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Reclamation Plan for Production Operation Phase of Quartz Sand Mine in Riau Islands

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Abstract
PT. X is a quartz sand mining company located in Riau Islands. PT. X has a mine life of 5 years, starting in the first year of 2023 until the last year of 2027. Mining activities have a negative impact on the environment, therefore reclamation activities are carried out at the production operation stage. The purpose of this study is to determine the area of land to be reclaimed, techniques and equipment to be used in reclamation, land stewardship, revegetation, maintenance, and reclamation costs. This research uses the actual calculation method this method has 4 stages, namely the preparation stage, the data collection stage, the research stage in the field, and the stage of preparing the final report. At the data collection stage using primary and secondary data owned by PT.X. Reclamation of the production operation stage carried out by PT. X uses Hybrid Coconut plants. Hybrid coconut will be reclaimed on former mining land during the life of the mine whose work process is carried out in tandem with quartz sand mining activities. The reclamation cost plan of PT. X consists of direct costs and indirect costs. The total cost plan of reclamation of PT. X amounted to Rp. 583,799,620.00.

1. Introduction

Mining is one of the activities of exploiting and managing natural resources in an effort to meet human needs and participate as the highest contributor to the country's foreign exchange [6]. The balance of economic, social, and environmental aspects is key to sustainable development [20]. Environmentally-oriented development is an important requirement for every nation and state that wants the preservation of natural resources. Therefore, natural resources need to be maintained and maintained for human survival now and for future generations [10]. Every mining business activity that aims to explore and process natural resources that have non-renewable properties is required to carry out reclamation activities. PT.X quartz sand mine located in the Riau Islands will carry out mining activities with a mine life of 5 years the first year namely 2023 to the fifth year, namely 2027. This quartz sand mining activity will cause potential changes in the landscape around the mining area and changes in environmental conditions, disturbed fauna and flora habitats and a decrease in surface water quality and groundwater quality. The surface of the mining system generally damages the soil and reduces soil properties as a result of which the system decreases the ecological function of the mining area [4]. Reclamation is an activity carried out throughout the stages of the mining business to organize, restore, and improve the quality of the environment and ecosystem so that it can function again according to its intended purpose [15].

Reclamation of the production operation stage is reclamation carried out in tandem with mining activities. The principle of reclamation activities is that reclamation activities must be considered as a whole unit ("holistic") of mining activities and reclamation activities must be carried out as early as possible and do not have to wait for the overall mining process to be completed [5]. In accordance with the contents of Law Number 3 of 2020 concerning Amendments to Law Number 4 of 2009 concerning Mineral and Coal Mining, article 123A paragraph 1 explains that IUP or IUPK holders at the Production Operation stage must carry out post-mining reclamation activities until they achieve a 100% success rate before WIUP or WIUPK is shrunk or returned [3]. One form of reclamation carried out is to convert

the function of ex-mining land into agricultural land and plantation land with three stages of reclamation, namely land function recovery, land function improvement, and land function maintenance [7].

The application of reclamation is carried out on land disturbed by mining both in the former mining area and the outside area of the former mine. Land outside the former mine includes overburdened landfills, raw material stockpiles, transportation roads, factories/processing/refining plants, offices and messes, and ports/docks [18]. Land outside the former mine is usually more focused on post-mining activities. The purpose of this study is to determine the area of land to be reclaimed, techniques and equipment to be used in reclamation, land use, revegetation, maintenance and reclamation costs

2. Methodology

This research uses actual calculation methods in the field as well as online consultations with sellers or related data providers to support planning reclamation plans aimed at obtaining results according to the current time. The methodology used is from the adoption of project and risk management theory and practice to develop a business model that can be applied in the implementation of post-mining reclamation project [16]. This methodology shows the combination and synthesis of (i). the functional and multidisciplinary nature of a reclamation project consisting of specific processes and (ii) in-depth evaluation (inter-disciplinary/intra-disciplinary) of the reclamation project. This research activity is divided into 4 stages of design starting at the preparation stage, the stage of collecting primary and secondary data, the stage of field research and the stage of preparing the final report.

2.1. Preparatory Stages

At this stage it is carried out by searching and then studying literature related to quartz sand mining, related environmental conditions, updated laws and regulations, data from previous research, sources from books, journals and company archives.

2.2. Stages of Data Collection

This stage is carried out by looking for supporting data, both primary data and secondary data. The data obtained are mostly obtained from the company, namely regional geological conditions, climate and rainfall data, profiles of areas around quartz sand mines and mining activity plans contained in feasibility study documents and environmental documents. Cost-Benefit Analysis is used to determine whether reclamation work carried out at mining sites in Indonesia is beneficial or just an additional cost burden for mining companies. Cost-Benefit Analysis is usually used to assess the feasibility of a public policy or project by weighing the estimated value of the benefits against the costs of the public policy or project [12]. In the mining industry, Cost-Benefit Analysis is used to determine financial profitability and economic contribution and describe externalities on the same basis [9]. Based on this definition, reclamation activities carried out by mining companies can be viewed as product policies determined by mining laws and regulations. In the cost analysis, reclamation costs are taken into account which include operational costs (materials, fuel, labor) and costs arising from the process or life cycle of reclamation work. Rather than just considering operational costs, the costs of the overall reclamation process are also considered, including the costs of using primary resources to produce output and the costs of emissions.

2.3. Stages of Research in the Field

This stage was carried out field observations at quartz sand mines in the Riau Islands. Then determine the boundaries of the area to be studied for reclamation plans, especially the reclamation of the production operation stage.

2.4. Stages of Final Report Preparation

This stage is carried out by making a reclamation plan map, reclamation planning according to the state of the region, calculating the costs of the reclamation plan and drawing conclusions and suggestions from research that has been prepared.

Table 1. Land area reclaimed production operations

No	Mining year	Reclamation plan year	Area of reclamation plan (ha)
1	2023	2024	6,0
2	2024	2025	8,50
3	2025	2026	8,50
4	2026	2027	8,54
5	2027	2028	8,65
Total			40,19

3. Results and discussions

3.1. Land in Quartz Sand Mine to be reclaimed

The area of ex-mining land that will be opened in the IUP mining process of PT. X in Riau Islands until the fifth year amounted to 40.19 Ha from the planned IUP area of production operations of 40.19 Ha [2]. The production operation reclamation plan will start in the second year of mining, namely 2024, the second phase of production operation reclamation in 2025 or the third year of mining, and so on until the final year of production operation reclamation in 2028 (see tabel 1)

The land of former mine openings during 5-year activities covers an area of 40.19 Ha where the area of reclamation of production operations in each year will vary depending on the area of mine openings. All ex-mining land will be reclaimed with hybrid coconut trees. Side rock deposits or overburden (OB) are at OB disposal covering an area of 1 Ha, this OB will later be returned to the former mine opening land then the disposal land will be reclaimed at the end of the mine closure. A good place to take top soil is the order ultisol. Ultisol are old soils that have undergone further weathering [8]. Mining roads certainly contribute to attention in the aspect of reclamation of production operations. Mining roads and hauling roads function to go back and forth mining process activities within the IUP will not be reclaimed because the road will be converted as a road for residents around quartz sand mines and hybrid coconut plantation roads.

3.2. Techniques and Equipment used in reclamation

The reclamation process applied to the location of the former mining land of PT. X uses pots/polybags. This method is intended for hybrid coconut plants. The equipment used for reclamation activities of production operations is quite simple, namely shovels, hoes and polybags. The population of the eighth hybrid plant will range from 161 trees per hectare with a planting distance between trees of 9 x 9 m using a quadrilateral planting pattern (see figure 1).

Figure 1. Illustration of Reclamation with Hybrid Coconut Plants (left), Illustration of Hybrid Coconut Tree Plant Spacing 9 x 9 m (right)

Figure 2. Illustration Hybrid coconut tree planting hole 70 x 70 x 70 cm (left), Illustration of Hybrid Coconut Seedlings Ready for Planting (right)

3.3. Land Stewardship

Land stewardship activities are activities to organize and regulate land so that it has carrying capacity and can be used optimally according to its designation. Land use management is important to overcome changes that occur in the land. Land use activities are carried out by backfilling former mining land openings and landform arrangements.

Backfilling of the opening of former mines is carried out by means of backfilling. There are two ways of stockpiling used, namely by the insite dump system (transfer of the transfer of stockpile material, both topsoil, and overburden in the mining area) and stockpiling by taking stockpile material at the disposal site.

Landform regulation is an effort to maintain a safe and stable condition against possible changes that occur on the land as an effort to prevent erosion and avalanches so that the land is not quickly damaged so that revegetation can run optimally. Land regulation is carried out by arranging the soil surface and setting the shape of the slope. The arrangement of the soil surface of the former landfill is made flat according to the side morphology that has not been opened with the aim of reducing the impact of surface soil erosion from run-off, this can result in the loss of nutrients needed by plants in the upper soil layer and can reduce land stability.

The slope arrangement aims to strengthen the slopes of ex-mining landfills and mining excavated slopes at the stage of reclamation activities of production operations. If the slope of the heap slope is 0-5%, there is no need for a cover crop on the land. Land management with this condition requires land regulation and arrangement with a design that provides protection and carrying capacity for land stability, especially efforts to prevent potential erosion so that the land will become safer and more stable and can function and be useful according to its designation.

Figure 3. Weeding hybrid coconut tree plants (left) [1], Illustration of Fertilization Area (right) [1]

Figure 4. Symptoms of Pestalotia palmarum attack on the leaves of hybrid coconut seedlings (left) [1], Symptoms of severe attack of Bipolaris incurvata on hybrid coconut canopy (right) [1]

3.4. Revegetation

Former quartz sand mining land needs to be rehabilitated using adaptive tree species and supported by soil improvement applications to improve soil properties from overburden [13]. The type of plant used in the reclamation of production operations is the herbicide coconut plant. Hybrid coconut is arguably a fairly productive plant because it can produce 140 grains per tree per year. Hybrid coconuts are suitable for growing and developing in areas with temperatures of 27ºC, if less than that then hybrid coconuts will not grow productively [17]. Revegetation is carried out with several stages of activities, namely field preparation, procurement of seeds, and implementation of planting. The physical properties and chemical properties of soil play an important role in influencing plant growth and microbial activity [11]. Field preparation begins with clearing the land from nuisance plants so that hybrid coconuts can grow optimally in obtaining nutrients and sunlight. Then soil processing is carried out by making the soil terrace slope above 5-10 degrees while rorak needs to be made on ramps as water flow and erosion prevention. Soil bulking is prepared so that the planting land is good and limiting the soil when the acidity level is high to reduce the acidity level of the soil.

Organic matter contained in the soil is certainly another reason for successful planting. This happens because organic matter can increase the chemical, biological and physical fertility of the soil [14]. In former mining land, undergrowth has a positive impact, including stabilizing the land but also has a negative impact, which can be a competitor to staple crops [19]. Environmental factors that can affect plant growth are temperature, rainfall, soil, humidity and climate. Ex-mining land has different land characteristics and environmental conditions from ordinary land [21].

Planting is carried out with a planting distance of 9 x 9 meters quadrilateral planting pattern. One month before planting hybrid coconuts, planting holes should be made in advance at the stake point with a size of 70 x 70 x 70 cm. Fertilizer also needs to be added to the hole as much as 100 grams to spur the growth of the roots of the newly planted hybrid coconut tree. There are 4 seeds per hectare or 161 Hybrid Coconut tree seedlings from the initial inventory or equal to 1% of the initial inventory, so that the total seeds provided are 16,237 Hybrid Coconut seedlings [1]. Supplies are prepared so that if any planted Hybrid Coconut tree seedlings do not grow well or die they can be immediately replaced or embroidered (see figure 2).

Table 2. Cost and Hourly Equipment Production Rate

No	Tools	Number of Tools	Production (BCM /hours)	Operating costs (Rp/ hours)	Labor salaries (Rp/hours)	Solar (Rp)	Oil (Rp)	Total (Rp/Hours)
1	Excavator Komatsu PC-200	1	293	400.000	18.750	330.000	77.000	825.750
2	Mitsubishi HD 120 PS	3	293	25.000	18.750	66.000	19.250	129.000
3	D825P	1	5.002	300.000	18.750	330.000	77.000	727.750
4	D825P	1	3.618	300.000	18.750	330.000	77.000	727.750

Figure 5. Symptoms of Colletotrichum sp. attack and Culvularia sp. on hybrid coconut seedlings (left) [1], Symptoms of Dry Blight attack on hybrid coconut seedlings (right) [1]

3.5. Maintenance

Plant maintenance is intended to spur the growth of Hybrid Coconut plants in such a way that optimal conditions can be realized for the growth of these plants. Weed control/weeding is an effort to free staple crops from plant competition (weeds) by clearing plants around staple crops. Weed control can be done manually in the form of weeding and watering or chemical in the form of spraying chemicals/ herbicides, depending on field conditions, soil conditions, types of plants and types of weeds. Usually weed cleaning is carried out 3-4 times in 1 year. Fertilization of Hybrid Coconut plants is carried out 2 times a year. Fertilization is carried out after weeding, this is so that fertilizer can be absorbed properly by Hybrid Coconut plants.

The distance of fertilization from the stem of the hybrid coconut with the age of the plant. Hybrid coconut is under 3 years old, the recommended trench distance for fertilizing is 50–100 cm from the base of the stem while for plants older than 3 years, the distance of the fertilization trench is 100–150 cm from the base of the stem (see figure 3).

Diseases of hybrid coconut plants that often occur include gray spot, polypathotipsis palmarum, brown spot, dry rot, yellow spot, shoot rot and fruit fall, and diseases caused by phytoplasma. These pests and diseases are very detrimental because they can cause a decrease in production, even causing the death of hybrid coconuts. How to overcome diseases in hybrid coconut trees must be observed regularly both during the seedling period to the harvesting period. Examples of ways to deal with brown spot hybrid coconut disease are if during seeding, the affected leaves are cut and burned so that the disease does not spread and with fungicides if more than 25% of the leaf surface area is covered with brown spots. Then how to deal with dry rot is if there are symptoms of disease in one seedling (see figure 5), it must be immediately removed and destroyed and prevention is carried out with fungicides made from active ingredients Cuprum (see figure 4).

Table 3. Cost of Land Clearing and Rooting Zone Arrangement per Hectare

No	Tools	Number of Tools	Production	Volume Of Top soil	Operating hours	Tools cost/hours	Total (Rp/ha)
A.	Cost of structuring, stocking of rooting zones						
1	Excavator Komatsu PC-200	1	293	1500	5,119	825.750	4.227.389
2	Mitsubishi HD 120 PS	3	293	1500	5,119	129.000	660.410
3	D825P	1	5.002	1500	0,300	727.750	217.638
4	D825P	1	3.618	1500	0,415	727.750	300.891
			Subtotal				5.406328
No			**Description**				**Total (Rp/ha)**
B.	Erosion control costs per hectare						
1	Erosion control is allocated as much as 2% of land arrangement and rooting zones						108.127
			Subtotal				108.127
			Total				**5.514.455**

Table 4. Cost of structuring, stocking of entrenchment zones and erosion control per year

No	Description	Mining Year				
		2023	2024	2025	2026	2027
1	Land arrangement (Ha)	-	6	8,5	8,5	17,189
2	Top Soil Stocking Cost per Ha (Rp)	-	5.514.455	5.514.455	5.514.455	5.514.455
3	Top Soil Stocking Cost per year (Rp)	-	33.086.754,7	46.874.936,8	46.875.466,2	94.789.877,7

3.6. Reclamation Cost Plan

The calculation of reclamation costs is the result of a survey by PT. X both in the field and in online consultation with the seller or provider. Reclamation costs are divided into 2, namely direct costs and indirect costs. Direct costs explain that these costs need to be calculated in the preparation of reclamation cost plans which include land use management costs, revegetation costs, acid mine water prevention and control costs, civil work costs according to their designation and utilization of ex-mining pits but this study will only discuss details about land arrangement costs and revegetation costs.

Land use costs include land arrangement costs, root zone soil stocking costs and erosion and sedimentation control costs. Land arrangement is not so much done because the cover land that was originally at disposal was moved to the former mine opening, then the land surface was arranged according to the designation. In knowing the amount of land arrangement costs, we first describe the hourly level of equipment production. The cost of hourly equipment varies depending on the type and designation (see table 2-3). Soil distribution of the rooting zone is carried out after the soil is laid out so that the expected nutrients can be obtained optimally (see table 4). Control of erosion and sedimentation in the implementation of mine reclamation must be pursued as well as possible, so that erosion and sedimentation do not occur. The cost of erosion mitigation, assumes 2% of the cost of structuring the land and rooting zones.

The cost of structuring, stocking rooting zones and erosion control in 2023 is not budgeted because it is still in the mining process, in 2024 it is Rp. 33,086,754.7, in 2025 it is Rp. 46,874,936.8, in 2026 it is Rp. 46,875,466.2 and in 2027 it is Rp. 974,789,877.7, so that the total cost of land arrangement, rooting and erosion zones from 2023 to 2027 is Rp. 221,627,035.4 with a land area laid out 40.19 hectares.

Revegetation costs include the cost of soil quality analysis, fertilization, procurement of Hybrid Coconut seedlings, planting and maintenance of Hybrid Coconut trees. Soil quality testers will be taken every year when planting Hybrid Coconut trees. This is done in order to find out that the quality of the soil is qualified in planting Hybrid Coconut trees. Sampling was carried out 1 time in 2 hectares. With Cost per sample, namely Physical Analysis of Rp. 100,000 and Chemical Analysis of Rp. 200,000 [18].

The fertilization to be used is in the form of initial fertilizer in the form of a type of Urea fertilizer. Based on the calculation, one hectare requires 12.2 kg with a cost per kg of Rp. 15,000. Initial fertilization activities are carried out simultaneously with planting activities [18]. The procurement of Hybrid Coconut seeds will use seeds that have been found in many mining locations. Prepared seedlings are seedlings that are ready for planting. This seed procurement includes initial seeds and additional seedlings as much as 1% of the initial seedlings for embroidery activities if there are seeds that are not good in growth or die with a total of 4,863 seedlings covering an area of 40.19 openings. The value of seeds per stem is Rp. 17,500 / stem, in addition to Hybrid Coconut, legume plants will be sown between Hybrid Coconut tree plants 2 kg Pueraria javanica and 5 kg Colopanginium moconoides per hectare. The price per kg of Pueraria javanica is Rp. 100,000 and Colopanginium moconoides is Rp. 35,000. The cost of planting Hybrid Coconut trees is done manually, namely using a hoe, where it takes 2 people for payroll and 2 people for making holes as well as initial Urea fertilizer and 2 planting people.

Table 5. Total Cost

No	Description	Mining Year 2023	2024	2025	2026	2027
Direct Costs (Rp)						
1	a. Land Arrangement Costs	-	33.086.755	46.874.937	46.875.466	94.789.878
	b. Revegetation Costs	-	28.578.024	40.487.291	40.487.748	81.872.865
	c. Maintenance Costs	-	514.490.012	20.528.408	20.528.640	41.512.275
	d. Monitoring costs	-	1.200.001	1.700.075	1.700.094	3.437.870
	e. Cost of Prevention and Control of Acid Mine Water	3.000.000	3.000.000	3.000.000	3.000.000	3.000.000
	f. Post-mining civil works costs	-	-	-	-	
	Sub Total Direct Costs	3.000.000	80.354.792	112.590.711	112.591.949	224.612.887
Indirect Costs (Rp)						
2	a. Cost of Mobilization and Demobilization of Tools	75.000	2.008.870	2.814.768	2.814.799	5.615.322
	b. Reclamation Planning Costs	60.000	1.607.096	2.251.814	2.251.839	4.492.258
	c. Administration fees and third-party benefits	90.000	2.410.644	3.377.721	3.377.758	6.738.387
	d. Supervision Fees	60.000	1.607.096	2.251.814	2.251.839	4.492.258
	Sub Total Indirect Costs	285.000	7.633.705	10.696.118	10.696.235	21.338.224
	Total cost	3.285.000	87.988.497	123.286.828	123.288.184	245.951.112
	Total cost for 5 years			583.799.620		

Indirect costs contain a description of costs regarding costs that must be included in the calculation of reclamation and determined using reference standards determined and agreed upon by the management of IUP PT. X. Indirect costs include the cost of mobilization and demobilization of equipment amounting to 2.5% of direct costs or based on calculations, Reclamation planning costs of 2% of direct costs, administrative costs and profits of third parties as implementers of the reclamation stage of Production Operations amounting to 3% of direct costs and supervision costs amounting to 2% (two percent) of direct costs.

Total costs are direct costs plus indirect costs and they take into account future value of money. The total cost of the reclamation plan needed in 2023 is Rp. 3,285,000, in 2024 it is Rp. 87,988,497, in 2025 it is Rp. 123,286,828, in 2026 it is Rp. 123,288,184 and in 2027 it is Rp. 245,951,112. So that the amount of the cost of reclamation IUP PT. X in total for 5 years from 2023 to 2027 is Rp. 583,799,620. (see table 5)

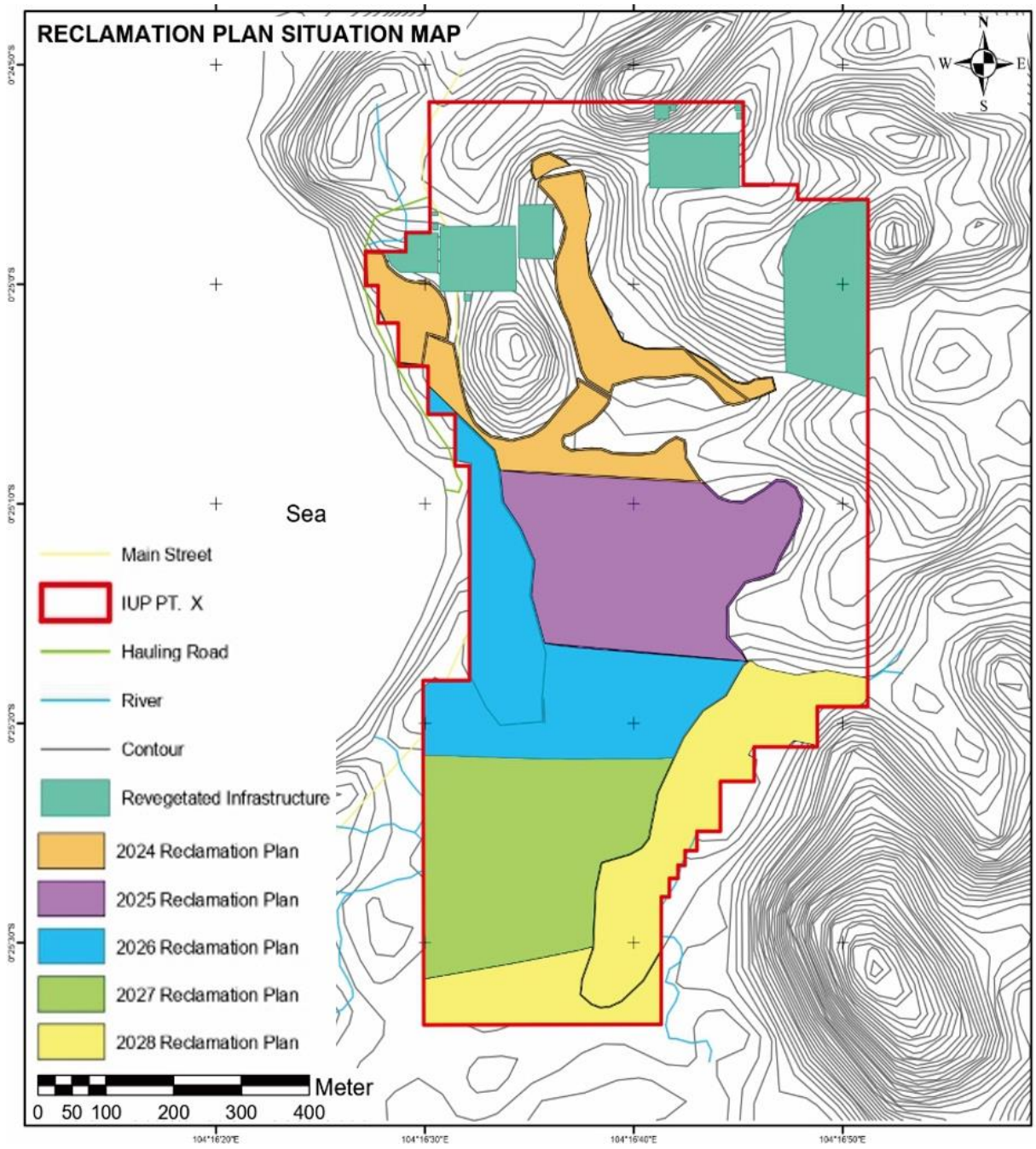

Figure 5. Reclamation Plan Map of PT.X [1]

4. Conclusion

From the results of research on the reclamation plan for the production operation stage, it can be concluded that the area of land to be reclaimed by PT. X in 2024-2028 covering an area of 40.19 Ha. The plants used for reclamation are Hybrid Coconut plants with a total of 16,237 seedlings. The planting distance of Hybrid Coconut at the time of reclamation is 9 x 9 meters with each planting hole 70 x 70 x 70 cm. Hybrid coconuts under 3 years old, the distance of the trench is fertilized with a distance of 50-100 cm from the base of the trunk while hybrid coconuts that are more than 3 years old, the distance of the fertilization trench is 100-150 cm from the base of the trunk. The total cost of the reclamation plan needed in 2023 is Rp. 3,285,000, in 2024 it is Rp. 87,988,497, in 2025 it is Rp. 123,286,828, in 2026 it is Rp. 123,288,184 and in 2027 it is Rp. 245,951,112. IUP reclamation cost of PT. X in total for 5 years from 2023 to 2027 is Rp. 583,799,620.

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