil Texture (%)			Soil Salinity
	pH (H20)	pH (KCl)	Ca	Mg	Sand	Silt	Clay	
S-1	5.89	4.19	<0.01	0.12	74.27	24.99	0.74	0
S-2	6.34	5.18	<0.01	0.17	98.71	1.2	0.08	0
S-3	5.75	5.7	0.01	0.13	97.53	2.44	0.03	0
S-4	4.82	4.79	0.04	0.17	96.7	3.19	0.12	0
S-5	5.31	5.19	0.06	0.15	98.3	1.98	0.02	0
S-6	5.74	5.48	<0.01	0.13	98.47	1.48	0.05	0
S-7	6.35	6.13	0.01	0.16	98.41	1.56	0.03	0
S-8	7.52	7.12	0.03	0.18	98.44	1.54	0.02	0
S-9	5.81	5.05	0.01	0.11	97.43	2.55	0.02	0
S-10	5.38	5.34	0.08	0.07	97.98	2	0.01	0
S-13	6.44	6.27	<0.01	0.08	98.87	1.11	0.02	0
S-12	5.05	5	<0.01	0.05	94.93	5.01	0.06	0

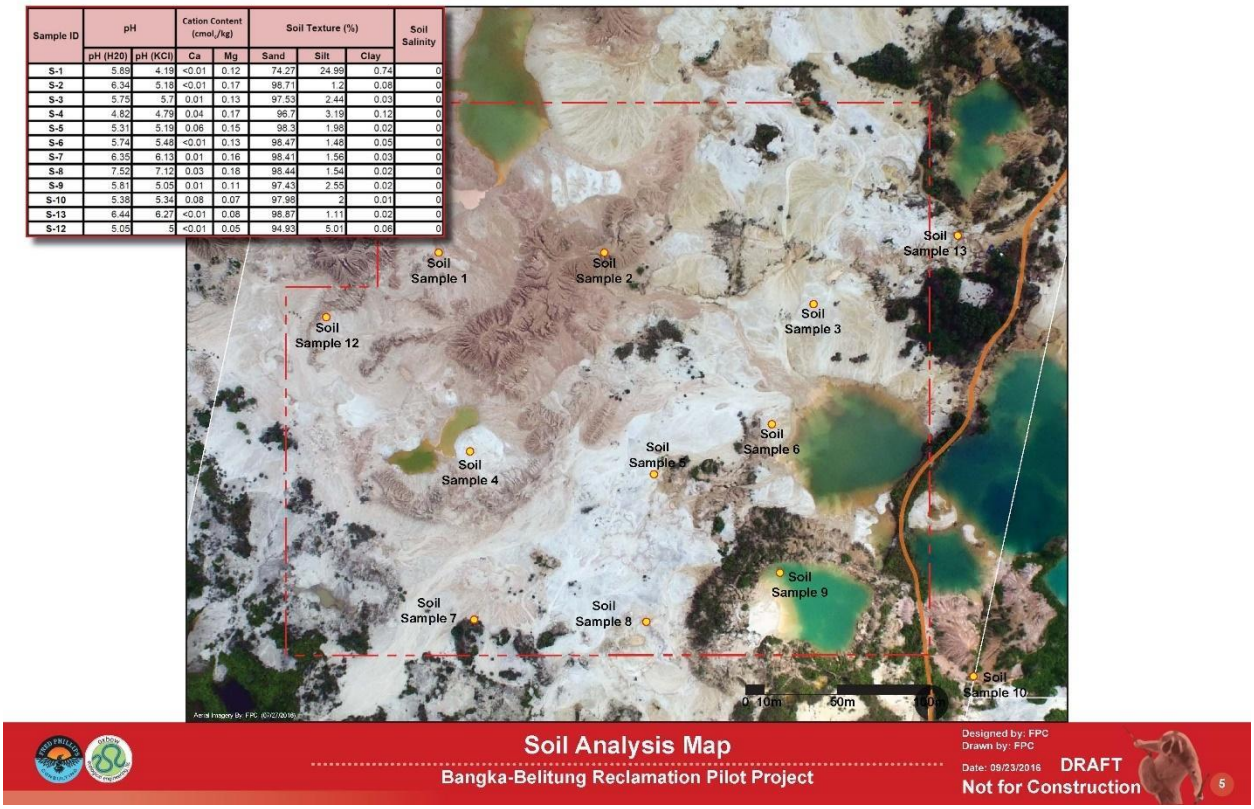

Figure 1-4. Map showing the locations of soil samples at the project site.

To assess soil conditions at the reclamation site, samples were collected at 12 sites in August 2016. The samples were sent to the PT Anugrah Analisis Sempurna Analytical Laboratory in Jakarta Bogor to assess soil pH, cation exchange capacity, soil texture, and salinity. Soil pH was assessed using both water and KCl methods to determine field pH and extractable aluminum pH. Calcium and magnesium content were assessed using an ammonium acetate extraction buffered to pH 7. Soil texture analysis determines fractions of sand, silt, and clay content in each soil. Soil salinity was also assessed on all samples, although none was detected for any of the samples.

The results of the analysis are provided in Table 1-2.

Table 1-2. Laboratory results of soil samples collected at the project site.

Sample ID	pH		Cation Content ($cmol_c/kg$)		Soil Texture (%)			Soil Salinity
	pH (H20)	pH (KCl)	Ca	Mg	Sand	Silt	Clay	
S-1	5.89	4.19	<0.01	0.12	74.27	24.99	0.74	0
S-2	6.34	5.18	<0.01	0.17	98.71	1.2	0.08	0
S-3	5.75	5.7	0.01	0.13	97.53	2.44	0.03	0
S-4	4.82	4.79	0.04	0.17	96.7	3.19	0.12	0
S-5	5.31	5.19	0.06	0.15	98.3	1.98	0.02	0
S-6	5.74	5.48	<0.01	0.13	98.47	1.48	0.05	0
S-7	6.35	6.13	0.01	0.16	98.41	1.56	0.03	0
S-8	7.52	7.12	0.03	0.18	98.44	1.54	0.02	0
S-9	5.81	5.05	0.01	0.11	97.43	2.55	0.02	0
S-10	5.38	5.34	0.08	0.07	97.98	2	0.01	0
S-13	6.44	6.27	<0.01	0.08	98.87	1.11	0.02	0
S-12	5.05	5	<0.01	0.05	94.93	5.01	0.06	0

Soil pH was assessed using both water-based pH measurements and by extraction with a KCl electrolyte solution. To measure soil pH with water, soil and deionized water are mixed together in a 1:1 ratio and then measured with a pH probe. Water-based measurements provide general measurements of soil pH in the field. Samples measured indicate slightly acidic soils at the site, with pH averaging 5.87. Measuring pH with a KCl solution indicates the presence of exchangeable aluminum. If the KCl pH is below 5.2, exchangeable aluminum is present. Six of the soil samples tested indicate potential for available aluminum which suggests some variability throughout the site. Aluminum is known to inhibit plant growth and is common in acidic soils, where calcium content is low.

Cation Exchange Capacity (CEC) is a measure of the available base cations (e.g. Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+}). These cations are essential for plant growth and are adsorbed to soil particles, where they are available for uptake. As plants use base cations, hydrogen (H^{+}) and aluminum (Al^{3+}) ions can replace them in soils, increasing soil acidity over time if base cations are not replaced. When base cations become depleted, the ability of soils to support plant production becomes limited. Because tropical soils tend to be more weathered, CEC is naturally low. In mining sites, increased acidification from mining spoils can further deplete base cations, lowering the ability of soils to support plant growth. Analysis of calcium and magnesium at the site suggests very depleted amounts of base cations, with five samples having calcium concentrations measured below the instrument detection limits. The low levels suggest a decreased capacity for supporting plant growth and decomposition (Astera 2014), and a higher potential for high concentrations of aluminum and hydrogen ions. Soil additions from fly ash, limestone, bones, or crushed shells are recommended to increase availability of these nutrients and improve soil pH.

Soil texture analysis indicates soils with very high sand content, and very low silt and clay content, which is indicative of tropical soil systems. Tropical systems, which are known for their warmer climates and frequent precipitation, have high turnover of nutrient cycling and decomposition, this can leave soils weathered and depleted at much faster rates that soils in more temperate climates. This also limits the availability of such resources for plant growth, as nutrients and organic matter can be depleted from the system with each precipitation event. Silt and clay content are needed to help soils retain moisture and to provide exchange sites for nutrients. High sand content indicates a limited ability to retain water, nutrients, and organic matter, which are necessary for sustainable plant growth

Overall the results indicate that soils are depleted of much needed nutrients and have high pH which may inhibit plant growth and establishment in the area. High sand content, coupled with low calcium content, also limits nutrient availability and can reduce decomposition as soils have a limited ability to retain moisture. Low soil pH, evident in many of the samples (below 5.7) suggests that soils will not sustain much plant growth in their current state. As these are tropical soils, they are already highly weathered and sandy, which limits their ability to support plant production for very long. These results indicate that substantial inputs are needed to help restore nutrient availability, stabilize soil pH, and increase soil clay and organic matter. This may require the addition of multiple soil improvement treatments prior to planting to properly restore the potential of these soils to support plant production.

Improvements that should be considered for the site include the incorporation of existing topsoil, and organic soil amendments from compost, manure, and mulch. These inputs will add much needed organic matter and sediments to help soils retain nutrients and water for plants. They also provide materials for plant growth, such as base cations, nitrogen, and carbon, and may help alleviate high concentrations of aluminum and hydrogen ions. Using locally sourced compost, manure, and mulch is recommended to introduce much needed native biota, such as microbes and fungi, that can help facilitate plant growth and nutrient uptake as plants become established. Cover crops, such as *Centrosema pubescens* and *Pueraria javanica* should also be used be used to help retain moisture and nutrients in at least the top few inches of soils while larger plants are established. However, inputs from high nitrogen fertilizers, are not recommended. Because soils in the site are so porous and have a limited ability to retain water and nutrients, high nitrogen inputs have the potential to result in leaching from the site, further robbing soils of needed minerals and trace elements.

Site Topography and Morphology

No existing topographic data was available for the PT BBTS Reclamation Site at the time of this study, however, several generalizations can be made about the morphology of the site based on a detailed analysis of drone photography (see Figure 5 for reference). The site is characterized by:

- Tall, barren, unconsolidated mining spoil piles with steep erodible slopes cut with rills and deep gullies.
- Depressional/pit areas that retain surface water. Most of the pits area are situated at the lower portions of the site catchment areas and likely collect most of the overland stormwater flow from adjacent mining spoil piles.
- What appear to be flatter, barren areas that separate the pit and pond areas.
- The topography of the site is dynamic as artisanal miners are still active.
- According to a translated version of the 2016 *PT. BANGKA BELITUNG TIMAH SEJAHTERA Reclamation Report,* slopes on the site range from 5-20% and elevations range from 18-50 meters above sea level.

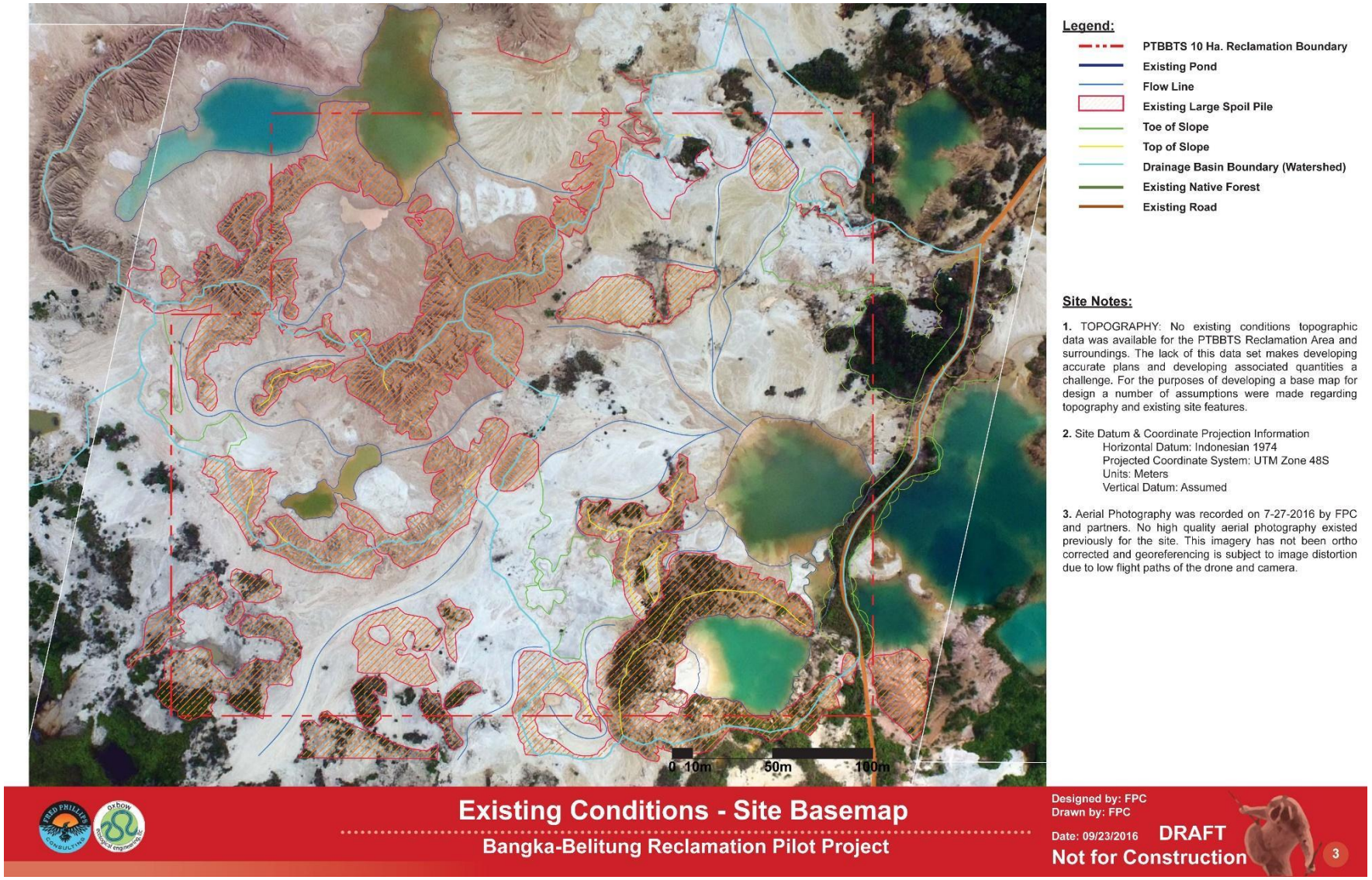

Figure 1-5. Existing topography and morphology for the project site.

2. Reclamation Design Elements

Conceptual Design

The concept design was developed based on existing site information and recently developed mine site reclamation plans. To start with the design development, the project team collected all existing site information. With the available budget, aerial photography was taken using a drone to create high-resolution imagery for the design. The project team also collected soil and water samples to do an initial analysis of water quality and soil chemistry. From this information, site topography and features were interpolated.

In addition to collecting site-specific information, existing reclamation plans, reclamation research, and recent planting projects were also assessed. This information was gathered from the Ministry of Mines and Energy, local government agencies, universities, and local community groups. The information was gathered into a literature review to evaluate existing methodology, design features, and information on previously successful work in similar areas and within the region. A copy of the final review is available in Appendix C.

The project team developed a design approach to maximize suitable areas for reforestation and wetland areas while minimizing earthwork operations. The resulting design seeks to create connectivity between the surrounding habitats, forming corridors for species. Existing water on the site is used to create wetland habitats to help improve water quality. Road and trails are incorporated to provide access for maintenance and monitoring work at the site.

Overall, this concept design presents a holistic approach to drive the reclamation of wasted lands by improving ecological health through reforestation and wetland restoration. The hope is that by restoring ecological function to the site, additional economic activities, such as agriculture, ecotourism, and animal production may also be developed over time, providing additional opportunities for income generation. The goal of this design is to enhance the existing site as a model of reclamation that may be replicated in other mined sites in the region.

Site Preparation

Purpose and Goals

The purpose of site clearing and preparation is to prepare the project site for revegetation and construction of site improvements. The goal of site clearing is to eliminate unwanted vegetation within the project site.

Prior to the start of planting, the project areas should be evaluated to determine current site conditions, including soil and water quality, and bed preparation. Parameters for soil amendments or mitigation will be based on the individual needs of the plants grown at the site and on current soil conditions, as assessed through additional laboratory analyses.

Mechanical Clearing

Mechanical clearing will utilize heavy machinery and equipment to remove vegetation from the project site. Clearing, grubbing, and stripping are recommended for portions of the site where large areas of vegetation will be removed. Once cleared, the removed material can be cut down and used in the composting facility as part of the initial production.

See Appendix B for additional information

Selective Clearing

Selective site clearing is used when only a few plants should be removed from a site prior to earthwork or soil preparation. For selective site clearing, some native plant species may be retained at a site, such as native trees, shrubs, and grasses that may be incorporated into the site design. Vegetation may be cleared using more selective methods such as hand pulling, hand-held tools and equipment, or through the application of chemicals to specific plants.

Vegetation Control During Construction

In the reforestation areas, all unwanted plant species should be cleared, while native plant species will remain. It is recommended that plants be controlled through selective techniques as these techniques create less soil disturbance on the site, which can encourage the growth of some undesirable species.

Earthwork

For the site, 10 hectares of earthwork is recommended to develop the planting areas in the conceptual plan. This will include the removal of vegetation on site, leveling and grading of site features, and construction of features to connect existing habitat to the site. Below are brief descriptions of the proposed earthwork needs. Additional information can be found in the Concept Design in Appendix A and in the Good Management Practices detailed in Appendix B.

The "PT. BANGKA BELITUNG TIMAH SEJAHTERA Reclamation Report" lists a production target of ~6,000 m^3/hectare of earth moved for land surface shaping, which equates to 33 hr/HA given a production rate of 180 m^3/hr for a single D65 Bulldozer. For a 10 HA site, this equates to ~330 hours or ~42 days of land shaping work. If an additional equipment were mobilized as part of this work, it is reasonable to assume that work could be completed in one month.

Land Shaping and Smoothing

Based on the existing land topography, as determined from aerial images, several different portions of the area will need to be reshaped and smoothed to allow for the development of wetlands and reforested areas. Land shaping and smoothing plans have been developed to limit the amount necessary at the site to help reduce costs. Details can be reviewed in the attached Design Plans (Appendix A). The following are different elements recommended for the site:

- Land Shaping to create lakes, wetlands, and native forests

- Grading for roads and trails to provide access to different areas on the site
- Construction of culverts for wetland water maintenance

Maintenance Roads

Roads and trails are recommended on the site to provide access for personnel to assist with maintenance of the site. Roads and trails shall be staked, cleared, and soils compressed. Roads and trails should be constructed to allow runoff to flow away from them to prevent washouts and channelization. Roads and trails will provide access to vehicles and to those on foot. Specifications for roads and trails are detailed in Appendix B.

Culverts

A culvert with a pipeline is recommended to maintain water levels and water flow in the southeastern pond. The culverts would be installed between the two lakes at the bottom portion of the site, allowing water flow to help improve water quality.

See Appendix B for more information.

Composting and Soil Preparation

Prior to the start of planting, the project areas should be evaluated to determine current site conditions, including soil and water quality, and bed preparation. Parameters for soil amendments or mitigation will be based on the individual needs of the plants grown at the site. Site boundaries and locations of fields for forestry should be determined. Soil samples from existing topsoil, proposed fields, and nearby non-mined areas should be collected and assessed. This will provide information on what additional inputs are needed prior to planting. Soil testing should evaluate parameters such as pH, nitrogen and phosphorous content, and organic matter. Analysis for cation exchange capacity and an SMP test are also recommended to determine application rates for liming treatments. Water testing should evaluate pH, dissolved oxygen, and dissolved solids from water sources on site. Once testing is done, soils should be prepared to help break up consolidated materials, aerate soils, and incorporate organic material, compost, and synthetic fertilizers. Any topsoil that was reserved at the site prior to mining activities should be reapplied to planting areas at this time. Additional information on soil preparation can be found in Appendix B.

Drainage Structures

Overall, planting should take place during the onset of the rainy season during the months of October and November per the GMPs for each plant species. This will help reduce the need for supplemental irrigation significantly and increase the survival rate of planted species. Drainage culverts are proposed for wetland areas, to connect one of the proposed lakes to an existing pond found on the eastern edge of the proposed site. The drainage culvert will help with maintaining the pond level and can introduce additional water flow to the site. Drainage structures are described in more detail in Appendix B and above in the Earthwork Section.

Revegetation Design

Basis of Design

The basis of the revegetation design was to establish plants that have been previously grown or utilized in the region. The design is focused on development vegetation in two main areas: reforested areas and wetlands. Each of these areas use a variety of native plant species that can improve the ecological health of the site and provide habitat for wildlife endemic to the area.

For reforested areas, the conceptual design was based on a review of previous research studies conducted in the region and on countless interviews with local specialists. This information was used to determine what species could be used for the site in its current condition. The reforested area is designed to reconnect surrounding forest habitats while using a variety of native tree and understory plants, creating a multi-layered habitat. The design seeks to build on the work of previous reclamation efforts by utilizing the species and techniques that have worked on similar sites.

The wetland areas are proposed around the lakes and water catchment areas. The species and restoration design for these areas are designed to be multifaceted. The grading is designed to facilitate runoff flow into lakes and ponds through the proposed wetlands. The wetland species are selected to help reduce water acidity and remove dissolve trace metals. Together they function by treating existing water using phytoremediation and biochemical treatment. The wetland areas should also create habitat for local species, while also creating biomass for composting and fiber production.

Planting Plan

Table 2 describes the plants that are included within the conceptual design plan; however, a wide variety of species can also be utilized in the site. Specifications on each of the plant species included in the planting design are included in Appendix B. Additional plant species that may also be considered for the area for both reclamation and potential agricultural production are provided in Appendix E.

Table 2-1. Plants included in the conceptual planting design based on planting area.

REFORESTATION SPECIES			
Trees			
Scientific Name	**Common Name(s)**	**Form**	**Planting Notes**
*Schima wallichii**	Seruk, Needlewood Tree, Schima	Tree	5%, with 4m x 4m OC spacing
*Calophyllum inophyllum**	Penaga, Alexandrian Laurel, Beauty Leaf, Kamani, Nyamplung	Tree	20%, with 4m x 4m OC spacing
*Ficus superba**	kayu ara, beringin, Strangler Fig	Tree	10%, with 4m x 4 OC spacing
*Syzygium grande**	jambu hutan, Sea Apple	Tree	20%, with 4m x 4m OC spacing
*Shorea balangeran**	Belangeran, Red Balau	Tree	10%, with 4m x 4m OC spacing
*Hibiscus tiliaceus**	Waru laut, Beach Hibiscus, Cottonwood	Shrub/small tree	20%, with 4m x 4m OC spacing
*Melaleuca cajuputi**	Gelam, Cajuput or white samet	Tree	10%, with 4m x 4 OC spacing
Paraserianthes falcataria	sengon laut	Tree	5%, with 4m x 4m OC spacing
Shrubs			
*Desmodium hiterocarpon**	Akar Entimor	Herb/shrub	4m x 4m OC spacing in 1 quadrat
Commersonia bartramia	tlimpuk, kelimpuk	Shrub/small tree	4m x 4m OC spacing, in 1 quadrat
Grasses			
Cymbopogon winterianus	Citronella grass	Grass	2kg/ha on 4 ha
*Paspalum notatum**	bahiagrass	Grass	2kg/ha on 2 ha
Fimbristylis pauciflora	rumput jenggot	Sedge	2kg/ha on 2 ha

WETLANDS			
Trees Near Water			
Scientific Name	**Common Name(s)**	**Form**	**Notes**
*Alstonia scholaris**	Pulai tree	Tree	Along border, every 50 m
*Dillenia suffruticosa**	Simpor bini	Shrub	Along border, every 5 m
Wetland Plants			
*Azzola microphylla**	Azola, mosquito fern	Aquatic fern	2m x 2m OC spacing in lower 1/3 of wetlands
*Eleocharis dulcis**	Purun, Chinese water chestnut	Sedge	2m x 2m OC spacing in upper 2/3 of wetlands

Planting Specifications

Reforestation Areas

The reforestation areas are proposed as a mix of native tree species, shrubs, and grasses to provide connectivity to neighboring forest habitats, covering 8.53 ha of the site. Trees will be planted with seedlings spaced 4m by 4m apart using a variety of native species at differing coverages in the area (see Table 2-1). Shrubs are planted approximately 4m x 4m apart in half of each hectare, in a checkerboard pattern with a single species planted in a quadrat (See Appendix A for details). This is proposed to help reduce the costs for plant procurement and labor. Prior to planting shrubs and trees, each grass species should be seeded at 2 kg per hectare. Citronella grass (*Cymbopogon winterianus*) is seeded on 4 ha of the reforestation area, while bahiagrass (*Paspalum notatum*) and rumput jenggot (*Fimbristylis pauciflora*) are seeded on 2 ha of the site. The arrangement of trees, shrubs, and grasses will help restore understory and overstory diversity to the site, improving biodiversity and habitat connectivity. Also many of the species selected, such as *Melaleuca cajuputi,* citronella grass, and belangen have commercial value for timber and essential oil production. Depending on the species, supplemental irrigation may be needed to help with plant establishment. See Appendix B for more details.

Wetland Restoration

Plugs of *Eleocharis dulcis* and *Azolla microphylla* will be planted in a 20 m wide buffer around the ponds and lakes on the site, accounting for 0.95 ha of the site. *Eleocharis dulcis* will be planted in the upper 2/3rds of the wetland area, with *A. microphylla* planted in the lower third, directly adjacent to the pond, as it requires more water. Both species will be planted in a 2m x 2m grid pattern. *Alstonia scholaris* and *Dillenia suffruticosa* will be planted around the borders of the wetlands. *A. scholaris* will be planted every 50m, while *D. suffruticosa* will be planted every 5m.

Maintenance and Monitoring

Maintenance of all portions of the site is recommended along with monitoring of revegetation success. Monitoring can provide valuable information on how different techniques work on the site. Monitoring guidelines and habitat assessments should also be developed to evaluate the success of the project. These assessments may include evaluating plant growth in tree and understory species, utilization of the area as habitat for key wildlife species, and/or recruitment of native plant species in the area. These assessments can be used to help guide additional reclamation activities and provide a means for adjusting or adapting the reclamation design as needed for improved project success. Successful plant establishment insights can be shared with similar or replicated for similar projects. Monitoring can also help provide information on less successful techniques to allow the project team to adjust their approach and re-evaluate other causal factors that may affect revegetation.

Some maintenance is recommended for each of the different areas. During the first few years, many species may need supplemental irrigation during dry periods. Reforested areas may need vegetation management to control the growth of undesirable plant species. Additional inputs compost may also be necessary to encourage plant growth. Maintenance recommendations for specific plant species can be found in the GMPs in Appendix B.

Implementation: Planning and Scheduling

Institutional Organization

As a prototyping project for multi-stakeholder work on reclamation, all parties will be included as part of the organizing body to help implement this program. Of utmost importance, the local community should be involved at the beginning of the project to strengthen the overall program. Telapak and PT. BBTS will help build the organization and create a structure with clear job descriptions for each task within the reclamation area. Successful implementation will also involve participation of contractors, such as civil engineers, during the process. Initiative and leadership for the project should come from the community to promote their ownership of this project. Telapak will lead this process within the community, using the community engagement strategy on outlined below.

Community Engagement and Organizational Structure

Telapak will facilitate meetings in Belilik to build a cooperative organization at the village level. This cooperative will be a vehicle for economic activities based on the people's 'common dream' in Belilik. Telapak's approach will begin with understanding the 'common dream' by identifying common goals and needs for community members and will achieve the sustainable livelihood in the end. This information will be used to help refine and further develop the reclamation project, as well as informing how the project will be managed by the community cooperative.

The following (Figure 1) describes the approach for addressing community engagement and involvement for this project, covering its initial implementation and long-term management. The engagement process seeks to develop on-the-ground support and oversight for reclamation work at artisanal mining sites, through local engagement, community management, and partner development. The ultimate goal of such work is to pair scientific experts and practitioners with local community members to develop reclamation projects that meet local needs, address environmental issues, and provide long-term support. Such work is valuable for the sustainability of reclamation work, allowing the project to provide realistic economic opportunities and giving local communities effective means for their continued management and development.

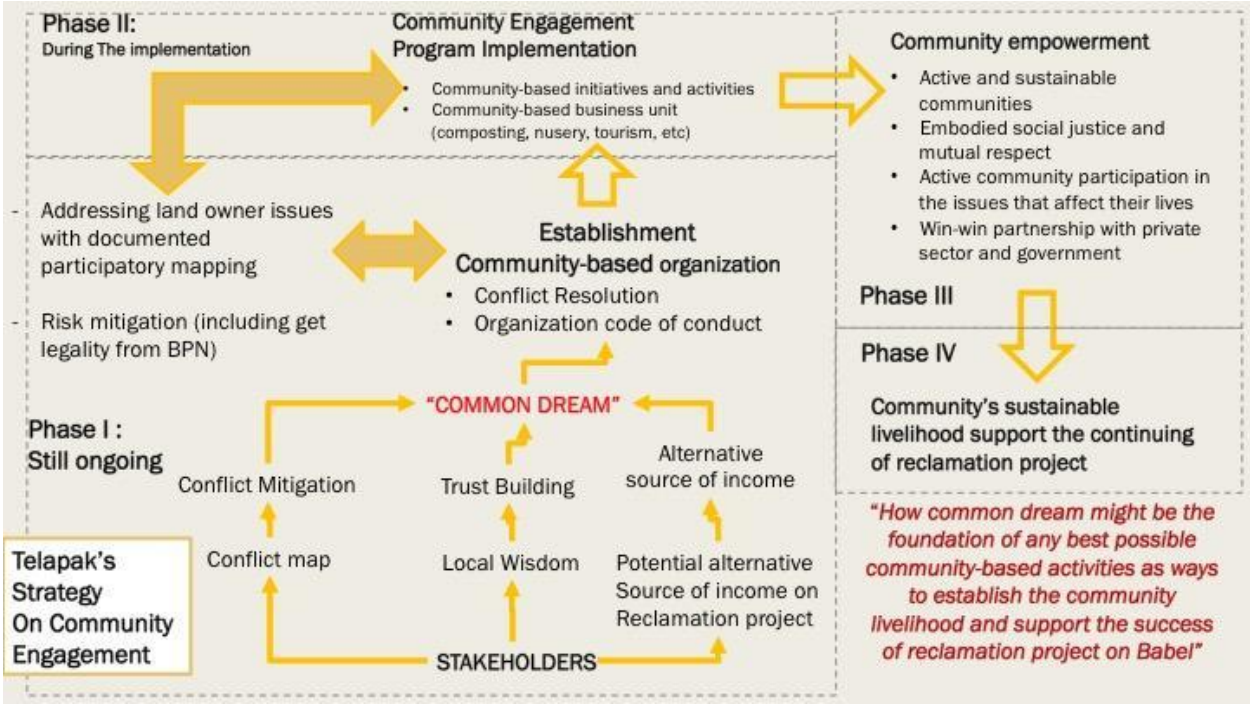

Figure 2-1. Schematic for the community engagement process for establishing community management and ownership of reclamation projects.

Phase I. Community Organization (Currently Underway)

The first phase of community engagement involves identification and engagement with potential stakeholders in the local community. This includes meeting with local community leaders, government representatives, and other members who would be most impacted by the reclamation work. These meetings would identify key needs and challenges the community has regarding reclaiming the site. This is done through a series of individual and group meetings and focuses on developing a common dream for the project among local community members. Discussions should address three major components: (1) identifying local customs, traditions, and needs (economics, social, and cultural) to develop trust among members; (2) identifying sources of conflict and how those conflicts affect working relationships among project partners; and (3) identifying economic barriers and needs in the local community to assist with developing reasonable economic alternatives. Such engagement requires contacting and engaging members of the community who may express doubts or concerns, to ensure that planning and project development is comprehensive in its approach. The final goal of Phase I is to begin a community-based organization among local residents to provide a guiding vision for the project.

The Community-Based Organization will be responsible for providing locally-based management for the project and developing financial support for its long-term management (Figure 2). A community-organized General Community Cooperative can be created to oversee and manage the reclamation effort. This Cooperative will organize the Board of Executives and

the Board of Supervision to directly oversee the project. The Board of Executives will manage the day-to-day operations (like the executive board of a company) of the reclamation site and develop sustainable business practices. The executive board will consist of at least one chief, a secretary, and a treasurer. They will coordinate all cooperative activities for each activity unit (e.g. site preparation, reforestation, etc.). Proposed activity units may include a cooperative unit to directly oversee reclamation project management, as well as a nursery, forestry, and agricultural project, if developed. Units may change depending on the outcome of the community engagement process and project development. The Board of Supervisors (like the commissioners of a company) will be monitoring and evaluating executive activities. These two Boards will work together to provide comprehensive management and organization for the cooperative. The structure of cooperative will develop like this:

First, Telapak will work with villagers to build the production cooperative. Based on Telapak's oversight mapping to the community in Belilik Village, we will continue development of existing economic income-generating activities, like agriculture, cattle, and composting. This work will continue during the initial implementation activities related to reclamation project, such as nursery development and site reclamation to restore soils and productivity to the site. In reclamation project management, community members will manage all activities in reclamation project including: tree thinning, forest health assessments, potential timber production, wildlife habitat assessments and management, and concessions if the reclamation project can be used as a tourism destination. By developing alternative means for a sustainable livelihood, people have an incentive to maintain and manage the reclamation site.

Second, if the production cooperative is going well, a financing cooperative will be organized. From experience, when people can generate income from their activities, another mechanism must be created to make sure the money is properly managed by the community. With the financial cooperative, a savings and loan system can be created. If an emergency or unforeseen situation arises, the community will not be forced to leave their management commitments to the reclamation project but can borrow funds from the financial cooperative.

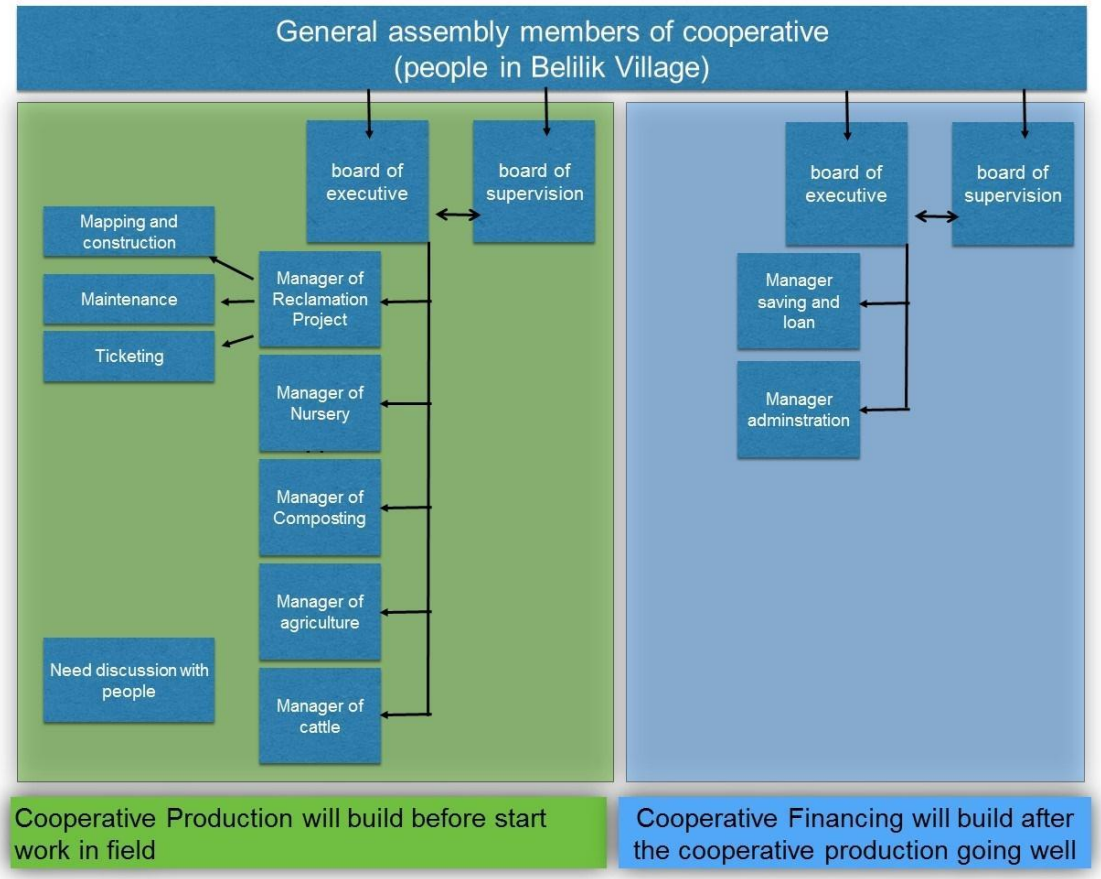

Figure 2-2. Proposed organizational structure of the cooperative, Community-Based Organization tasked with managing the Bangka-Belitung Reclamation Program associated with this project.

Telapak has currently been working on the initial engagement work for the first phase of the Community Engagement Process and has conducted meetings with several people in the Village District of Belilik Namang. Telapak has held 15 meeting with the head of the village, elders, women, indigenous leaders, young people, and local business owners. Telapak has found that community members support developing agricultural production and restoring habitat in the area. However, members are skeptical of how such enterprises would benefit the local community. There is also concern that the time and costs needed to start such industries in the area may not meet the immediate economic needs of the local community, resulting in many returning to mining as a way to generate income, and converting the reclaimed area back into mining land. Thus, the long-term success of the project is tied with its ability to create income, providing an incentive for the community to manage the project sustainably. These concerns are currently being addressed through an economic analysis of the project to assess the feasibility of the different income generating activities, such as forestry and agriculture. Additionally, it is recognized that some members of the community may need to see the project in action before they are able to fully support its long-term management.

Phase II – Project Implementation

Phase II of the project further develops the capacity of the Community-Based Organization to begin organizing and managing the reclamation work. Members of the community can provide on-the-ground expertise to develop mapping and collect site-specific data needs; as well as addressing land owner issues and concerns as they arise. They will continue to develop support for the project by organizing local initiatives and campaigns in the community to highlight the benefits of the project. This may include providing tours to residents to see work in progress, inviting other organizations to partner with the work being done, or developing public relation materials to help community members understand the goals of the project. The Community-Based Organization will also seek to hire local managers to oversee nursery development, site preparation, and reforestation. Managers will develop support staff from the local community, to provide consistent and community-based management of the site as it is developed.

Phase III – Community Empowerment

As the site is developed and the different reclamation areas are installed, the Community-Based Organization will be responsible for continual engagement and management of the project's relationship with local community members. They will organize regular meetings with local citizens, government organizations, and private entities to strengthen partnerships and capacity building to further support the environmental and economic goals of the reclamation work. This may include seeking additional opportunities to support and engage local community groups, developing partnerships with other organizations, regular communication with government agencies on project work, and developing additional economic opportunities. Ongoing engagement with local community groups will allow the Program to further support and address concerns and issues regarding the management and organization of the reclamation work. The group will also continue to identify and plan for additional projects in the area, and assess the efficacy and utility of the reclamation techniques used at the pilot project. This information will be used to inform and plan additional projects as well as to share knowledge with similar groups in the region.

Phase IV – Sustainable Support

At this stage, the Community has become fully engaged in the management, execution, and organization of reclamation efforts. In Phase IV, the Community-Based Organization will continue its efforts to develop and manage the site, by seeking additional opportunities to develop its economic enterprises, develop partnerships with other similarly minded organizations, and address further enhancements to the site. Such tasks will take place through increased community engagement and participation in the day-to-day operations and management of the site. During this phase, the Community-Based Organization can seek more diverse ways to provide sustainable livelihoods for the community. Such efforts may include development of ecotourism facilities and business enterprises, development of agricultural

products, expansion of reforested areas, or partnerships with other reclamation groups to provide additional insight into effective reclamation techniques.

Opportunities and Challenges

During Telapak's meetings with the local community, they identified key areas of concern and areas of opportunity related to reclamation. Further development of the necessary management and organizational structure presents some opportunities for growth as well as challenges. However, the need for current economic incentives are needed to prevent villagers from converting the area back into a mining site. Additionally, many members of the community are skeptical that reclaiming the site to restore ecological function can lead to the economic benefits in the long-term. Below are a few of the opportunities and challenges identify for the development of the organization needs for this project.

Opportunities

- Strategy is in line with the policies of President Jokowi
- Try new and innovative concepts to address restoration of the site
- Project has the potential to create new business and economic opportunities
- There are few success stories on reclamation in Indonesia. This project could serve as a test case for future projects.

Challenges

- It will require time and patience to help people understand the project and the potential opportunities it could develop
- Many people will not get on board until they can see success or progress.

Construction Phasing and Schedule

1. Finalize Conceptual Design Plan (October 2016) – Concept Design Team
2. Finalize Implementation Plan (November 2016) – Stakeholders
    - Select and designate implementation tasks
3. Establish Cooperative Land Management and Construction Agreements (November 2016).
4. Begin growing reclamation plants (Ongoing).
5. Selective and mechanical site clearing (Two weeks in December 2016)
    - Establish staging areas
    - Survey project boundary. Remove vegetation along site lines and access points. Clear maintenance road alignments.
    - Community training for hand clearing crews

- Remove all exotic plant materials from project site. All cleared material will be taken to the on-site composting facility.

6. Ongoing weed maintenance (Ongoing throughout project)
    - Reforested areas should be cleared of all undesirables. All native plants should remain and allowed to grow.
7. Earthwork Operations
8. Surface treatments of roads and trails (Two weeks)
    - Compacting soils
9. Construction of pond drainage culvert.
10. Purchase and/or harvest plant materials (Three weeks).
    - See Project Plant Schedule for details
    - Prepare soils and add necessary amendments (See Appendix B)
11. Establish planting areas (TBD).
    - See Plant Schedule for individual plant numbers and estimates.
    - Plants should be established in the following order:
        i. Plant wetland buffers
        ii. Plant and seed reforestation areas
12. Begin maintenance and monitoring program (Ongoing).
    - Establish monitoring program for irrigation needs, plant production, and harvesting activities
    - Plant for intensive weeding maintenance for the first three years, including replanting/seeding areas that are weeded or have plant failure.
    - Address site security and protection

Insert the Gantt Chart schedule here. Replace this page in the PDF with the PDF schedule.

Figure 2-3. Estimated schedule for implementing the proposed Final Concept Plan for Bangka-Belitung 10-ha Site.

Success Criteria

Land Use

Activities include land use planning activities, land surface modifications, top soil condition and erosion control, and water management for the project site. Land use planning can be evaluated based on the development of more detailed restoration plans, and the development of stakeholder agreements and a cooperative planning and implementation structure to implement reclamation activities.

For land surface modification success criteria, there are some parameters. The first is how well the area being improved matches the proposed design plan. Next, the stability of the slopes and grades on site. Additional earthwork operations may also be evaluated based on plan recommendations.

The next activity is spreading a layer of topsoil. Success criteria for spreading top soil layer parameter include how the area will be stocked and how much volume the top soil layer will be stocked. Improvements may also include the evaluation of how fertilizers, compost, and mulch to improve soil moisture and organic content

Erosion control and water management will be assessed based on drainages and presence of sediment settling ponds. Water quality and loss of topsoil can be used as indicators of these criteria.

Revegetation

Revegetation success will be assessed based on soil sampling, survival of seedling plants, fertilizer applications, and ongoing plant maintenance.

The topsoil in mine reclamation activities is used as a growing medium for plant roots. The topsoil is spread on land which has been prepared to a thickness of about 50-100 cm. Topsoil may be obtained from proposed mine areas. The required amount of topsoil may be considerable depending on the project site and the thickness of topsoil needed. If insufficient, topsoil should be sought from other sites around the mine. To determine the amount of topsoil needed, it is detailed land survey are needed to estimate the needed volume.

Improvements in topsoil also require regular plant maintenance, such as weeding around seedlings, fertilizing, and pest control for plant diseases. Plant treatments should be done periodically, so that the condition of the plants can be evaluated from time to time. The condition of the plant leaves can also provide an indication of nutrients deficiencies, such as yellow spotting on leaves can indicate K deficiency, pale green can indicate N deficiency, the purple coloring and indicate P deficiency.

Once the topsoil is ready, a cover crop may be planted to maintain soil quality until more desirable plants are ready for the site. Then, the number of plants that grow should be compared to the number originally planned as appropriate. Revegetation can be evaluated using the percentage of plants that grew as part of the planned revegetation.

Final Evaluation

Final evaluation of the reclamation plan is based on the fulfillment percentages for each of the reclamation activities and objects described above. The following table describes the reclamation success criteria (Table 2-2).

Table 2-2. Evaluation criteria based on PT BBTS Belilik Reclamation Plan Report

Reclamation Activity	Object/Event	Parameter	Standard	Result
Land Preparation	Land Surface	Area perimeters marked	In accordance with plan?	
		Slope Stabilization	Reduction of erosion and soil loss on site	
	Planned Area of Reclamation	Portion of area reclaimed	Good = 75%, moderate = 50% -75% of the whole area of the former mine	
		Volume topsoil	In accordance with plan?	
	Erosion Control and Water Management	Drainage canals	No erosion	
		Sediment Ponds	Meets water quality standards	
Revegetation	Soil Preparation	Soil Sampling	As planned	
		Soil pH	Good (5-6), Moderate (4.5<5)	
	Planting	Size of planting area	In accordance with plan?	
		Survival of plants	Good = 80%, Moderate = 60-80% of plan	
		Plant growth	Good = 80% Moderate = 60-80% of plan	
	Site maintenance	Fertilization	Appropriate applications	
		Weed and Pest Control	Control based on results analysis	
		Irrigation	In accordance with number of plants dead	
Final Evaluation	Reclamation Compliance	Level of Success	Success of all factors	

Preliminary Construction Costs

Table 2-3. Estimated construction costs for implementing the reclamation design.

Bangka Reclamation Plan					
Final Draft Conceptual Construction Costs					
Description	**Unit Description**	**Unit Amount**	**Unit Cost (Rupiah)**	**Total (Rupiah)**	**Total (U.S. $)**
Project Design and Management (all performed in house by BBTS)					
Grading and Revegetation Construction Documents (for 10 Ha Site)	Lump	1	- IDR	- IDR	**$-**
Project Construction Management (for 10 Ha Site)	Lump	1	- IDR	- IDR	**$-**
TOTAL Design and Management				**- IDR**	**$-**

Grading & Improvement	**Unit Description**	**Unit Amount**	**Unit Cost (Rupiah)**	**Total (Rupiah)**	**Total (U.S. $)**
Mobilization & Demobilization					
Komatsu D65 Bulldozer (2.4 m^3 Blade Capacity)	Each	1	1,000,000.00 IDR	1,000,000.00 IDR	$75.43
Komatsu PC200 Excavator (1.2 m^3 Bucket Capacity)	Each	1	2,000,000.00 IDR	2,000,000.00 IDR	$150.85
Dump Truck (6 m^3 Dump Capacity)	Each	4	125,000.00 IDR	500,000.00 IDR	$37.71
Earthwork					
Clearing, Grubbing, & Stripping	Hectare	10	2,500,000.00 IDR	25,000,000.00 IDR	$1,885.65
Lake Shaping Area	Hectare	0.5	6,000,000.00 IDR	3,000,000.00 IDR	$226.28
Wetland Shaping Area	Hectare	0.9	6,000,000.00 IDR	5,400,000.00 IDR	$407.30
Native Forest Shaping & Smoothing Area	Hectare	8.6	10,000,000.00 IDR	86,000,000.00 IDR	$6,486.65
Road & Trails	Meters	1,000	10,000.00 IDR	10,000,000.00 IDR	$754.26
Drainage & Irrigation					
Drainage Culvert	Each	1	20,000,000.00 IDR	20,000,000.00 IDR	$1,508.52
Total Grading and Improvement				**152,900,000.00 IDR**	**$ 11,532.66**

Planting Construction	Unit Description	Unit Amount	Unit Cost (Rupiah)	Total (Rupiah)	Total (U.S. $)
Analysis of Soil Quality (done in house by mining company)					
Soil Analysis	Per sample	12.0	- IDR	- IDR	$-
Water Quality Analysis	per sample	4.0	- IDR	- IDR	$-
Plant Purchase					
Trees					
Schima wallichii /Needlewood Tree, Schima*	batang	270	10,000.00 IDR	2,700,000.00 IDR	$203.65
Calophyllum inophyllum /, Beauty Leaf, Kamani,*	batang	1080	20,000.00 IDR	21,600,000.00 IDR	$1,629.21
Ficus superba /Strangler Fig*	batang	540	15,000.00 IDR	8,100,000.00 IDR	$610.95
Syzygium grande/Sea Apple*	batang	1080	20,000.00 IDR	21,600,000.00 IDR	$1,629.21
Shorea balangeran/Belangen*	batang	540	10,000.00 IDR	5,400,000.00 IDR	$407.30
Hibiscus tiliaceus /Beach Hibiscus*	batang	1080	10,000.00 IDR	10,800,000.00 IDR	$814.60
Melaleuca cajuputi/Cajuput*	batang	540	15,000.00 IDR	8,100,000.00 IDR	$610.95
Paraserianthes falcataria/Sengon laut	batang	270	15,000.00 IDR	4,050,000.00 IDR	$305.48
Alstonia scholaris/Pulai Tree*	batang	17	15,000.00 IDR	255,000.00 IDR	$19.23
Dillenia suffruticosa/Simpor Bini*	batang	165	7,000.00 IDR	1,155,000.00 IDR	$87.12
Shrub Purchase					
Desmodium hiterocarpon/Akar Entimor*	batang	1332	5,000.00 IDR	6,660,000.00 IDR	$502.34
Commersonia bartramia/timpuk	batang	1332	5,000.00 IDR	6,660,000.00 IDR	$502.34
Grasses					
Citronella	clump	40000	500.00 IDR	20,000,000.00 IDR	$1,508.52
Paspalum notatum/bahiagrass*	kilogram (biji)	4	300,000.00 IDR	1,200,000.00 IDR	$90.51
Fimbristylis pauciflora/rumput jenggot	kilogram	4	300,000.00 IDR	1,290,000.00 IDR	$97.30
Wetland Plants					
Azzola microphylla/Azola*	clump	784	2,000.00 IDR	1,568,000.00 IDR	$118.27
Eleocharis dulcis/Purin, Chinese water chestnut*	clump	1591	2,000.00 IDR	3,182,000.00 IDR	$240.01
Agricultural Plants					
Plant Materials and Labor					
Planting Delivery (per truck)	Truck	1	600,000.00 IDR	660,000.00 IDR	$49.78
Reforestation Planting Labor crew	days	20	1,100,000.00 IDR	22,000,000.00 IDR	$1,659.38
Wetland Planting Labor crew	days	4	1,100,000.00 IDR	3,850,000.00 IDR	$290.39
Organic Compost (20 tons per hectare made onsite)	Tons	200	300,000.00 IDR	60,000,000.00 IDR	$4,525.57
Total Planting Construction				**210,830,000.00 IDR**	**$15,902.10**

One Year Site Maintenance	Unit Description	Unit Amount	Unit Cost (Rupiah)	Total (Rupiah)	Total (U.S. $)
First Year Maintenance Costs					
Annual Site Maintenance and Irrigation					
Site Irrigation/Weeding Maintenance Year One (1 labors/90 days)	days	90	150,000.00 IDR	13,500,000.00 IDR	$1,018.25
Plant /Site Monitoring	Year	1	500,000.00 IDR	500,000.00 IDR	$37.71
Organic Compost (4-10 tons per acre made with onsite factory) 10HAx5Tons=50	Tons	50	300,000.00 IDR	15,000,000.00 IDR	$1,131.39
Total One Year Maintenance Costs				**29,000,000.00 IDR**	**$2,187.36**
Overall Cost					
Total Estimated Conceptual Cost				**392,730,000.00 IDR**	**$29,622.11**
Cost Per Hectare (10)				**39,273,000.00 IDR**	**$2,962.21**

Note: This feasibility-level estimate provides a planning tool for construction and implementation of the project. It does not represent a bid for services. Estimated quantities are based on draft design planimetrics and details. Prices of services and recommended products have been researched from current sources but are subject to change. All costs are based in USD and converted to Rupiah with the exchange rate current as of 8-25-2016.

Costs Not Included in Conceptual Estimate

Development of on-site Compost Factory/Nursery (could be funded with budget earmarked for compost/plants)

Kelekak and Park Area and Structures

Flying Fox

Overlooks

Workshop

Site Steward House

Materials yard

Pump

Fertilizer

Road building materials

Project construction documents and management

Costs revised to reduce per Hectare cost down	
Removed year two and three maintenance	
Removed project final design and project management	**Done in house**
Removed soil and water analysis	**Done in house**
Reduced road surfacing costs	
Removed Pump and irrigation piping	
Removed all agricultural plants from project	
Reduced spacing of wetland plants	
Reduced planting costs	
Removed Contingency costs for project	

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APPENDICES

Appendix A. Concept Design

Bangka-Belitung Reclamation Pilot Project

Final 10 HA Reclamation Concept

Nov. 1st, 2016

Sheet Index

Site Context Map.....p.2
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Conceptual Grading Plan.....p.8
Conceptual Site Details.....p.9
Wetland Restoration.....p.10
Native Forest Restoration.....p.11
Draft Planting Schedule.....p.12

Site Location Map

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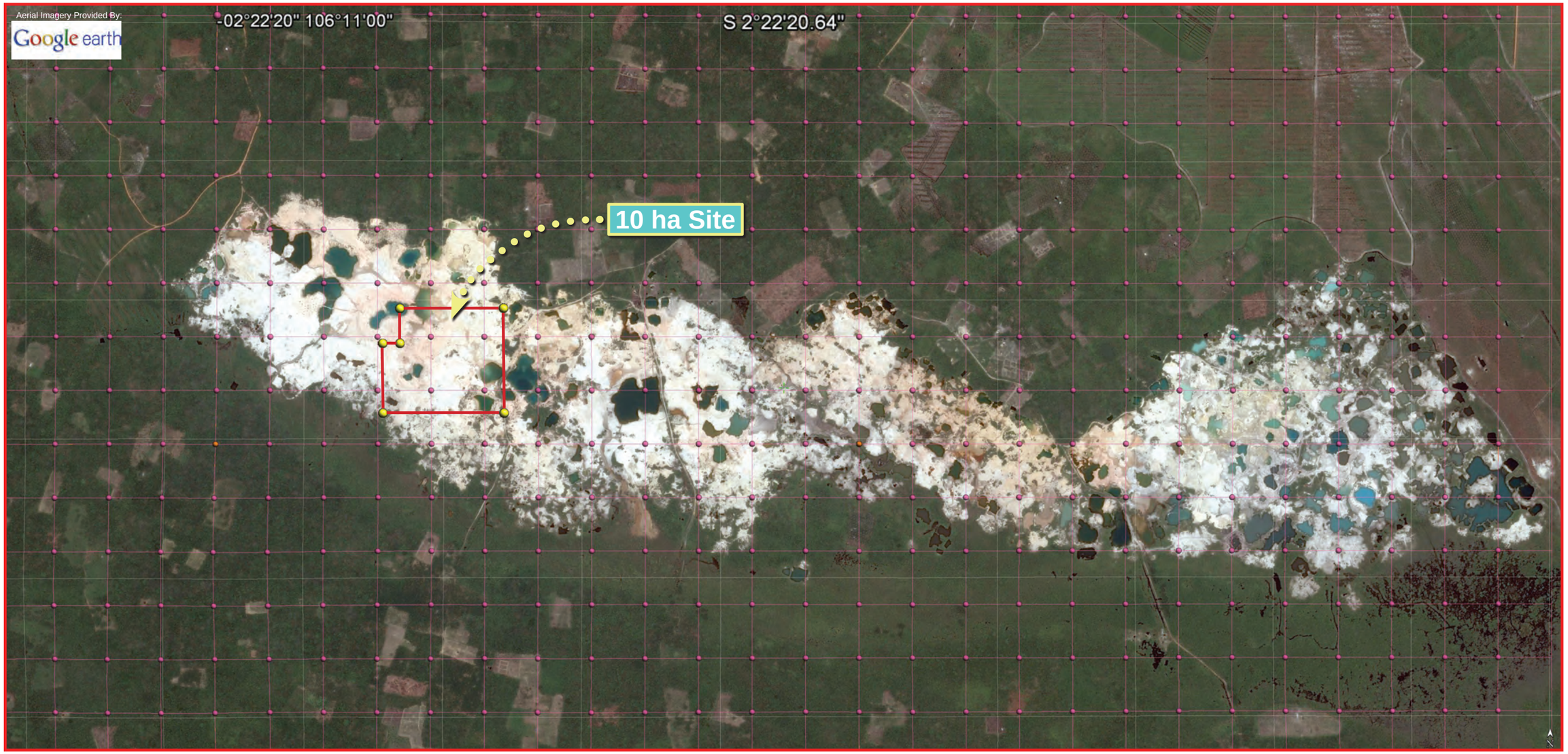
Credits:

This project was made possible thanks to: AETI, IPB, UBB, the Ministry of Mines and Energy, the Tin Working Group, SEAMEO-BIOTROP, the National Land Office (BPN), the members and leaders of the Belilik community and the people of Bangka-Belitung Islands of Indonesia.



Scale Grid = 150 Meters

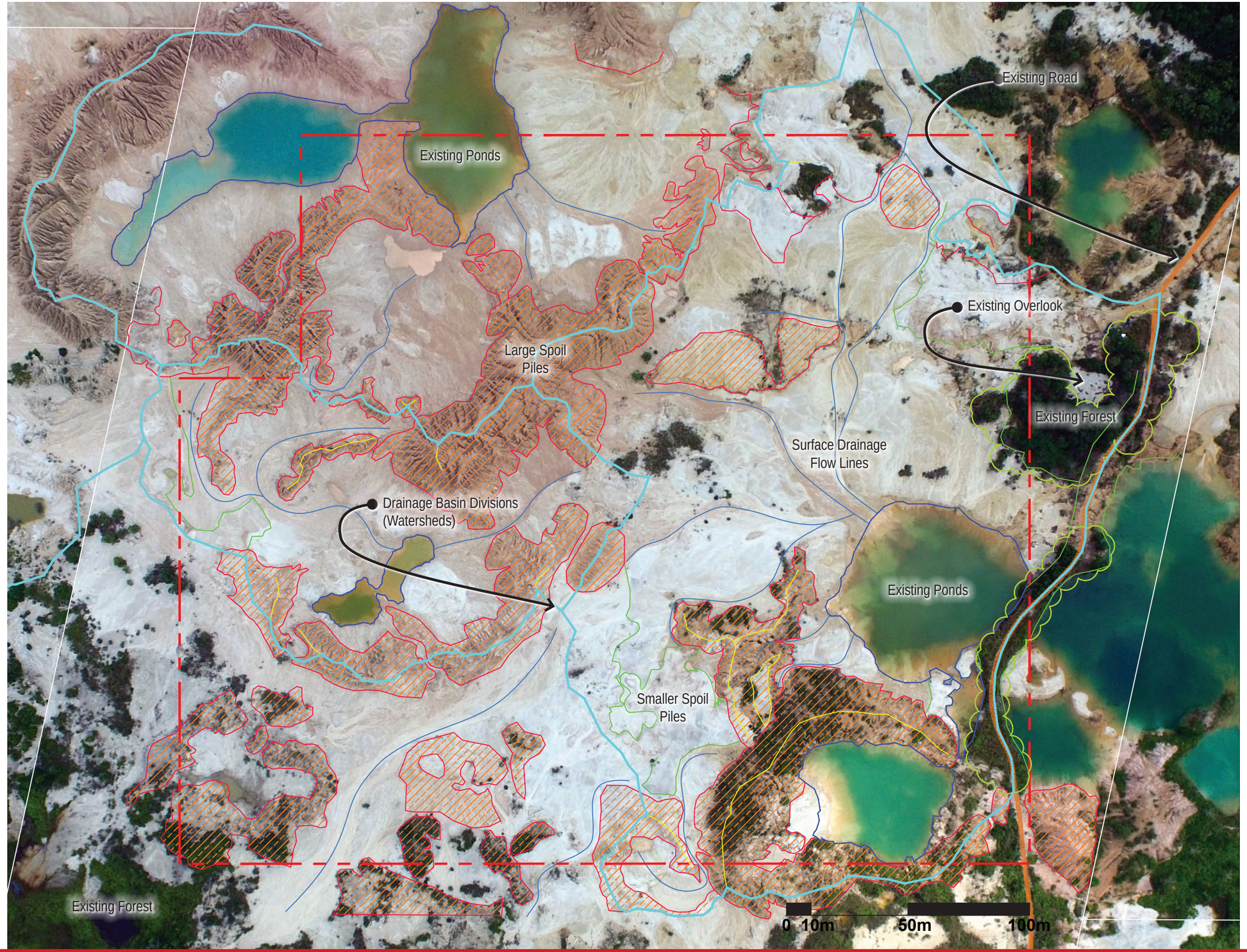
Site Context Map - Belilik

Bangka-Belitung Reclamation Pilot Project

Designed by: FPC
Drawn by: FPC

Date: 11/01/2016

Not for Construction



Legend:

- PTBBTS 10 Ha. Reclamation Boundary
- Existing Pond
- Flow Line
- Existing Large Spoil Pile
- Toe of Slope
- Top of Slope
- Drainage Basin Boundary (Watershed)
- Existing Native Forest
- Existing Road

Site Notes:

1. TOPOGRAPHY: No existing conditions topographic data was available for the PTBBTS Reclamation Area and surroundings. The lack of this data set makes developing accurate plans and developing associated quantities a challenge. For the purposes of developing a base map for design a number of assumptions were made regarding topography and existing site features.

2. Site Datum & Coordinate Projection Information
Horizontal Datum: Indonesian 1974
Projected Coordinate System: UTM Zone 48S
Units: Meters
Vertical Datum: Assumed

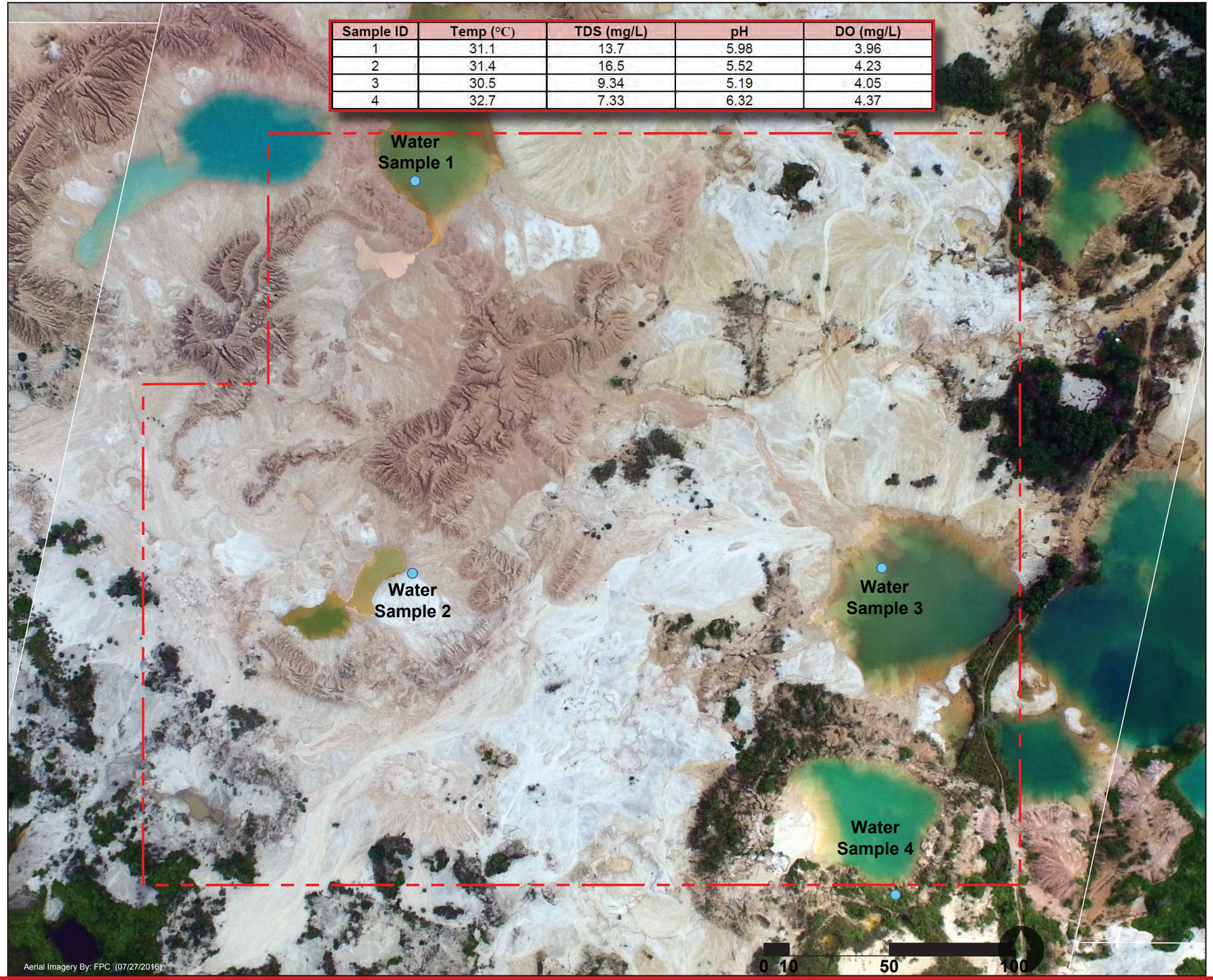
3. Aerial Photography was recorded on 7-27-2016 by FPC and partners. No high quality aerial photography existed previously for the site. This imagery has not been ortho corrected and georeferencing is subject to image distortion due to low flight paths of the drone and camera.

Existing Conditions - Site Basemap

Bangka-Belitung Reclamation Pilot Project

Designed by: FPC & OEE
Drawn by: FPC & OEE
Date: 09/23/2016 **DRAFT**
Not for Construction

Sample ID	Temp (°C)	TDS (mg/L)	pH	DO (mg/L)
1	31.1	13.7	5.98	3.96
2	31.4	16.5	5.52	4.23
3	30.5	9.34	5.19	4.05
4	32.7	7.33	6.32	4.37



Water Analysis Map

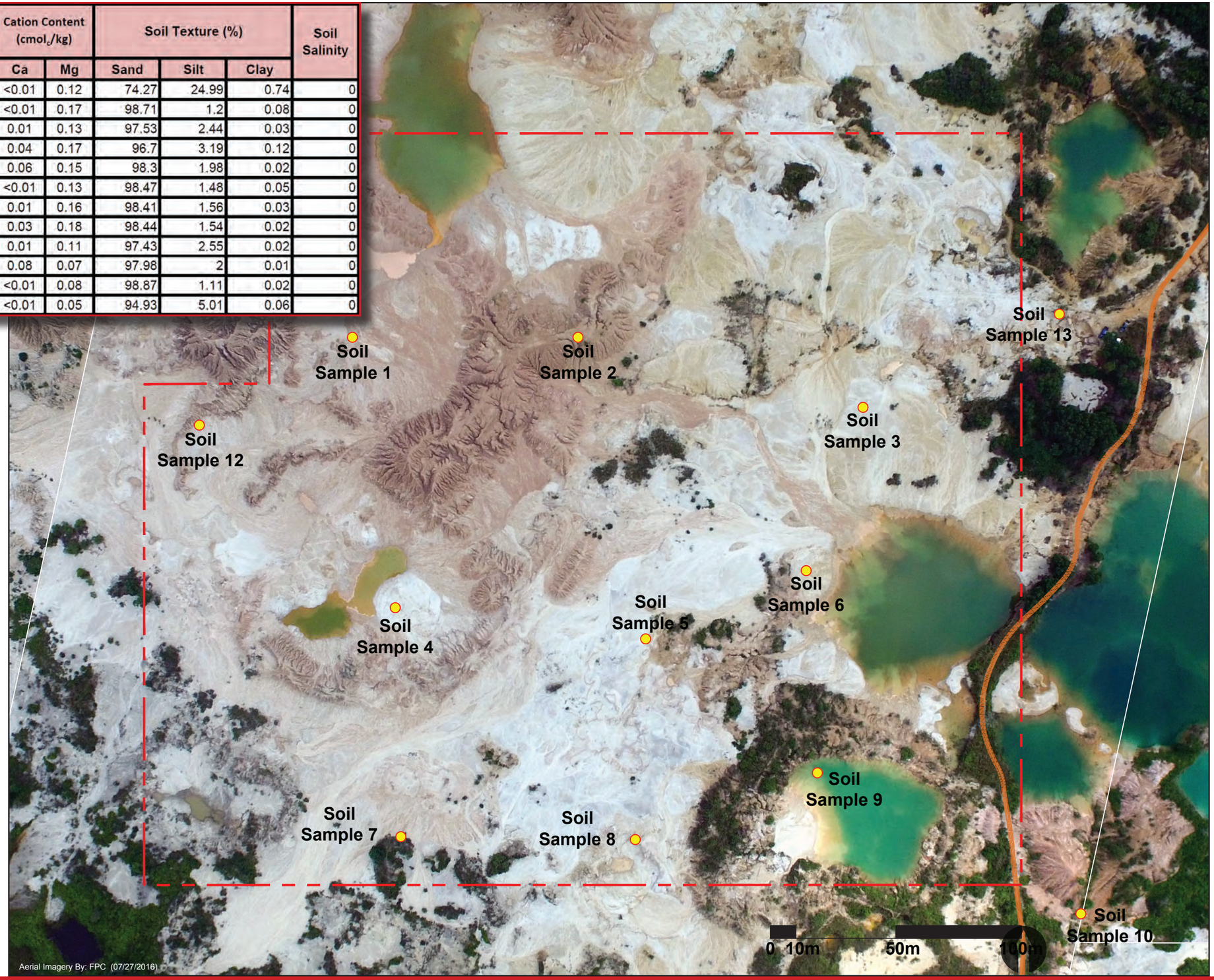
Bangka-Belitung Reclamation Pilot Project

Designed by: FPC
Drawn by: FPC

Date: 11/01/2016

Not for Construction

Sample ID	pH		Cation Content ($cmol_c/kg$)		Soil Texture (%)			Soil Salinity
	pH (H20)	pH (KCl)	Ca	Mg	Sand	Silt	Clay	
S-1	5.89	4.19	<0.01	0.12	74.27	24.99	0.74	0
S-2	6.34	5.18	<0.01	0.17	98.71	1.2	0.08	0
S-3	5.75	5.7	0.01	0.13	97.53	2.44	0.03	0
S-4	4.82	4.79	0.04	0.17	96.7	3.19	0.12	0
S-5	5.31	5.19	0.06	0.15	98.3	1.98	0.02	0
S-6	5.74	5.48	<0.01	0.13	98.47	1.48	0.05	0
S-7	6.35	6.13	0.01	0.16	98.41	1.56	0.03	0
S-8	7.52	7.12	0.03	0.18	98.44	1.54	0.02	0
S-9	5.81	5.05	0.01	0.11	97.43	2.55	0.02	0
S-10	5.38	5.34	0.08	0.07	97.98	2	0.01	0
S-13	6.44	6.27	<0.01	0.08	98.87	1.11	0.02	0
S-12	5.05	5	<0.01	0.05	94.93	5.01	0.06	0



Soil Analysis Map

Bangka-Belitung Reclamation Pilot Project

Designed by: FPC
Drawn by: FPC

Date: 11/01/2016

Not for Construction

Concept Plan - Final 10 HA Reclamation Project

Bangka-Belitung Reclamation Pilot Project

Designed by: FPC
Drawn by: FPC

Date: 11/01/2016

Not for Construction

Drawn by: Veduta Design

Conceptual Rendering

© Fred Phillips Consulting, llc

Existing Site

Assume Mean Water Surface Elevation for Lake = 10.0m (See Note 1)

Excavate & Connect Adjacent Lakes

Lake (0.1 HA)
FG=8m± (min)

A.1 / 9

Wetland (0.3 HA)
FG=9.9m±

Native Forest
(8.3 HA)
FG=Varies

Assume Mean Water Surface Elevation for Lake = 10.0m (See Note 1)

A.1 / 9

Install Culvert to Connect Adjacent Ponds

Excavate as Required to Connect Adjacent Lakes

Lake
(0.4 HA)
FG=8m± (min)

Native Forest
(0.3 HA)
FG=Varies

Wetland (0.6 HA)
FG=9.9m±

Meters

50 0 50 100

LEGEND:

Existing:

- PTBBTS Reclamation Boundary (10 HA)
- Roads/Trails
- Mining Spoil Piles (Approximate)

Proposed:

- FG = 8.0m — Conceptual Finished Grade Elevation (See Note 1)
- Coneptual Land Shaping Slope Direction
- A / 9 — Cross Section/Detail Indicator
  - Cross Section/Detail Identifier
  - Sheet Reference

CONCEPTUAL DESIGN ELEMENTS:

- Clearing, Grubbing, & Stripping Area
- Lake Shaping Area (See Detail A.1, Sheet 9)
- Wetland Shaping Area (See Detail A.1, Sheet 9)
- Native Forest Shaping & Smoothing Area (See Detail A.1, Sheet 9)
- Road & Trails (See Detail A.1, Sheet 9)
- Drainage Culverts (See Detail B.1 & B.2, Sheet 9)

NOTES/ASSUMPTIONS:

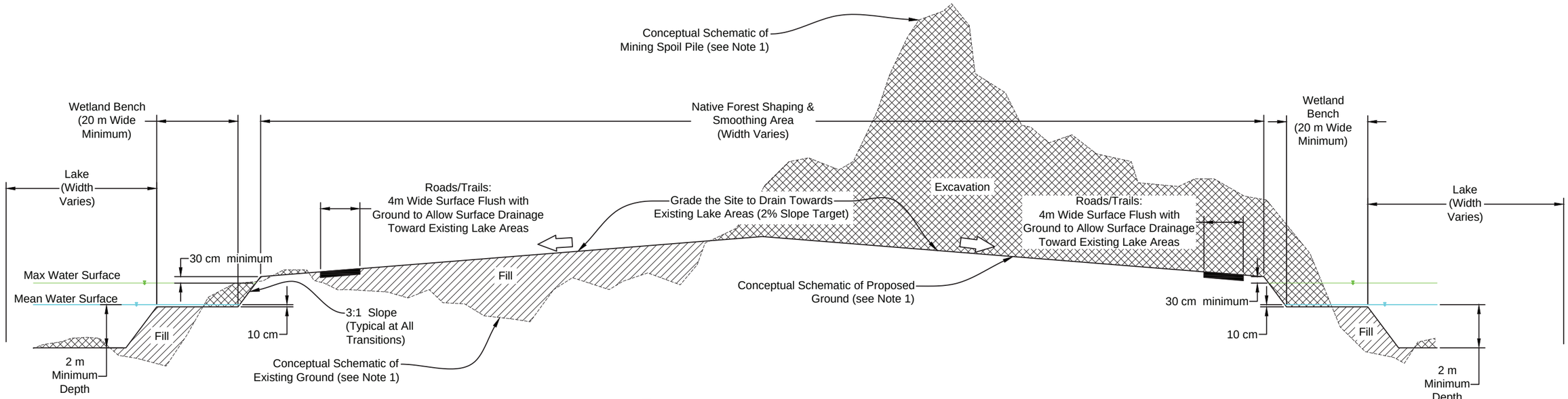
1. TOPOGRAPHY: No existing conditions topographic data was available for the PTBBTS Reclamation Area and surroundings. The lack of this data set makes developing accurate grading plans and developing associated quantities a challenge. For the purposes of developing a conceptual design a number of assumptions were made regarding topography:
   - 1.1. The mean water surface elevation of the existing lakes was assumed to be 10.0m.
   - 1.2. Conceptual finished grade elevations are referenced to the mean water surface elevation of the existing lakes and are provided for reference only.
   - 1.3. It is critical that existing elevations be field verified prior to construction and final ground elevations be field engineered and adjusted to balance earthwork on site and optimize push/haul distances.
2. MATERIAL QUANTITIES: The "PT. BANGKA BELITUNG TIMAH SEJAHTERA Reclamation Report" lists a production target of ~6,000 m^3/hectare of earth moved for land surface shaping. For purposes of this conceptual plan and associated feasibility-level cost estimate it was assumed that land shaping and smoothing would be similar and the cost per hectare outlined in the report reflects this assumption.

Conceptual Grading & Improvement Plan

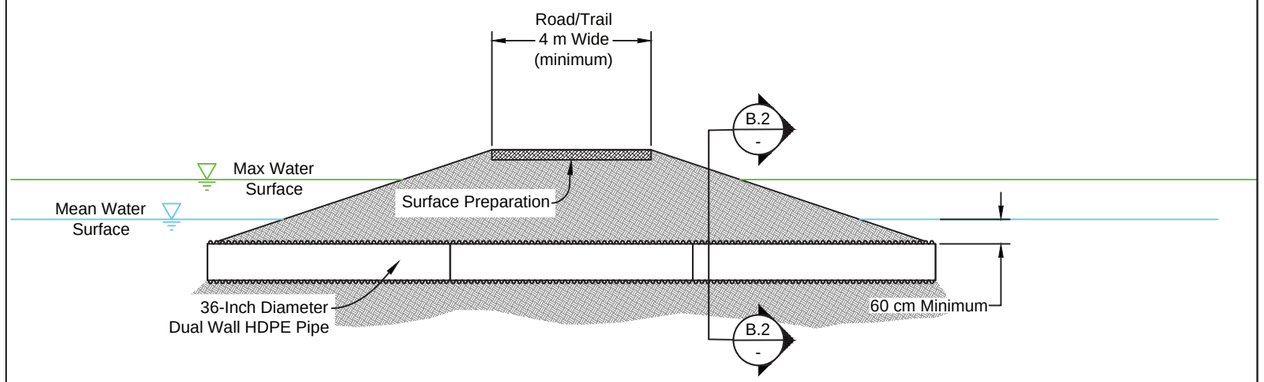
Bangka-Belitung Reclamation Pilot Project

Designed by: OEE
Drawn by: OEE
Date: 09/23/2016

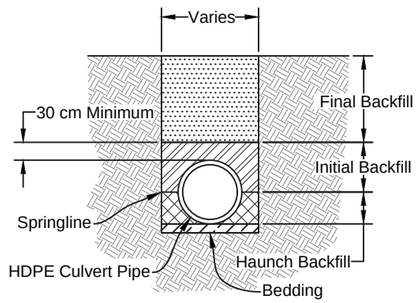
DRAFT
Not for Construction



A.1 - Earthwork Elements
Conceptual Representative Section Not to Scale



B.1 - Drainage Culverts
Conceptual Profile Not to Scale



B.2 - Drainage Culverts
Conceptual Trench Detail Not to Scale

NOTES/ASSUMPTIONS:

1. TOPOGRAPHY: No existing conditions topographic data was available for the PTBBTS Reclamation Area and surroundings. The lack of this data set makes developing accurate grading plans and developing associated quantities a challenge. For the purposes of developing a conceptual design a number of assumptions were made regarding topography:
   - 1.1. The mean water surface elevation of the existing lakes was assumed to be 10.0m.
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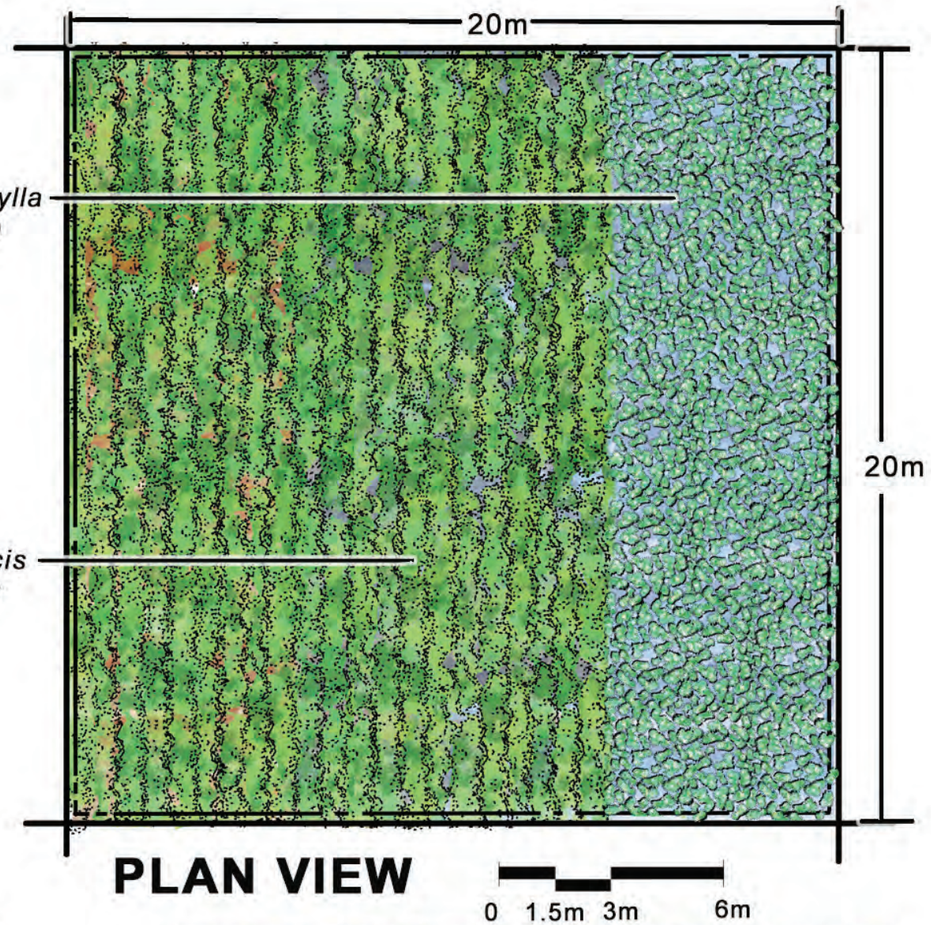
Conceptual Grading & Improvement Details

Bangka-Belitung Reclamation Pilot Project

Designed by: OEE
Drawn by: OEE
Date: 09/23/2016 DRAFT
Not for Construction


Source: http://ozanarafarm.blogspot.com/2015/10/pakan-organik-protein-tinggi-harga.html


Source: http://thailand.ipm-info.org/crops/waterchestnut/waterchestnut.htm




Source: http://www.berberita.com/2016/05/cara-membuat-olahan-pangan-dari-azolla-microphylla.html

In order to establish wetland plants, plant roughly 1,650 *Eleocharis dulcis* plugs per ha.


Source: http://www.berberita.com/2016/05/cara-membuat-olahan-pangan-dari-azolla-microphylla.html

In order to establish wetland plants, plant roughly 875 *Azolla microphylla* plugs per ha.

Wetland Restoration Planting:

Azolla microphylla & Eleocharis dulcis plugs planted in a 20 m buffer around ponds.


Source: http://suksesbisnisusaha.com/usaha-perikanan/jenis-pakan-alami-untuk-ikan-gurami-atau-gurame

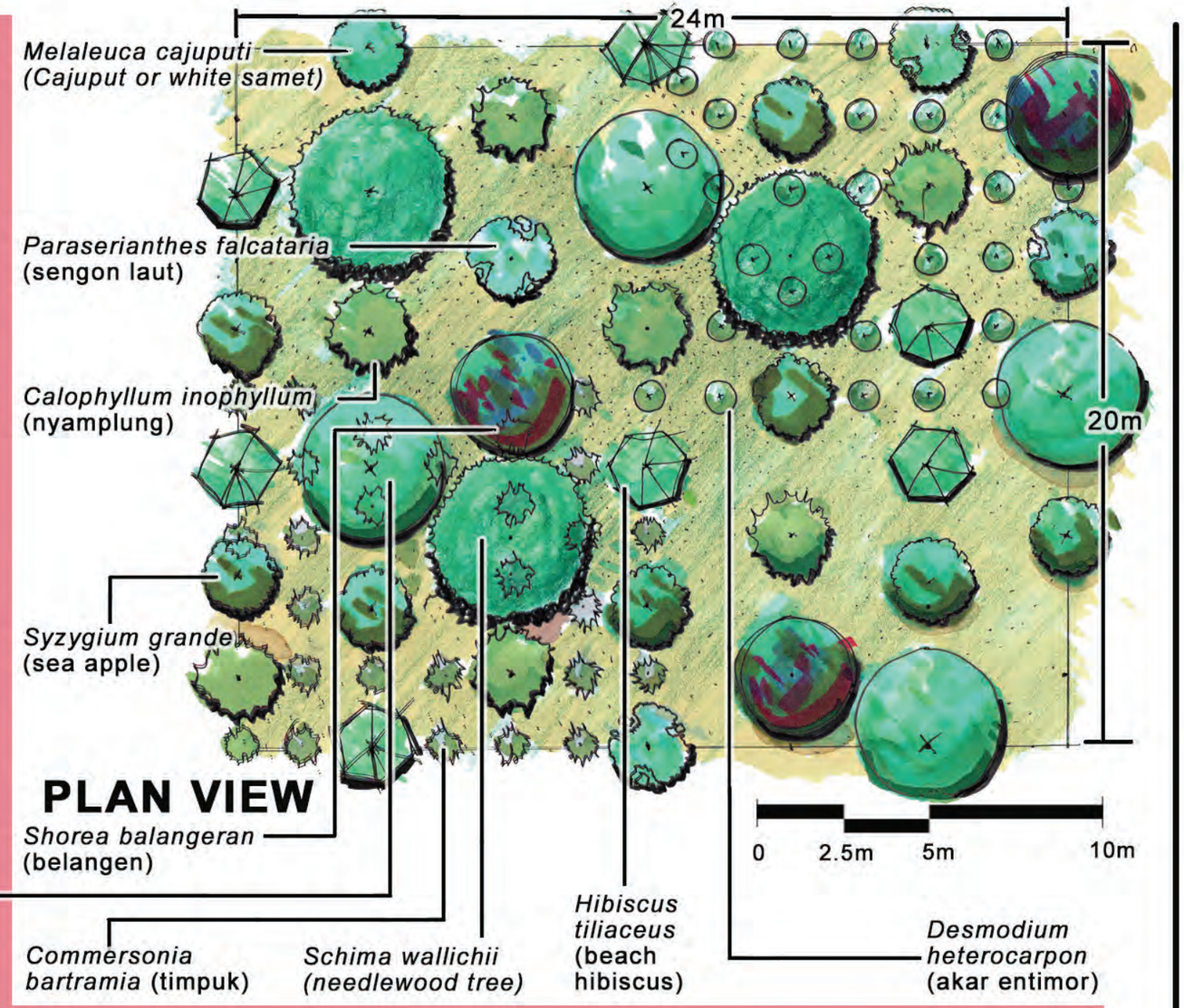
Irrigation Type: None (wetland)

Plant Spacing Details:

PLUGS 2X2 m = 2,500 plants/ha

Eleocharis dulcis “plugs” or “transplants” will be harvested from old ponds and planted in a 2 meter by 2 meter pattern with a zone buffer around the pond. The upper 2/3rds of the 20 meter wetland area will be planted with Eleocharis dulcis (about a 13 meter wide area). The lower 1/3rd of the wetland area will be planted with Azolla microphylla as it requires more water.

Azolla microphylla will also be planted in a 2 meter by 2 meter grid pattern (about a 7 meter wide band around the ponds). Wetland transplants should be kept moist, and planted within 48 hours of harvest. Plugs can also be rooted in a nursery for future planting. Alstonia scholaris is planted every 50 m and Dillenia suffruticosa will be planted every 5 m in one row around the wetland.



Native Forest Restoration:

High density reforestation reconnecting jungle

Irrigation Type: None (seasonal rainfall)

Plant Spacing Details:

TREES:4X4 m = 625 plants/ha
SHRUBS:4X4 m=312 plants/ha
SEEDS: 2 kg/ha
PLUGS 2X2 m = 10,000 plants/ha

It is recommended that seedlings be planted approximately 4 meters by 4 meters apart for shrubs. Only half (i.e. 2 quadrats) of each hectare is planted in a checkerboard fashion with a single species (312 plants/ha). Larger trees should be planted at 4 meters by 4 meters or 625 seedlings per ha across the entire forest restoration area. Grasses should be seeded at 2 kg per ha. Grass species will not be seeded together but each species will be planted in 2 ha. Citronella grass will be planted as plugs in 4 ha of the native forest area in a 2 meter by 2 meter grid. Citronella should be planted the the 4 ha more accessible to roads to make harvesting more efficient. Remember to seed before planting tree and shrub seedlings whenever possible. Seedlings may need supplemental irrigation during the establishment period.

Refer to GMP's for land preparation, planting, irrigation and maintenance and harvest.

PLANT SCHEDULE

	Wetland Restoration	Native Forest
Plant Spacing Description (Refer to GMP's for land preparation, planting, irrigation and maintenance and harvest practices.)	PLUGS 2X2 m = 10,000 plants/ha Plant Spacing Details: Eleocharis dulcis "plugs" or "transplants" will be harvested from old ponds and planted in a 2 meter by 2 meter pattern with a zone buffer around the pond. The upper 2/3rds of the 20 meter wetland area will be planted with Eleocharis dulcis (about a 13 meter wide area). The lower 1/3rd of the wetland area will be planted with Azolla microphylla as it requires more water. Azolla microphylla will also be planted in a 2 meter by 2 meter grid pattern (about a 7 meter wide band around the ponds). Wetland transplants should be kept moist, and planted within 48 hours of harvest. Plugs can also be rooted in a nursery for future planting. Alstonia scholaris is planted every 50 m and Dillenia suffruticosa will be planted every 5 m in one row around the wetland.	TREES:4X4 m = 625 plants/ha SHRUBS:4X4 m=312 plants/ha SEEDS: 2 kg/ha PLUGS 2X2 m = 10,000 plants/ha Plant Spacing Details: It is recommended that seedlings be planted approximately 4 meters by 4 meters apart for shrubs. Only half (i.e. 2 quadrats) of each hectare is planted in a checkerboard fashion with a single species (312 plants/ha). Larger trees should be planted at 4 meters by 4 meters or 625 seedlings per ha across the entire forest restoration area. Grasses should be seeded at 2 kg per ha. Grass species will not be seeded together but each species will be planted in 2 ha. Citronella grass will be planted as plugs in 4 ha of the native forest area in a 2 meter by 2 meter grid. Citronella should be planted the the 4 ha more accessible to roads to make harvesting more efficient. Remember to seed before planting tree and shrub seedlings whenever possible. Seedlings may need supplemental irrigation during the establishment period.
Planting Method	**Hand Planted**	**Hand Planted**
Irrigation Type	**None**	**Flood**
Hectares	**0.95**	**8.53**
Trees		
***Calophyllum inophyllum* (Alexandrian Laurel, beauty leaf, kamani, nyamplung)**		**1,080**
***Schima wallichii* (needlewood tree, schima)**		**270**
***Ficus superba* (strangler fig)**		**540**
***Syzygium grande* (sea apple)**		**1,080**
***Shorea balangeran* (red balau, belangen)**		**540**
***Hibiscus tiliaceus* (beach hibiscus, cottonwood)**		**1,080**
***Melaleuca cajuputi* (Cajuput or white samet)**		**540**
***Paraserianthes falcataria* (sengon laut)**		**270**
***Alstonia scholaris* (pulai tree)**	**17**	
***Dillenia suffruticosa* (simpor bini)**	**165**	
Shrubs		
***Desmodium hiterocarpon* (akar entimor)**		**1,332**
***Commersonia bartramia* (tlimpuk, kelimpuk)**		**1,332**
Grasses		
***Cymbopogon winterianus* (citronella grass) plugs**		**4**
***Paspalum notatum* (bahiagrass) seed**		**4**
***Fimbristylis pauciflora* (rumput jenggot) seed**		**4**
Wetland Plants		
***Azolla microphylla* (azolla, mosquito fern)**	**784**	
***Eleocharis dulcis* (purun, chinese water chestnut)**	**1,591**	
Total Plants	**2,557**	**8,076**

Appendix B. Good Management Practices

GENERAL REQUIREMENTS

GENERAL RESPONSIBILITIES

CONTRACTOR'S QUALITY CONTROL

It is the intent of these specifications and the construction plans that the work performed under the contract shall result in a complete operating system in satisfactory working condition with respect to the functional purpose of the installation, and no extra compensation will be allowed for anything omitted but fairly implied. The prices paid for various items in the bid shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and doing all work necessary to complete the finished product as provided in the plans and specifications.

The statement "or equal" in these specifications shall mean that the Contractor may substitute another manufacturer's product as a substitute for that specified. The Contractor will thereby warrant that the product will perform as good as or better than that replaced. The statement "or approved equal" in these specifications shall mean that the Contractor must submit information and obtain prior approval from the Project Sponsor or authorized representative before making a substitution. Acceptance as equal by the Project Sponsor or authorized representative does not relieve the Contractor of responsibility for the performance of the substitute product.

Where the contract requires that materials or equipment be provided or that construction work be performed, and detailed specifications of such materials, equipment, or construction are not set forth, the Contractor shall perform the work using materials and equipment of a quality comparable to the materials and workmanship specified for other parts of the work and at least equal to the general standard of quality found within existing work, from firms of established good reputations, and shall follow best practices in the performance of construction work. All equipment and materials to be incorporated into the work shall be stored in a manner to prevent damage from the elements, work, or handling. No damaged or deteriorated materials will be accepted. The work performed shall be in conformity and harmony with the intent to secure the best standard of construction and equipment of work as a whole or in part.

CONSTRUCTION SCHEDULE

Prior to Construction, the Contractor shall submit to the Project Sponsor a critical path schedule that is detailed enough to reasonably allow the Project Sponsor or authorized representative to follow the progress of the work. The schedule shall be updated periodically as required by the work and as requested by the Project Sponsor.

PRIORITY OF WORK & COORDINATION

The Contractor shall prioritize and order construction to meet the contract requirements. The Contractor shall prioritize and schedule aspects of work in such a manner that access to work site locations is closely coordinated in conjunction with other contractors who might be working at the site and ongoing operations, maintenance, and agricultural activities at the site and surrounding lands.

PERMITTING

All permits acquired by the Project Sponsor will be made part of the Contract documents and the Contractor shall abide by the requirements of those permits. All additional local, state, and federal permits and authorizations that are applicable to the construction and/or operation shall be obtained prior to construction by the Contractor.

SUBMITTALS

The Contractor shall be responsible for providing submittal information for approval as required in these specifications to the Project Sponsor or authorized representative before purchasing the material or performing the work. The Project Sponsor or authorized representative will review and approve or reject initial submittals in writing within 7 working days after receipt. Where the Project Sponsor or authorized representative requests additional information or rejects an initial submittal, the Project Sponsor, or authorized representative shall use such time as is necessary to review the additional materials or new submittals. Approval of this information shall not relieve the Contractor of his/her responsibility to meet the requirements of the Contract.

PROGRESS MEETINGS

Before starting any construction, a meeting shall be held with the Project Sponsor, Contractor, Subcontractors, and the Engineer or authorized representative to plan and coordinate the schedule of construction and to review intent of contract documents.

The Contractor shall hold progress meetings on the site with the Project Sponsor or authorized representative, to discuss job-related problems. Persons designated by the Contractor to attend and participate in the meetings shall have all required authority to commit the Contractor to solutions agreed upon in the project meeting.

SUPERVISION OF CONSTRUCTION AND WORKERS

The Contractor shall supervise and direct the work using his best skill and attention. The Contractor shall be solely responsible for all construction means, methods, techniques, sequences, and procedures and for coordinating all portions of the work under the Contract. The Contractor shall also designate a person(s) to be the Contractor's representative/superintendent on site. The superintendent will serve as the project contact person and will represent not only the Contractor but also any subcontractors used on the project. The superintendent shall be responsible for requesting inspection, notifying the Project Sponsor or authorized representative when segments of the work are complete, and communication of instructions to all employees and subcontractors on the job site. Except in emergency situations all specified notifications, submittals, and communications shall be considered valid only if they are received by the Project Sponsor or authorized representative from the designated superintendent.

Any person employed by the Contractor who, in the opinion of the Project Sponsor or authorized representative, does not perform his work in a proper skillful manner, or is disrespectful, intemperate, disorderly, or otherwise objectionable, shall by written request (detailing reasons) of the Project Sponsor or authorized representative to the Contractor be removed from the work site by the Contractor employing the person, and that person shall not be employed again on any portion of the said work.

INSPECTION AND TESTING

Where the Contractor has reached a point in construction where inspection is required to proceed, he or she will provide a minimum of 48 hours' notice to the Project Sponsor or authorized representative before demobilizing equipment that may be necessary to adjust or modify the work in question. The Project Sponsor or authorized representative will make every effort to provide inspection on shorter notices Regardless of any test results; the Contractor is solely responsible for the quality of workmanship and materials and for compliance with the requirements of the contract documents. The Contractor shall, without charge, replace or correct work or materials found not to conform to the contract requirements. The costs of all retests may be deducted from monies due, or to become due the Contractor.

CONSTRUCTION OBSERVATION

The undertaking of periodic site visits by the Project Sponsor or authorized representative shall not be construed as supervision of actual construction; nor make him or her responsible for construction means, methods, techniques, sequences or procedures; nor make him or her responsible for providing a safe place for the performance of work by contractors or contractor's employees, or those of suppliers or subcontractors, or for access, visits, use, work, travel, or occupancy by any person.

GENERAL SAFETY & PROTECTION

CONSTRUCTION SITE-SAFETY

The Contractor shall be responsible for initiating, providing, maintaining and supervising all safety programs and precautions in connection with the work in accordance with federal, state, and local laws and regulations and with generally accepted safety practices. The Contractor shall provide protection devices including barricades, fencing, warning signs, lights, and other devices necessary to ensure security and safety within the project site during all aspects of the Work. The Contractor shall ensure access and safety are maintained continuously during the performance of the Work.

SITE ACCESS & INFRASTRUCTURE PROTECTION

When crossing private property, the Contractor shall confine his activity to only access roads indicated on the Plans, unless otherwise specified by the Project Sponsor or authorized representative. The Contractor's use of the project site shall be limited to its construction operations. The Contractor shall minimize disturbance outside the construction limits, and not unnecessarily disturb land on or adjacent to the site. Haul routes and areas of disturbance may be limited at the Project Sponsor or authorized representative's discretion.

It shall be the Contractor's responsibility to determine and verify the location of existing utilities before commencing any work in the vicinity. The Contractor shall indemnify and save harmless the Project Sponsor or authorized representative from and against any and all claims, actions, suits, demands, damage or costs howsoever arising because of any damage to existing utilities.

The Contractor shall be responsible for all damage and/or restoration of roads whether existing, constructed, public, or private, used in conjunction with the construction of a project. All roads shall be returned to a condition equal or better to that existing prior to their use in construction of the project. Repair and or restoration work of roads shall be at the expense of the Contractor.

Any existing fencing dismantled or removed by the Contractor so as to accommodate the construction or access to site shall be replaced or rebuilt to its original condition prior to the Contractor leaving the site. Before any dismantling or removing of fence on private property, the Contractor shall get written permission from the local landowner of that property. All costs incurred for this dismantling or removing shall be borne entirely by the Contractor.

PROTECTION OF CULTURAL & HISTORICAL RESOURCES

If any cultural or historic resources (artifacts) are found during construction, all work shall immediately cease and Contractor shall notify the Project Sponsor or authorized representative. Project Sponsor or authorized representative shall determine whether to continue or cease construction activities as appropriate and shall inform the Contractor of his decision. Contractor will be compensated for work completed to the point of cessation of activities. Any additional claims will be reviewed by the Project Sponsor or authorized representative.

PROTECTION OF HABITAT & WILDLIFE

The project site and adjacent areas contain sensitive habitat areas for protected wildlife, and may include endangered species. The Contractor shall provide protection, operate temporary facilities, and conduct construction in ways and by methods that: 1) comply with environmental regulations, 2) adhere to special provisions and/or permits included in the Contract, 3) comply with environmental awareness training provided to project personnel, 4) protect wildlife and water quality, and 5) minimize possible air, waterway, and subsoil contamination or pollution or other undesirable effects. Wildlife or plant life shall not be intentionally harmed and destroyed.

FIRE PREVENTION & PROTECTION

The Contractor shall take all necessary precautions to prevent grass, brush and forest fires. The Contractor shall be responsible for all damage from fires due directly or indirectly to his/her own activities or to those of his subcontractors or employees.

PROTECTION OF EXISTING VEGETATION

Contractor shall take precautions to protect native trees and other vegetation not intended to be removed. Vegetation designated to remain undisturbed shall be protected from damage throughout the entire construction period. The Contractor shall repair any damage resulting from the Contractor's operations or neglect. The contractor is required to notify and coordinate with Project Sponsor or authorized representative prior to removing trees or vegetation and all efforts will be made to preserve standing live trees not directly in the way of improvements. Large wildlife snags identified by Project Sponsor or authorized representative will be avoided.

Spoil, stockpiling of materials, vehicular parking, and excessive foot or vehicular traffic shall not be allowed within the dripline of vegetation designated to remain in place. Vegetation damaged by any of these or similar actions shall be replaced with viable vegetation of the same species or as specified in the plans and approved by the Project Sponsor or authorized representative.

Any cuts, skins, scrape, or bruises to the bark of the vegetation shall be carefully trimmed and local nursery accepted procedures used to seal damaged bark. Any limbs or branches 0.5-inch or larger in diameter that are broken, severed, or otherwise seriously damaged during construction shall be cut off at the base of the damaged limb or branch flush with the adjacent limb or tree trunk. All roots 1 inch or larger in diameter that are cut, broken, or otherwise severed during construction operations shall have the end smoothly cut perpendicular to the root. Roots exposed during excavation or other operations shall be covered with moist earth and/or backfilled as soon as possible to prevent them from drying.

CONTROL OF WORKS

SITE LAYOUT AND CONTROL

The Contractor is responsible for and shall perform all surveys and measurements required to accurately layout and control work as shown on the plans. The Project Sponsor or authorized representative will coordinate closely with the contractor, at the Contractor's request, to aid in laying the site out. The Contractor shall assume full responsibility for dimensions and elevations measured from such stakes and for checking the location and elevation of the individual units. The Contractor shall be responsible for the preservation of temporary benchmarks, stakes, and identified survey pins, and the cost of replacement if disturbed.

POLLUTION PREVENTION & CONTROL

Construction activities shall be carried out in such a manner and sequence that erosion, air, and water pollution are minimized and held within legal limits, utilizing standard Best Management Practices (BMPs). The Contractor shall comply with all requirements of the environmental permits. All pollution prevention measures and temporary works shall be adequately

maintained in a functional condition for the duration of the construction period. All temporary measures shall be removed and the site stabilized and restored to near original condition.

The equipment that the Contractor utilizes to undertake the Work shall be maintained in a manner that minimizes the potential for spills of fuels, lubricants, and other hazardous construction materials. The Contractor shall employ at a minimum the following prevention, control, and response measures:

- Only perform equipment fueling, maintenance and repair as needed for efficient performance of the work, and in a manner that is protective of water quality and the environment.
- Spill prevention shall include but not be limited to the placement of drip pans under equipment, the draining of leaking fluid reservoirs and/or lines, and the repair of leaking gaskets.
- In the event of any accidental leaks or spills, immediately clean up the spill and contain any contaminated waters. Remove any contaminated soils, contaminated water, sludge, spill residue or other hazardous materials offsite in accordance with all applicable laws and dispose of at a lawfully permitted facility.
- Maintain onsite a spill kit for emergency containment and cleanup.

The Contractor shall immediately notify the Project Sponsor or authorized representative in the event of any spill or release of chemical in any physical form within the project site or adjacent waterways. The Contractor shall be solely responsible for all costs of fines, cleanup, sampling, and analysis, reporting and monitoring that results from any fuel or chemical release caused by the Contractor.

SITE MAINTENANCE

The Contractor shall keep the work site, and areas beyond the construction area affected by construction operations, in a neat and orderly condition at all times. Care shall be taken to prevent excessive soil erosion by either wind or water. Waste materials, rubbish, mud, gravel, and other debris shall be promptly and regularly removed from the site by the Contractor. Upon completion of the work, the Contractor shall promptly remove all remaining materials, rubbish, litter, debris, temporary structures, excess materials and plants, and shall clean up the site and works to the satisfaction of the Project Sponsor or authorized representative.

TRAFFIC CONTROL

The Contractor shall obtain and comply with all road permits issued by all agencies having jurisdiction over the roads used. The Contractor shall make proper provisions for maintaining traffic on roads. The Contractor shall minimize disruption to all highways and adjacent road traffic. Vehicular and pedestrian traffic shall not be stopped, restricted, or diverted except when specified in the Contract documents.

SURFACE & SUBSURFACE WATER CONTROL

The Contractor is responsible for the control of surface water, subsurface water, and drainage during the construction period. Because of the project site's close proximity to the Gila River and associated backwater habitat, the Contractor should anticipate encountering groundwater during excavation operations at elevations near the observed water surface elevation, but subsurface conditions may vary, depending on actual soil and groundwater conditions. The Contractor shall provide dewatering and/or diversion provisions that allow drainage from the work site during construction and allow the proper construction and installation of all items shown in the plans. All temporary fills, crossings, culverts, or other facilities necessary to promote drainage will be installed and removed at the Contractor's expense prior to acceptance of the work. Any claims arising from upstream or downstream damages as a result of the construction or failure of these temporary works will be the Contractor's responsibility.

MOBILIZATION & DEMOBILIZATION

GENERAL

DESCRIPTION

The work shall consist of mobilizing equipment, supplies and securing bonds necessary to do the work as stated in the contract and/or agreement and demobilization of excess materials and equipment from the work site.

SCOPE OF WORK

A. Mobilization: Mobilization shall include all activities and associated costs for transportation of Contractor's personnel, equipment, and operating supplies to the site; establishment of offices, buildings, temporary restroom facilities and other necessary general facilities for the Contractor's operations at the site; premiums paid for performance and payment bonds including coinsurance and reinsurance agreements as applicable; and other items specified in the plans.

B. Demobilization: Demobilization shall include all activities and costs for transportation of personnel, equipment, and supplies not required or included in the contract from the site; including the disassembly, removal, and site cleanup of offices, buildings, and other facilities assembled on the site specifically for this contract.

IMPLEMENTATION

All mobilization and demobilization will be performed in a safe and orderly manner with particular care not to damage existing vegetation or undue disturbance to the ingress-egress route. Ingress and Egress routes to the project sites will be identified during the project "Walk Through." When specific routes are identified, the Contractor shall avoid traveling over other areas. Unless otherwise approved by the Project Sponsor or authorized representative, mobilization operations shall commence no later than one week after the notice to proceed. De-mobilization shall be finished within two weeks after substantial project completion.

During all operations, the Contractor is responsible for maintaining public and private property in original condition. Damage to existing roadways and roadway shoulders shall be repaired to the satisfaction of the authorized representative at the Contractor's expense.

EXAMPLES

Figure 1. Komatsu D65 Bulldozer

Figure 2. Komatsu PC200 Excavator

Figure 3. Dump Truck

CLEARING, GRUBBING, & STRIPPING

GENERAL

DESCRIPTION

The work shall include the supply and transport of all labor, material, and equipment to successfully complete clearing, grubbing, and stripping activities for the project.

SCOPE OF WORK

This specification shall cover the following work:

A. Clearing
B. Grubbing
C. Stripping

IMPLEMENTATION

CLEARING

Clearing shall consist of the cutting, removing, disposing, and cleaning up of all brush, trees, logs, stumps, roots, heavy sod, vegetation, broken concrete or other pavement, and rubbish above natural ground within designated work areas. Existing native trees and other native vegetation designated for preservation shall be protected from damage and left undisturbed per the "Protection of Existing Vegetation" below.

GRUBBING

Grubbing shall consist of the removal and disposal of all roots, stumps, or imbedded logs or objectionable debris/trash below natural ground within designated work areas. Grubbing and complete removal of non-native tree stumps and major root systems is critical to minimizing re-sprouting prior to native revegetation planting efforts. As such, non-native stumps and root shall be grubbed to the depth of material encountered to the satisfaction of the Project Sponsor or authorized representative. Other native tree stumps and roots, not designated for preservation, shall be grubbed to a depth of 1 meter below natural ground. Brush and similar materials shall be grubbed to a minimum depth of 30 centimeters below natural ground.

STRIPPING

Stripping shall consist of the complete removal of grass, weeds, and all earth materials contaminated by organics within designated work areas. The Contractor shall strip all such materials regardless of the depth of material encountered to the satisfaction of the Project Sponsor or authorized representative.

DISPOSAL OF CLEARED, GRUBBED, & STRIPPED MATERIAL

Woody material, brush, and other vegetation from clearing and grubbing operations shall be mulched on site and consolidated in mounds in the areas designated by the Project Sponsor or authorized representative. Mounds shall be no larger than 15 meters in diameter and 5 meters tall. A minimum of 15 meters shall be left between each mound and/or existing vegetation stands or site infrastructure. The size and number of mounds may need adjustment depending on the size and density of the cleared material. If mounds are approved for burning by the Project Sponsor or authorized representative, it is recommended that they be allowed to cure for one month prior to burning. The piles shall then be burned completely.

Trash and other non-organic debris from clearing and grubbing operations shall be stockpiled in the areas designated by the Project Sponsor or authorized representative. These materials shall then be hauled offsite and disposed of at the proper waste facility. All stripped materials shall be stockpiled in areas as designated by the Project Sponsor or authorized representative. The Contractor shall coordinate stockpiling activities on nearby and more distant areas of the site as directed by the Project Sponsor or authorized representative. Unless otherwise specified, upon completion of the construction, the stockpiled material shall be spread and finished to a reasonably smooth surface.

INVASIVE SPECIES MANAGEMENT

Additional treatments using manual, site selective clearing, and/or chemical methods will be required to prevent target non-native species from recolonizing the site. Such treatments should occur until the scheduled dates for planting and revegetation. These treatments for managing invasive species are beyond the scope of "Grading and Improvement" activities and shall be covered in GMP's for the "Native Revegetation Planting Plan".

PROTECTION OF EXISTING VEGETATION

Contractor shall take precautions to protect native trees and other vegetation not intended to be removed. Vegetation designated to remain undisturbed shall be protected from damage throughout the entire construction period. The Contractor shall repair any damage resulting from the Contractor's operations or neglect. The contractor is required to notify and coordinate with Project Sponsor or authorized representative prior to removing trees or vegetation and all efforts will be made to preserve standing live trees not directly in the way of improvements. Large wildlife snags identified by Project Sponsor or authorized representative will be avoided. Spoil, stockpiling of materials, vehicular parking, and excessive foot or vehicular traffic shall not be allowed within the dripline of vegetation designated to remain in place. Vegetation damaged by any of these or similar actions shall be replaced with viable vegetation of the same species or as specified in the plans and approved by the Project Sponsor or authorized representative. Roots exposed during excavation or other operations shall be covered with moist earth and/or backfilled as soon as possible to prevent them from drying.

DISCLAIMERS

The Contractor shall be solely responsible for developing and implementing all necessary safety, fire, and emergency plans required to perform the work. Only trained professionals should operate equipment, and the Contractor shall be solely responsible for ensuring the proper training, safety, and proper use of personal protective equipment (PPE). The Contractor shall be responsible for obtaining and maintaining all clearances and permits required to perform the work.

All work areas where operations are implemented shall be clearly marked with signs posted near the project site and notifications sent to local authorities and news outlets (i.e. newspapers and radio). The public shall not be permitted to access the site during operations for safety reasons. Any alterations or substitutes to the methods described in these operations must first be approved by the Project Sponsor or authorized representative.

EXAMPLES

Figure 4. Bulldozer with Root Ripper (Photo Credit FPC)

Figure 5. Low Ground Pressure Bulldozer (Photo Credit FPC)

Figure 6. Bulldozer with Brush Rake (Photo Credit FPC)

Figure 7. Small Burn Piles. (Photo Credit FPC)

LAND SHAPING

GENERAL

DESCRIPTION

The work shall include the supply and transport of all labor, material, and equipment to successfully complete land shaping activities.

SCOPE OF WORK

This specification shall cover the following work:

A. Lake Shaping
B. Wetland Shaping
C. Native Forest Shaping & Smoothing

MATERIALS

NATIVE SOIL

Native fill is composed of natural earth materials that can be placed and compacted by construction equipment, hand tamping, manually directed power tampers, or vibrating plates, or their equivalent operated in a conventional manner. All fill material s shall be collected from excavation and shaping activities or designated borrow areas within the project area. The selection, blending, routing, and disposition of material in the various fills shall be subject to approval by the Project Sponsor or authorized representative. Fill materials shall contain no sod, brush, roots, or other perishable material.

IMPLEMENTATION

SURVEY & FIELD ENGINEERING

Currently no existing conditions topographic data is available for the PTBBTS Reclamation Area and surroundings. It is critical that existing elevations be field verified prior to construction and final ground elevations be field engineered and adjusted to balance earthwork on site and optimize push/haul distances.

LAKE SHAPING

Existing lakes shall be excavated and shaped to the lines and grades shown on the plans. The lake shaping area is designed to improve open water habitat and recreational access, as well as provide irrigation pumping locations, by expanding existing lake features and connecting adjacent water bodies.

Prior to lake excavation activities, the work area shall be cleared, grubbed, and stripped in accordance with the *Clearing, Grubbing, and Stripping* GMP. Materials excavated as part of lake excavation and shaping that conform to the material requirements for earthfill, may be used to the extent as needed. Surplus/overburden or unsuitable material shall be disposed of in accordance with *Disposal of Unsuitable or Surplus/Overburden Material* GMP outlined below**.** Areas that have been over-excavated shall be replaced with suitable materials compacted to a density at least equal to that of the in-situ material or to the satisfaction of the Project Sponsor or authorized representative.

WETLAND SHAPING

The perimeter of existing lakes shall be excavated/filled and shaped to the lines and grades shown on the plans. The wetland shaping area is designed to improve wetland habitat by providing a wide, frequently inundated bench.

Prior to wetland shaping activities, the work area shall be cleared, grubbed, and stripped in accordance with the *Clearing, Grubbing, and Stripping* GMP. Materials excavated as part of lake excavation and shaping that conform to the material requirements for earthfill, may be used to the extent as needed. Surplus/overburden or unsuitable material shall be disposed of in accordance with *Disposal of Unsuitable or Surplus/Overburden Material* GMP outlined below**.** Areas that have been over-excavated shall be replaced with suitable materials compacted to a density at least equal to that of the in-situ material or to the satisfaction of the Project Sponsor or authorized representative.

Soils shall be placed in lifts that do not exceed 15 centimeters. Equipment shall be routed to obtain compaction sufficient to minimize settlement. The terraces shall be smoothed and graded to prevent surface ponding, and finally precision land-leveled to remove surface irregularities and brought to grade as shown on the plans.

Surplus/overburden or unsuitable material shall be disposed of in accordance with *Disposal of Unsuitable or Surplus/Overburden Material* GMP outlined below**.** Areas that have been over-excavated shall be replaced with suitable

materials compacted to a density at least equal to that of the in-situ material or to the satisfaction of the Project Sponsor or authorized representative.

NATIVE FOREST SHAPING & SMOOTHING

Native Forest areas shall be excavated/filled and shaped to the lines and grades shown on the plans. Native Forest and shaping and smoothing areas are designed to provide a stable, smooth platform for native reforestation efforts.

The footprint for all earthfill for smoothing construction shall be stripped, cleared, and grubbed in accordance with the *Clearing, Grubbing, and Stripping* GMP. All land-leveling areas shall be scarified and wetted in preparation for the first soil lift.

Soils shall be placed in lifts that do not exceed 15 centimeters. Equipment shall be routed to obtain compaction sufficient to minimize settlement. The ground shall be smoothed and graded to prevent surface ponding, and finally precision land-leveled to remove surface irregularities and brought to grade as shown on the plans.

Surplus/overburden or unsuitable material shall be disposed of in accordance with *Disposal of Unsuitable or Surplus/Overburden Material* GMP outlined below**.** Areas that have been over-excavated shall be replaced with suitable materials compacted to a density at least equal to that of the in-situ material or to the satisfaction of the Project Sponsor or authorized representative.

Prior to planting, the land shall be prepared in accordance with the *Land Preparation GMP*

DISPOSAL OF UNSUITABLE OR SURPLUS/OVERBURDEN MATERIALS

Cleared, grubbed, and stripped material shall be disposed of in accordance with ***Section 201, Section 3.4 Disposal of Cleared, Grubbed, & Stripped Material.*** Surplus/overburden or unsuitable excavated material shall be disposed of in designated areas, as shown on the plans or as directed by Project Sponsor or authorized representative. Excavated materials shall be deposited in uniformly and continuously placed windrows. All haul roads, access roads and temporary crossings are to be removed.

EXAMPLES

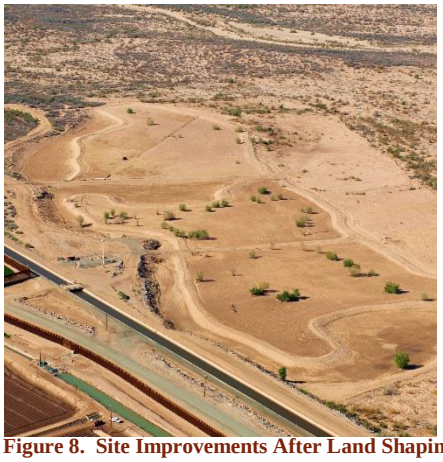


Figure 8. Site Improvements After Land Shaping (Photo Credit FPC)

Figure 9. Site Improvements after Planting (Photo Credit FPC)

ROADS & TRAILS

GENERAL

DESCRIPTION

This work shall include the supply of all labor, materials, and equipment required to complete road & trail construction and surfacing

SCOPE OF WORK

A. Grade road or trail footprint

INSPECTION

The Contractor shall stop work and call for inspection at the following points of construction:

A. Upon discovery that the road/trail alignments conflict with infrastructure and live standing native trees and brush

MATERIALS

NATIVE SOIL

Native fill is composed of natural earth materials that can be placed and compacted by construction equipment, hand tamping, manually directed power tampers, or vibrating plates, or their equivalent operated in a conventional manner. All fill material s shall be collected from excavation and shaping activities or designated borrow areas within the project area. The selection, blending, routing, and disposition of material in the various fills shall be subject to approval by the Project Sponsor or authorized representative. Fill materials shall contain no sod, brush, roots, or other perishable material.

IMPLEMENTATION

GRADING OF ROADS & TRAILS

Prior to grading the footprint of the roads and trails, the Contractor shall stake the road and trail alignments. If the alignments, as staked, appear to conflict with any existing infrastructure or standing live native trees or brush, the Contractor shall notify and coordinate with Project Sponsor or authorized representative. Prior to disturbing infrastructure or removing trees or vegetation, all efforts shall be made to realign the roads to preserve the infrastructure or vegetation (see the *General Requirements* GMP, Protection *of Existing Vegetation)*.

The footprint of the road/trail shall be cleared, grubbed, and stripped prior to surfacing in accordance with the *Clearing, Grubbing, and Stripping* GMP. The stripped footprint shall be scarified, moistened as necessary, and compacted. Where the road alignment crosses voids, headcuts, embankments, steep topography or other irregularities, the road footprint shall be shaped and smoothed to provide a safe and comfortable transition for vehicles. Following completion of the work, edges of roads areas shall have neat, smooth transitions to undisturbed ground and any berms or piles of loose material graded to an even condition to allow drainage. All haul roads, access roads and temporary crossings are to be removed

Figure 10. Trail Surfaced with Aggregate Base. (Photo Credit FPC)

CULVERTS

GENERAL

DESCRIPTION

The work of this section shall include the supply of all labor, materials, and equipment required to complete the installation of the culverts and other conduits as called for on the drawings and/or specified herein. This work shall consist of excavation; bed preparation; pipe assembly; and backfill.

SCOPE OF WORK

A. Installation of culvert pipe and appurtenances

INSPECTION

The contractor shall stop work and request inspection prior to placement of pipe to allow inspection of the excavation and initial backfill.

QUALITY CONTROL

All workmanship and materials furnished and supplied under this specification are subject to close and systematic inspection and testing by the Project Sponsor or authorized representative including all operations from the selection and production of materials through to final acceptance of the specified work. The Contractor shall be wholly responsible for the control of all operations incidental thereto notwithstanding any inspection or approval that may have been previously given. The Project Sponsor or authorized representative reserves the right to reject any materials or works, which are not in accordance with the requirements of this specification.

The Project Sponsor or authorized representative shall be afforded full access for the inspection and control testing of materials, both at the site of work and at any plant or borrow pit used for the supply of the materials, to determine whether the materials are being supplied in accordance with this specification.

MATERIALS

CULVERT PIPE, FITTINGS, & APPURTENANCES

The Contractor shall supply all culvert pipe of the nominal size and lengths shown on the plans. Pipe shall be Dual Wall High Density Polyethylene (HDPE) or approved equal. The Contractor shall supply all fittings, nuts, bolts, sealants, lubricants, and all accessories recommended by the material manufacturer or necessary for a complete installation.

NATIVE SOIL

Native fill is composed of natural earth materials that can be placed and compacted by construction equipment, hand tamping, manually directed power tampers, or vibrating plates, or their equivalent operated in a conventional manner. All fill material s shall be collected from excavation and shaping activities or designated borrow areas within the project area. The selection, blending, routing, and disposition of material in the various fills shall be subject to approval by the Project Sponsor or authorized representative. Fill materials shall contain no sod, brush, roots, or other perishable material.

IMPLEMENTATION

HANDLING AND STORAGE OF MATERIALS

The manufacturer's special handling requirements for all materials shall be strictly observed. Culvert pipe and appurtenances shall be inspected prior to any handling of materials. The Project Sponsor or authorized representative shall be notified of damage or unsuitable material prior to handling for installation. The Contractor shall be responsible for replacement and reinstallation of any pipe or other supplied materials at his/her own expense.

UNSUITABLE MATERIAL

If in the opinion of the Project Sponsor or authorized representative, the site-excavated material is unsuitable for backfill, the Contractor shall supply, from an assigned borrow area, suitable backfill material. The payment for supplying this fill shall be considered incidental to the water control structure installation.

TRENCH EXCAVATION

Trench excavation shall extend one meter beyond the ends and 30 centimeters beyond the sides of the pipe. The base of the trench shall be excavated to a depth such that the installed pipe and associated water level control structure meet pipe invert elevations as shown on the plans. The resulting bed shall be fully leveled and compacted by suitable compaction equipment to a minimum of 90% of maximum density as determined by the Standard Proctor Method ASTM D698 throughout the full width and length of the trench, such that the pipe is fully supported for their entire length/width. If necessary, the excavation shall be dewatered in order to prevent disturbing the natural soil conditions at the base of the excavation and to allow the placing and compacting of the backfill material in the dry.

Trench excavations shall comply with Occupational Safety and Health Administration (OSHA) Construction Industry Standards (29CFR Part 1926) Subpart P, Excavations, Trenching, and Shoring. All excavations shall be completed and maintained in a safe and stable condition throughout the total construction phase. Structure and trench excavations shall be completed to the specified elevations and to the length and width required to safely install, adjust, and remove any forms, bracing, or supports necessary for the installation of the work. Excavations outside the lines and limits shown on the drawings or specified herein required to meet safety requirements shall be the responsibility of the contractor in constructing and maintaining a safe and stable excavation. Surplus or unsuitable material shall be disposed of in accordance with the *Clearing, Grubbing, and Stripping* GMP.

ASSEMBLY OF PIPE

The Contractor, after preparation of the trench and pipe bed, shall assemble the pipe, in strict accordance with the manufacturer's instructions. All pipes shall be inspected prior to assembly for chipping or damage in handling and shall be repaired as directed by the Project Sponsor or authorized representative. All materials damaged, distorted by more than 5 percent of nominal dimensions, lost, broken or deemed unsuitable due to the Contractor's method of installation, handling or from neglect shall be replaced by the Contractor at his/her expense.

HAUNCH BACKFILL

The area of the pipe between the springline and the bottom of the pipe is considered the haunch area. The most important factor in assuring proper pipe-soil interaction is the haunching material and its density. This material provides the majority of the support that the pipe requires to function properly in regards to performance and deflection. This material should be placed and worked carefully under the haunches of the pipe and between pipe corrugations, to provide continuous support throughout the entire pipe length. In doing so, proper control should be exercised to avoid vertical and horizontal displacement of the pipe from proper alignment. In order for the haunching to provide adequate support, it must be consolidated at regular intervals to the springline of the pipe. The haunching backfill material shall be placed in layers that have a maximum thickness of about 15 centimeters and compacted by suitable compaction equipment to a minimum of 90% of maximum density as determined by the Standard Proctor Method ASTM D698. During compaction operations, care shall be taken to ensure that the tamping or vibratory equipment does not come in contact with the pipe and the pipe is not deformed or displaced. If necessary, the excavation shall be dewatered in order to prevent disturbing the natural soil conditions at the base of the excavation and to allow the placing and compacting of the backfill material in the dry.

INITIAL BACKFILL

This portion of the pipe embedment begins at the springline of the pipe and extends to 30 centimeters above the top of the pipe. The initial backfill material shall be placed in layers that have a maximum thickness of about 15 centimeters and compacted by suitable compaction equipment to a minimum of 90% of maximum density as determined by the Standard Proctor Method ASTM D698. During compaction operations, care shall be taken to ensure that the tamping or vibratory equipment does not come in contact with the pipe and the pipe is not deformed or displaced. If necessary, the excavation shall be dewatered in order to prevent disturbing the natural soil conditions at the base of the excavation and to allow the placing and compacting of the backfill material in the dry. Vehicles shall not be permitted to cross the pipe until initial backfill is completed.

FINAL BACKFILL

After initial backfilling has been completed, the remaining backfill shall be executed to the lines and grades shown on the plans and as specified herein. The final backfill material shall be placed in layers that have a maximum thickness of about 15 centimeters and compacted by suitable compaction equipment to a minimum of 90% of maximum density as determined by the Standard Proctor Method ASTM D698. If necessary, the excavation shall be dewatered in order to prevent disturbing the natural soil conditions at the base of the excavation and to allow the placing and compacting of the backfill material in the dry.

CONTROL OF SURFACE & SUBSURFACE WATER

To achieve proper moisture content and compaction for foundations and subsequent earthfill, surface and subsurface water will need to be controlled per *General Requirements* GMP, *Surface & Subsurface Water Control*.

Figure 11. Dual Wall HDPE Culvert Pipe

MINE WATER REMEDIATION

BACKGROUND

Tailings and waste left behind from mineral mining often leads to the creation of acid mine drainage (AMD). Part of the process for extracting metals from rock ends up exposing sulfides in the rock to oxygen and water. This exposure leads to the formation of sulfuric acid, which results in cascading effects within affected water sources. The formation of sulfuric acid decreases the pH of the water and further accelerate the oxidation of trace metals also found in the waste materials. This process can continue for hundreds, even thousands, of years until the sulfide materials in the exposed rock are exhausted. In the meantime, the acidic mine drainage can be carried offsite, where it can affect nearby water sources and severely damage water quality and kill aquatic life.

Artisanal metal mining sites, such as the one in Bangka, Indonesia, are smaller operations, leading to the formation of fewer tailings and waste materials. However, the small amount of waste left at sites, can still have significant impacts on the water quality.

Constructed wetlands can help remediate acid mine drainage to reduce acidity and remove the harmful trace metals, making them safe to use for agricultural purposes and for release back to nearby water sources. To start, water quality testing is important to know what metals are present. Acid mine drainage can contain higher than normal concentrations of several heavy metals (Table 1)

	Metal Concentrations	
	Acidic	**Neutral**
pH	5-6	6.5-8.5
Iron	2.5-5	2
Aluminum	0.1-4.25	0.2
Manganese	0.7-2.25	0.3
Copper	7-300	20
Zinc	70-750	100
Cadmium	0.3-2	5

Table 1. Estimates of dissolved metals based on water pH from Acid mine drainage (Balintova et al. 2012)

Constructed wetlands are a passive treatment method which utilizes natural biochemical processes to reduce heavy metal contamination and increase pH. These processes are facilitated through the use of microbial activity, phytoremediation (or treatment with plants), and naturally occurring chemical processes. The use of additional chemical treatments may be necessary to help facilitate or further enhance these processes, but would also increase the overall costs for remediation.

Currently water at Bangka has a pH ranging from 5.5 to 6.5. The ponds in these areas are also providing habitat to a few species of fish and a few plants. However, additional treatment may be necessary to improve water quality to allow use of for agriculture. As a result, wetland plantings are recommended in areas around the settling ponds.

DESIGN FEATURES

WATER SHOULD BE TESTED FIRST FOR HEAVY METAL CONCENTRATIONS. This can help identify which metals should be monitored in the ponds. Based on the mining activities and the color of the water in the ponds, zinc and copper are likely contaminants. Other metals, such as aluminum, are also likely to be present.

Once the water quality is assessed, wetland areas can be modified to address the various contamination concerns. The following are descriptions of various components often found in constructed wetland treatments (ITRC 2010, White 2010).

- AEROBIC WETLAND (Required) – Facilitates oxidation of heavy metals and binding of metals to plant materials.
  - Use of native rhizomatous plants and tubers
  - Wetlands should be shallow (less than 1 m depth)
  - Wetlands will be a 20m buffer around the existing ponds.
  - Ponds should be excavated to allow water to flow from the wetlands to ponds with better water quality
  - Regular monitoring of pond sediments and water quality is required to assess wetland remediation
- ANAEROBIC WETLANDS (As needed) – Facilitates the reduction of heavy metals through abiotic conditions.
  - Recommended to remediate waters with low pH (~3) and high heavy metal contamination (i.e. iron, manganese, and sulfate contaminates)
  - Water flows through a subsurface system which is capped on top with clay and/or plants to maintain an anaerobic condition below the surface
  - The soil below is rich in organic matter and alkalizing agents to maintain a higher pH. Manure-based organic matter is preferred.
  - Sulfate-reducing bacteria precipitate heavy metals and sulfides.

- After treatment in anaerobic wetlands, water flows to an aerobic settling pond to collect precipitates and further treat remaining metals.

If heavy metal contamination becomes high in wetland sediments, soils may need to excavated and replaced to help maintain biochemical process and prevent saturation of soils. Saturation will be indicated when heavy metal concentrations show little or no observable changes between water entering and leaving the wetlands.

MONITORING

Establishing and implementing a monitoring program is essential to determine the success of the project activities. Monitoring efforts should determine the effectiveness of remediation treatments. Monitoring will include regular testing of water in all phases of the remediation process and heavy metal testing of wetland soils. Over time, wetland soils should store and sequester the resulting precipitates into more useful and stable forms.

Contractors will be responsible for conducting regular water and soil testing to evaluate the efficiency of the system at removing heavy metals and sulfates from the treated water. Issues identified in the system's ability to improve water pH and reduce heavy metals should be addressed promptly once identified.

MAINTENANCE

Maintenance of a constructed wetland may be required to maintain proper biochemical processes and to address the long term

Replanting may be necessary to prevent channelization in parts of the wetlands. Channelization can reduce the overall efficiency of the system by concentrating water treatment in certain areas. This can also be done by moving plants within the wetlands.

Soils in aerobic and anaerobic wetlands may need to be replaced or may receive amendments to prevent saturation with heavy metals. Heavy metal saturation can reduce the ability of the system at remediating the water.

DISCLAIMERS

1. Mine drainage remediation wetland should not be placed in areas prone to flooding or where flood damage potential is high.
2. Consideration should be made of hydraulic routing and existing site hydrology when designing a constructed wetland for water treatment.
3. Any waste material from maintenance activities (i.e. dredging, replanting, and soil replacement) should be reclaimed in a manner compliant with the Ministry of Minerals and Energy.
4. Use of native plants for wetlands is highly recommended.
5. Care should be taken to prevent consumption of plants in constructed wetlands by livestock, humans, or other animals unless it has been determined that plants are safe to eat and have not been contaminated with heavy metals. This will require testing of plant parts above and below ground.
6. The Contractor shall immediately notify the Project Sponsor or authorized representative in the event of any spill or release of chemicals in any physical form within the project site or adjacent waterways. The Contractor shall be solely responsible for all costs of fines, cleanup, sampling, and analysis, reporting and monitoring that result from any fuel or chemical release caused by the Contractor.
7. All work areas shall be clearly marked with signs posted near the project site and notifications set to the proper authorities. The public shall not be permitted to access the site for safety reasons.

EXAMPLES

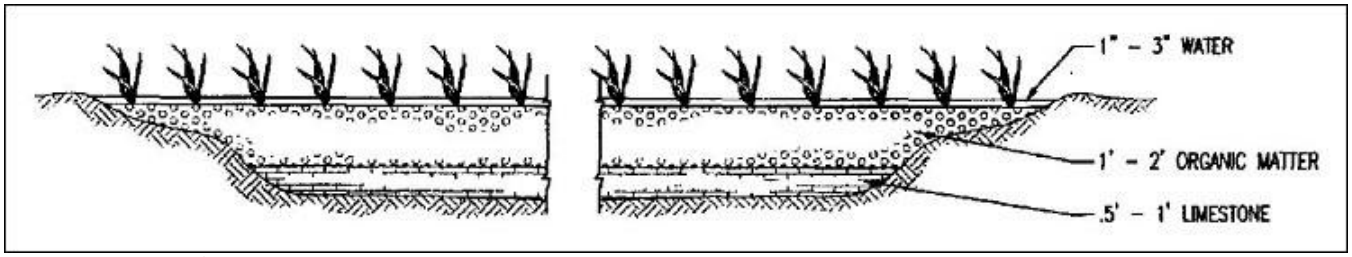


Figure 12. Example of an anaerobic wetland cell (Baum and Mercurio 1997)

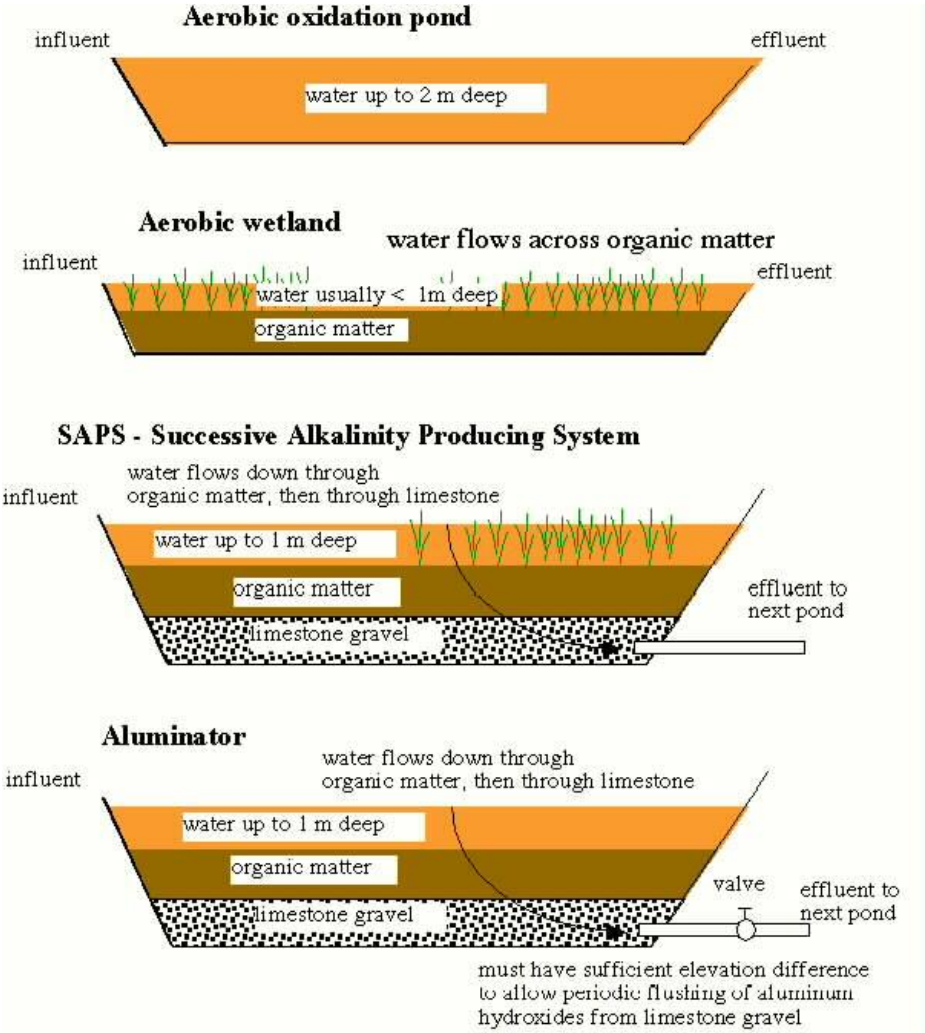


Figure 13. Example of schematic cross-sections of oxidation ponds, aerobic wetlands, successive alkalinity producing ponds and aluminator ponds. Source http://www.facstaff.bucknell.edu/kirby/4ponds.html.

Figure 14. Constructed wetland. U.S. Department of Agriculture.

SOIL AMENDMENTS

BACKGROUND

Tropical soils, like the ones found at the reclamation site, are known for being low in pH and available nutrients. Organic matter, carbon, and nitrogen also tend to be low in soils in this area. Warmer temperatures and frequent precipitation can wash essential nutrients away and increase weathering of bedrock, reducing the overall potential of soils to support increased plant growth. Mining can further exacerbate the issue by increasing soil acidity and further stripping soils of much needed base cations. Amendments are needed to help restore nutrient availability, re-introduce microbial processes, and improve soil pH. For this project, the following amendments are recommended:

- Liming (restores base cations for plant growth, increases soil pH, reduces high aluminum)
- Compost (reuses plant waste, adds organic matter and nutrients back to the soil, adds microbial inputs)
- Mulch Additions (supply additional nutrients after planting)

Liming of soils through the addition of calcium inputs such as limestone, crush bone or shell, and/or gypsum are recommended to use with this method. Liming can help increase calcium inputs to restore cation exchange capacity for plant growth, increase soil pH, and reduce harmful aluminum in soils. Compost tea from compost facilities can be potent additions to soils and can be added as part of the irrigation regime. Mulch from plant material collected in the surrounding area can also be beneficial to soils. Mulch can provide organic matter as well as reintroduce important microbial communities to the soils that can help with decomposition and plant nutrient uptake.

In the reclamation area, compost and soil amendments will provide the nutrition and growing media needed for plant growth. Composting is a simply way to incorporate organic matter and nutrients that are often stripped from soils in mining areas. Compost can be supplied from local facilities or agricultural producers. While compost can only be incorporated into the soil prior to planting, other inputs are also recommended to provide continual nutrient inputs to soils.

Large Woody Debris or LWD (logs or large branches) collected from nearby forest should also be used to supplement mulch and compost for long term soil improvement. LWD should be used as a "top dressing" after tilling of compost and mulching in the Native Forest Restoration areas prior to planting and seeding. LWD will help trap and preserve nutrients in the soil, contribute to biological diversity, create habitat, trap moisture, and organic matter, contribute to micro-climate and micro-topography and add to long term soil nutrients and topsoil development. See LWD section below for more information.

Continual inputs will be necessary to sustain continued plant growth and establishment. Because tropical soils cannot hold onto soil nutrient, water, or organic material for very long, regular input will be needed. These inputs can include top dress additions of compost, adding mulch over soils as they become depleted, and adding compost tea. These can supply plants with nutrients that may become depleted in the soils over time, allowing for more sustained growth.

While soils in tropical systems need amendments to help improve productive function, use of high nitrogen fertilizers, such as urea or synthetic fertilizers, is NOT recommended. The use of such fertilizers can exacerbate the issue of nutrient availability by causing leaching into nearby waterways.

LIMING- CALCIUM INPUTS

SITE ANALYSIS

Before determining the application rate for calcium additions, soils should be analyzed for heavy metal content, specifically cadmium and lead, or an SMP test to measure exchangeable hydrogen in the soils. Analysis for cation exchange capacity and pH are also recommended. When collecting soil samples, it is also recommended that control samples also be collected in non-mined areas near the reclamation site. These samples can provide a comparison to determine how mining effort may have affected the soils. These tests will determine rates and preferred materials to use for lime applications. Lime additions should be done during site preparation, just prior to planting.

MATERIALS AND APPLICATION RATES

A variety of different materials can be used to help improve soil calcium and cation exchange capacity. Materials may include gypsum, calcium carbonate, crushed bones and/or shells, or dolomite. Selection of the best material should be made after soil testing is complete. In general, use of dolomitic lime is preferred due to the magnesium deficiency in the soils. If using pure calcium carbonate, apply at a rate of up to 1,200 lbs. /acre.

COMPOSTING

COMPOST APPLICATION

Compost should be applied to sites in an even layer at the recommended rate of 10 tons per hectare. Once applied, compost should be mixed and incorporated into the soil with the deepest tilling tractor drawn implements available. Mixing should aim to incorporate the mix to around a half meter depth. Use increasingly less invasive tools to bring soil to the desired consistency.

Top mulch should be applied on top of composted soils using wood chips, palm fronds, forest litter, etc., in an even layer. The layer will buffer the effects of the tropical climate by helping slow water infiltrations and slowing decomposition. Mulch materials should be collected and gathered from local forests near the reclamation site. This can also help introduce beneficial microbes and flora that can help support newly planted vegetation.

MAINTENANCE

Once planting is completed, additional inputs of compost can be applied up to three times a year. These applications should be at a lower rate than the one used to prepare the site and will not be incorporated into the soils to avoid damaging plants. Compost should be applied in a top dress, or even layer, providing continual inputs to plants at the site.

EXAMPLES

LARGE WOODY DEBRIS (LWD)

SOURCE MATERIAL

Large woody debris can be found and harvested from the nearby jungle. Any and all woody debris not used for mulching or compost can be utilized as LWD. Ideal LWD should be 3-5 meters long and 25-40cm in diameter, but the larger the better. Any amount of organic matter, branches, soil, small wood, or litter that can be collected along with the LWD is beneficial. Both freshly cut and (fallen wood) or old decaying wood is good, and it is ideal to obtain wood in a variety of states of decomposition.

APPLICATION

LWD should be used as an initial treatment to improve long term soil health prior to planting or seeding native forest areas, but only after tilling of compost, lime, or other soil amendments. LWD is harvested and placed with heavy machinery as a

“top dressing” and scattered evenly across the treatment area. Place LWD directly on the final graded surface or slightly embedded into the soil to stabilize. The target density of LWD should be a minimum of 25 logs per hectare, each log or piece should be a minimum 3-5 meters long and 25-40cm in diameter. Space evenly and as needed across the site, starting from the furthest location from the harvest site or source and working across the site. No maintenance is required for LWD and should be used as an initial soil treatment prior to planting. LWD should decompose over time and reduce future maintenance and soil treatment.

EXAMPLE

Example of LWD placed on a forest restoration site

FORESTRY PLANTING

DESCRIPTION

Preparation of forested areas can rehabilitate tin-mined soils through improved soil microclimate and through the input of organic material from leaf litter. Forested areas will also provide connectivity with existing habitats, providing corridors for wildlife on the island, as well as providing resources for food, fiber, and timber for the local community. Establishment of recommended tree species for reforestation areas is provided as additional GMPs in this section. These guides provide recommendations for site preparation, planting specifications, and maintenance needs based on individual species.

Figure 15. Reforested area on Bangka Island 14 months after planting (Source: Nurtjahya et al. 2008)

IMPLEMENTATION

LAND PREPARATION

Mapping of tailing sites can provide accurate information for where to plant each different trees species. It is recommended that tailing sites be leveled (Fig. 2). Prior to planting, soils will be prepared by mixing with recommended fertilizers and compost. Top soil may also be needed to provided based on individual cultivation needs for different tree species. Planting holes can be dug 30 cm x 30 cm x 30 cm with 40 cm width x 30 cm depth small ditches. Fencing may also be in every 12 m x 12 m plot to support the edge of the sand tailing. Thirty liters of mineral soil and 7 liters of sawdust-cow dung fermented compost are recommended for each planting hole (Nurtjahya et al. 2008).

PLANTING

Seeds from many species can be collected from surrounding areas on Bangka Island. Species that are recommended for initial plantings include *Callophyllum inophyllu, Hibiscus tiliaceus, Schima wallichii, Ficus superba,* and *Syzygium grande*. Other species recommended for the site planting palette may also be considered. Species should be able to survive within nutrient-deficient soils and sandy soil conditions for best results. Seeds can be germinated in sieved-white sand in 1 m x 1 m germination boxes in a 5 m x 5 m green house. Each box should contain one species. Seeds may be prepped for germination by dipping in a 1% (v/v) humic acid liquid for about 2 – 6 hours prior to planting. The outer layer of *V. pinnata* seeds may then be peeled off in water. When seedlings reach the 3 leaf stage, they can be transplanted in 10 cm x 20 cm polyethylene bags filled with soil. When their height reaches at least 35 cm, they can be acclimatized at the mine site for three weeks prior to planting (Nurtjahya et al. 2008).

Below are the recommended planting specifications for the different plant types within the reforestation areas:

Plant Type	Spacing Recommendation	Density
Trees	4m x 4m on 100% of site	625 plants/ha
Shrubs	4m x 4m on 50 % of site in checkerboard, with each quadrat planted with a single species.	625 plants/ha on planted quadrants
Grasses	2kg per species (See species for areas)	

Each planting areas will be divided into quadrats. Trees will be planted with 4m by 4m on center spacing between plants throughout the planting area. Shrub species will be planted with 4m by 4m spacing in 50% of the reforested areas, with opposing quadrats planted in a checkerboard fashion. A different species will be planted together in each quadrat (see Appendix A for planting specifications). Grasses will be planted at 2kg per hectare, with each species covering a portion of the reforested area.

IRRIGATION

Seedlings may need supplemental irrigation during the first few months of establishment. It is recommended that seedlings be give approximately one liter of water on days when rainfall is not anticipated (Nurtjahya et al. 2008)

MAINTENANCE

Assuming average annual rainfall, there should be no need to provide additional irrigation or water to trees once established. If, however, rainfall is lower than normal during the first six months after planting, plants should be irrigated to help sustain plant establishment.

Undesirable weed species should be removed from reforested sites during the first two to help plants establish and to reduce competition with tree seedlings and native understory plants.

Water wells for individual trees should be maintained in case supplemental irrigation is needed. Dirt and plants should be removed from the holes to allow watering of trees.

WALLICHII (*SCHIMA WALLICHII*)

FACT SHEET

Wallichii (*Schima wallichii*) is a tropical evergreen tree and member of the tea family prevalent throughout Southeast Asia and the Pacific. It is also known as the needlewood tree, or kayu seru.

Figure 1. Wallichii tree (Source: Wikipedia commons)

Figure 2. Wallichii tree bark (Source: Wikipedia commons)

DESCRIPTION

GROWTH HABIT

Wallichii is an evergreen tree which reaches heights of 47m (Orwa et al. 2009). Wallichii has grey bark (figure 2). The white flowers are in clusters of three (figure 3).

Figure 3. Wallichii tree flowers(Source: Wikipedia commons)

HABITAT NEEDS

Wallichii can grow in a wide variety of soils and climates. Wallichii does not require full sun and is tolerant of partial shade. It grows at altitudes up to 2400m and requires around 1400 to 5000mm of rainfall annually (Orwa et al. 2009). Although Wallichii prefers well drained soils, it can grow in a variety of soil types and is even tolerant to boggy or swampy sites.

USES

Wallichii is used firewood; leaves are sometimes used for fodder. It is possible to use the wood for paper pulp. Wallichii bark can be used for its tannins to make dyes. The wood is also useful for medium to light construction purposes. Parts of the leaves and flowers are sometimes used in traditional medicine. Wallichii has also been utilized as a cover for understory crops.

PLANTING

PROPAGATION

Trees can be planted from seedling with very high rates of success when planted with a spacing of 1.8 by 1.2 m or 3.6 by 1.8 m; resulting in larger diameter if the larger spacing is used (Orwa et al. 2009).

Wallichii will be planted on 5% of the reforested areas. Seedlings will be spaced 4m x 4m on center.

IRRIGATION

Wallichii should not require supplemental irrigation once established.

MAINTENANCE

Wallichii should not require additional maintenance once established.

KAMANI (*CALOPHYLLUM INOPHYLLUM*)

FACT SHEET

Kamani (*Calophyllum inophyllum*) is a large evergreen tree species in the Clusiaceae family which is native East Africa, through India and Southeast Asia to the Philippines, Taiwan, and the Marianas. Other common names include nyamplung and penaga.

Figure 1. Kamani (*Calophyllum inophyllum*). (Source: David Eikhoff, Wikimedia Commons)

DESCRIPTION

GROWTH HABIT

Kamani is an evergreen tree species reaching with a low branching and irregular crow when full grown can reach a height of 20 m. The trunk of the tree is usually twisted and reaching up to 150 cm in diameter without buttresses. The bark is yellowish or rusty orange tint, with a smooth texture. Leaves of the tree are thick, smooth, and elliptical-shaped. The greyish-green fruit are typically 25-50 mm long and contain a single seed. The trees produce fruit throughout the year (Orwa et al. 2009).

Figure 2. Kamani flowers (Source: Wikimedia Commons)

HABITAT NEEDS

The kamani is tolerant of salt, wind, and brief waterlogged soil conditions and thus grows in coastal regions along the shore lines above the high-tide mark. The species is also found inland and grown in sandy soils and along river margins. The species will tolerantly grow in clay, rock, and calcareous soils. The kamani will not grow in high elevations, dense canopy cover, cool areas, or very dry conditions. Although once the species is established it will tolerate a dry season of up to 4 months.

USES

The kamani can be used for soil stabilization purposes, a fire/wind break, and timber. Indigenous people burn the fruit and use it as a mosquito repellent. Oil can be extracted from the seeds and have medicinal and cosmetic uses. The flowers of the tree have been known to be used to scent clothing and hair.

PLANTING

PROPAGATION

The kamani is moderately easy to propagate by seed. Germination and initial growth is slow, and thus seedlings should be started 6 months before they are required. Once seedlings are transplanted from the nursery to the desired location, they require full sun. The young plantings are tolerant to wind, salt spray, and drought. Ripe fruits should be collected from the ground under trees. Seed may keep for a few months stored in a cool and dry place with the husk removed. Ripe fruit (skin is yellow or brown and wrinkled) may be soaked overnight to remove skin. Just prior to planting it is best to crack shells or shell seeds entirely using a hand tool. Plants should be started in containers at least 6 cm (2.4 in) in diameter, or larger. Partial shade is useful during the first few weeks in hot climates. Seedlings should be grown in full sun after the initial 30- 60 days. Seed germination is slow if the entire fruit is planted. Shelled seeds germinate faster than seeds in their shells Seedlings are ready for transplanting 5-6 months after germination. Seedlings should be hardened-off in full sun before transplanting. Seedlings should have a well-

developed root plug and be 20–30 cm (8–12 in) tall before transplanting. Survival is typically high, although the seedlings grow slowly at first and need to be protected from weeds during the first several years of growth. Direct seeding maybe used; seeds should be sown about 2.5 cm deep. Wildlings may also be transplanted from under mother trees. (Orwa et al. 2009)

Kamani will be planted in 20% of the reforested areas. Seedlings will be planted at 4m by 4m on center.

STRANGLER FIG *(FICUS SUPERBA)*

FACT SHEET

Strangler fig (*Ficus superba*) is a spreading deciduous tree and hemiepiphytite named for its tendency to strangle its host tree by wrapping around it as it grows (Figures 1 and 2).

Figure 1. Strangler fig (*Ficus superba*) wrapping around its host tree (Source: Wikipedia commons)

Figure 2. Typical growth of strangler fig (Source: Wikipedia commons)

DESCRIPTION

GROWTH HABIT

Strangler fig is a buttressed tree (Figure 3) which can reach heights as tall as 30m (National Parks Board, Singapore 2013). The bark is reddish with rough with scaly bumps running which run vertically. It has elliptical leaves which are alternate and approximately 12 cm long. Strangler fig produces a purple fleshy fruit (Figure 4).

Figure 3. Strangler fig buttresses (Source: Wikipedia commons)

HABITAT NEEDS

Strangler figs range is throughout Southeast Asia, the Pacific Islands, and Australia. Strangler figs grow in riverine habitats or littoral rainforest as well as coastlines, and rocky and sandy sites at low elevations and in full sun. Strangler figs often grow on steep rocky slopes but can reach taller heights when growing on more fertile soil.

USES

The strangler fig is sometimes used for food as the fruit is edible (figure 4) but is more appropriate for wildlife forage for the many birds, bats, and insects that eat it. It is also used as an ornamental and to attract birds.

Figure 4. Strangler fig fruit (Source: Wikipedia commons)

PLANTING

PROPAGATION

Strangler fig can be propagated through both seed as well as through cuttings or by layering.

Strangler fig will be planted in 10% of the reforested areas, with seedlings spaced at 4m by 4m on center.

IRRIGATION

Strangler fig should not require supplemental irrigation once established.

MAINTENANCE

Strangler fig should not require additional maintenance once established.

SEA APPLE (*SYZYGIUM GRANDE*)

FACT SHEET

Sea Apple (*Syzygium grande*) is a flowering evergreen tree species in the Mytales family.

Figure 1. Sea Apple (*Syzygium grande*). (Source: Wikimedia Commons)

DESCRIPTION

GROWTH HABIT

The sea apple can grow up to 25-30 meters with broadly elliptic leaves. The bark of the tree is pale grey to pink brown with a flakey texture. Leaves are opposite and broadly elliptical, measuring between 9.4-25 cm long and 4 to 13cm wide. Leaves appear dark green above and lighter green underneath with a down-turned leaf tip and two veins that run parallel to the leave margin. The bud of the flower is pear-shaped with a spherical head. Producing fragrant white-yellowish flowers and green fruit when ripe. Fruits are round to oblong elliptical and are 1.5-4 cm long. Flowering occurs at the start of wet periods and can be intense after prolonged dry periods (National Parks Board Singapore, 2013)

Figure 2: Sea apple budding fruit (Source: Wikimedia Commons)

HABITAT NEEDS

The Sea apple is tolerant of salt and grows in coastal regions throughout Southeast Asia. The Sea apple will grow in a sandy and rocky soil conditions, but does best in deep, humid soils (Fern 2014). Plants are known to grow in tropic areas in elevations up to 1700m. The species is native to Banka Island (Silk, 2009, Marisa and Setiawan 2012).

USES

The Sea apple's bark does not burn easily, making it useful for planting fire breaks. Other uses include as an ornamental or as a road-side tree. Wood is also grown for structural timber, but also for use in musical instruments, tool handles, furniture, ship building, flooring, and other carpentry uses (Fern 2014). The fruit provides food source for a range of animals from insects to birds and primates. Fruits are also edible, though somewhat tough (National Parks Board Singapore, 2013).

PLANTING

The species can be propagated through seeds and cuttings. The sea apple prefers full sunlight, moderate water, and planting distance of 12 m. The overall maintenance and care is low (National Parks Board Singapore, 2013). Trees can be fast growing and germinate readily, making it a good tree to help with site regeneration. Seeds are best propagated when fruit is ripe (Fern 2013).

Sea apple will be planted in 20% of the reforested areas, with trees spaced at 4m by 4m on center.

BELANGEN (*SHOREA BALANGERAN*)

FACT SHEET

The Belangen tree (*Shorea balangeran*) is a species in the Dipterocarpaceae family and native to Southeast Asia. The Belangen tree is a critical endangered plant species.

Figure 1. Belangen trees (*Shorea balangeran*). (Source: Kementerian Kehutanan)

DESCRIPTION

GROWTH HABIT

The Belangen tree can grow to heights between 20 and 25 m. The first 15 meters of the trunk have no branches. The diameter of the trunk is typically 50 cm in length (MacKinnon 1996).

HABITAT NEEDS

The Belangen is native to the tropics and grows on the edge of peat swamp and flooded margins of rivers (The Ecology of Kalimantan). Although, the belangen tree can grow in a variety of environmental conditions such as dry open land, deep peat, and soil ultisol or latosol (MacKinnon 1996, Suryanto et al. 2012). Trees prefer full sun for best growth.

USES

The belangen tree is used for carpentry timber because of its even surface. Belangen tree has a strong quality and durable in wet and dry conditions. In addition to carpentry, wood from the belangen tree is also widely used as raw material for boat materials (e.g. kelotok [small boat]). Although highly desirable, the species has cut ripe age of over 20 years (MacKinnon 1996, Suryanto et al. 2012).

PLANTING

PROPAGATION

Germination is rapid and seeds can only be stored for 12 days in a container by wet charcoal. When seedlings reach a height of 30-50cm, they are ready for transplanting. When transplanting the species in a row, the spacing should be 2-3 m. Young plantings require maintenance for 4-5 years. Weeds and other plants that may outcompete belangen trees should be treated every 3 months until plants are 2 years old to reduce competition for water, light, and nutrients. This should include cutting and removing undergrowth on trees to help retain good plant growth. When the tree has fully matured, the grower must be aware that it requires full light conditions. Flowering and fruiting season does not occur every year. Fruiting season is strongly affected by local climate conditions.

Belangen trees will be planted in 10% of the reforested areas, with seedlings spaced apart at 4m by 4m on center.

BEACH HIBISCUS (*HIBISCUS TILIACEUS*)

FACT SHEET

Beach Hibiscus (*Hibiscus tiliaceus*) is a flowering evergreen tree species in the mallow family which is native throughout the tropics.

Figure 1. Beach Hibiscus (*Hibiscus tiliaceus*). (Source: Wikipedia commons)

DESCRIPTION

GROWTH HABIT

Beach Hibiscus is an evergreen tree species reaching up to 10m in height when full grown with a trunk reaching up to 15cm in diameter (Skolmen et al 1989). The tree has a crooked, sprawling growth type with curving branches. Leaves are large and heart-shaped and alternate along the branches. Bark is light brown with vertical fissures becoming rough with age. The tree has cup-shaped yellow flowers (Figure 2), which will turn orange before falling. Fruit are brown; oval-shaped capsules about 2 cm long containing 10 seeds per fruit (Elevitch et al 2006). The root system of the beach hibiscus consists of lateral spreading roots close the surface, making it susceptible to blow-down in high winds.

Figure 2. Hibiscus flowers (Source: Wikipedia commons)

HABITAT NEEDS

Beach hibiscus grows in coastal regions throughout the tropics. Opinions vary as to whether the tree is native to Tropical Asia or the Americas as it has been widely dispersed by humans. The tree is most often found in riparian areas and will spread rapidly when introduced in stream beds. The tree prefers full sun and will not grow well in shady conditions. Beach hibiscus can grow on a variety of soils including boggy and brackish conditions, as well as well drained sandy soils. The tree is tolerant of soil pH ranging from 5 to 8.5 (Elevitch et al 2006).

USES

The beach hibiscus can be used for soil stabilization purposes, protection of coastline, or as a hedge. Because of its flowers it is often used as an ornamental species and for bonsai. It produces wood which is used for traditional crafts including canoe parts and fence posts as well as for fire wood for slow-smoking food. Propagated cuttings can be used to for living fences or hedges. The inner bark fiber can be used for rope making and weaving. Parts of the plant are also used in traditional medicine, making the tree culturally significant in many places throughout its range.

PLANTING

PROPAGATION

Propagation of beach hibiscus is possible both from seed and from branch cuttings. Propagation from branches is the most effective way to reduce competition when establishing a new planting. To gather cuttings, clip straight branch sections of 2 to 3 m in length. Keep cuttings moist and plant them as soon as possible after gathering. Rooting hormone may be applied but it is not necessary to ensure rooting success. Bury cuttings at least 1 meter deep in moist soil during the rainy season. By planting a continuous row of cuttings, a living fence can be created.

Beach hibiscus will be planted on 20% of the reforested areas, with seedlings spaced at 4m by 4m on center.

IRRIGATION

Once beach hibiscus cuttings are established after about 4 months, little irrigation is required. Until established, cuttings will supplemental irrigation once or twice a week if conditions are dry (Elevitch et al 2006).

MAINTENANCE

Once established, beach hibiscus requires virtually no maintenance.

CAJUPUT (*MELALEUCA CAJUPUTI*)

FACT SHEET

Cajuput (*Melaleuca cajuputi*) is a tree which is found throughout Southeast Asia and Australia. It has many uses, its most important being the source of cajuput oil.

Figure 1. Cajuput (*Melaleuca cajuputi*) tree. (Source: wildsingapore.com)

DESCRIPTION

GROWTH HABIT

Cajuput is a medium to tall tree which can reach heights of 35 m. Its bark is papery in texture (figure 2) and ranges from brown to whitish. Its leaves are alternate and glabrous and taper at each end. Flowers are white to greenish to yellow in color and grow in a clustered spike. Its fruit is woody and cup-shaped clustered along its branches (figure 3).

Figure 2. Cajuput bark (Source: wildsingapore.com)

Figure 3. Cajuput seed pods (Source: wildsingapore.com)

HABITAT NEEDS

Cajuput grows in woodland, vine, savannah, and coastal swamp forests. It prefers clayey and peaty loam soils and is tolerant to poor soil conditions. Cajuput prefers a mean annual rainfall between 1300 to 1750 mm (globinmed.com). It is somewhat fire tolerant and tolerant of salt spray but not of saltwater estuary conditions.

USES

Cajuput is often used for firewood and making charcoal in Southeast Asia. The wood is sometimes used for light construction of fences, frames, floorboards. Its bark has been utilized as caulking material for creating water tight canoes. The bark is also highly flammable and useful for torches due to its oil content. Its oils have been used in traditional medicine for various purposes as a liniment and inhalant. Its leaves have been used for creating tea for the same purpose. Cajuput oil is now a commercial product as well which is extracted and sold as an essential oil for many purposes from flavorings to cosmetics.

Cajuput oil

PLANTING

PROPAGATION

Cajuput can be propagated from seed pods collected from wild sources. Clip seed pods (figure 3) from a healthy tree and dry them for 4 days in paper bags until seed pods open and seeds release. Germinate the seeds in a seed potting mix and keep moist (enviroed.com.au). Transfer healthy saplings to the ground when they are established enough to resist drying out.

Cajuput will be planted in 10% of the reforested areas, with seedlings spaced apart at 4m by 4m on center.

IRRIGATION

Cajuput should not require supplemental irrigation once established.

MAINTENANCE

Cajuput should not require additional maintenance once established.

SENGON LAUT (*PARASERIANTHES FALCATARIA*)

FACT SHEET

Sengon laut (*Paraserianthes falcataria*) is a pioneer tree species sometimes known as batay. It is used in industrial forestry in Indonesia for the production of plywood and paneling.

Figure 1. Sengon laut (*Paraserianthes falcataria*) tree leaves and seed pods (Source: Wikipedia commons)

Figure 2. Large sengon laut tree for timber production (Source: Krisnawati et al. 2011)

DESCRIPTION

GROWTH HABIT

Sengon laut is a fast growing pioneer species. It is a large tree, reaching up to 40 m in height (Krisnawati et al. 2011). It forms a large spreading canopy if grown in the open. It has greenish white or grey bark forming slight fissures as it ages. Leaves are bi-pinnately compound forming a frond-like appearance. Flowers are white or yellow. Long seed pods hold 15 to 20 seeds each. It is considered a nitrogen fixer.

HABITAT NEEDS

Sengon laut's native range includes the Pacific Islands and Australia but it is propagated throughout the tropics. It will grow on a variety of soil types, growing well in dry soils, damp soils, and even salty to acidic soils as long as drainage is sufficient. However, but may need initial fertilizer if grown on marginal sites to help accelerate initial growth. Once trees develop their ability to fixate nitrogen, additional inputs are not needed. Optimal annual rainfall for sengon laut is between 2000 and 3500 mm.

USES

Sengon laut is used in forest plantations throughout Indonesia or the industrial production of plywood and paneling. It is also utilized for paper and pulp production particularly in Java. It is planted for many reasons including as a shade tree, ornamental, as a wind break, nitrogen fixer, or for its leaf fall which can be used as feed for chickens or as a compost. Its bark is sometimes utilized for its tannin content. It has even been used as a soap substitute in various locations.

PLANTING

PROPAGATION

Sengon laut can be propagated by sewing seed directly into the soil. Prior to planting, seed beds should be sterilized to avoid damping off. Soils should be loose and well drained. For best results cover seeds with sand and mulch following seeding, up to 1.5cm deep. Additionally, plants can also be started from cuttings or nursery stock. Regardless of the planting method chosen all planting should be scheduled to coincide with the onset of the rainy season. Spacing of plants should be between 2 and 6 meter depending on desired production outcomes. If planting seedlings, seedlings should be planted at the beginning of the rainy season. All weeds should be removed from the planting site. Seedlings can be planted with different spacing options with 3mx3x spacing being optimal for pulpwood production and 6mx6m production recommended for saw logs (Krisnawati et al. 2011).

Sengon laut will be planted in 5% of the reforested areas, with seedlings spaced apart 4m by 4m on center.

IRRIGATION

Sengon laut should not require supplemental irrigation once established.

MAINTENANCE

If grown for timber, sengun laut areas should be kept weed free for the first two years, with weeding conducted every 2-3 months. Additional fertilizer may also be applied using 100g of NPK fertilizer for each tree after planning. Additional fertilizer may be applied again after 5 years.

Sengon laut should be pruned at 6 month intervals up until 2 years of age to reduce forking if timber production is the desired outcome. Thinning may also be a part of the silvicultural practice used for the tree depending upon goals. Additional maintenance may require the removal of pest infested trees if necessary (Krisnawati et al. 2011).

AKAR ENTIMOR (*DESMODIUM HETEROCARPON*)

FACT SHEET

Akar entimor (*Desmodium heterocarpon*) is a perennial shrub native to tropical Africa, Asia, and the Pacific. It is an aggressively creeping plant that will produce dense low ground cover.

Figure 1. Akar entimor (*Desmodium heterocarpon*) flower. (Source: Wikipedia commons)

DESCRIPTION

GROWTH HABIT

Akar entimor is a diffuse spreading shrub or herb with stems and branches reaching 1 m long (Cook et al. 2005). Runners can develop adventitious roots where they come in contact with soil. Leaves are trifoliate (Figure 2) and range from glabrous to densely covered with small whitish hairs. Long narrow seed pods have 4 to 8 joints and are generally brown in color. Flowers are most commonly pink but range in color slightly (Figure 1).

Figure 2. Akar entimor (*Desmodium heterocarpon*) trifoliate leaves. (Source: Wikipedia commons)

HABITAT NEEDS

Akar entimor can tolerate a range of well drained-soils and low soil pH, but requires moderate soil phosphorous levels. Akar entimor requires around 2,500 mm of annual rainfall in some places but has been known to grow with as little as 1,250mm in Florida (Cook et al. 2005). The shrub can tolerate light frosts and can generally grow at elevations of up to 200m in Pacific regions (HEAR 2008). It is tolerant of a range of light from full shade to full sun but prefers partial shade.

USES

Akar entimor is often used as pasture fodder since it is resilient and often times practical. In some places parts of the plant are used in traditional medicine. It is often planted as ground cover below trees. As a legume, it can help improve soil fertility through nitrogen fixation.

PLANTING

PROPAGATION

Akar entimor can be seeded on bare beds at a rate of 3 to 5 kg/ha or on grass dominated areas at a rate of 5 to 10 kg/ha (Cook et al. 2005). It is recommended to fertilize with annual applications of 300kg/ha of 0-10-20 NPK fertilizer. At certain sites lime should be added at a rate of 2.5 t/ha.

Akar entimor will be planted as a shrub in reforested areas. Shrub seedlings will be planted in at a spacing of 4m by 4m apart in one quadrat per planting area. Planting quadrats for shrubs will be positioned in checkerboard fashion.

IRRIGATION

Once established, akar entimor should not require supplemental irrigation.

MAINTENANCE

Akar entimor should be protected from grazing animals during the establishment stage. Once mature, the shrub is highly tolerant of grazing and 3 to 6 week rotational grazing can be used to prevent shrub dominance and increase pest resistance if necessary. When planted in neutral or alkaline soils akar entimor can suffer from trace nutrient deficiency. Mature plants are drought tolerant but seedlings should not dry out.

TLIMPUK (*COMMERSONIA BARTRAMIA*)

FACT SHEET

Tlimpuk (*Commersonia bartramia*) is a shrub common throughout Australia, Southeast Asia, and the Pacific. It is also known as kelimpuk, brown kurrajong, and scrub Christmas tree. It is known for its grey mottled bark and showy white flowers.

Figure 1. Tlimpuk shrub (*Commersonia bartramia*). (Source: Wikipedia commons)

Figure 2. Flowering tlimpuk (Source: Wikipedia commons)

DESCRIPTION

GROWTH HABIT

Tlimpuk is a medium tree reaching eights of about 20 m. It has mottled grey bark and large serrate leaves. The flowers are white and showy and mostly bloom during the month of December. The fruit is a woody capsule which splits into five sections.

HABITAT NEEDS

Tlimpuk grows in rainforests throughout its range and is typically found most often following disturbance. It is also often found on roadsides due to its fast growing and early establishing nature. It can grow at elevations of up to 800 m.

USES

The fibrous inner bark of tlimpuk is used to make cordage for making mats, ropes, and fish nets. The wood of the tlimpuk is not very strong and so is not generally utilized as a building material. The wood is however frequently used for firewood. It is sometimes planted as an ornamental due to its attractive flowers and bark. In some places the roots are used in traditional medicine (NTBG 2016).

PLANTING

PROPAGATION

Tlimpuk can be grown from seed or through cuttings. If using seeds, they must first be scarified using either a mill or some form of blender to break up the whole capsules. Next pour almost boiling water over the resulting mixture and sow the resulting fibrous mixture. Alternatively, tlimpuk can be grown quite easily from propagating cuttings (Fern 2014).

Tlimpuk will be planted as a shrub in reforested areas. Individual plants will be planted together in one quadrat of each planting area, with seedlings spaced 4m by 4m apart on center. Planting quadrats for shrubs will be positioned in a

IRRIGATION

Tlimpuk is a fast growing pioneer species adapted to rainforest habitats and thus should not require supplemental irrigation once it is established.

MAINTENANCE

Tlimpuk does not typically require maintenance. Once established it is a fast growing species with little need for additional cultural treatments.

CITRONELLA GRASS (*CYMBOPOGON WINTERIANUS*)

DESCRIPTION

Citronella grass (*Cymbopogon winterianus)* is a tropical grass cultivated for its culinary and medicinal purposes. It is sometimes called lemon grass because of its smell.

Figure 1. Tuft of healthy citronella grass (*Cymbopogon winterianus)* (Source: Wikipedia, Creative Commons)

Figure 2. Citronella grass for sale in a market (Source: Wikipedia, Creative Commons)

HABITAT NEEDS

Citronella grass is cultivated in tropical climates at temperature ranges between 10 and 33°C. The grass requires between 700 and 3,000 mm of rainfall annually. It can grow on a range of soils but prefers sandy to clay loam soils with good drainage. It can be grown in industrial waste sites, poor soils, steep conditions, and rehabilitation sites.

USES

Citronella grass is used as both a culinary and medicinal herb in various places. The oil from the grass is used as a pesticide, fungicide, and preservative. Its oil has also been used as an additive to cosmetics, in aromatherapy, for candle making, and as an insect repellant. It is also used in traditional medicine. Citronella can be planted in gardens to ward off certain insects. For culinary purposes, citronella grass is well known for its strong, aromatic, and citrusy flavor and is used to help flavor a wide variety of dishes.

IMPLEMENTATION

LAND PREPARATION

Before beginning soil preparations, test the soil in various places across the intended planting area. Fertilizer is an important aspect of land preparation for citronella grass. Apply nitrogen and phosphorus such as DAP or NPK according to soil test results or at a rate of 100 g per 1 m of linear row. Care should be taken to avoid heavy inputs of nitrogen or other soil nutrients, as it can lead to leaching of much needed minerals from soils. Spread the fertilizer evenly in bands approximately 90cm wide and till it into the soil. Optionally, lime or gypsum can be added to enhance growth.

PLANTING

When planting citronella, be sure to find healthy nursery stock which is pest-free and healthy. Plant in October or November to take advantage of rainy season. Pay attention to the weather forecast and time of planting to coincide with a rain event. Ideally slips will be planted in moist soil immediately following a rain event and continue to get rain daily for the week following planting. Planting dimensions are 1m by 1m or if desired 0.5m by 0.5m for greater production. Mix 3 kg of compost into the soil at each planting site. When planting the slips, bury the roots and bottom 5 cm of the grass stalk in the compost rich planting site. After the first rain the soil around the base of the freshly planted slips may need to be tamped down to secure the young plants in place.

In the reforestation area, citronella will be planted as seed at a rate of 2kg per hectare. Citronella grass is proposed for 4 ha of the reforestation area, which can provide multiple benefits to the area. The grass can act as a natural deterrent for insects to protect other marketable products in these areas, as well as being produced for essential oil production and as a natural pesticide for the reclamation site.

IRRIGATION

The soil around freshly planted citronella slips needs to stay moist until roots develop and can start pulling moisture from the soil. In an un-irrigated field, ideally the slips will be planted immediately after or during a rain event. The moisture gathered by soil and incorporated compost will keep the freshly planted slips healthy until young roots can begin growing.

HARVEST

If plants stay healthy after planting, first harvest can begin six months after planting. Because citronella oil is contained mostly in the green leaves, the lower woody part of each stalk can be left attached to the clump. Cut the green leaves free from the plant 15 to 20 cm from the center of the clump. Freshly harvested leaves need to be processed within 24 hours as the oil is volatile and evaporates from the leaves as they dry. The citronella will regrow from this residual clump allowing one more harvest after the first year of planting. As the crop ages beyond one year, harvest interval can be increased to once every 3 months.

At peak production, citronella planted on a 1m by 1m grid can be expected to produce an annual yield of 10 kg of biomass /ha per 4 months which will equate to about 76 kg of distilled oil. Peak production will be reached in year 2. If planted on a 0.5 m by 0.5 m grid, production should be doubled. Current price for citronella grass is between 150,000 – 170,000 IDR. The oil can be used back on the site as well as a biopesticide to help reduce costs for maintenance. The oil is also marketable as a mosquito repellant and for use in a wide variety of soaps, lotions, and other household products. Local sellers and distillers have set up operation in Bangka, making it feasible to develop collaborative agreements between agricultural producers and refiners for citronella products.

MAINTENANCE

Weeds can begin to grow in the crop after the first irrigation or rain event. It is important to manage weeds by pulling them or hoeing them throughout the life of the crop. If they are left to grow unchecked, they will rob the crop of fertilizer and of available soil moisture. In extreme cases they can outgrow the crop shading it, causing severe stunting. Be sure to pull or hoe weeds before they go to seed. If weed growth is managed in this manner, over the course of a few years, it is possible to rid the soil in the field of some undesirable species.

Fertilize plants as needed and control weeds during the first year of growth until plants are established. Within one year, citronella grass should reach its full height. Citronella grass should be protected from domestic animal browse during the first year of establishment. Trim citronella grass annually using a hedge trimmer or tractor mounted disc mower. This will help reduce the chance of leaf diseases developing and help prevent dead centers from forming in each tuft of grass.

BAHIA GRASS (*PASPALUM NOTATUM*)

FACT SHEET

Bahia grass (*Paspalum notatum*) is a fibrous, rhizomatous grass species native to subtropical South America, but naturalized throughout much of Asia. Also known as rumput pencasilan or ya-bahia in other parts of southeast Asia. It is commonly used as forage for grazing animals, and to protect soils from erosion.

Figure 1. Mat-forming growth of *Paspalum notatum* (Source: Harry Rose, CC)

DESCRIPTION

GROWTH HABIT

Bahia grass is a low-growing perennial grass species that spreads by short, woody runners and seeds. The runners have large, fibrous roots that form a dense, tough sod over soils. Leaf blades are hairy on the margins and less than 1cm wide, growing up between 2-5cm in length. Flowers grow in a panicle, usually with two racemes that are 5-10cm longs with spikelets (Cook et al. 2005).

HABITAT NEEDS

Bahia grass is commonly found in sandy or light-textured soils. It can grow in areas between sea level to 2300m in elevation, and is tolerant of periods of frost. While the species grows best in fertile soils, it has some root associations with nitrogen-fixing bacteria in the rhizosphere, allowing it to grow in even infertile soils. It can grow in a range of soil pHs, preferring slightly acidic soils (5.5-6.5) and is moderately tolerant of aluminum. Some cultivars are known to be salt tolerant. Bahia grass can grow in habitats with annual rainfall totals between 700 and 1500mm per year. It is drought tolerant and can tolerate flooding, surviving over 30 days of inundation. The species prefers full-sun, but can tolerate some reductions in light (Cook et al. 2005).

Figure 2. Flowerheads of *Paspalum notatum* (Source: Harry Rose, Wikimedia Commons)

USES

Bahia grass is used to protect soils from erosion and as forage for heavily grazed pastures. It is drought resistant, and can provide good ground cover in shaded or high traffic areas. It can be used to help stabilize terraces and protect soils from erosion (Skerman and Riveros 1988). In terms of forage, plants are most palatable when young, with declining palatability as plants age. Grazing is recommended in six-week intervals to obtain the best yields and nutritional values for older pastures or every 3 to 4 weeks during early establishment (Skerman and Riveros 1988). Bahia grass may be used for hay production if fertilized, but prior to seedhead production (Cook et al. 2005). *P. notatum* can also be used to treat soils with high phosphorous when planted with nitrogen fertilizer to facilitate P uptake.

PLANTING

PROPAGATION

A number of different cultivars exist for *Paspalum notatum*, with the "Pensacola" cultivar most commonly used in Australia. Soil beds should be prepared, with an addition of 25-30kg/ha of nitrogen to help with early germination and development, especially in soils with poor nutrient content. If nitrogen fixation is facilitated, additional inputs of fertilizer may not be necessary. Grasses plant best using seeds drilled into a fine seed-bed and then rolled. Seeds may also germinate from animal dung. Seeds should be planted no deeper than 1cm below the surface and then

covered with soil. Seeds can be drilled at a rate of 2-5kg/ha. Seed germination may be improved with hammer milling or chemical treatments. Plants do take time to grow and establish.

Bahia grass will be planted as ground cover in the reforested areas. It will be seeded on 2 hectares of the forest at a rate of 2 kg per hectare.

IRRIGATION

If planted during the wet season, supplemental irrigation is not necessary. However, irrigation can help increase sowing rates when coupled with fertilizer applications and weed control measures.

MAINTENANCE

Due to the slow initial growth rate, seeded areas should have weeds or other broad-leafed plants removed to prevent shading and to reduce competition. Weed establishment is best controlled by mowing seeded areas every three to four weeks. *P. notatum* seedlings are susceptible to phenoxy herbicides so chemical treatments are not recommended.

Additional inputs of fertilizer may be needed to help increase seed production and plant growth at regular intervals. Nitrogen can be added at a rate of 200 kg/ha per year. Some applications of phosphorous have also been known to increase plant growth and seed yields. Excessive management of soil pH is not recommended as plants have been known to die off when soil pH reaches above 7.5 when treated with lime. If plants are showing signs of iron chlorosis, iron applications may be necessary in less acidic soils (Cook et al. 2005).

RUMPUT JENGGOT (*FIMBRISTYLIS PAUCIFLORA*)

FACT SHEET

Fimbristylis pauciflora (rumput jenggot) is a smooth perennial herb distributed throughout Southeast Asia, New Guinea, and northern Australia.

Figure 1. *Fimbristylis pauciflora* (rumput jenggot). (Source: Stephanie Haslam, Noosa Native Plants)

DESCRIPTION

GROWTH HABIT

Rumput jenggot form in large clusters and its rust-coloured stems are 10cm in diameter, and 5-40cm in length. The leaves are usually bladeless or with threadlike blade up to 6 cm in length. Inflorescens are small as a single terminal spikelet. (Shuren et al. 2010).

HABITAT NEEDS

Rumput jenggot is native to Western Australia but grows in woodlands, swamps, and vine forests throughout the tropics. Rumput jenggot grows in sunny to shady light conditions, in sand or clay soils. Rumput jenggot has been found along the edges of swaps, and rice fields. Furthermore, it is often found along watercourses and in seepage areas. The species prefers soils that are sandy or clayey. The grass will grow at elevations up to 800 m (Cook et al. 1984).

USES

Rumput jenggot have used as biological filter to remove heavy metals such as copper, zinc, and cadmium because of its relatively high tolerance to metals (She et al. 1984)

PLANTING

Rumput jenggot sprigs (rhizome cutting including both crown and root) should be planted at or near the edge of a watercourse or pond. The addition of mulch or compost into the top 5 cm of soil surrounding the plantings will increase plant success (Cook et al. 1984).

Rumput jenggot will be seeded as ground cover in reforested areas. It will be seeded on 2 hectares of forest at a rate of 2kg per hectare.

PULAI TREE (*ALSTONIA SCHOLARIS*)

FACT SHEET

The Pulai tree (*Alstonia scholaris*) is a large deciduous tree that grows to about 40m high with tessellated corky grey to grey-white bark. It is native to Australia and parts of Southeast Asia. Other common names include the milkwood tree, pulai linlin, or rite.

Figure 1. Growth habit of the Pulai Tree (Source: Unknown) and the flower clusters (Source Meneerke Bloem, Creative Commons)

DESCRIPTION

GROWTH HABIT

The Pulai tree is a large stately tree that can grow to about 40m tall with corky bark. The trees are often deciduous, losing their leaves at irregular intervals (Fern 2014). Trees are grown for their timber, with the best wood grown in moist, protected environments. Leaves are grown in whorls of 4 to 8 leaflets with an obovate to elliptical-lanceolate shape. The upper leaf surface is dark green and the lower surface is green-white. Flowers grow in a much branched panicle of white to white-green flowers. Each flower is between 7-10mm long with hairy tubes and lobes. Flowers also have a strong odor. Fruits are long pods that are 15-32 cm long containing numerous, flat, oblong brown seeds (Orwa et al. 2009). Trees only flower after prolonged periods of dry weather and are best pollinated by insects, such as butterflies and bees.

Figure 2. Fruit of the Pulai tree (Source: Public Domiain)

HABITAT NEEDS

The Pulai tree is found in coastal tropical forests between elevations of 0 to 900m and where annual rainfall is between 1200 to 1400mm. It grows best in full sun with fertile, moist, but well-drained soils and is tolerant of a range of soil conditions.

USES

The Pulai tree is known for its wide variety of uses. Latex from the tree sap is used to make chewing gum, while the flowers have been used in making essential oils. Timber is a popular use and can be used for carvings, moldings, plywood, and core stock. The bark from the wood is used for fiber production and for pulp and paper production. Wood can also be used for making charcoal, which is used as gun powder in some areas (Orwa et al. 2009).

PLANTING

PROPAGATION

Trees are best propagated from seed, which can be stored up to 2 months while still retaining a 90% germination rate. Seed should be sown in full sun, with seeds sprouting around 12 days after seeding. Vegetative propagation is done by planting 30-40cm long branches into raised seedbeds. Vegetative plantings should be covered to minimize transpiration losses. Rooting typically begins after 60 days. Vegetative propagation is the most effective method for propagation as seed germination rates are generally low. If plants will be propagated from seed, seeds should be started in a nursery, in raised beds mixed with sand. Seedlings can be transplanted when they reach a height of 8-10cm, or after 3-4 months. Seedlings should be spaced 2m x2m a part. (Ravindranath et al. 2004)

Pulai trees will be planted around the outer edge of the wetland habits, with each tree planted every 50 m.

IRRIGATION

Light watering, with a fine spray can, is only necessary if propagating in nursery. Once planted in field, additional watering is not necessary.

MAINTENANCE

If growing for fuelwood, 6-8 year rotations work best, allowing species to reach a height of 3.6m with a 10cm diameter and cutting every 3.5 years in a mixed age stand. For timber production, trees should reach an average height of 23.5m in height and a diameter of 51cm dbh, with timber removal every 18 years. Maximum height is reach (35m with a 109cm dbh) is reached at around 41 years in age. Trees may be susceptible to damage from the leaf skeletonizer, *Parotis marginata*, which can damage nursery stock and young plantations. Timber is also susceptible to damage from termites, pinhole, and marine borers. Sapwood is susceptible to damage from lyctid borers (Orwa et al. 2009)

SIMPOR BINI (*DILLENIA SUFFRUTICOSA*)

FACT SHEET

Simpor bini *(Dillenia suffruticosa)* is a large flowering shrub species. The flowers of the Simpor bini open and close at precise time intervals. It a native to the Bangka-Belitung Islands of Indonesia.

Figure 1. Simpor bini *(Dillenia suffruticosa)*. (Source: Wikipedia commons)

DESCRIPTION

GROWTH HABIT

The large shrub can grow up to 10 m in height. The ribbed leaves are elliptic to obovate shaped and 15-35 cm in length. The scentless flower is yellow with five 8-10 cm petals. The fruit of the plant is pink with red to orange colored seeds. Simpor bini fruits set on the 36th day after the first petals fall. Unfailingly, the flowers and fruit open at 3AM for dawn. The shrub can live up to 100 years. The presence of simpor bini is an indication of a ground water source

Figure 2. Fruit of Simpor bini *(Dillenia suffruticosa)*. (Source: Wikipedia commons)

HABITAT NEEDS

Simpor bini grows in variety of habitats but is native to subtropical regions. Although the species is only found in altitudes at or below 700 meters. It can grow in swamps, white sand areas, riversides, and ridges. Sands in shady conditions. Beach hibiscus can grow on a variety of soils including boggy and brackish conditions, as well as well drained sandy soils. The shrub is tolerant of soil pH ranging from 5 to 8.5 (Elevitch et al 2006). It prefers full sun.

USES

Simpor bini leaves and roots are used medicinally to treat itchy skin, inflammation, stomach aches, and it is given to mothers after delivery. The large leaves are used in wrapped food recipes. Plants can also be used as ornamentals as it naturalizes easily (Fern 2014). They are also attractive to a wide variety of animal species, providing good habitat for birds, insects, and other foragers (NTBG 2014)

PLANTING

Plants can be propagated from seed or from cuttings. The seeds can germinate in the sand and the roots will migrate vertically until an underground watercourse is reached. Plants need moderate amounts of water and maintenance during establishment to reduce competition with other plant species (National Parks Board, Singapore 2016)

Simpor bini will be planted along the outer edge of the wetland habitats, with trees planted 5 m apart.

AZOLLA (*AZOLLA MICROPHYLLA*)

FACT SHEET

AZOLlA *(Azolla microphylla)* is free-floating freshwater fern that coexists with *Anabaena azollae*, a nitrogen-fixing bacterium. Azolla is native to Asia, Africa, and the Americas

Figure 1. AZOLA *(Azolla microphylla)*. (Source: Wikipedia commons)

DESCRIPTION

GROWTH HABIT

Azolla grows rapidly in nitrogen deficient habitats. The diameter of the plant ranges from 15 cm for large species and 1-2.5 cm for small species. The main stem grows on the surface of the water, with alternate leaves and adventitious roots branching from the stem at regular intervals. The fronds can be triangular or polygonal and float on the water surface (Hasan and Chakrabarti 2009)

Figure 2. Azolla used in rice production (Source, Philippine Rice Research Institute, Wikimedia Commons)

HABITAT NEEDS

Azolla are distributed throughout sub-tropical and tropical regions of the world. The growth potential of the species is restricted by climatic factors, water, phosphorous requirements, precedence of pests and immunity. The availability of water is critical to growth and multiplication of *Azolla* and thus is extremely sensitive to the lack of water. *Azolla* favor water depth of centimeters because the roots are close to the soil, and the effect of wind is reduced. Strong winds will clump *Azolla* together and thus slow the growth rate. *Azolla* can tolerate a water pH ranging from 3.5-10. Optimum water and soil pH for the species occurs at 4.5-70 and 6-7 respectively. *Azolla* growth requires 25-50 percent full sunlight and growth quickly decreases in heavy shade. Tolerance to salt is species dependent. For instance, *A. filiculoides* is the most salt-tolerant species. Phosphorous is the most limiting element for growth. Symptoms of a phosphorous deficiency are red-pigmented fronds. The species had low tolerance to extreme heat. *Azolla microphylla* grows best in water temperatures between 25-30°C (Lumpkin and Plueknett 1985, Hasan and Chakrabarti 2009)

USES

Azolla has high crude protein content than most forage crops and is rich in lysine (amino acid), which is essential for livestock nutrition. Farmers use *Azolla* for animal feed, and crop manure (source of Nitrogen). *Azolla* is also supports aquatic systems through its strong photosynthetic oxygen –releasing capacity.

PROPAGATION

Azolla are generally propagated in shallow pools or ponds. Be sure no large fish are present which can eat the fern as it is establishing. If an adequate pool is not present use tarps to create a pool between 5 and 20 cm deep. Place seedlings into water deep with a mixture of manure or fish waste on the bottom. Be sure the roots of the seedlings can reach the manure mixture. Every three months the pool will need an application of water soluble P fertilizer. If leaves begin to turn brown they may require a shade cloth to protect from the sun. If mosquitos begin to breed in the pool, the addition of small fish such as guppies can help.

Azolla will be planted as part of the wetland habitat created around the proposed lakes/ponds. The wetland areas will be planted in a 20m band around the open water, with *Azolla* planted the in 1/3 width next to the open water. Plants will be spaced 2m by 2m on center within this band.

PURUN (*ELEOCHARIS DULCIS*)

FACT SHEET

Purun (*Eleocharis dulcis*) is a tufted perennial plant that resembles rush-like species. The plant has short rhizomes that are cultivated for food in many parts of Asia.

Figure 1. Purun growing in shallow water with azolla (Source: Flickr, Creative Commons) and harvested corms sold at local markets (Source: Anna fFodesiak, Creative Commons)

DESCRIPTION

GROWTH HABIT

Purun grows as a perennial herb with short rhizomes. The plant is leafless, with stems or culms performing the photosynthesis for the plant. Culms are erect, grayish green, cylindrical and hollow in the middle, growing between 15 and 60cm in height. It produces clusters of flowers in a spikelet, which are cylindrical and straw-colored. Each plant has two tubers attached to the bottom. The first can be used for propagation of the plant, while the second is used for below-ground storage and is the edible portion of the plant. The tubers, or corms, are round turnip shaped bulbs with brown skin and bright white flesh (National Parks Board Singapore, 2016).

Figure 2. Flower cluster of purun (Source: Nadiah Manjato, Creative Commons)

HABITAT NEEDS

Purun is most commonly found in marshy areas with shallow water in areas below 1200m in elevation. Plant grow is optimal between 30-35°C during the leafy stage, with corm growth occurring at slightly lower temperatures, with a minimum temperature of 15°C for tuber development. Purun prefers neutral soils (pH 6.9-7.3) that are high in clay content, but well fertilized. It grows best in full sun. Plants should be grown in water that is at least 10cm deep about a month prior to harvesting and then drained prior to harvest. Plant requires 7-8 months of growing to produce corms for harvest. Harvested corms should be stored in cool, but damp areas if used for replanting (Fern 2014). Purun does not grow well in acidic soils, which can encourage the growth of different fungi to grow on the stem.

USES

Purun is commonly cultivated for the corms to use as food. The tubers can be consumed raw or cooked. They can also be dried and used as a flour or starch to thicken sauces or as a coating for deep-fried foods. In some areas, the plant is used as a form of traditional medicine due to its anti-bacterial properties. Leaf stems can also be dried and used for weaving bags, mats, baskets, and hats (Fern 2014)

PLANTING

PROPAGATION

Areas where purun is planted should be graded to allow for flooding of plants throughout the growing season. Soils should be well limed, approximately 5-20cm deep with compost or organic material a few weeks prior to planting. Soil should also be free of hard debris, such as stones and woody plant to help make harvesting easier.

Plants are best propagated from the collected corms. Corms are best collected at the end of the growing season and should be store in a cool, moist environment until ready for use. When ready for planting, tubers should be planted about 10cm deep in soils with spacing of 2m x 2m apart. Soils should then be flooded for at least 24 hours to a depth of 7-10cm after planting and then allowed to drain naturally (Moore 2008).

Purun will be planted as part of the wetland habitats in the reclamation site. Purun corms will be planted 2m by 2m apart in the portion of the wetland belts that borders the reforestation areas. Corms will be planted in 2/3 of the width of the wetland belt.

IRRIGATION

Purun needs regular flooding to enhance plant growth and corm development. Fields should be regularly flooded to a depth of 7-10cm to maintain plant growth and corm development. Water should be drained off before harvesting to expose the corm and aid in corm collection (Moore 2008)

HARVESTING

When leaves start to yellow, the corm will begin to develop the chestnuts or corms at their end of the rhizomes. Over a period of a few weeks, the leaves will begin to turn brown and die back. Corms are best harvested after the above ground growth has died off (Moore 2008).

MAINTENANCE

Purun needs moderate maintenance, with care taken to regularly irrigate plants. It can grow well in conjunction with *Azolla* in marshy, wetland areas.

Appendix C. Literature Review

Bangka-Belitung Tin Mining Reclamation Projects

Literature Review

August 2016

Bangka-Belitung Tin Mining Reclamation Projects

Literature Review

AUGUST 2016

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Introduction

This document was created with the aim of consolidating the many sources and types of information needed to design a successful restoration pilot project. As such, a wide variety of source materials are represented here, expressive of the many possible restoration uses for ex-mining land. In all sections except Aquaculture, our notes are divided by the source from which they were derived. In the Aquaculture section, we have synthesized our finding further, citing sources as necessary. For some sources, not all reference information was available. For those sources, we apologize for any omitted citation information.

Restoration

Bangka-Belitung Tin Mining Reclamation Projects, Site Visit and Team Capability Statement

Fred Phillips Consulting

Three Reclamation Pilot Projects described:

1. Bangka/RBT Bamboo Farming and Forest Restoration Project (50/150 Hectares). Nearest city: Penyamun City (70% currently miners). Wages needed: $250/month (laborer), $500/month (foreman).

2. E Belitung/PT Timah Ecotourism Project (500 Hectares). Priorities could include: Belitung Island Tarsier, coral reefs, mangrove forests, beaches, rivers, and rainforests degraded by the impacts of tin mining.

3. Bangka Tengha/Aeti Agricultural/Biomass/Restoration Project (500 Hectares). Includes the production of biomass for energy creation and agricultural products including: bamboo, palm oil, and pepper.

Other issues raised:

- Access to facilities to process raw agricultural products.
- Access to capital for villagers to start farms and cooperatives.
- The possibility of the soil degradation in mining areas prohibiting agriculture until several years of soil treatment have been completed.
- The need for a mining-free beachfront for ecotourism to flourish.

Personal Communication between FPC and UBB Faculty

- Drip irrigation recommended as most effective and least costly.
- Lowered pH in mining lands may contribute to mangrove mortality.
- Suggests the difficulty of getting local buy-in. Suggestions: transfer ownership to village, seek out approval from medicine men and other informal leaders (as opposed to elected officials). Paying people is not enough. Re-mining will always be a concern; they do not know of a restoration project that hasn't been re-mined.

Reclamation of Ex-Tin Mine Site on Bangka Island

Irdika Mansur, Southeast Asian Regional Centre for Tropical Biology

- Reclamation of tin-mining sites in Bangka is focused on developing reclamation projects that support the local community and improve productivity of the area for agricultural enterprises.
    - Aim to prevent re-mining of site by providing economic incentives
    - Income generation through diversified agricultural programs
    - Improve site conditions by addressing loss of soil productivity and water quality
- One of the biggest concerns for reclamation is the uncertainty of the land status and limited support from local government or local communities, which often leads to reclaimed sites being re-mined.
- Need to determine the specific goals of the reclamation of Bangka to help focus the design and proposed components of the reclamation. Should benefit as many as possible.
- Need analysis of site to determine conditions, issues with community, and land access issues.
- Two important components include development of a plant nursery and composting facilities

  Plant Nursery
    - Collect and propagate desired species
    - Conduct research on collection techniques
    - Income generation from selling seedlings
    - Support local environmental education programs

  Composting Facilities
    - Reduce costs for purchasing compost from outside sources.
    - Reduce use of inorganic fertilizers and lime to rehabilitate soils
    - Generate income by selling additional compost
    - Compost facilities should aim to be fully mechanized to help reduce costs and make practices sustainable (may not be fully supported due to loss of potential jobs)
- Selection of plant species will depend on the goal for reclamation. Monocultural stands or agroforestry systems (or a combination)?

- Landscape design will be helpful for making the site attractive, functional, and sustainable. Should include facilities (e.g. exhibition house, training house, offices, etc.) to help maximize use of the site.
- Also need to address long-term organization and management of the site after reclamation is completed.

ITTO Tropical Forest Update, Fellowship Report

Eddy Nurtjahya

Project Description: Restoration of sand tin tailings (current swamp)
Study Site: Riding Panjang village, in the Province of Bangka Belitung

- Notes that "improving microclimates, by using methods such as alternating rip cultivation with high planting density and high species richness, is one technique that has had some success (Rachmawati et al. 1996; Parrotta and Knowles 2001)."
- This project planted some plots with and some plots without coconut shells. They found that coconut shells significantly reduced soil temperatures near the seedlings in the late dry season (by 4.3°C) and in the wet season (by 2.1°C) and soil humidity in the dry season (by 7.6% – 12.2%) and in the wet season (by 0.8% – 7.8%).
- This project also planted plots with various soil amendments, including (1) control, (2) 500 grams powdered slime tailing under Lepironia articulata, (3) equal composition (1:1) 30 kg ha-1 of legume cover crops (lcc) Calopogonium mucunoides and Centrosema pubescens, (4) lcc and 2.5% humic acid, and (5) lcc and top soil.
- Of various soil amendments, the highest survival rate occurred where both top soil and legume cover crops had been added. Of the various planting densities, the highest survival rate occurred with the highest density planting.
- Project costs for planting were $1700 per 625 seedlings /ha^ -1, $2600 per 2500 seedlings /ha^ -1 and $5300 per 10,000 seedlings /ha^ -1.

Revegetation of Tin-Mined Land Using Various Local Tree Species in Bangka Island, Indonesia (Full Article for ITTO Tropical Forest Project)

Eddy Nurtjahya, Dede Setiada, Edi Guhardja, Muhadiono, I. and Yadi Setiadi

- Species selected were pioneers in lowland forest and abandoned farmland; see table below.
- Germinated in sand, dipped in 1% humic acid (2-6 hrs). At 35 cm, seedlings were acclimatized at mine site for 3 weeks before planting.
- Site preparation: Local youth soccer club dug 30 cm holes, 40x30 cm ditches, and installed fences in each plot to support edge of sand tailing.
- Planting done in late April by local women; dead plants were replaced three weeks later. Plants were watered with one liter/plant by hose each afternoon on days that it did not rain.
- Coconut shells (3-4 pieces) were placed around the root collar of some plants.
- Presence of fish species in nearby ponds indicated that water quality was high.
- Survival rates for all plants at 3 months was 98.8%, at 6 months it was 87.9%, and 71.8% at the end of 9 months and 12 months.

- For the highest-performing treatment (Icc and topsoil with a planting density of 1x1m) yielded and overall survival rate of 78.7%, or ~7% above the average survival rate.
- Conclusions: The authors believe that the faster plant cover was achieved, the more favorable the outcome. They attribute this to greater organic matter, which in turn contributes to more suitable soil and air temperature and soil humidity.

Succession on Tin-Mined Land in Bangka Island

Eddy Nurtjahya, Dede Setiadi, Edi Guhardja, and Yadi Setiadi

Abstract (excerpt): "The seedling composition of the oldest tin-mined land [38 years old] was less than 2 % similar to that of a riparian forest. Natural regeneration on 7-year old tin-mined land began with herb species belonging to *Cyperaceae*, *Poaceae*, and *Melastomaceae*; followed by herb species belonging to *Asteraceae* and *Poaceae* on 11-year old; then by *Poaceae* and shrub species of *Myrtaceae* on 38-year old tin-mined land. Older tin-mined land tended to have less sand, higher nutrients and cation-exchange capacity. The phosphate solubilizing bacteria showed a gradual increase along with the more newly abandoned tin-mined land but decreased in barren tin-mined land, while the number of arbuscular mycorrhizal fungal spores showed the opposite."

Conclusions: Natural revegetation is highly ineffective for the duration the study covered (38 years post-mining). The authors point out that during this protracted revegetation, the ex-mining land is not useful, either economically or ecologically. As such, they recommend active revegetation for ex-mining land.

Improved Mined Land Rehabilitation in Indonesia through Capacity-Building for Practitioners

Environmental Leadership & Training Initiative, Tropenbos International – Indonesia Programme (TBI Indonesia), Bogor Agricultural University (IPB), and University of Bengkulu (UNIB)

Issue: Indonesia requires progressive reclamation of mined lands to address environmental degradation of sites as a result of mining practices. Many companies lack the technical capability to address such obligation, especially for small-scale operations. Government organization responsible for enforcing the rehabilitation requirements also lack the technical capacity for effectively monitoring and evaluating rehabilitation efforts.

Solution: A partnership of interested organizations held a 3-day workshop among practitioners, government regulators, and civil society organization to develop materials and institutional infrastructure to better prepare these organizations for addressing and providing more technical expertise for mining reclamation work. Results of the workshops including developing curriculum and training materials to help meet the governmental requirements and building relationships between practitioners across Indonesia for better support, research, and information on mining land reclamation techniques and practices.

Soils

Soil Reclamation of Abandoned Mine Land by Revegetation: A Review

V. Sheoran, A. S. Sheoran, P. Poonia

Notes that mine reclamation sites are frequently acidic and that soil pH should be within the neutral range (6-7.5) for ideal growing conditions.

- "The color of a mine spoils or weathered mine soil can tell us much about its weathering
  history, chemical properties, and physical make up.
- Bright red and brown colors in spoils and soils generally indicate that the material has been oxidized and leached to some degree. These materials tend to be lower in pH and free salts, less fertile, low in pyrites, and more susceptible to physical weathering than darker colored materials.
- Gray colors in rocks, spoils, and soils usually indicate a lack of oxidation and leaching. These materials tend to be higher in pH and fertility. Very dark gray and black rocks, spoils, and mine soils contain significant amounts of organic materials and are often quite acidic.
- Dark colored spoils are also difficult to re-vegetate during the summer months because they absorb a great deal of solar energy and become quite hot (Daniels, 1999)." (4)

Stresses importance of added N and P for depleted mine lands and suggests the use of legumes and other nitrogen-fixing species.

- Sites a study that found that improving replaced topsoil "with hay and processed sewage sludge was more effective than topsoil inoculation in stimulating bacterial growth and activity" (Lindemann et al., 1984). (9)
- "Saw dust and sewage sludge have been widely recognized as effective short-term fertilizers and sources of long term slow release nitrogen (Sydnor and Redente, 2002; Munshower, 1994; Hall, 1984)" and increase water-holding capacity. (9)
- Other suggested additives include woodchips and other wood residue for improved plant establishment and growth.
- "The maintenance of plant available phosphorus (P) in mine soils over time is hindered by two factors: (i) fresh mine spoil are generally low in readily plant available (water soluble) P; (ii) as mine soils weather and oxidize they become enriched in Fe-oxides that adsorb water soluble P which is then "fixed" into unavailable forms." (10)

Development of Abandoned Tin Mining Pools in Indonesia

Djajadiredja, R., & Hardjamulia, A.

- Claims that ex-mining pools on Bangka-Belitung can be used for aquaculture. Notes that tin mining pools are estimated to take up 5-10% of the total area of these islands.
- Tilapia mossambica was introduced to ex-mining pools on Belitung in 1954, and Trichogaster pectoralis was introduced the next year.

Soil Consists of:

(a) Granite, which forms red-yellowish podzolic soils. This type of soil is acid, unfertile, comprised mostly of coarse and fine quartz sand.
(b) Sandstone, which is composed of quartz. Yellow podzolic soil is formed, which is also unfertile and acid. In the deep layer of the soil, brown organic matter and ferric oxide is commonly found. Water draining from this soil is brown or black.
(c) Crystalline schist which forms red-yellowish podzolic soils.
(d) Diabase which forms latosol soil. This soil is also unfertile and acid.

For Bangka:

0-10 cm: Black cover of decomposed material intermixed with coarse quartz sand.
10-25cm: Loose, greyish-black humus quartz sandy layer.
25-40cm: Loose, greyish-white quartz sandy layer.
40-70cm: Dark brown and very compact quartz sandy hardpan.
70-100cm: Loose, light-brown quartz sandy layer.

Early Growth Response of Container-Grown Selected Woody Boreal Seedlings in Amended Composite Tailings and Tailings Sand

Rozita, A., Rasidah, K., Aminuddin, H., Rosenani, A., & Asma, I.

- Study found that the use of oil palm empty fruit bunch (EFB) mulch mat with NPK fertilizer reduced leeching of fertilizer for the first 16 weeks after application. After 16 weeks, the EFB mulch mat had no effect when compared with fertilizer applied alone.

Agroforestry

BABEL Bamboo Project

Haas Alias

Sites: In Bangka: the Penyamun area. In Belitung: the Air Tenggarong Selatan.

- Key factors in choosing a design: i. will generate income for the community, ii. low start-up cost, iii. provide stable employment and use the skills the community already has, and iv. be ecofriendly.
- Three options considered: small scale spirulina cultivation, 10-50 hectare bamboo cultivation, and a sustainable bamboo harvesting cultivation.
- Spirulina is a highly nutritious algae. It provides protein with less environmental depletion (including less water used) that other sources, such as soy, and is an excellent oxygen producer.
- Bamboo is already widely cultivated, making selling simple. It also uses relatively few resources (water being the exception), and improves soil quality and produces more oxygen than a comparable timber plantation.

Trade off table of design options

Design Criteria	The Nothing Option	Bamboo Housing	Spirulina Cultivation	Bamboo Plantation
StartSUp Cost	2	1	1	1
Create Revenue	0	1	2	2
Improve Annual income	0	1	1	2
Build on Existing skills	0	1	1	2
Create employment	0	1	1	2
Environmentally friendly	2	2	2	2
Community run	0	1	2	2
Selfsustaining	0	1	2	2
Outside input required	0	1	1	1
Total	**4**	**10**	**13**	**16**

- Betung bamboo was chosen for its promising yield (750-1,000 culms/hectare annually) and ability to grown in relatively poor soil conditions and with minimal rainfall (tolerates 25-24°C). It also the most abundant bamboo species in Indonesia and an established plantation species.

Net value predictions (In 000

Year	1	2	3	4	5	6
Expenses	1,500	5,000	1,848	50,226	50,226	50,226
Income	0	0	0	60,000	60,000	60,000
Net value of project	-1,500	-5,000	-1,848	9,774	9,774	9,774

- Bamboo requires well-drained soil, but can grow with less than 750mm rainfall and as much as 4000mm rainfall.
- Plantstock: ideally grown in nursery, hardened for 2-3 weeks prior to transport. For 200 plants/hectare, plant 250. Fencing may be necessary in the first two years.
- Ideally planted in a north-south orientation, with 6m x 8m spacing, with holes dug to 60cm x 60cm in drier climates.
- Planting should occur at the beginning of the wet season, and plants placed with roots 10cm below ground level. Manure or fertilizer can be mixed with the topsoil used for fill.
- For the first 2 years, it is possible to keep growing other crops on the land.
- Estimated labor needs: 18 laborers/ha *Note: no time amounts were given or

Labour requirements per hectare

Clearing shrubs etc	9 labourers/ha
Other work	4 labourers/ha
Weed control	3 labourers/ha
Fertiliser Application	2 labourers/ha
Total	18 labourers/ha

- Key maintenance tasks for the first 2 years: weeding and mulching (every month as often as needed to remove all weeds within 60cm of each plant), manual soil aeriation (using pitchfork) within 1m of each plant 3 times/year, replanting rotted or damaged plants (during wet season only).
- Key maintenance tasks after 2 years: clump management (removing broken or rotting clumps, thinning clumps).
- Harvest: 4th or 5th year during dry season (to avoid borers) with very sharp machete or ax, leaving young culms and a few mature culms. Bamboo should immediately be stored away from sunlight or chemically treated.
- Cost and scalability led them to choose the boucherie process of chemical treatment (mechanically forces a preservative solution through bamboo). There are non-chemical options as well. Includes a detailed description of the boucherie process.
- Uses: bamboo is already widely used locally and could stay within the area. It could also be used for paper or for water filtration systems.

A Model of Greened Ex-Tin Mine as a Lowland Biodiversity Depository in Malaysia

Ang, L. H., M, H. W., & Tang, L. K.

Project Site: ex-tin mine covering 121.5 ha located in Bidor, Perak, Malaysia (Forest Research Institute Malaysia has)

Site notes: Man-made forest 17 years old that contains 60 tree species. Primary species (hardwoods) listed in planting palette.

Agriculture vs. restoration: The authors cite two factors in choosing to plant tree species instead of using the land for agriculture. On one hand, agriculture on ex-mine land requires lots of fertilizer, which drives up costs. On the other, the authors write that food grown on ex-mines sites had found to have unusually high levels of heavy metals, creating food safety concerns.

Soil chemical properties: Authors note:

> *application of ground magnesium limestone (GML) is absolutely necessary if the ex-mining land is originally a peat swamp forest. The soil pH of the project site is from 4.0 to 6.5, and with the application of about 200 g GML per planting point, the growth of the seedlings was observed to be healthier at one year after planting.*

Water table: Notes that the porosity of the sand that dominates this site inversely affected water retention. ”If sand dunes are situated more than 4 m above standing water table level (aswl), a drought of two weeks (rainfall < 4 mm day-1) would dry up the available water of the 0-15 cm depth of sand dune (Ang et al., 1999). “

Agriculture

Study of Superior Commodities and its Spatial Distribution in Bangka Belitung Archipelago Provinces

Agricultural commodities on Bangka-Belitung

Food crops: wet field paddy, dry field paddy, maize, cassava, sweet potatoes, peanuts, taro, and soybeans
Vegetables: scallion, mustard, long beans, great chili, cayenne pepper, tomato, eggplant, beans, squash, cucumber, kale, spinach, and watermelon
Fruits: avocado, starfruit, duku, guava, water guave, siam citrus, mango, mangosteen, jackfruit, pineapple, papaya, banana, rambutan, snake fruit, sapodilla, soursop, breadfruit, malinjo, and petai
Herbal plants: ginger, galangal, kencur, turmeric, and lempuyang
Ornamental plants: orchids, anthurium, carnation, gladiolus, heliconia, rose, tuberose, jasmine, and palm
Plantation commodities: pepper, rubber, coconut, oil palm, palm sugar, clove, cashews, chocolate, hazelnut, and coffee
Livestock: buffaloes, cows, goats, horses, sheep, pigs, chicken, quail, and ducks

Bangka-Belitung - Horticulture » Production of Fruits - Production of Fruits – Pineapple

- In 2012, Bangka-Belitung produced 24,107 tons of pineapple.

Bio-accumulation of mercury, lead, arsenic and cadmium by pineapple grown as an agroforestry crop for ex-tin mines in peninsular Malaysia

Ang, L. Tang, L. Ho, W. Fui, H.and Ramli, M.

Study site: Sand tailings in Southern Perak District, Malaysia

- Giant Kew pineapple fruit grown on sand tailings were found to have negligible amounts of heavy metal contamination, with the exception of an insignificant amount of mercury. The authors concluded that pineapple can be safely grown on heavy-metal contaminated ex-mining sites.

Growth of 'Sugarloaf' pineapple on mine tailings amended with mineral soil and palm mesocarp fiber

Tang, L. and Ang, L.

Study Site: Ex-tin mine located at Tin Tailings Afforestation Center at Bidor, Batang Padang, Perak, Malaysia

- Sugarloaf pineapple (Ananas comosus) was grown in ”untreated sand tailings (control), or sand tailings amended with good mineral soil, oil palm mesocarp fiber or mineral soil and mesocarp fiber…The results indicate that sand tailings treated with mesocarp fibers alone is more cost-effective as transportation of soils is an expensive endeavor in site preparation for pineapple growing. “

Use of Bamboo for Reclamation of Mined Areas – October 11, 2011

Peters, M. – PT Bambu Nusa Verde

Study Site: Ex-tin mine located at Tin Tailings Afforestation Center at Bidor, Batang Padang, Perak, Malaysia

- Mineral mining causes significant damage to the environment through contamination of soils and water from mine tailings, increased erosion, the formation of wastelands, and diminished availability of soil nutrients for restoring vegetation.
- Methods used to help protect remaining soil, to re-establish agricultural economic benefits are time consuming, and soil remediation techniques are time-consuming and labor intensive.
- The use of bamboo can help with the restoration of mine reclamation sites:
    - Bamboo can be used initially as a cover crop as it is a fast growing grass species
    - Bamboo can grow in limited, shallow soils, uses water efficiently, and requires minimal nutrient inputs.
    - Bamboo litter can be used a fertilizer to help enrich soils
    - Grows in a variety of regions (low pH, arid and mountainous regions)
    - Versatility of bamboo makes it ideal for economic benefits (multiple uses for different bamboo crops) and it a good agroforestry crop as it can be planted with other cash crops.

Bamboo Species and Recommended Uses:

Species	Construction	Pulp& Paper	Furniture	Land Rehab	Other 1	Other 2	Other 3
Dendrocalamus asper (Bambu petung)	VV		V	V	Handicraft	Shoot for food	Music Instruments
D. membranaceus (Bambu membra)	V				Soil erosion control	General Purpose	
Gigantochloa atter- legi		V	V		Handicraft	B-boards	
Bambusa Tuldoides Bambu pagar				V	Recovery Marginal land	Ornamental	Biomass
Balcooa – B Balku	V	V		VV	Implements	Fodder	
Bambos – B duri	V	V	V	VV	Handicraft	Ornamental	
Oldhamii	V	V	V		General Purpose	Industrial Use	
Phyllostachys aurea				V	Biomass	Ornamental	Re-Greening

(V)V: (very) well suited

Planting Bamboo Species parameters:

Species	Plants per Ha	Height	Diameter	Aver. Weight
Bambusa balcooa	100 -400	15 –20 m	15 –20 cm	30 kg
Bambusa bambos	156 -400	Up to 30 m	15 –18 cm	60 kg
Bambusa oldhamii	238 -500	15 m	10 cm	25 kg
Bambusa tuldoides	400 –1100	6 –10 m	3 –5 cm	5 kg
Bambus vulgaris	278 –625	10 –20 m	4 –10 cm	33 kg
Dendrocalamus asper	100 –400	20 –30 m	8 –20 cm	66 kg
Dendrocalamus giganteus	100 –240	Up to 30 m	18 –25 cm	88 kg
Dendrocalamus hamiltonii	238 –500	18 –24 m	15 –18 cm	50 kg
Dendrocalamus latiflorus	156 –400	14 –25 m	8 –20 cm	48 kg
Dendrocalamus membranaceus	156 –400	20 –24 m	6 –10 cm	22 kg
Gigantochloa atter	204 –500	Up to 25 m	5 –10 cm	15 kg
Oxytenanthera abbysinica	286 –500	5 –10 m	8 –10 cm	15 kg

Currently, bamboo is not currently considered a major agricultural product in Indonesia. The county lacks sufficient nurseries and cultivation enterprises to support its use as a valuable economic crop or for land rehabilitation.

Cultivation of bamboo is also an issue:

- Bamboo seeds are rarely available due to the long intervals between seeding crops and the lack of success with their use for cultivation.
- Propagation of culm and branch cuttings is expensive and labor intensive
- Tissue culture of bamboo has been successful in addressing both problems but requires specialized laboratories, greenhouses, and expertise.

OPRINS TC Bamboos in collaboration with PT Bambu Nusa Verde have established a successful bamboo tissue culture commercial operation in 2007 in Yogyakarta, Indonesia. Through their operation, the following species are available as either a poly-ba soil, plugs, or Stage 3+ ex vitro.

PLANTATION –INDUSTRIAL Bamboo

1. *Dendrocalamus aper –Bambu petung*
2. *Dendrocalamus aper Thai –B. petung Thai*
3. *Dendrocalamus membranaceus –B. membra*
4. *Gigantochloa atter –B. legi or ater*
5. *Bambusa tuldoides –B. blenduk atau pagar*
6. *Bambusa balcooa –B. balku*
7. *Bambusa bambos –B. duri / ori*
8. *Bambusa vulgaris vulgaris green –B. ampel Hijau*
9. *Bambusa vulgaris wittata yellow –B. ampel Kuning*
10. *Bambusa oldhamii –B. oldhami*
11. *Phyllostachys aurea –B. unce/uncue*
12. *Dendrocalamus giganteus –B. sembilang*
13. *Dendrocalamus latiflorus –B. taiwan atau sayur*
14. *Dendrocalamus aper black –B. petung hitam*
15. *Dendrocalamus hamiltonii –B. hamiltoni*
16. *Oxythenathera abyssinica –B. oxythenathera*
17. *Guadua amplexifolia –Guadua*
18. *Gigantochloa robusta –B. mayan*
19. *Bambusa blumeana –B. duri / ori*
20. *Bambus textilis –B. tektsil*

ORNAMENTAL Bamboo

1. *Gigantochloa atter –B. legi or ater*
2. *Bambusa tuldoides –B. blenduk atau pagar*
3. *Bambusa balcooa –B. balku*
4. *Bambusa vulgaris vulgaris green –B. ampel hijau*
5. *Bambusa vulgaris wittata yellow –B. ampel kuning*
6. *Bambusa vulgaris waminii/budha – B. buddah*
7. *Phyllostachys aurea –B. unce/uncue*
8. *Dendrocalamus giganteus –B. sembilang*
9. *Dendrocalamus aper black –B. petung hitam*
10. *Bambusa glaucophylla –B. putih*
11. *Bambusa multiplex –B. china / pagar*
12. *Bambusa lako –B. lako*

Planting Requires:

- Soil pH between 4.5 and 5.5
- Soil electrical conductivity between 300 and 500
- Bare root shipments should be acclimated in either top soil, rice husks, or manure prior to planning.
- Planting should be in areas cleared of soil in a 30x30x30cm square hole.
- Fertilizer may be required at the bottom of the planting hole
- Plants should be regularly watered for first 2 months along with intensive control.
- Planting estimates are 200 to 600 plantlets per hectare.

Integrating biodiversity conservation and agricultural production in mine reclamation for sustainable development

Mansur, Irdika

Mining operations in Indonesia have increased significantly in recent years and is an important component of the country's national income. However, mining practices have negative environmental effects from the removal of flora and fauna, air and water pollution, reduced soil fertility, and the formation of ponds. Additionally, the country relies on imports of major agricultural products such as meat, rice, soybeans, milk, and fruit to meet the needs of its growing population. There is economic potential for

mining reclamation to help address both issues by creating productive sites that can support agricultural development and biodiversity conservation.

Biodiversity Conservation

- PT INCO TbK successfully used native tree species from areas near mining operations to reclaim mined lands.
- Native species tend to be slower growing, which reduces the mining company's responsibility as they would not be doing the timber harvest (focus only on establishment, not long term production for harvest)
- Applying high standards of security to tree conservation areas fits in well with current mine security techniques.
- Conserving local trees enhances the company's image with local communities.
- The Indonesian Ministry of Energy and Mineral Resources gives higher grades to companies that use local tree species.

Recommended species:

- *Anthocephalus macrophyllus*
- *Duabanga moluccana*
- *Octomeles sumatrana*
- *Ficus variegate*

Agricultural Production to Incorporate into Mining and Reclamation

- Vegetation removed from mining sites can be processed for compost for later use.
- Soils removed from mining sites can be stored and treated in another location by covering with mulch or cover crops to prevent degradation or erosion. Soils can then be used later to cover the top of reclaimed sites when mining has been completed.
- Treating potentially acid-forming rock from overburden to prevent acidic drainage during mining operations.
- Planting cover crops, such as legumes, can provide fodder for livestock, which could also provide much needed fertilizer to reclaimed soils. However, livestock should not be used in areas where heavy metals may contaminate water or livestock fodder.
- Use of mining ponds for fisheries or shrimp production

Potential Crop Species used in other:

- Legumes (cover crop)
- Upland rice (cover crop)

- Sorghum (feed and wheat flour replacement)
- Oil Palm (biodiesel and palm oil)
- Jatropha (bio-diesel)
- Cacao
- Rubber trees

To accomplish such reclamation tasks, there is need for mining companies to have staff with training and education in agriculture, forestry, fisheries, and animal husbandry, with attention to tackling the adverse conditions commonly seen in mining sites which include erosion-prone soils, contaminated soil and water, lack of shade, remoteness of sites, loss of soil fertility. Thought should be taken toward reclamation before, during, and after mining operations at sites.

Aquaculture

Water Quality in Tin Mined Ponds

The Water Quality Index (WQI) is a predictive index tool to assess water quality in Indonesia (Table 1). The WQI was established by the Indonesian Government Policy Number 82 in 2001. There are several parameters that are measured and have indicative units to identify the class of the water body. The class identifies the purpose or use of the water body that is reasonable for the water quality condition (Table 2). This table can be used to understand the water quality tested in tin mining ponds and the general uses that the water quality can sustain. However, the table does not look at other elements that may be common in water bodies created from mining activities that would have an effect on aquatic organisms and humans if consumed such as uranium, radon, and thorium.

Table 1. Water Quality Standards in Indonesian Government's Policy No. 82 Year 2001

Parameter	Unit	Class			
		I	II	III	IV
TDS	**mg/L**	**1000**	**1000**	**1000**	**2000**
TSS	mg/L	50	50	400	400
pH	**–**	**6–9**	**6–9**	**6–9**	**5–9**
BOD	mg/L	2	3	6	12
COD	mg/L	10	25	50	100
DO	**mg/L**	**6**	**4**	**3**	**0**
TP	mg/L	0.2	0.2	1	5
NO_3	mg/L	10	10	20	20
Ammonia	mg/L	0.5	(–)	(–)	(–)
Ar	mg/L	0.05	1	1	1
Co	mg/L	0.2	0.2	0.2	0.2
Ba	mg/L	1	(–)	(–)	(–)

B	mg/L	1	1	1	1
Se	mg/L	0.01	0.05	0.05	0.05
Cd	mg/L	0.01	0.01	0.01	0.01
Cr (VI)	mg/L	0.05	0.05	0.05	1
Cu	mg/L	0.02	0.02	0.02	0.2
Fe	mg/L	0.3	(–)	(–)	(–)
Pb	mg/L	0.03	0.03	0.03	1
Mn	mg/L	0.1	(–)	(–)	(–)
Hg	mg/L	0.001	0.002	0.002	0.005
Zn	mg/L	0.05	0.05	0.05	2
Cl	mg/L		600	(–)	(–)
CN	mg/L	0.02	0.02	0.02	(–)
F	mg/L	0.5	1.5	1.5	(–)
N	mg/L	0.06	0.06	0.06	(–)
SO_4	mg/L	400	(–)	(–)	(–)
H_2S	mg/L	0.002	0.002	0.002	(–)
Fecal coliform	total/100ml	100	1000	2000	2000
Total coliform	total/100ml	1000	5000	10,000	10,000
Oil & grease	µg/L	1000	1000	1000	(–)
Detergent	µg/L	200	200	200	(–)
Phenol	µg/L	1	1	1	(–)
BHC	µg/L	210	210	210	(–)
Aldrin	µg/L	17	(–)	(–)	(–)
DDT	µg/L	2	2	2	2
Lindane	µg/L	56	(–)	(–)	(–)
Methoxychlor	µg/L	35	(–)	(–)	(–)
Endrin	µg/L	1	4	4	(–)
Toxaphan	µg/L	5	(–)	(–)	(–)

Table 2. The classification of water quality based on purpose or Use

Class	**Purpose/Use**
I	Drinking Water
II	Recreation
III	Aquaculture
IV	Agriculture and other equal purposes

There are limited studies of water quality from Indonesia, however one study collected water quality samples from 15 mining pools in Banka during May 1971 and April 1974 (Table 3) (Djajadiredja and Hardjamulia 1974). According to the WQI standards listed above, all but three of the pools were in Class IV for pH. This study indicated that, in general, the age of the mining pools determines the water characteristics, whereas the older the pool the better the water quality. Older mining pools in Banka and Belitung showed that young, unused mining pools

have a pH around 4.5 to 5.5, while the older pools have a pH from 6 to 6.5 (Djajadiredja and Hardjamulia 1974). Another study showed that water condition of the newly created pools (0-5 years) were unsuitable for aquaculture (Samuel 1999). In medium (5-20 years) and old (more than 20 years) pools temperature, transparency, depth, pH, dissolved oxygen (O_2) and carbon dioxide (CO_2) levels were suitable. However, fish growth rate was slow and reproduction was not optimal.

Table 3. Physical and Chemical Properties of Water, in Some Mining Pools in Bangka (Djajadiredja and Hardjamulia 1974).

Mining Pools	Time of Observation		Transparency (cm)	Temperature ('C)		pH	Alkalinity (ppm $CaCO_3$)	O_2 (ppm)	CO_2	Remarks
	Date	Hour		Air	Water					
Semabung	7-May-71	1720	10	27	28	5	0.077	2.78	8.8	Deep: 3-4 m; turbid
Hijau	7-May-71	1755	15	—	—	4.5	0.055	4.3	4.1	Deep: 101 m; clear
Pasar Sayur	8-May-71	1735	—	26	30	5	0.11	6.63	14.4	Deep: 3 m; turbid
Rakyat Air Item.	8-May-71	1700	25	28	31	5	0.077	17.05	14.4	Deep: 25-30 m; clear
Eng Tai	9-May-71	1130	40	35	30	5.5	0.113	4.07	4.4	Deep: 1.5 m; clear
King Dul	9-May-71	1130	40	—	—	6	—	—	—	Greenish water
S. Renagkui	9-May-71	N/A	—	—	—	5.5	—	—	—	Clear Water
Merawung I Parit.	8-May-71	N/A	220	29	29	5	0.077	13.94	13.9	Clear Water
Merawung II	8-May-71	1100	65	35	32	5	0.077	2.74	4.4	Clear Water
Lempur-1	24-Apr-74	1200	—	—	—	4.5	—	—	—	—
Lempur-2	24-Apr-74	1300	—	—	—	4.5	—	—	—	—
Air Merapin (Sei. Liat)	25-Apr-74	1130	—	32.5	33	6.5	8.5	—	2.2	—
Belakang Bengkel (Sie. Liat)	25-Apr-74	1000	—	—	—	6.5	14	—	2.2	—
Kaeang Pedang	25-Apr-74	1600	—	—	—	6	5.5	—	3.3	—
Air Kentong	27-Apr-74	900	—	33	31.5	4	0	—	13.2	—

More research is available for water quality in tin mining pools occurring in Malaysia. A study looking at water quality in fourteen 10-year old tin mine pools in Malaysia showed that temperature was within the normal range (mean=32.5 C°), pH was a class III (mean=5.71), electric conductivity was class III (mean=1707 µS/cm), salinity was class I (mean=0.28%), turbidity was class I (0.19NTU), dissolved oxygen was class II (6.5 mg/l), and total dissolved solids was class III (mean=2870mg/l) (Ashraf et al. 2010). Malaysia has an Interim National Water Quality Standard (INWQS) that applies to surface waters to evaluate the use of the water based on the water quality measurements and the aquatic organisms that the water can support (Table 4).

Table 4. Interim National Water Quality Standard for Malaysia

Class	Uses
CLASS I	Conservation of natural environment water supply 1 – practically no treatment necessary. Fishery I- very sensitive aquatic species.
CLASS IIA	Water Supply II – conventional treatment required Fishery II- sensitive aquatic species
CLASS IIB	Recreational use with body contact
CLASS III	Water Supply III – extensive treatment required Fishery III – common, of economic value, and tolerant species livestock drinking
CLASS IV	Irrigation
CLASS V	None of the above

Adjusting pH in Water

Adjusting pH in highly acidic water is hard to accomplish. Adding lime or flyash to mine water can rapidly raise the pH and precipitate all iron, manganese and base metals from the solution (Wisotzky and Obermann 2001, CLAIRE 2004). However, at pH values <5 chemical precipitation is very slow. Care must be taken to make sure that the precipitates are not re-suspended. Limestone or lime is a limiting factor on Bangka (Djajadiredja and Hardjamulia 1974); therefore, sources will have to be identified. One passive treatment system that was implemented at the Wheal Jane Mine in the United Kingdom included (CLAIRE 2004):

- Artificial reed beds to facilitate precipitation of iron with arsenic removal
- Anaerobic cell to encourage bacterial reduction of sulfate, which was used to increase alkalinity and precipitate metals
- Shallow rock filters to promote the growth of algae to raise the pH level

Another study showed that blue algae and other plants (alkali sacaton (*Sporabolis airoides*) and four-wing saltbush (*Atriplex canescens*) have been found to take up many cations, including radium through their root systems (Yusof et al. 2001).

Use of Tin Mining Ponds

Aquaculture is identified as a viable commodity in Indonesia and Bangka Island in particular. In 1954, an individual introduced Mozambique tilapia (*Tilapia mossambica*) into some mining pools on Belitung by a private individual (Djajadiredja and Hardjamulia 1974). The Nile tilapia (*Tilapia nilotica*) and Mozambique tilapia are common freshwater fish species that are raised in mining pools in Malyasia. Other aquatic organisms collected from several mining pools on Bangka during 1971 and 1974 are listed in Table 5. There is also identification of the danger that mine pools pose to flooding in the drainages that they exist. This danger reinforces the need to stabilize these pools and prevent further flooding.

Table 5. Aquatic species collected from several mining pools in Bangka (in 1971 and 1974)(Djajadiredja and Hardjamulia 1974)

English Name	Species	Local Name
Emeral Eye Rasbora	*Rasboru dorciocellatu*	Seluang
Spotted Barb	*Barbodes binototus*	Sapadak
Blue panchax	*Aplocheilus panchax*	Kepala Timah
Panda Barb	*Puntius fasciatus*	Seluang
Malayan Leaffish	*Pristolepis fasciata*	Sengat
Snakeskin gourami	*Trichogaster pectoralis*	Sepat Siam
Chevron snakehead	*Channa striata*	Gabus
Knifefish	*Notopterus chitala*	Belida
	Cryptoterus sp.	Lais
Climbing Perch	*Anabas testudineus*	Pupuyu
Mozambique tilapia	*Tilapia mossambica*	Mujaer
Hampala Barb	*Hampala macrolepidota*	Kabarau
	Siluroides hypothalamus	Lais
Bronze Featherback	*Notopterus notopterus*	Belida
Hard-lipped Barb	*Osteochilus vittatus*	Kajong
	Puntius waandersi	Cipo or Kepiai
Giant gourami	*Osphronemus goramy*	Gurame
	Macrones sp.	Baung
Giant freshwater prawn	*Macrobrachium rosenbergii*	Udang Galah

Example projects on Banka or Belitung

Kolong Grasi, District Sungailiat Bangka Regency, Province of Bangka Belitung Archipelago at coordinates S01052.464 '; E106007.005 is an abandoned tin mine that was used for aquaculture to raise Nile tilapia and jambal catfish (*Pangasius* sp.) (ROBIN 2012). A study conducted during 2012 looked at the lead content in these two species after introduced to the lake for aquaculture. They found that after three months the lead concentration in every organ of both fish species exceeded the safe level for consumption. Cultivation was discontinued after four months.

Fish were collected from the pools listed in Table 3, which were likely part of an aquaculture project, however no official documentation of this was found.

Additional Questions Experts/Landowners

1. Are there any local laboratories that can analyze cations, anions and heavy metals (uranium, lead, and radon) in water quality?
2. Are the existing aquacultural sites developed with gates and walkways?
3. What are the aquatic species (fish, shrimp, prawn) preferred for consumption?

Economy

Population Density and the Conservation Status of Belitung's Tarsier *Tarsius bancanus saltator* on Belitung Island, Indonesia.

Indra Yustian

- Local communities believe encountering the Tarsier to be bad luck, but the belief does not seem to be deeply-held.
- There is a proposed tarsier reserve in Gunung Tajam that could promote ecotourism.
- The Tarsius requires forest with significant undergrowth for movement and sleeping.

Scoping Study on Possible Activities of the European Partnership for Responsible Minerals (EPRM), A research paper prepared for The Netherlands Ministry of Foreign Affairs (Rep.)

Profundo & Estelle Levin Ltd. For the Netherlands Ministry of Foreign Affairs

- Provides a big-picture summary of possible activities related to sustainable mineral trade, with significant sections on the major players in the Indonesian tin industry and pertinent research, including the Tin Working Group, the Dutch Sustainable Trade Initiative, Apple, Telepak, and Fred Phillips Consulting. In addition, the report discusses:
- AETI, an association of private tin exporters that donate a portion of sales to a fund for the restoration of post-mine lands.
- The TWG's work with the University of British Columbia to develop a training program for artisanal miners.
- Pact's Mine to Market program, which will aim to promote efficient and safe mining along with government coordination and capacity-building.

Situational Analysis and Sustainability Assessment of Tin Production in Bangka-Belitung, Indonesia

Estelle Levin Ltd. For IDH

- Estimates there are between 15,000 and 50,000 unconventional miners on Bangka-Belitung. The majority work on Bangka, are migrants from other islands, and are working illegally.
- These islands produce 1/3 of the world's tin, approximately 70-80% of which is produced illegally.
- While Bangka has rampant offshore mining, Belitung has relatively little. This may be due to a more influential local government and fishing and tourism sectors.
- Viable mine-sites, onshore and off, are becoming scarce. PT Timah's approach has shifted to "Farther, Deeper" (for offshore and onshore, respectively).

- There is a marked difference between the environmental degradation caused by formal and unconventional miners because the former are required to perform reclamation and the latter do not.
- Much informal mining occurs on PT Timah's concession, including areas that have already been rehabilitated.
- The lack of viable surface deposits has started driving unconventional miners into protected forests, which could affect drinking water.
- There has been no comprehensive study of how much offshore environmental degradation (declining fish populations, damage to coral reefs, etc.) is due to mining vs. other activities (fishing, tourism, dredging).
- Report attributes the majority of sustainability issues to the local and national government, i.e. corruption, poverty, and lack of civil society. Report calls for the House of Representative to pass the 2009 Mining Law to clarify grey areas and close loopholes. Because this law has not been passed, local governments have not been able to issue permits since 2009, preventing illegal miners from obtaining legal permits and precluding the local government from regulating illegal mining. *unclear whether this law has been adopted since this report was written.
- 100,000 ha of ex-mining land have not been rehabilitated.
- Due to a lack of existing interventions, report recommends that the TWG develop and implement new interventions.

Sources of social tension: largely due to government issuance of licenses such i. overlapping concessions, ii. mining near tourism sites, and iii. port access for fishers and offshore miners.

Development: while Bangka-Belitung has some of the lowest poverty rates and illiteracy rates in the country, it also has very low rates of school attendance. The first and last of these is likely due to the tin mining industry.

Coral reefs: cover approximately 350,000 square kilometers east of Bangka and around Belitung, containing 187 coral species, 218 coral fish, 105 molluscus, and 35 crustaceans. In the areas west of Belitung, where no mining takes place, the coral reefs are in better condition. In the more heavily mined areas of Banka and west of Belitung, coral reefs have an average 25% cover.

Mangrove forests: once covered 122,000 hectares; 70% of that area has been damaged by tin mining and palm oil farming. Destruction of mangrove forests leaves the island more vulnerable to strong tides, winds, and tsunamis, and floods, siltation, erosion, and abrasion. Aquatic habitat is also lost. 20 mangrove species present.

Forests: 50% of the 648,000ha of forests are in critical condition; mining accounts for 70% of damage to terrestrial forests.

Conservation areas: The east coasts of Bangka and Belitung are conservation areas, as is part of Bangka's western shore. Total conservation areas: 335,863 hectares, 225,509 of which are on Belitung.

Regulation: Many attribute the current regulatory climate of corruption and environmental damage to the move from centralized control to region autonomy in the 1990s following the end Suharto's authoritarian New Order Era (1965-1996).

'Customary' authorities: Typically, unconventional miners must address two authorities to continue working. 1. They make payments to the nearest village (via the village head) in the

form of lead concentrate at the end of each workday. 2. They will purchase a flag for approx. $175 that belongs to a powerful person (police officer, business man, etc.) or rent equipment from a powerful person, which protects against property confiscation in the event of a raid.

Fluctuations in mining activity: Many participate in mining opportunistically. These include fishermen who convert their boats to mine when tin prices are high, migrants who leave when prices drop, and the many people who divide their time between pepper farming and mining.

Ministry of Energy and Mineral Resources: issues mining permits.

Ministry of Trade: issues import and export permits.

State Ministry for the Environment: assesses mining company's EIAs and environmental monitoring reports.

Ministry of Forestry: manages protected areas and regulates mining in these areas.

Ministry of Marine Affairs and Fisheries: monitors impacts of offshore mining.

Mining Zones (WP): While large scale mining (in Mining Business Areas) is governed by the regulations described in the Economy section of the literature review, small scale mining (in Small Scale Mining Areas) does not have national-level regulation for either safety conditions or environmental standards. These areas, up to 25 hectares, are determined by local authorities, who are also responsible for environmental standards and safety.

Sustainable Economic Development Based on Bamboo

Bambu Nusa Verde and Yayasan Bin Darma

Bamboo can help communities in developing their economics by helping address productivity needs, improving local economies, and improving the natural environment. The benefits of using bamboo include:

- It is environmental friendly as it has better carbon absorption, oxygen production, and water retention than most common tree species.
- Production of wood from bamboo can occur year-round, providing a more stable source of income for communities.
- Its high production efficiency and diversity of uses can cut down on time for production of other goods. For example, bamboo can be used for timber, fiber, fuel, and food.
- Use of bamboo for fuel can be used for electricity generation.
- Can be used to support a wide range of industries and products that are used globally.

Currently, Indonesia contributes only 2.2 of the world's bamboo supply. Over the last 20 years in China, bamboo production has increased to a $12 billion a year industry. The industry in Indonesia has not seen that kind of growth as bamboo production is slow and inefficient. It is often viewed as a low value product and few understand the potential market for bamboo products at home and abroad.

Bamboo Nusa Verde has developed a tissue culture technique for cultivating bamboo to help germinate large numbers of bamboo plants efficiently and with improved production results. They are currently looking for project partners in Indonesia who are interested in using bamboo for economic development and local cultivation.

Energy

Integrated Biomass-Gasification

From "GE Launched Distributed Power Business" by Erin Voegele *and*

GE's Integrated biomass-gasification Presentation for AETI 6/30/15

- "GE announced it has signed a contract for Indonesia's first integrated biomass-to-power plants for on-grid applications using bamboo and woody biomass feedstocks." (GE Launches…)
- Integrated biomass-gasification allows for the removal of tar and other impurities, reducing carbon emissions (compared to combustion).
- With biomass, gasification is considered a renewable energy source.
- Typically implemented on smaller-scale (less than 100MW).

Biomass Power Plant Role in the Development of Electricity on Indonesia's Smallest and Outer Islands

- Indonesia's estimated electrification rate ranges from 64.5% to 80.5%
- Current energy deficit that is predicted to increase. The Indonesian trade deficit is partly attributable to the import of energy.
- Transmission costs are very high due to the country's geography. As such, distributed (small-scale, local) biomass is a promising option.
- Of possible renewable energy sources in Indonesia (hydro, geothermal, solar, wind, ocean), biomass has the largest potential capacity (49,810MW).
- Bamboo is the preferred energy source for biomass because it requires few resources, can grow on ex-mining land, and produces high heat with little ash.
- Prices have been set by the government for biomass energy (with location increase ratios).

Regulation

Reclamation and Post-Mining in Mineral and Coal Mining Business Activity (Regulations)

Generally, these regulations describe different, but similar, processes for exploration phase, production phase, and post-mining phase, each of which requires reclamation. The production phase seems to be given the most importance. Where not specified, assume that regulations apply to all three phases.

These reclamation plans should be submitted to the Minister through the Director General, governor, or regent/mayor.

Exploration plans: there must be a reclamation plan in place that has been authorized prior to exploration. This plan should cover general land resource management, how land will be affected by exploration, criteria for success for reclamation, and planned cost of reclamation.

Plans for mines that are already operational: These mines must formulate a plan for reclamation during the production phase. This plan should cover a period of five years and describe land resource management before and after the production phase, plan for opening land for activity during the production phase, reclamation program during the production phase, criteria for success of reclamation, and planned cost of reclamation. Reclamation should take the form of revegetation or other allocation (meaning resettlement area, tourism, water resources, or cultivation area). If a mining hole will be left, this plan should cover slope stabilization, security for the hole, restoration and monitoring of water quality.

For mines off-shore: the reclamation plan should cover management of sea water quality, mitigation of abrasion or coast sedimentation, and protection of biodiversity.

Post-mining plans: should cover location and coverage of area, land ownership and designation, initial environment condition before mining (morphology, surface water, biology, and human conditions—social, cultural, and economic). They should describe the nature of the mining activities and the final environmental condition of the post-mining land (same factors as pre-mining). They should also cover the post-mining reclamation plan itself, including site reclamation, social, cultural, and economic development, maintenance and monitoring. They should also include a timetable, criteria for success, and planned cost. This document should be formulated with the input from stakeholders (meaning the Ministry of Energy and Mineral Resources, provincial or regency/municipal government, other related institutions, and communities to be directly affected by mining).

Evaluation and Approval: If the exploration plan changes, so must the reclamation plan. If changes are not approved within thirty days, they are assumed approved. For most steps of the process, things must turn around in thirty days. If the plan doesn't fulfill the above requirements, it will be returned so it can be perfected before being resubmitted.

Guarantee: Amount is determined by Director General. These should be placed as a deposit in the government bank within thirty days of the approval of the work plan. For an exploration guarantee, the Director General can change the guarantee amount if the exploration plan changes or if the operational cost of exploration does not match the plan for reclamation in the exploration phase. For a production guarantee, there are a few more options for how to give it to the government, but other factors are the same. The regulations specify that placing the guarantee does not eliminate the obligation to perform reclamation during the production phase. For a post-mining guarantee, similar guidelines apply. It also specifies that post-mining reclamation must be performed with thirty days of the end of exploration. It also specifies that these regulations apply to various stockpiles, facilities, roads, and installations, in addition to the mine site itself.

To get the exploration guarantee back, the mining company must submit a report on the execution of reclamation every year. Following that report, they may apply to get the guarantee back. The ministry will evaluate the report and if it receives 100% in accordance with these guidelines, they will return the guarantee within 30 days. The Director General may conduct a site visit as part of this process. The results of this site visit must be documented.

For the production guarantee, the mining company will get up to 60% back if they have done all the following: refilled ex-mining site, distributed rooting zone soil, erosion control and water management. They will get up to 80% back if they have also planted a cover crop, planted a fast-growing crop, planted a local species plant, and/or controlled acidic mining water. They will get up t0 100% back if they meet the guidelines in this document. For the production guarantee, there must be a site visit with documentation. The post-mining guarantee follows a similar procedure.

If the mining company fails to meet the success criteria (60%) for reclamation in the exploration phase, the government will hire a third party to do reclamation. This third party must bring it to the 80% point before the miner can execute mining activity (not sure if this means on other sites). The guidelines also stipulated that the reclaimed land must be delivered to the entitled party, but does not elaborate on how the entitled party is determined.

Proposed Planting Palette

Proposed Planting Pallette					
Scientific Name	**Common Name(s)**	**Human Use**	**Survival**	**Form**	**Notes**
Nurtjahya Ex-Mine Restoration Study Species					
Schima wallichii	Needlewood Tree, Schima	Medicinal	<10%	Tree	Late pioneers
Vitex pinnata	Malayan Teak, Leban	Medicinal	~70%	Tree	Late pioneers
Calophyllum inophyllum	Alexandrian Laurel, Beauty Leaf, Kamani	Medicinal	99.30%	Tree	Tolerant to salt spray, nutrient-deficient soil, and seasonal drought
Hibiscus tiliaceus	Beach Hibiscus, Cottonwood	Fermenting Tempe	100%	Tree	Tolerant to salt spray, nutrient-deficient soil, and seasonal drought
Macaranga sp.			<5%	Tree	Early pioneers
Mallotus paniculatus	Butaq, Bayur, Keminting boeroeng	Medicinal	<5%	Shrub	Early pioneers
Ficus superba	Strangler Fig	Edible fruit	99.90%	Tree	Adapted to sandy and rocky areas and sea winds
Syzygium grande	Sea Apple	Edible fruit	90.20%	Tree	Adapted to sandy and rocky areas and sea winds
Aporosa sp.	Nirvetti	Medicinal	15-20%	Tree	Commonly dominates in open and relatively dry areas
Syzygium polyanthum	Indonesian Bayleaf, Buah Salam, Kelat Samak, Serah	Food flavoring, edible fruit, dye and medicine	35-40%	Tree	Considered a catalytic species
Calopogonium mucunoides	Calapo, Kacang asu	Less-desirable forage for cattle	90%	Legume	Legume cover crop
Centrosema pubescens	Centro, Butterly Pea	Forage for cattle (introduced)	poor	Legume	Legume cover crop
Telepak Recommended Commercial Species					
Tectona sp.	Teak	Hardwood		Tree	
Acacia sp.	Acacia, Wattles	Hardwood		Tree	
Swietenia sp.	Mahogany	Hardwood		Tree	

Planting Palette, cont.

BABEL Recommended Bamboo Species					
Dendrocalamus asper	Betung Hitam, Rough or Giant Bamboo	Building supply; possibly biomass		Evergreen plant	
Recommended Mangrove Species					
Rhizopora apiculata	Mangrove sp.	Charcoal		Tree	
Rhizophora mucronata	Loop-root Mangrove, Red Mangrove or Asiatic Mangrove	Timber, food, medicine, charcoal		Tree	
Bruguiera sexangula	Upriver Orange Mangrove	Timber, food, medicine, charcoal		Tree	
Bruguiera parviflora	Red Mangrove	unknown		Tree	
Soneratia alba	Mangrove Apple	Timber, food, medicine, charcoal		Tree	
Avicennia sp.	Mangrove genus	unknown		Tree	Highly salt tolerant
Ceriops sp.	Mangrove genus	Timber, charcoal		Tree	
Recommended Hardwood Species from Ang Restoration Site (Malaysia)					
Fagraea crenulata	Malabira	Timber		Tree	
Acacia aulocapa, Acacia auriculiformis, Acacia mangium, Acacia crassicarpa	Akasia	Timber		Tree	
Acacia mangium x Acacia auriculifomris	Acacia hybrid	Timber		Tree	
Delbergia longipinnata	Rosewood	Timber		Tree	
Dyera costulata	Jelutong	Timber		Tree	
Hopea odorata	Merawan siput jantan	Timber		Tree	
Swietenia macrophylla	mahogany	Timber		Tree	
Khaya ivorensis	African mahogany	Timber, medicine		Tree	
Dryobalanops oblongifolia	keladan	Timber, edible nut		Tree	Threatened; endemic to Borneo
Recommended by Irdika Mansur					
Melaleuca cajuputi	Cajuput or white samet	Cajuput oil		Tree	
Cymbopogon nardus	Citronella grass	Oil (for insect repellant)		Perennial Grass	

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Appendix D. Photo Sheets

DRAFT

PROJECT SITE PHOTOS

DRAFT

SITE ANALYSIS PHOTOS

FREED PHILLIPS CONSULTING

oxbow ecological engineering, llc

idh the sustainable trade initiative

telapak


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Appendix E. Planting Palette

Master Plant List									
REFORESTATION SPECIES									
Scientific Name	**Local Name**	**English Name**	**Survival Rate**	**Adapted to Clay/Slime**		**Adapted to Sandy Soils**		**Availability**	**Notes**
				Early	**Late**	**Early**	**Late**		
*Schima wallichii**	seruk	Needlewood Tree, Schima	<10%				x	harvest locally	Late pioneers
Vitex pinnata	leban	Malayan Teak, Leban	~70%					harvest locally	Late pioneers
*Calophyllum inophyllum**	penaga	Alexandrian Laurel, Beauty Leaf, Kamani, Nyamplung	99.30%		x			harvest locally	Tolerant to salt spray, nutrient-deficient soil, and seasonal drought
*Hibiscus tiliaceus**	waru laut	Beach Hibiscus, Cottonwood	100%				x	harvest locally	Tolerant to salt spray, nutrient-deficient soil, and seasonal drought
Macaranga sp.	mang, mahang	Parasol leaf tree	<5%						Early pioneers
*Ficus superba**	kayu ara	Strangler Fig	99.90%				x	harvest locally	Adapted to sandy and rocky areas and sea winds
*Syzygium grande**	jambu hutan	Sea Apple	90.20%			x		harvest locally	Adapted to sandy and rocky areas and sea winds
Aporosa sp.		Nirvetti	15-20%					seed, harvest locally	Commonly dominates in open and relatively dry areas
Syzygium polyanthum	Salam	Indonesian Bayleaf	35-40%					seedling, purchase	Considered a catalytic species
Tectona sp.	jati	Teak	poor					seedling, purchase	
Acacia sp.	akasia, phon kertas	Acacia, Wattles	90%					purchase seed	
Swietenia sp.	mahoni	Mahogany	poor					purchase seed	
*Shorea balangeran**	Belangeran	Red Balau, Belangen	poor					n/a	Critically endangered
Recommended Hardwood Species									
Fagraea crenulata		Malabira							
Acacia aulocapa, Acacia auriculiformis, Acacia crassicarpa	Akasia	Acacia	90%					purchase seed	
Delbergia longipinnata		Rosewood							
Dyera costulata	Jelutong	Hill jelutong	50%					purchase seed	
Hopea odorata	Merawan siput jantan	White thingan	poor					purchase seed	
Swietenia macrophylla	mahoni	mahogany	poor					purchase seed	
Khaya ivorensis		African mahogany						purchase seed	
Dryobalanops oblongifolia	keladan	Keladan tree							Threatened; endemic to Borneo
*Melaleuca cajuputi**	gelam	Cajuput or white samet	70%		x			harvest locally	
Ploiarium alternifolium	reriang, riang-riang	Cicada tree	50%		x			harvest locally	
*Paraserianthes falcataria**	sengon laut	white albizia	70%			x		buy seed	
Trema orientalis	mengkirai, semirai	Charcoal tree	60%				x	harvest locally	
Recommended Mangrove Species									

Scientific Name	Local Name	English Name	Survival Rate	Adapted to Clay/Slime		Adapted to Sandy Soils		Availability	Notes
				Early	Late	Early	Late		
Rhizopora apiculata	bakau	Mangrove sp.	poor					seedling, harvest locally	brackish water
Rhizophora mucronata	bakau	Loop-root Mangrove, Red Mangrove or Asiatic Mangrove	poor					seedling, harvest locally	brackish water
Bruguiera sexangula	bakau	Upriver Orange Mangrove	poor					seedling, harvest locally	brackish water
Bruguiera parviflora	bakau	Red Mangrove	poor					seedling, harvest locally	brackish water
Soneratia alba	perepat	Mangrove Apple	poor					seedling, harvest locally	Highly salt tolerant
Avicennia sp.	api-api	Mangrove genus	poor					seedling, harvest locally	Highly salt tolerant
Ceriops sp.	bakau	Mangrove genus	poor					seedling, harvest locally	brackish water
Shrubs Species									
Scientific Name	**Local Name**	**English Name**	**Survival Rate**	**Adapted to Clay/Slime**		**Adapted to Sandy Soils**		**Availability**	**Notes**
				Early	**Late**	**Early**	**Late**		
Calliandra calothyrsus	kalliandra merah	Red Calliandra	unknown						
Glyricidea sepium	gamal	Quick-stick	40%			x		harvest locally	
Indigofera sp.		Indigo	unknown						
*Desmodium hiterocarpon**	Akar Entimor	ticktrefoil	unknown						
*Commersonia bartramia**	tlimpuk, kelimpuk	brown kurrajong	50%		x			harvest locally	
Melastoma malabatrichum	kedebik	Indian rhododendron	40%		x			harvest locally	
Mallotus paniculatus	balik angin	Butaq, Bayur, Keminting boeroeng	<5%				x	harvest locally	Early pioneers
Baeckea frutescens	sapu-sapu, kayu rachak	false rue	50%			x(?)	x	harvest locally	
Grasses and Other Species									
Scientific Name	**Local Name**	**English Name**	**Survival Rate**	**Adapted to Clay/Slime**		**Adapted to Sandy Soils**		**Availability**	**Notes**
				Early	**Late**	**Early**	**Late**		
Paspalum notatum, Paspalum orbiculare, Paspalum conjugatum*	paspalum	bahiagrass	70%		x	x		harvest locally	
*Fimbristyllis pauciflora**	rumput jenggot	fimbry	80%	x				harvest locally	
Scleria levis	sesayat	nutrush	70%	x				harvest locally	
Herbaceous Plants									
Scientific Name	**Local Name**	**English Name**	**Survival Rate**	**Adapted to Clay/Slime**		**Adapted to Sandy Soils**		**Availability**	**Notes**
				Early	**Late**	**Early**	**Late**		
*Calopogonium mucunoides**	kacangan	Calapo, Kacang asu	90%			x		buy seed	Legume cover crop
Centrosema pubescens	kacangan	Centro, Butterly Pea	80%			x		buy seed	Legume cover crop
*Rhodomyrtus tomentosa**	keramuting	Hill gooseberry	60%				x	harvest locally	

Scientific Name	Local Name	English Name	Survival Rate	Adapted to Clay/Slime		Adapted to Sandy Soils		Availability	Notes
				Early	Late	Early	Late		
Pueraria javanica	kacangan	tropical kudzu	80%			x		buy seed	Legume cover crop
Blumea balsamifera	sembang utan, capa	sambong	30%				x	harvest locally	
*Grammatophyllum scriptum**	Anggrek macan	Tiger Orchid	poor					N/A	Epiphytic plants, need special conditions to survive

WETLAND PLANTS

Trees Near Water

Scientific Name	Local Name	English Name	Survival Rate	Adapted to Clay/Slime		Adapted to Sandy Soils		Availability	Notes
				Early	Late	Early	Late		
*Alstonia scholaris**	jelutung	Pulai tree	40%	x	x			seedling, harvest locally	
*Dillenia suffruticosa**	simpur	Simpor bini	20%		x			seedling, harvest locally	
Nauclea orientalis		Canary wood	unknown						
Anthecephalus macrophylla		Red jabon	unknown						

Wetland Plants

Scientific Name	Local Name	English Name	Survival Rate	Pond		Availability	Notes
				Early	Late		
*Nymphaeaceae sp.**	terati	Water lilies	50%	x		purchase/harvest locally	
*Typha sp.**	tipa	Cattails	60%		x	purchase/harvest locally	
*Azolla microphylla**	azola	Azola, Mosquito fern	60%		x	purchase/harvest locally	
Eleocharis dulcis, Lepironia articulata*	Purun	Chinese water chestnut	80%		x	purchase/harvest locally	

AGRICULTURAL PLANTS

Scientific Name	Local Name	English Name	Form	Adapted to Clay/Slime		Adapted to Sandy Soils		Availability	Notes
				Early	Late	Early	Late		
*Cocos nucifera**	kelapa	coconut palm	poor						
*Dendrocalamus asper**	bambu	Betung Hitam, Rough or Giant Bamboo	20%				x	propagule	
*Chrysopogon zizanioides**		Vetiver grass	70%						essential oil
*Cymbopogon citratus**	serai	citronella grass	70%			x		propagule	
*Cymbopogon nardus**	serai	Citronella grass	70%			x			
*Cymbopogon winterianus**	serai	citronella grass	70%			x			
*Hylocereus undatus**	buah naga	dragon fruit	70%			x			
*Ananas comosus**	nanas	pineapple	80%			x	x	propagule	
*Piper nigrum**	sahang, lada	pepper corns	20%				x	propagule	
Aleurites moluccana	kemiri	candlenut	40%				x	seed	

KELEKAK PLANT

Scientific Name	Local Name	English Name	Form	Adapted to Clay/Slime		Adapted to Sandy Soils		Availability	Notes
				Early	Late	Early	Late		
Durio zibethinaus	durian	durian	Tree						
Artocarpus integer	Cempedak	chempedak	Tree						
Lansium domesticum	Lanseh, Langsat	lanseh	Tree						
Anacaridium occidentale	jambu mede, jambu monyet	cashew nut	Tree						
Plumeria sp.	kamboja	plumeria flower	tree						
Colocasia esculenta	keladi plant	coco yam	herb						

Scientific Name	Local Name	English Name	Survival Rate	Adapted to Clay/Slime		Adapted to Sandy Soils		Availability	Notes
				Early	Late	Early	Late		
Solanum melongena	terong	eggplant	herb						
Brassica chinensis	sawi	mustard greens, collards	herb						
Vigna unguiculata	kacang panjang	long beans	herb						
Capsicum sp.	Cabe	chili	herb						
Zingiber officinale var. rubrum rhizoma	jahe erah	red ginger	herb						
S. macca	jambu bandar	city guava, city cashew	Tree						

* = Denotes species with Best Management Practices and information provided in the Appendix