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Analysis of productivity in dredging project A case study in Port of Tanjung Perak Surabaya – Indonesia

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ANALYSIS OF PRODUCTIVITY IN DREDGING PROJECT

A case study in Port of Tanjung Perak Surabaya - Indonesia

By

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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"*The two most important days in your life are the day you are born and the day you find out why.*"
-Mark Twain-

ABSTRACT

Title of Dissertation: **ANALYSIS OF PRODUCTIVITY IN DREDGING PROJECT; A CASE STUDY IN PORT OF TANJUNG PERAK SURABAYA - INDONESIA.**

Degree: **MSc**

This dissertation is an assessment of the real productivity theory of a dredging project conducted in the port of Tanjung Perak Indonesia. The project was conducted in July 2012 and completed in December 2012 by Rukindo Corporation under the contract from the Indonesian Port Corporation III.

The assessment will analyse the gap between the proposed productivity of the dredgers by the contractor with the real productivity after the completion of the project that has taken into account the aspects that cause the delay of the project. It will combine the data from the literature reviews on the dredging operation with the actual data of the daily and weekly project report.

The researcher found that there is a difference of calculation of the productivity from the contractor with the actual productivity using the real productivity theory approach. The project productivity was influenced by several variable ranging from characteristics of the dredger to several project management issues. Several solutions will be proposed to accelerate the project and avoid the potential delay. The solution includes the usage of the TSHD 1000, TSHD 2900, TSHD 4000, TSHD 5000, grab clamshell 5.5 and grab clamshell 20.

The finding will seek to improve the planning of the dredging project in Indonesia Port Corporation III and in other cases where applicable.

KEYWORDS: *Productivity Analysis, Dredging Operations, Real productivity theory, Indonesian Port Corporation III.*

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LIST OF ABREVIATIONS

CA	: CHARTERING AGREEMENT
GT	: GROSS TONNAGE
IDR	: INDONESIAN RUPIAH
IPC	: INDONESIA PORT CORPORATION III
mLWS	: MEAN LOW WATER SPRINGS
SOC	: STATE OWN COMPANY
OP	: OTORITAS PELABUHAN (PORT AUTHORITY)
TSHD	: TRAILING SUCTION HOPPER DREDGER

1. Introduction

1.1. Background

Indonesia Port Corporation III, widely known as IPC III or Pelindo III is a state owned corporation responsible for managing the ports and harbours in the area of Central Java, East Java, Bali, South Kalimantan, Central Kalimantan, West Nusa Tenggara and East Nusa Tenggara. The operation is coordinated from the main office in the port of Tanjung Perak Surabaya, Indonesia. As one of the state owned corporation in the maritime domain, IPC III takes an active role in supporting the current administration's program especially in anticipating the user needs and improving the quality of the marine services. Several measures have been taken in order to ensure the progress, among them is to increase the depth of the Port basin to cater the operation of larger vessels with an investment of approximately $6.25 million (The Annual Report of Indonesian Port Corporation III , 2011 - 2014). Although the maintenance dredging has already conducted in the Port annually to maintain the current depth capacity, the new dredging project will be implemented as part of the long-term infrastructure development plan.

The purpose of a development plan is to review the overall status of the Port of Tanjung Perak, the second largest port in Indonesia. The port plays a crucial role in the sea transport services, stevedoring and container handling. The growth in the last few years has justified the need for upgrading such facilities, improving the equipment in cargo handling and easing traffic congestion in the shipping lanes. The volume of shipping traffic in port of Tanjung Perak was 14,198 in 2013. The number continues to grow each year by almost 10%.

1.2. Current condition of the port traffic

As the second largest port in Indonesia, Tanjung Perak Port has a strategic role i.e., to ease the sea traffic congestion, to support the distribution network and to promote economic growth in East Java in particular and Eastern Indonesia in general. The port of Tanjung Perak also acts as the transshipment point in international trade and domestic trade activities.

Table 1 below shows the statistic of ship traffic in the port of Tanjung Perak between 2009 and 2012. The figure shows the number of units on public terminals decreased by an average of growth each year falling by 2% from 14,472 units to 13,086 units. Meanwhile, in units of GT the number increased with an average growth of 6% each year from 55,540,270 million GT, and then increase to 66,979,761 GT. The changes were mainly caused by the increase traffic of container ships including passenger ships in the Public wharf, although the port basin at that time was still in the implementation phase of the port dredging project.

Table 1. Ship traffic based on type shipping and distribution

NO.	DESCRIPTION	UNIT	REALIZATION					AVERG. (%)
			2009	2010	2011	2012	2013	
1	2	3	4	5	6	7	8	9
I	**SERVICES AND DISTRIBUTION**							
1	**Public piers**							
	a. International sea transport	Unit	2.153	1.906	2.137	1.933	1.870	97
		GT	24.504.224	26.521.816	31.202.704	30.390.659	32.440.539	108
	b. Domestic sea transport	Unit	12.319	11.741	11.579	9.151	11.216	99
		GT	31.036.046	31.400.998	35.231.505	25.252.072	34.539.222	105
	JUMLAH 1 :	**Unit**	**14.472**	**13.647**	**13.716**	**11.084**	**13.086**	**98**
		GT	**55.540.270**	**57.922.814**	**66.434.209**	**55.642.731**	**66.979.761**	**106**
2	**DUKS**							
	a. International sea transport	Unit	282	208	79	115	136	94
		GT	5.018.544	4.036.271	1.984.517	3.037.603	3.624.680	100
	b. Domestic sea transport	Unit	310	343	322	272	396	109
		GT	2.689.336	3.997.223	4.311.862	3.280.263	3.911.022	113
	JUMLAH 2 :	**Unit**	**592**	**551**	**401**	**387**	**532**	**100**
		GT	**7.707.880**	**8.033.494**	**6.296.379**	**6.317.866**	**7.535.702**	**101**
3	**Rede/Dolphin/L.Point**							
	a. International sea transport	Unit	-	-	-	146	57	39
		GT	-	-	-	1.315.615	381.703	29
	b. Domestic sea transport	Unit	-	-	-	3.156	523	17
		GT	-	-	-	9.845.968	1.396.535	14
	JUMLAH 3 :	**Unit**	-	-	-	**3.302**	**580**	**18**
		GT	-	-	-	**11.161.583**	**1.778.238**	**16**
	TOTAL TRAFFIC (SHIPPING) :	**Unit**	**15.064**	**14.198**	**14.117**	**14.773**	**14.198**	**99**
		GT	**63.248.150**	**65.956.308**	**72.730.588**	**73.122.180**	**76.293.701**	**105**

Table 2 below shows that the statistic of the volume of ship traffic until 2013 increased to as much as 14,198 units or down by 1% on an annual average. In gross tonnage that would amount to 76,298,701 GT, up to 5% increase on average annually. It can be explained that the ship visits at public piers, especially container ships in the average unit fixed and GT average rose 8%, and dry bulk vessels decreased similarly, the average unit fell 15%, but in units of GT increased by 6 %.

Then for tanker fuel, unit basis dropped by an average of 13% and an average GT grew by 3%.

Table 2. Ship traffic by type of ships

NO.	DESCRIPTION	UNIT	REALIZATION					AVERG. (%)
			2009	2010	2011	2012	2013	
1	2	3	4	5	6	7	8	9
I	**SERVICES AND DISTRIBUTION**							
1	**Public piers**							
	a. International sea transport	Unit	2.153	1.906	2.137	1.933	1.870	97
		GT	24.504.224	26.521.816	31.202.704	30.390.659	32.440.539	108
	b. Domestic sea transport	Unit	12.319	11.741	11.579	9.151	11.216	99
		GT	31.036.046	31.400.998	35.231.505	25.252.072	34.539.222	105
	JUMLAH 1 :	**Unit**	**14.472**	**13.647**	**13.716**	**11.084**	**13.086**	**98**
		GT	**55.540.270**	**57.922.814**	**66.434.209**	**55.642.731**	**66.979.761**	**106**
2	**DUKS**							
	a. International sea transport	Unit	282	208	79	115	136	94
		GT	5.018.544	4.036.271	1.984.517	3.037.603	3.624.680	100
	b. Domestic sea transport	Unit	310	343	322	272	396	109
		GT	2.689.336	3.997.223	4.311.862	3.280.263	3.911.022	113
	JUMLAH 2 :	**Unit**	**592**	**551**	**401**	**387**	**532**	**100**
		GT	**7.707.880**	**8.033.494**	**6.296.379**	**6.317.866**	**7.535.702**	**101**
3	**Rede/Dolphin/L.Point**							
	a. International sea transport	Unit	-	-	-	146	57	39
		GT	-	-	-	1.315.615	381.703	29
	b. Domestic sea transport	Unit	-	-	-	3.156	523	17
		GT	-	-	-	9.845.968	1.396.535	14
	JUMLAH 3 :	**Unit**	-	-	-	**3.302**	**580**	**18**
		GT	-	-	-	**11.161.583**	**1.778.238**	**16**
	TOTAL TRAFFIC (SHIPPING) :	**Unit**	**15.064**	**14.198**	**14.117**	**14.773**	**14.198**	**99**
		GT	**63.248.150**	**65.956.308**	**72.730.588**	**73.122.180**	**76.293.701**	**105**

Table 3. The influx of goods based on the trade and distribution

NO.	DESCRIPTIONS	UNIT	REALIZATION					AVERG. (%)
			2009	2010	2011	2012	2013	
1	2	3	4	5	6	7	8	9
1.	International Trade							
	a. Import	Ton	3.116.887	3.808.458	5.563.362	7.067.544	7.628.910	126
		M3	185.302	130.806	90.344	48.718	89.839	94
		Ton/Ltr	4.001.044	1.900.762	2.728.309	956.992	924.991	81
	b. Export	Ton	815.982	774.170	644.494	657.457	479.780	88
		M3	47.985	36.832	34.299	37.533	14.450	79
		Ton/Ltr	-	-	-	-	-	0
	Total 1st	**Ton**	**3.932.869**	**4.582.628**	**6.207.856**	**7.725.001**	**8.108.690**	**120**
		M3	**233.287**	**167.638**	**124.643**	**86.251**	**104.289**	**84**
		Ton/Ltr	**4.001.044**	**1.900.762**	**2.728.309**	**956.992**	**924.991**	**81**
2.	Domestic Trade							
	a. Unloading	Ton	2.731.250	2.484.101	3.070.828	3.319.936	2.952.289	103
		M3	1.589.705	1.537.224	1.363.847	799.737	936.375	90
		Ton/Ltr	2.497.763	1.932.800	1.727.698	1.054.950	1.263.919	87
	b. Loading	Ton	1.546.572	1.279.849	1.763.172	1.959.443	1.488.288	102
		M3	388.224	322.620	390.169	165.092	183.491	89
		Ton/Ltr	-	-	421.200	413.950	749.398	140
	Total 2nd	**Ton**	**4.277.822**	**3.763.950**	**4.834.000**	**5.279.379**	**4.440.577**	**102**
		M3	**1.977.929**	**1.859.844**	**1.754.016**	**964.829**	**1.119.866**	**90**
		Ton/Ltr	**2.497.763**	**1.932.800**	**2.148.898**	**1.468.900**	**2.013.317**	**98**
	amount 1 + 2	**Ton**	**8.210.691**	**8.346.578**	**11.041.856**	**13.004.380**	**12.549.267**	**112**
		M3	**2.211.216**	**2.027.482**	**1.878.659**	**1.051.080**	**1.224.155**	**89**
		Ton/Ltr	**6.498.807**	**3.833.562**	**4.877.207**	**2.425.892**	**2.938.308**	**89**

The volume of the flow of goods based on the trading and distribution until 2013 in tons in total was 12,549,267 tons or an average increase of 12% annually. This is due to the growing flow of imported goods. While in units of cubic meters as much as

1,224,155, or an average fell by 11% annually; this was due to a decrease in the activity of loading and unloading plywood, molding and the displacement pattern of transporting goods to the type of cargo containers.

Table 4. Flow goods based packaging and distribution

NO.	DESCRIPTIONS	SAT.	REALIZATION					AVERG. (%)
			2009	2010	2011	2012	2013	
1	2	3	4	5	6	7	8	9
A	Public piers							
	a. Public piers	Ton	1.298.537	1.239.312	1.729.742	3.935.994	3.046.027	135
		M3	1.358.750	1.170.766	1.382.364	986.102	1.089.621	97
	b. Bag Cargo	Ton	1.687.193	1.429.075	2.243.267	2.234.906	1.997.642	108
		M3	19.188	5.445	146.834	8.485	223	683
	c. Unitized / Pallet	Ton	2.560	56.213	134.489	54.092	122.757	676
		M3	833.278	851.271	349.461	56.493	134.311	99
	d. Liquid bulk fuel	Ton/Liter	-	-	-	-	-	0
	e. Liquid bulk non-fuel	Ton	1.624.620	1.421.377	1.902.228	1.960.824	1.739.342	103
	f. Dry bulk	Ton	2.568.447	3.167.713	3.982.303	3.679.527	4.580.592	116
	g. Coal	Ton	-	-	-	-	-	0
	h. Log	M3	-	-	-	-	-	0
	i. Container	Box	315.858	353.735	538.658	577.185	623.146	120
		Teus	326.753	365.446	569.968	611.438	665.145	121
	AMOUNT PUBLIC PIER	**Ton**	**7.181.357**	**7.313.690**	**9.992.029**	**11.865.343**	**11.486.360**	**114**
		M3	**2.211.216**	**2.027.482**	**1.878.659**	**1.051.080**	**1.224.155**	**0**
		Ton/Liter	-	-	-	-	-	**0**
		Box	**315.858**	**353.735**	**538.658**	**577.185**	**623.146**	**120**
		Teus	**326.753**	**365.446**	**569.968**	**611.438**	**665.145**	**121**
B	DUKS							
	a. General Cargo	Ton	-	-	-	-	-	
		M3	-	-	-	-	-	
	b. Bag Cargo	Ton	-	-	-	-	-	0
		M3	-	-	-	-	-	0
	c. Unitized / Pallet	Ton	-	-	-	-	-	0
		M3	-	-	-	-	-	0
	d. Liquid bulk fuel	Ton/Liter	6.498.807	3.833.562	4.877.207	2.425.892	2.761.559	87
	e. Liquid bulk non-fuel	Ton	-	-	-	-	-	0
	f. Dry bulk	Ton	1.029.334	1.032.888	1.049.827	1.139.037	1.239.656	105
	g. Coal	Ton	-	-	-	-	-	0
	h. Log	M3	-	-	-	-	-	0
	i. Container	Box	-	-	-	-	-	0
		Teus	-	-	-	-	-	0
	AMOUNT DUKS	**Ton**	**1.029.334**	**1.032.888**	**1.049.827**	**1.139.037**	**1.239.656**	**105**
		M3	-	-	-	-	-	**0**
		Ton/Liter	**6.498.807**	**3.833.562**	**4.877.207**	**2.425.892**	**2.761.559**	**87**
		Box	-	-	-	-	-	**0**
		Teus	-	-	-	-	-	**0**
C	Rede /LP/ Dolphin							
	a. General Cargo	Ton						0
		M3						0
	b. Bag Cargo	Ton						0
		M3						0
	c. Unitized / Pallet	Ton						0
		M3						0
	d. Liquid bulk fuel	Ton/Liter						0
	e. Liquid bulk non-fuel	Ton						0
	f. Dry bulk	Ton						0
	g. Coal	Ton						0
	h. Log	M3						0
	i. Container	Box						0
		Teus						0
	AMOUNT Rede/LP/Dolphin	**Ton**	-	-	-	-	-	**0**
		M3	-	-	-	-	-	**0**
		Ton/Liter	-	-	-	-	-	**0**
		Box	-	-	-	-	-	**0**
		Teus	-	-	-	-	-	**0**
T O T A L		**Ton**	**8.210.691**	**8.346.578**	**11.041.856**	**13.004.380**	**12.726.016**	**112**
		M3	**2.211.216**	**2.027.482**	**1.878.659**	**1.051.080**	**1.224.155**	**89**
		Ton/Liter	**6.498.807**	**3.833.562**	**4.877.207**	**2.425.892**	**2.761.559**	**87**
		Box	**315.858**	**353.735**	**538.658**	**577.185**	**623.146**	**120**
		Teus	**326.753**	**365.446**	**569.968**	**611.438**	**665.145**	**121**

The volume of the flow of goods to 2013 on a public pier amounted to 11,486,360 million tons or an average increase of 14% and amounted to 1,224,155 m3 or fell by an average of 11%. The shifting patterns of general cargo freight container led to this decline.

The volumetric movement of containers from 2009 to 2013 are as follows:

Table 5. Container Flows

NO.	DESCRIPTIONS	SAT.	REALIZATION					AVERG. (%)
			2009	2010	2011	2012	2013	
1	2	3	4	5	6	7	8	9
1	Conventional terminal							
	a. International	Box	2.942	22.915	36.022	8.584	3.254	249
		TEU's	2.953	23.098	36.235	8.965	3.260	250
	b. Domestic	Box	309.181	330.820	502.637	568.601	619.892	120
		TEU's	320.041	342.348	533.735	602.473	661.885	121
	Amount conventional terminal	**Box**	**312.123**	**353.735**	**538.659**	**577.185**	**623.146**	**120**
		TEU's	**322.994**	**365.446**	**569.970**	**611.438**	**665.145**	**121**
2	Container terminal							
	a. International	Box						0
		TEU's						0
	b. Domestic	Box						0
		TEU's						0
	Amount container terminals	**Box**	-	-	-	-	-	**0**
		TEU's	-	-	-	-	-	**0**
	Amount 1 + 2	**Box**	**312.123**	**353.735**	**538.659**	**577.185**	**623.146**	**120**
		TEU's	**322.994**	**365.446**	**569.970**	**611.438**	**665.145**	**121**

Volume handled until 2013 reaching 623,146 boxes at an average increase of 20% annually, and in units amounted to 665,145 TEU's achieved TEU's, at an average increase of 21% annually.

The flow of passenger ships up to 2013 realized as many as 738,326 people or on average fell by 5% annually. The trend is the use of air transportation of passengers in the country in recent times is preferred by the community with the affordability of ticket prices as well as being faster and more efficient in terms of time compared with other modes of marine transport. while for passengers abroad, which began in 2012, there were as many as 1,200 people and the realization by 2013 as many as 3,526 people.

Table 6. The flow of passengers

NO.	DESCRIPTIONS	UNIT	REALIZATION					AVERG. (%)
			2009	2010	2011	2012	2013	
1	2	3	4	5	6	7	8	9
1	INTERNATIONAL							
	a. Debarkation	Person	-	-	-	601	1.762	293
	b. Embarkation	Person	-	-	-	599	1.764	294
	Amount 1	**Orang**	-	-	-	**1.200**	**3.526**	**294**
2	DOMESTIC							
	a. Debarkation	Person	472.347	428.399	473.982	464.014	399.282	96
	b. Embarkation	Person	465.450	489.637	506.871	432.302	335.518	93
	Amount 2	**Person**	**937.797**	**918.036**	**980.853**	**896.316**	**734.800**	**95**
TOTAL		**Person**	**937.797**	**918.036**	**980.853**	**897.516**	**738.326**	**95**

Table 7. The flow of animal

NO.	DESCRIPTIONS	UNIT	REALIZATION					AVERG. (%)
			2009	2010	2011	2012	2013	
1	2	3	4	5	6	7	8	9
1	INTERNATIONAL							
	a. Import	Ekor	28.980	13.486	4.686	-	-	41
	b. Export	Ekor	-	-	-	-	-	0
	Amount 1	**Ekor**	**28.980**	**13.486**	**4.686**	-	-	**41**
2	DOMESTIC							
	a. Unloading	Ekor	14.339	7.631	3.594	12.499	24.173	160
	b. Loading	Ekor	-	-	-	65	-	0
	Amount 2	**Ekor**	**14.339**	**7.631**	**3.594**	**12.564**	**24.173**	**161**
OVERALL TOTAL		**Ekor**	**43.319**	**21.117**	**8.280**	**12.564**	**24.173**	**108**

Flows of animals up to 2013 realized as much as 24,173 animals or or an average increase of 8% annually.

1.3. Aim and Objectives of the research.

In order to guide the structure of the research, I have set up the aim and objectives of the study as follows:

1.3.1. Aim of the research

The aim of this study is to assess the effectiveness of the operational calculation method used in the dredging operation. The study will analyze the calculation method used by the contractor in comparison to the realization of the project. The study will seek to identify the gap between the calculations used by the contractor, the reason behind the phenomenon and suggest a better approach in calculating the productivity of the dredging operation.

1.3.2. Objectives of the research

The objectives of the research are;

- To analyze the real productivity of dredgers working on the project site (Port of Tanjung Perak basin);
- To identify the problems in dredge operations;
- To propose alternative solutions in improving the productivity of dredging operations.

1.4. Methodology

This research will use the quantitative analysis method, by reviewing the implementation of the dredging project at Tanjung Perak Port in 2012. The data will be collected from available sources such as contract of the project, weekly project reports, and drawing projects. The analysis will further perform calculations on the theory of real productivity of existing dredger according to the findings in data collections and then analyze the volume and the rest time of execution of project based on project data. Then, it will aim to determine the type of alternative dredger fleet owned by the contractor in accordance with the material and location of dredging, calculating productivity dredgers alternative based on approach method and project data. Further, the acceleration time will be calculated based on the real productivity theory of the existing dredging and alternative solutions including financial costs. The aim, therefore, will be to present a wide range of alternative solutions based on the analysis. Raw data for the objective will be obtained from the following sources:

a) IPC III, the Main Branch Office Tanjung Perak port of Surabaya: Chartering Agreement (CA) Implementation of Port Dredging Tanjung Perak Surabaya in 2012.

b) PT Rukindo, daily and weekly Report on The implementation of Port Dredging Project Tanjung Perak Surabaya.
c) Annual report of IPC III from 2011 through 2014: reports uptake of investment within a year.
d) Regulation of the Minister of Transportation of the Republic of Indonesia No. KM. 70 In the year 2010, regarding standard costs in 2011 in the ministry of transportation.

1.5. Limitations of the Research

Scope and limits the discussion of problems in this research are:

a) The analysis is restricted to the port dredging project of Tanjung Perak Surabaya for 2012-2013.
b) Discussion on dredgers is limited to the dredgers held in the inventory of PT Rukindo as the local contractor.
c) The calculation of the acceleration of the work using an alternative addition of dredgers based on analysis of the selection of dredgers that can generate higher productivity.
d) Calculation of the financial cost of each alternative solution is based on the rules that apply to the Regulation Minister of Transportation of the Republic of Indonesia No. KM. 70 In the year 2010, regarding standard costs in 2011 in the ministry of transportation.

1.6. Structure of the Research

The research will cover the following subjects:

a) *Introduction*. Covering the background of the research, scope of work, the methodology used, an objective that will be achieved and structure and organization of the research
b) *Literature review*. In-depth information about dredging concept on how dredging project operations through a combination of dredgers including types

of dredgers used, estimation of productivity dredgers, consideration of the reduction factor, dredging operation and type of soil dredged.

c) *Analysis*. Analysis of the productivity and cost estimate calculations are based on a case study of delay in dredging in the Port of Tanjung Perak Surabaya. This chapter will present an analysis of project delays that occurred in the project, plus information related to the type of dredgers involved in the project, and the calculation of the productivity of each kind of dredger including the kind of dredger. In addition, the calculation of estimated achievement of the project according to the type dredgers and cost calculation will be based on the type of dredger selected.

d) *Recommendations*. Following the findings of an analysis of the possibility of acceleration of the implementation of dredging, recommendations will be proposed with the aim of improving the performance of dredging in the area of IPC;

e) *Conclusion*. The conclusion will endeavor to present a summary of all the information, analysis, results, and recommendations.

2. Geographical and business condition of the Port of Tanjung Perak

2.1. Background

Ports are places for the ship to moor, anchor, embark or disembark passengers, loading or unloading of goods and are equipped with the safety of shipping and port supporting activities as well as the displacement of intra and inter-modal transport (Bichou, 2009). A port is also a gateway to a country as a connecting infrastructure in the form of import-export goods flow between regions, ship traffic, both foreign and domestic, as well as; the flow of animals and animal products and plants.

IPC III is an SOC that is involved in port and harbor services in Seventh Indonesian province including 43 ports covering Central Java, East Java, Bali, West Nusa Tenggara, East Nusa Tenggara, Central Kalimantan and South Kalimantan.

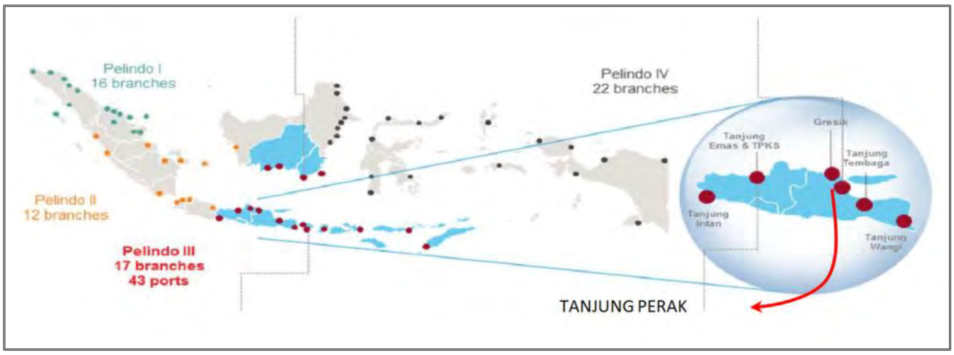


Figure 1. Indonesian port territorial division

Tanjung Perak is one of the gateways to Indonesia, which serves as a trans-shipment hub for transportation of goods from and to the eastern part of Indonesia, including the province of East Java, because of its strategic location. It is well connected with the hinterland and plays a very significant role in promoting national economic growth in East Java and region East Indonesia. This port belongs to the main class port owned by Pelindo III, and it is located in position E 112 32' 22" and S 07 11" 54", precisely in the Madura Strait, north Surabaya. The port covers a water area of 1,574.3 hectares and a land area of 574.7 hectares area.

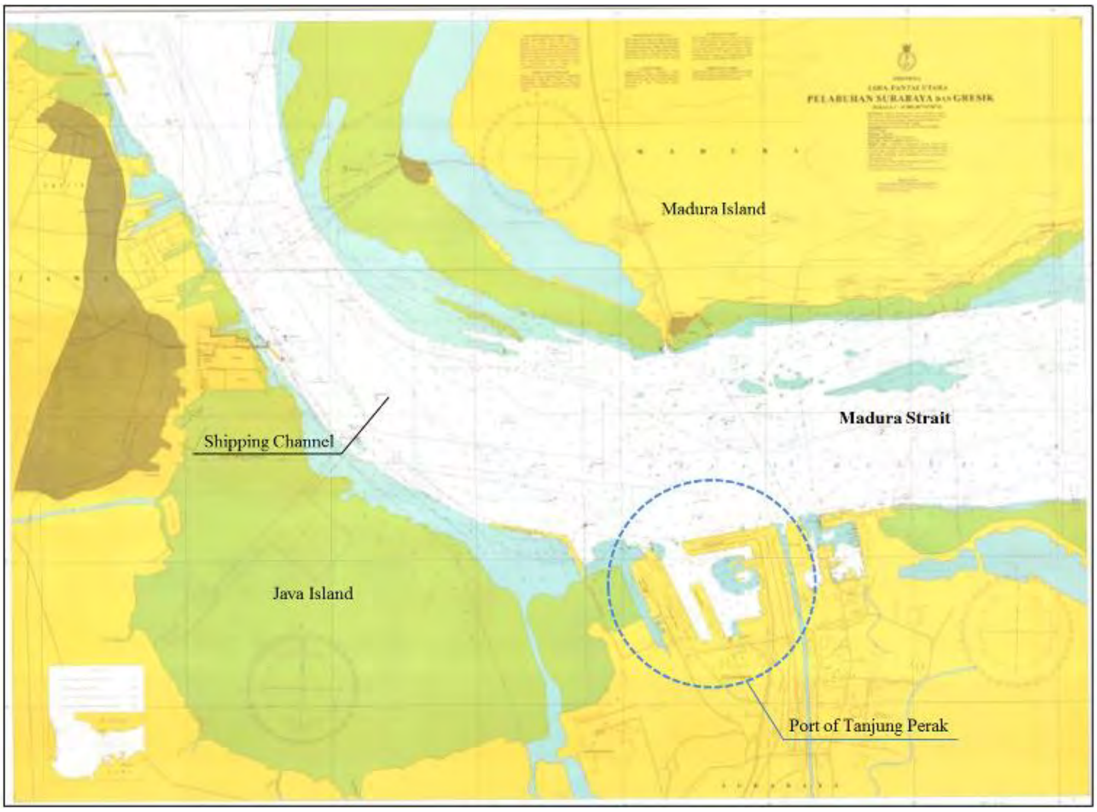


Figure 2. Conditions around the entrance port of Tanjung Perak

Due to the increased activities of the port, IPC III decided to expand the port and port operations by the planned development of some port facilities. The development, in general, can be divided into four main activities comprising, development of Container Terminal III, improvement of western navigation channel, improvement of the Jamrud Terminal, deepening of port basin and the a construction of a New Passenger Terminal. As highlighted in the development plan, deepening of the port basin is the immediate activity that needs to be undertaken. Furthermore, the nature of the bottom in the Madura Straits is silts, clay and sand. Therefore, the use of a combination of mechanical dredgers namely grab clamshell or TSHD would be recommended. In the actual maintenance dredging of the port basin of Tanjung Perak, large portions of the dredging work are carried out by TSHD, and grab bucket Dredgers (clamshell) are used as well in front of the wharf walls or narrow slips of the water area where TSHD cannot enter. Hence, a combination of TSHD and grab clamshell is applied in the port development project as the most economical dredging method with high productivity. The designated area for dumping dredged material by OP, is approximately 6 nautical miles from Port of Tanjung Perak. The dumping ground is located in the following coordinate;

07º 10' 28"S, 112º 45' 58"E ***07º 11' 31"S, 112º 45' 57"E***

2.2. Dredging contractual terms and conditions

The general description contained in the dredging project contract, states the type of work namely dredging, transporting and disposal of dredging material. In addition, dredging location in the port of Tanjung Perak Surabaya, along with the area to be dredged (Figure 1), and the depth details (Table 8). Furthermore, the type of material, along with the siltation rate of 10%. Also, the general obligations and rights of the both parties are as follows;

1.5.1 Obligations of the owner of the project (PT Pelindo III);

- Giving an advance and the periodic payments based on the progress of the project as agreed;
- Carring out the pre-dredge sounding;
- Carrying the final sounding together with the contractor;
- Coordinating with contractors to smooth the process of implementation of the work.

1.5.2 Project owner rights:

- Conducting supervision or put the officer as monitors the implementation of the work;
- Giving warning of omission conducted by the contractor;
- Receiving periodic reports of work.

1.5.3 Obligations of project implementers (contractors)

- Carrying out the dredging project, transportation, and disposal of dredging material issues in the implementation of dredging;

- Executing the project by using a type of trailing suction hopper dredger dredger (TSHD) and a clamshell with a number of tools are sufficient and in good condition and ready for operation (working);
- Proposing the replacement of the type and number of dredgers if necessary from the project site and must be approved by the project owner;
- Repairing any damage to dredger and does not bother project implementation schedule has been agreed;
- Completing any kind of project activity with occupational safety and health equipment for all workers involved in the project.

1.5.4 Rights of contractor:

- Accept payments on the results of the dredging in accordance with the agreed rules;
- Give priority related to the place and time in conducting the dredging operations.

1.5.5 Several parameters affecting the unit price of dredger are as follows:

- The distance dispose which affects the trip;
- The base price of the fuel economics of High Speed Diesel (HSD) solar taken from Indonesian state-owned oil company (PT Pertamina).
- HSD diesel economical price basis used in the project is from the average data the previous year of IDR 8,108, - / litre.

2.1. Sedimentation

Sedimentation is a significant cause of concern in the port basin and shipping lanes. In 2012, the deposition levels in the six terminals reached more than one million cubic meters, and therefore it became critical to do the dredging immediately, considering that this port is the second largest owned by the Indonesian state. However, for the sixth terminal, the area comprises of North Jamrud Terminal, South Jamrud Terminal, East Berlian Terminal, West Berlian Terminal, Nilam Terminal, and Mirah Terminal, with a total volume of 1,190,595 m^3. This dredging project is being carried out in collaboration with PT Rukindo, a state-owned dredging company and the work is planned for 150 calendar days.

2.2. Productivity issues

In the past, it has been observed that during the implementation of dredging work by local contractors, the productivity was very low. This was because the age of the dredger was based on a ship's particular documents and despite the old age of the vessel, the productivity was being reflected very high. Other factors contributing to the low productivity were the ship traffic, the level of expertise of the crew, and the level of maintenance of the ship and inability of the crew to adjust with the local weather. Delays in the implementation of this work are extremely detrimental to the owner of the port because it can cause congestion, vessel queues become longer and lead to far-reaching effects for the economy.

2.3. Administrative delays

Delays in the implementation of the dredging project in the IPC region are often caused by the low productivity performance of local contractors as well as the difficulty of obtaining a license for dredging project from the government, which eventually leads to the project not being completed according to the contractual obligations thereby resulting in the termination of contracts. As for some of the existing dredging projects in the port area of IPC III, such as the dredging project at the Port of Tanjung Perak for 2012-2013, with a total contract value of IDR 60 billion (physical realization of the target of the fourth quarter of 2013 only 75%) and dredging the pond in TPKS front dock Semarang in 2012-2013 with a total contract value of IDR 22 billion Rupiah (physical realization of the target of the fourth quarter of 2013 only 30%). (Annual Report of Indonesian IPC III, 2011 - 2014).

2.4. Management issues

The future contracts require a good dredging project operational management to anticipate the problems, address delays in completion of work thereby addressing the port congestion. Further in-depth observations are needed to determine the cause of the delay in the implementation of this dredging project. In addition, ways and means have to be devised for on-time completion by improving the productivity of dredging and accelerating the project to finish on schedule. For issues concerning the above, particularly the dredging project at Tanjung Perak Port, all stakeholders should plan to control the risk of possible delays in the execution of work by reviewing capacity production vis a vis dredger age and maintenance. In addition, an approach for the analysis of productivity vis a vis the dredging equipment being employed on the dredging project through calculations needs to be adopted as the best approach.

In general, the environmental conditions around the port of Tanjung Perak as follows;

2.5. Shipping Channel

The Western shipping channel is the main route to enter the port of Tanjung Perak (Figure 3), which is 25 nautical miles in length, 100 meters wide with depths varying between 9.7 to 12 mLWS. The navigable channel has been equipped with 24 buoys and a pilotage station in Karang Jamuang serving 24/7, throughout the year. The other channel, the East shipping channel is 22.5 nautical miles in length, 200 meters wide with a depth of between 2.5 to 5 mLWS and along this pathway has been equipped with 8 buoys.

2.6. Port water area

The port of Tanjung Perak has extensive outer port water area extending to 15.5563 million m2 and 784,000 m2 respectively, as well as a well-marked anchorage area defined by the following coordinates;

1. 07°11’18” S / 112° 42’42” E
2. 07°11’32” S / 112° 43’19” E
3. 07°11’28” S / 112° 43’30” E
4. 07°11’17”S / 112° 43’30”E

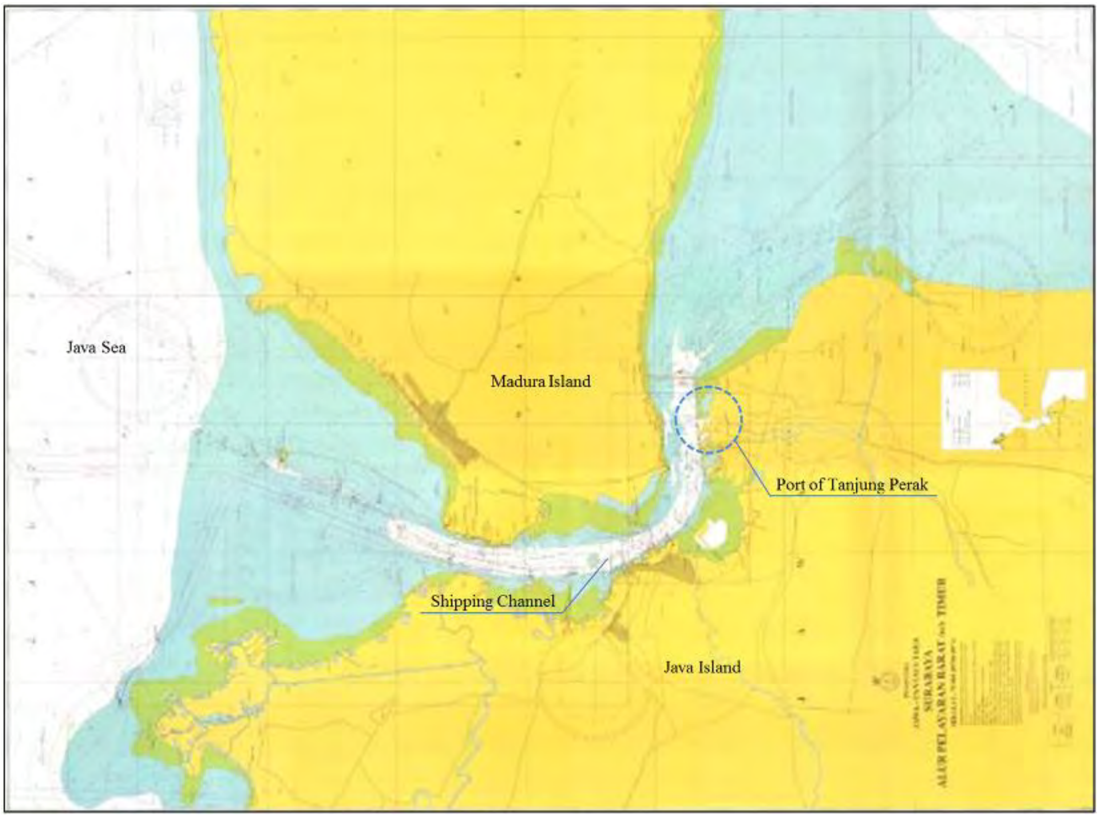
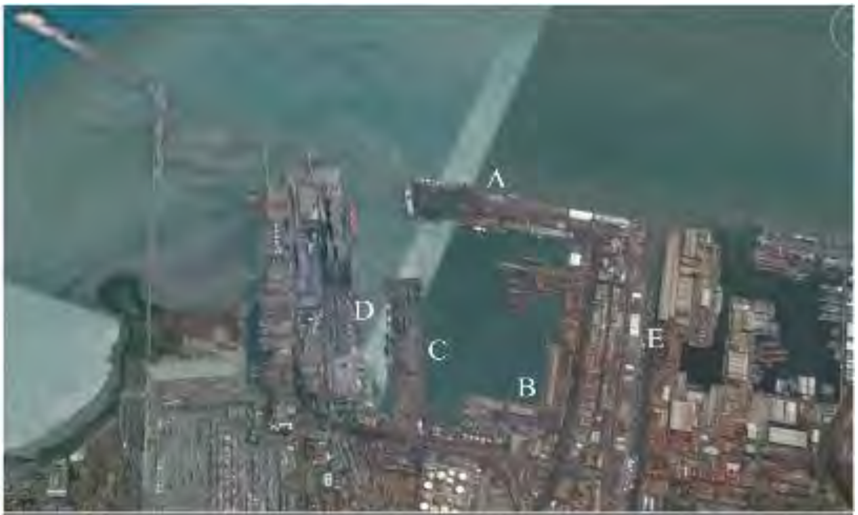


Figure 3. Conditions shipping channel toward the port of Tanjung Perak

2.7. Port pilotage

Pilotage is compulsory in the port. Therefore, 39 pilots have been employed, some of whom serve to guide the ship for sailing in the designated shipping lanes and other are pilots in charge of navigational guidance of vessels in the port area. The pilot station is located at the Karang Jamuang station outside at the position S 06° 53’34” and E112° 43’ 46” with a water depth of 12 mLWS, which can be reached via radio IJHV on channel 6- 8 - 12 - 14 and 16 for 24 hours non-stop. Tug and security assistance has been provided by means of six tugs powered by 800- 2400 HP engine and three waveguides vessel powered by 350-960 EB 'and 6 coastal vessels powered 125-250 MK.



TANJUNG PERAK PORT TERMINAL FACILITIES					
DESCRIPTIONS	JAMRUD A	MIRAH B	BERLIAN C	NILAM D	KALIMAS E
LONG WHARF (m)	2.190	640	1.620	930	2.270
EXTENSIVE WAREHOUSE (m2)	43.265	13.450	11.375	-	6.180
EXTENSIVE FIELD (m2)	34.000	24.000	40.000	40.000	4.000

Figure 4. Tanjung Perak port layout

2.8. Current, Wave and Wind

There are two dominant currents found in shipping lanes and berths, i.e., from west to east and from east to west. Substitution direction occurs every 6 hours at a speed of 3 knots. The maximum wave height around the outside threshold is about 1.5 m and at the berth approximately 0.5 m. The average wind speed in the port is at around 12 knots.

Figure 5. Dredging project area

Table 8. Depth design of port basin

No	LOCATION	DESIGN DEPTH
A	**TYPE OF *HOPPER* DREDGER**	
1.	**In front of the pier until the middle of an Eastern Berlian** (12.5 m - 75 m) from the front of the pier, South Jamrud (10 m - 40 m) from the front of the pier, West Jamrud (50 m) from the front of the pier.	-10m LWS
2.	**In middle pond between East Nilam and West Berlian** (50 m) from the front of the East Nilam pier.	-9 m LWS
3.	**In front of East Berlian**	
	Design -9m LWS (125 m from the front of pier)	-9m LWS
4	**Middle pond between East Berlian, Mirah, and DOK**	
	a. 125m – 175m from the edge of East Berlian	-8m LWS
	b. 175m – 225m from the edge of East Berlian	-7m LWS
	c. 100m – 180m from the front of Mirah pier	-7m LWS
	d. 225m from the front of East Berlian Pier	-5m LWS
	e. 275m from the front of Pier	-5m LWS
5.	South Jamrud (50m from the front of Pier)	-7m LWS
6.	South Jamrud (50m from the front of Pier)	-8m LWS
B	**TYPE OF *CLAMSHELL* DREDGER**	
1.	In front of East Nilam (kade meter 100 – 300)	-9m LWS
2.	In front of East Nilam (Kade meter 300 – 900)	-9m LWS
3.	In front of Mirah Pier	-7m LWS
4.	In front of South Jamrud Pier (2,5m – 50m)	-8m LWS
5.	In front of South Jamrud (2,5m – 50m)	-10m LWS
6.	In front of West Jamrud (2,5m – 50m)	-10m LWS
7.	In front of North Jamrud (kade meter 0 – 450)	-10m LWS
8.	In front of North and West Berlian Pier (2,5m – 50m)	-9m LWS
9.	In front of East Berlian (2,5m – 50 m)	-10m LWS
C	**TURNING BASIN (TYPE OF *HOPPER* DREDGER)**	
1.	Turning Basin D = 280m (In between East and Nort Jamrud)	-10m LWS
2.	Turning Basin D = 150m (In between South Jamurd and Middle of pond)	-9m LWS

3. Literature of Dredging Project

3.1. Project Definition

A project is defined as a business / activity of complex, non-routine, limited by time, budget, resources, and performance specifications that are designed to meet the needs of consumers and have several characteristics (Lester & Lester, 2007). The characteristics of a project by lester definition include:

1. Having a particular purpose;
2. Having a point (early) and a certain point;
3. Involving multiple departments and professions;
4. Often doing something that has never been done before;
5. Having specific time, cost and performance requirements.

Another aspect, which is crucial in project, is scheduling. It is an important thing in a project because scheduling provides information about the timetable and progress of the project in terms of resources in the form of performance fees, labor, equipment and material as well as the duration of the project and progress plan for the project completion time (Mubarak, 2015).

3.2. Dredging Project Definition

Bray et al. (1997) explained that dredging is the removal of soil or rock underwater or from one place to another (e.g., from a riverbed or sea to other places) by using dredger (vessel or floating plant equipped with a machine, mechanically and/or hydraulically). Dredger are used for dredging the shipping lane and port basin to keep the depth and ensure the safety of the ship operations. The dredging work can be divided into two types, namely: capital dredging and maintenance dredging. The capital dredging is used to make a new port; while the maintenance dredging is used in the existing port in order to keep the depth of the port basin and shipping channel from the sedimentation (Bray, 1997).

3.2.1. Common Factors that affect the dredging project

There are several factors that can affect the dredging project. Some of the factors are classified as technical factors while the others are classified as management factors. (*Dredging for Navigation: A handbook for port and waterways authorities,* 1991):

1. Technical Factors
   a. The existence of wrecks. Wrecks are usually the remainders of a ship or any others object found in the sea (floating, submerged or sunken). Large wrecks usually floating and can be mapped. Small ones often move freely in the water and hard to detect with the bare eyes. A surveillance by magnetometer or side scans sonar detection will be able to detect the wrecks that are not visible and not found in nautical maps. The inclusions of possible wrecks in a dredging project is important to be taken into consideration in the planning due to potential increase in the cost and safety measures required during the operations.

   b. The ruins / debris

      Ruins/ debris is any object that is floating in the sea that are not part of a ship. Ruins/Debris can lead to many disadvantages in the use of hydraulic dredgers. The problems of ruins/debris can be solved by using the tool grabs, a clause shape mechanism that can be install as an extention of the dredger.

   c. The content of the base.

      This problem occurs in dredging tool buckets, grabs, hopper, wheel cutters and pipeline. The high density of the soil can cause the high intensity of adhesion (stickiness). As a result, the effectiveness of the tool is disrupted, it reduceses the work productivity and would be problematic in the employment contract.

   d. Coating base.

      Lack of soil density, gas content in it and the tendency of large waves can cause difficulties in the dredging work.

2. Management Factor
    a. The condition of the contract agreement

       The contract agreement related to the knowledge and ability to execute the work in the use of the latest technological tools. Technology evolves over time and the implementing work should be able to cope with the technical development in the field of dredging.
    b. Methods of measurement and certification work.

       The executor of the dredging work should be professional and trustworthy. Professional means that the executor must be certified and knowledgeable in the dredging works. He/she has to obtain sufficient experience of the dynamic challenges in the field.
    c. Rules agreed on payments.

       Every job, have a system of payment varying according to the agreement between the operators and users dredging services. Therefore, the work rules that have been agreed by both parties must be complied with and implemented as a whole.
    d. The relationship between the employer and the contractor.

       Their proper relationship that should exist between the employer and the contractor as the executor will have an impact both on the implementation of work.

3.2.2. Stages of The Dredging Planning

The initial planning phase of the dredging project is to make a characterization of the area to be dredged and conduct an in-depth analysis of the dredging, the amount material disposal, and the amount of reclamation (Tsinker, 2004). As for the general planning of the dredging project started with conducting investigation of soil properties (material) at the dredging site, continued by estimating the amount of material to be dredged sediment by firstly measuring the added through hydrograph survey. The next stage is to decide the type, capacity, and the quantity of the dredger to be used by considering the the characteristic of the disposal place and the location.

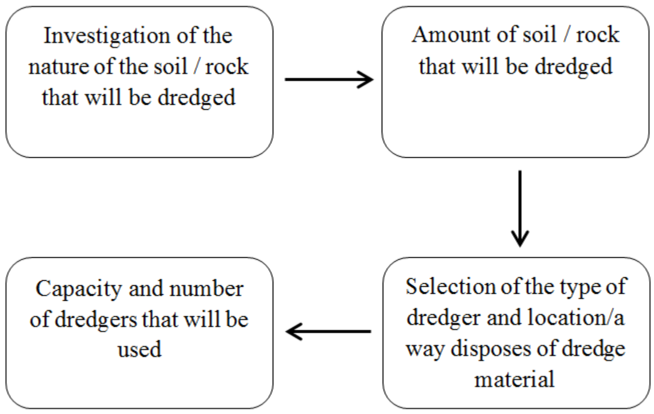


Figure 6. Flowchart of dredging activities planning procedure

According to Huston (1970), in order to support the investigation process of sedimentation either soil or stone, it requires the measurement of submerged land through hydrography, taking soundings before and after dredging. The site investigations also include hydrography, side-scan sonar surveys, sub bottom profile surveys, geotechnical investigations and laboratory testing work based on soil boring. The geotechnical data are used to evaluate the dredging characteristic of the material and to assess its impact related to other purposes such as reclamation or environmental concern. Historical bathymetric data and dredging records should also be reviewed, where available, to help assess the local sedimentation rates and estimate long-term maintenance dredging requirements. The geotechnical data are used to evaluate the dredging characteristic of the material and to evaluate its performance as fill for reclamation or as dredge spoil. This analysis may be supplemented by hydrodynamic and sedimentation transport numerical model studies to evaluate future deposition pattern and rates (Tsinker, 2004). Hydrograph survey is usually conducted by the contractor as the executor of the work. While the owner also performed similar work through a civil engineer consultant in order to confirm the finding by the contractor (Huston, 1970).

The calculation of dredging quantities is an iterative process related to optimization of the overall of a port and its breakwater system. Sometimes the layout and numbers estimates cannot be finalized until the later stages of the design effort, pending the results of physical hydraulic model tests of the port performance and navigation simulation studies to confirm the design of the entrance channel and turning basin. In calculating the dredging quantities, an allowance should be included to account for over dredging beyond the nominal design dredge depth. This can be a critical component of the total dredge volume for dredging in relatively deep water where only a thin layer of sediment needs to be removed (Tsinker, 2004).

According to the Bray et al. (1997), hydrography or sounding on dredging activities should be conducted in four stages of processing, i.e.,

1. Pre-dredge Sounding

   An initial survey undertaken prior to the dredging work is held, and the resulting data is used as the basis for calculating the volume of material to be dredged in the intended location.

2. Check Sounding

   Check sounding is a measurement or survey to see the results from the temporary work areas that have been dredged and the resulting data is used to control implementation of the dredging at the site. Determination of the measurement time period depends on the duration of the project and the type of dredgers are used. As for the term of analysis carried out regularly either twice a month or a maximum of four times a month as needed.

3. Progress Sounding

   Progress sounding is conducted to be reported to the owner and as the requirements for a contractor in billing. In sounding progress is made in accordance with the need for billing. During the implementation of the progress sounding, there is the owner come to accompany.

4. Final Sounding

   Final sounding is conducted by the project owner with the companion of the contractor.

3.3. Dredging Equipment

Generally, the selection of dredging equipment for the implementation of certain projects is based on the availability of fleet of dredgers owned by the contractor as a candidate for the project implementation (Pullar & Hughes, 2009). Therefore, it is not easy to decide the dredging equipment in ideal way, as desired by the project owner.

There are several aspect that need to be consider by the contractor in term of he contract, content and layout of the dredging project.

a) The effectiveness of dredging equipment adapted to the type of sedimentation.
b) The ability of dredging equipment to transport sediment from the dredging area to the disposal site.
c) The flexibility in the work of dredging related to the weather conditions at the project site.
d) Considerations of environmental aspect at the disposal site.
e) The efficiency of the project.

According to Bray (1997), the selection of the dredgers to be used in dredging involves many aspects such as the type and characteristics of the dredger itself, the characteristics of the soil / rock from the bottom of the sea / river, the amount of soil / rock being dredged, the condition of the sea / river, weather conditions, ship traffic in waters, bathymetry, and the period of implementation of the dredging. Herbich, (1992) explains that, in general, the dredgers are divided into two groups: the type of hydraulic and mechanical, in which the dredging work at the port and waterways is pretty much involved. As for the type of hydraulic dredgers, there are hopper dredgers, cutter head, dustpan, sidecasting, and suction dredgers that use centrifugal pumps to pump such a dredged sedimentation and slurry (water mixture) and removes the dredged sedimentation from port and waterways. Meanwhile, for the type of mechanical dredgers, there are a bucket, grapple (barge equipped with "clamshell" bucket), dragline, bucket-leader, backhoe, and dipper dredgers (Herbich, 1992). In addition, thera are many others of other types of dredgers that refers to the workings or type of dredged material.

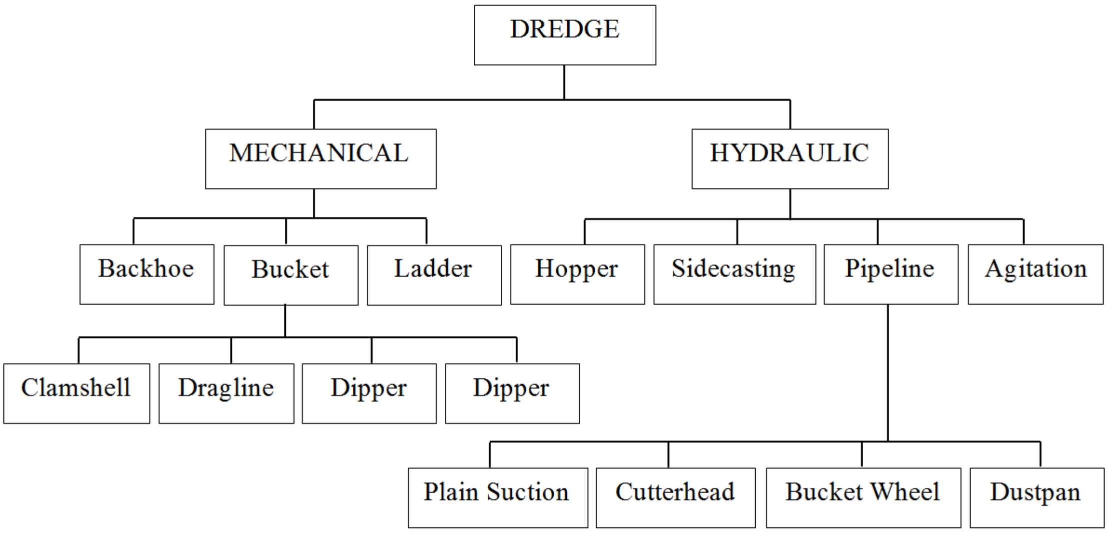


Figure 7. Classification of types dredgers (adapted from Tsinker, 2004)

According to the method of excavation / demolition material, the dredger is divided into two types (Herbich, 1992).

1. Mechanical Dredger

Mechanical means the works are done by way of digging or cutting. Excavation work will be done by using a bucket with many different forms. The effectiveness of these operations depends on the power that is channeled to the bucket / blade as well as the shape of the outskirts / blade bucket stuck on the ground. Due to the large forced needed to cope with the rigors of the land, there are several type of the bucket that are used, such as ;

a) Shovel shape at the Dipper Dredger;
b) Shape backhoe on Dredger;
c) Form chain on Dredger bucket;
d) Shape grab on Dredger;
e) Shape of a wheel on a wheel excavator;
f) Form drag on Dragline.

Job cuts are usually carried out by using a blade by way of "slicing" in order for the results of the excavation to be separated from the original soil mass.

2. Hydraulic Dredger

A hydraulic dredger is operated using using water power. The force from the water jet can be directed toward the dredgers or away from the dredgers. The water jet will take the mixture of water and soil which is drawn by the dredger. The process of soil lifted hydraulically / pneumatic is with a centrifugal pump, with a jet pump, by utilizing the air (airlift) and with pump seabed. Centrifugal pumps used to raise (vertical) and "transport" (horizontal). Characteristics of the selected pump should be adjusted to the workload. The dredging pump is not much different from the large water pumps, only impeller designed so as to allow chunks rather large to pass them. Pump-jet typically is a tool system that uses centrifugal pumps. Jet-water at high pressure leads into the suction pipe. Jet-water flow with a mixture of water and soil into a suction pipe and tube venture-energy jet of water is converted into a "high-pressure water" (pressure head).The dredger effectiveness depends on the speed of the water jet and the characteristics of the material. Suction head shape assortment, includes:

a) Head-suction-flat as the Suction Dredger;
b) Ship-pull like the Trailing Suction Hopper Dredger;
c) Dust pan head as in Dustpan Dredger.

Sometimes ship-pull dust pan head was equipped with a jet of water to help the "exploitation" easier.

3.3.1. Trailing suction hopper dredgers (TSHD)

According to De Heer (1989), TSHDs are self-propelled vessels using a trailing arm to move along the water floor to collect material, simply described as having capabilities such as excavate, transport, and discharge seabed material. The record of the usage of TSHD can be traced back to the Dutch dredger which was used for the first time during the construction of the New Waterway, the new entrance to Rotterdam port (1878 – 1880). A typical hopper dredge is illustrated in Figure 9. As a category of the hydraulic dredger, the hopper dredgers utilize a centrifugal pump to entrain sediment in water for removal and transport. When the vessel is above the desired dredge site; the dragarms are lowered from the side until the draghead rests on the water floor and then the centrifugal pump are energized. In this stage, the vessel is moving forward slowly which is typically to two knots to allow the water to flow in the draghead and up to the dragarms. The water in the draghead then begins to erode the sediment, and the slurry moves up in the dragarm and achieves a certain threshold of material content. Next, physically, the dredging material is a combination of water and sediment is also known as slurry, and the slurry is kept in the hopper section of the ship.

Tsinker (2004) described that the dredging is done by hydraulic dredger fleet TSHD or other types sedimentation with composition solids concentration is 20% and the remaining 80% is water. Dragheads that relies on the erosive flow of water is commonly used more than those that are equipped with water jets or mechanical scrapers to break harder materials. Once the capacity of the slurry in the hopper reaches the between 750 to 10,000 cubic meters (1,000 to 13,000 cubic yards), a maintenance work need to be done to clear the sedimentations that have been attached to the inner side of the suction pipe (Bray et al., 1997).

In order to maximize the concentration of sediment in the bin hopper, sometimes it is possible to continue loading hopper over the intended times to initially fill with slurry mixture. However, at the time the sediment have reached the maximum of the bin the pumps have to be stopped in order to prevent the overflow of sediment back into the water Bray et al. (1997). The practice in the field, will be different from one location to another based on the existing existing government regulations and the nature of the sediment.

Once the hopper is full, the dragarms are lifted out of the seabed. The dredger will then empty the hopper at the disposal site using a disposing mechanism. Some dredgers have a split hull design. The two hull sections hinged along the centerline and split apart by hydraulic power to open the underside of the hull and unload the hopper quickly. A shown in Figure 8, the full cycle of TSHD after which the dredged sediment is dumped on landfill sites and back again to its original location to return dredging again and repeat all the stages of the cycle sail, load, sail, and unload. This can simply be described as the production cycle. The production cycle of THSD depends on the specifications and site characteristics. The cycle can last for less than an hour, up to several hours.

Hopper dredger or TSHD are commonly used for maintenance dredging which is to remove the accumulated material from the navigation channels that have previously been dredged (De Heer, 1989). The reason is for this is that the draghead is very effective for less hard material. Self-propulsion is another unique part of the hopper dredge because it allows easy navigation, maneuvering, and traffic avoidance. Moreover, it can eliminate most of the mobilization/demobilization costs related to other dredgers such as cutter-suction, mechanical bucket or dipper-types that can require tow services to get to a project site, and as well as other miscellaneous support for vessels during operation.

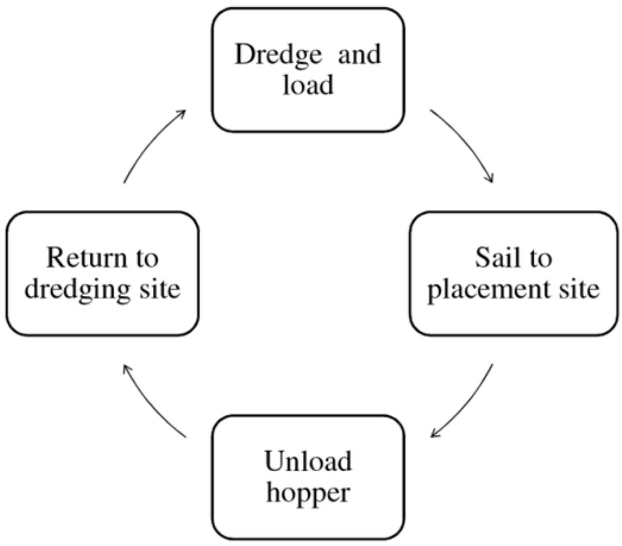


Figure 8. Operation cycle of trailing suction hopper dredger (Adapted from Hollinberger, 2010)

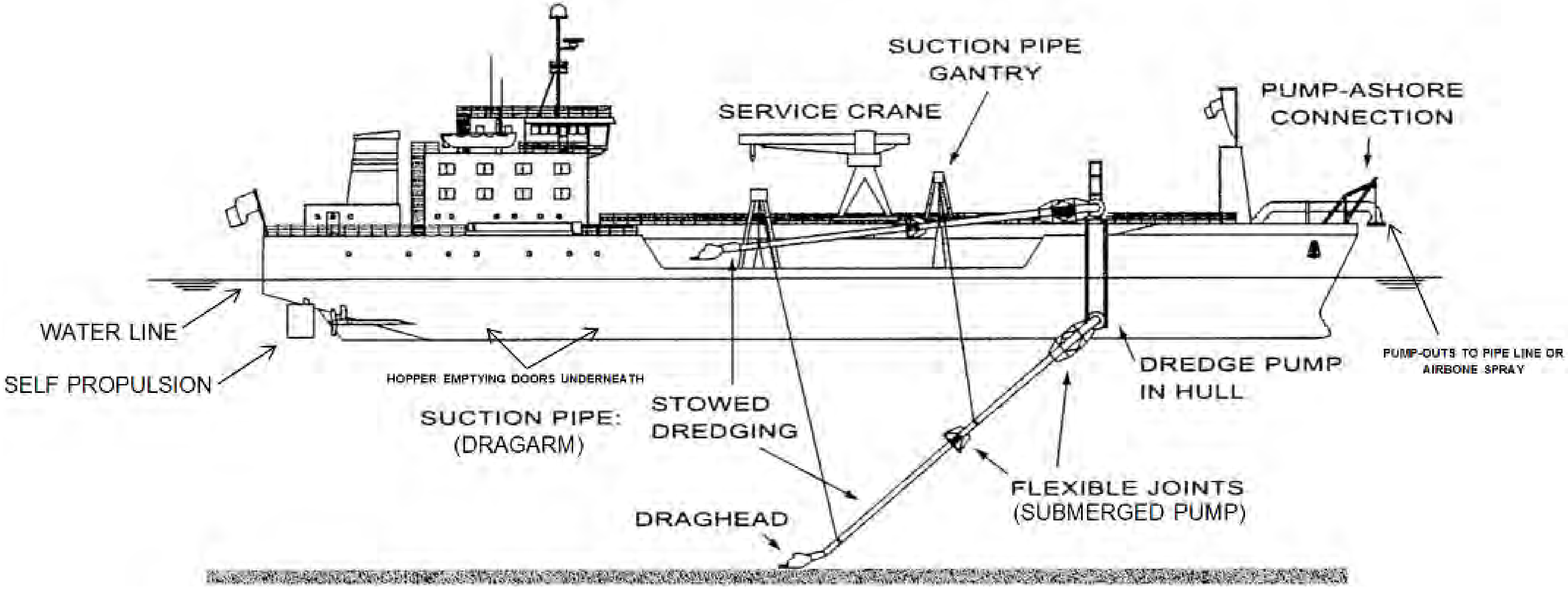


Figure 9. Typical characteristics components of trailing suction hopper dredger (Adapted from Agerschou, 2004)

3.3.2. Estimation production of TSHD

Production of a dredger can be estimated through a variety of ways depending on the types of dredgers used (Adair, 2005). The terms of productivity have several variations of understanding. As for the production, which takes into sub-cycle dredgers as output per hour is commonly known by the nominal theoretical production (P_{nom}) which expressed the amount of productivity in the technical specification documents in this respect is the capacity hopper. However, in the execution of dredging this production could not be achieved because there are some external influences. Therefore, corrective measures are required regarding this production, which can represent actual performance. Further, a simple understanding of the productivity hopper dredger can be interpreted as follows;

$$_{max} \quad \frac{\text{Total load}}{\text{Total cycle time}} \qquad (1)$$

Where the total load is the capacity of the hopper dredger and the total cycle time is the time in one cycle of dredging activity (Bray, 1997). In addition, Wowtschke (2016) described where the components total load can be obtained from the calculation of the multiplication of the C_H or the maximum capacity of the hopper dredger which is expressed in cubic meters then multiplied by f_e or proportion factor of the hopper filled by the sediment, which is further divided by the result of multiplying B or bulking factor with t_{load}, t_{turn}, t_{sail}, and t_d which denotes the discrepancies component of the dredging cycle and is expressed in hours. So that now the estimates of productivity dredger can be defined to be;

$$_{max} \quad \frac{f_e}{t_{load} \quad t_{turn} \quad t_{sail} \quad t_d} \qquad (2)$$

where P_{max} means maximum productivity with the circumstances under ideal conditions. The bulking factors are described by Bray et al. (1997) as output or productivity in this regard is defined as the volume of in situ soil dredged within a specified period. The dredging material will be changed during the process of dredging and transportation to be placed on the dumping area (dredging cycle). The changes are caused by natural factors such as the material shrinkage due to loss of the water component and void. In other words, the dry density of dredging material is increased from its previous condition. So, in the end, this form of further improvement is expressed as a ratio or a comparison of the two volumes. Table 9 shows the typical variation of the value used in the calculation of the reduction, including types of hydraulic dredgers whose level of bulking factors also varies depending on the density of dredging material.

Table 9. Bulking factor, B, for various soil types when excavated by mechanical dredger

Soil type	Bulking factor, B
Hard rock (blasted)	1.50 – 2.0
Medium rock (blasted)	1.40 – 1.80
Soft rock (blasted)	1.25 – 1.40
Gravel, hardpacked	1.35
Gravel, loose	1.1
Sand, hardpacked	1.25 – 1.35
Sand, medium soft to hard	1.15 – 1.25
Sand, soft	1.05 – 1.15
Silts, freshly deposited	1.00 – 1.10
Silts, consolidated	1.10 – 1.40
Clay, very hard	1.15 – 1.25
Clay, medium soft to hard	1.10 – 1.15
Clay, soft	1.00 – 1.10
Sand/gravel/clay mixtures	1.15 – 1.35

Hollinberger (2010) explained that the loading time, $t_{load,}$ is a function of time to process the pump flow rate into the hopper capacity which is then expressed as productivity where it depends on the type of dredging material concentration. Loading time in general is by pumping continuously during the period 10 to 20 minutes will fill the capacity of the hopper (Bray, 1997). Wowtschke (2016) has described that the turning time in hours ($t_{turn)},$ is the total time required to turning the dredge in the process of loading material which is expressed by multiplying a number of turns and the time needed for the dredge to make a turn. Further, the complexity of the conditions of environmental dredging projects such as the size of the area of dredging and soil conditions and other factors will require more than one turn and in the end would increase non-productive time work (Bray, 1997). Sailing time, t_{sail}, is the cycle time for dredgers to sail from location of the dredging project to the dumping area and back to the starting place (Wowtschke, 2016). Finally, the time required by the dredger to dump the dredging materials is incorporated; In addition, it also depends on the whether the method used as the TSHD uses bottom-dumped, then the default t_d is 0.1 hrs.

However, in the execution of dredging there are times when the ideal situation is difficult to achieve continuously which includes the operational efficiency of the crew, the traffic around the project site and, the weather and the condition of machinery (Bray, 1997). So, it is no longer as it had been expected. Thus, it is further expressed by Bray et al. (1997), the real productivity theory is defined by including all of these components as the reduction factor as described below;

$$ {}_{max} \quad f_d \quad f_o \quad f_b \qquad (3) $$

Where P is the real production expressed in cubic meters. The delay factor (f_d) is the reduction factor of productivity dredger due to bad weather and obstructions in the maritime traffic. Furthermore, f_d described by the total available working time is reduced by total time lost because of the delay (due to maritime traffic obstruction and weather), So it can be expressed by the following equation;

$$ f_d \quad \frac{\text{Total working time available} \quad \text{time lost due to traffic during working hours}}{\text{Total working time available}} \qquad (4) $$

Then further, operational factors (f_o) is the reduction factor due to the inefficiency of the crew and the project management. The f_o determined by looking at the degree of expertise of the crew itself as can be seen from Table 10.

Table 10. Operational factor, f_o for given personal ratings (valid for good climate)

Management rating	Crew rating				
	Poor	Mediocare	Average	Good	Very good
Very good	0.67	0.73	0.78	0.84	0.9
Good	0.65	0.71	0.77	0.82	0.88
Average	0.64	0.69	0.75	0.8	0.86
Mediocare	0.62	0.67	0.73	0.79	0.84
Poor	0.6	0.65	0.71	0.77	0.82

The mechanical breakdown factor (f_b) is the reduction factor due to the level of failure or damage which cannot be avoided from the equipment that leads to a work stoppage. Theoretically, the machine has been used continuously, which will require good maintenance periodically so that the machine can still work well. However, after several years of damage, this would occur due to wear and tear and this cannot be unavoidable and if damage occurs, then productivity will decreases (Bray, 1997). De Heer et al. (1989) explained that the f_b was defined by calculating the age level of dredgers, which will continuously fall by 1% per year (after the first 5 years of the new age), down to 0.85 before overhaul (typically 20 years).

3.3.3. Grab Dredger / Clamshell

According to Bray et al. (1997), there are five classifications of mechanical dredgers. A backhoe dredger is the one where the backhoe is attached to the barge or vessel to dredger the soil. A dipper dredger uses a rigid arm with a bucket to cut through the sediment. A bucket ladder is the one that uses a chain of buckets on a belt to dredge the soil. The dragline dredge puts the bucket in the sediment and drags the bucket back toward the vessel. Lastly, the grabber dredger uses a bottom opening bucket at the end of a crane.

Among all these mechanical dredgers, the grabber dredger is the most common type, and it is mainly used in North America. De Heer (1989) mentioned that grabber dredger is well used for mining purposes in the Far East. Bray et al. (1997) pointed out two types of grabber dredgers, which are the stationary grab dredger or dump dredger, which disposes its dredged sediments into hoppers alongside, and a self-propelled grab dredger, which has its own hoppers or barge. Both kinds of these grabber dredgers are the same in a sense that they use grab to excavate the sediment, but the difference is that they have a different method of transportation.

The clamshell is the most common form of grab bucket. A two-sided bucket is dropped into the bottom of the water so that it enters the soil. This is crucial because if the edges of the bucket do not penetrate the soil correctly, the bucket will get empty soil when the edges close. Two wires are used in the dredging method, the hoist wire and the closing wire. The hoist wire is used to move the wire up and down, while the closing wire is used to close the bucket. It should be noted that bucket size is an important characteristic in the mechanical dredgers. Adair (2005), provides a description (Figure 10) of the different bucket sizes used in the United States in 2003. From Figure 10, it is very clear that the size of the bucket 15 yd^3 is the most frequently used. There are also several more sizes between 15 and 30 yd^3 (11 and 23m^3). A few bucket sizes are bigger than 30yd^3 (23m^3). The largest bucket is 50 yd^3.

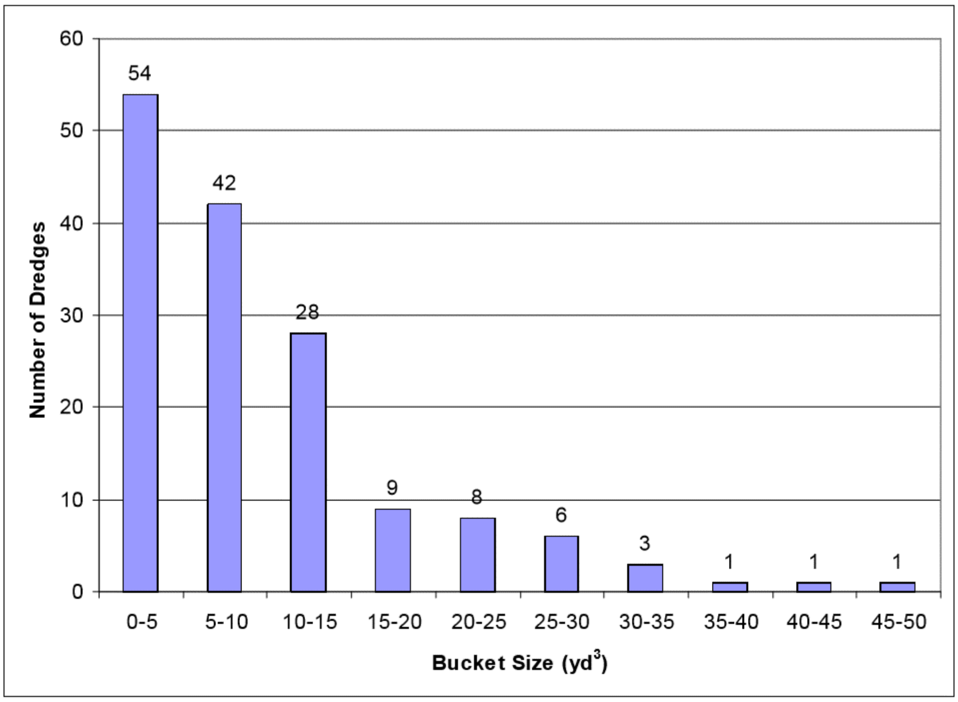


Figure 10. Distribution of bucket sizes in the united states, multiply by 0.765 for m^3 (Source Adair, 2005)

Figure 11 shows a mechanical clamshell dredger in the port basin of the port of Tanjung Perak Surabaya. In the picture, it can be seen that there are many principal components of the mechanical dredger. The dredger is a crane-like structure. In the dredging process, the crane puts the buckets above the desired location and lowers the bucket into the bottom of the waterway. When the bucket closes, it collects sediment. The crane raises the bucket out of the water and positions it over the barge. The bucket is opened, and then the dredged material is discharged in the barge. This cycle is then repeated until the desired depth is achieved.

Figure 11. Mechanical dredge in port of Tanjung Perak Indonesia, 2012

Figure 13 shows the different parts on a clamshell bucket. The hoist wire is used to support the weight of the clamshell and the sediment. It is used to pull the bucket up and down. In the dredging operation, the bucket is lowered into the sediment. The cutting edges of the bucket cut the sediment, and the bucket is then closed. Next, the bucket is pulled out of the water. In generally Bray et al. (1997), explained that the production cycle the grab dredger includes a swing to mark or the bucket is moved toward the point of dredger, which will depend on the angle of the swing. Then the grab is lowered or the grab bucket is directed downwards at an open position, so it will depend on the type of material dredged. Then, the grab or bucket is raised and reappointed in the closed position with contents inside; it depends on the speed of the lift. After that, the swing to discharge or grab is directed toward the hopper, and this will depend on the angle of the swing, and at the end it is discharged.

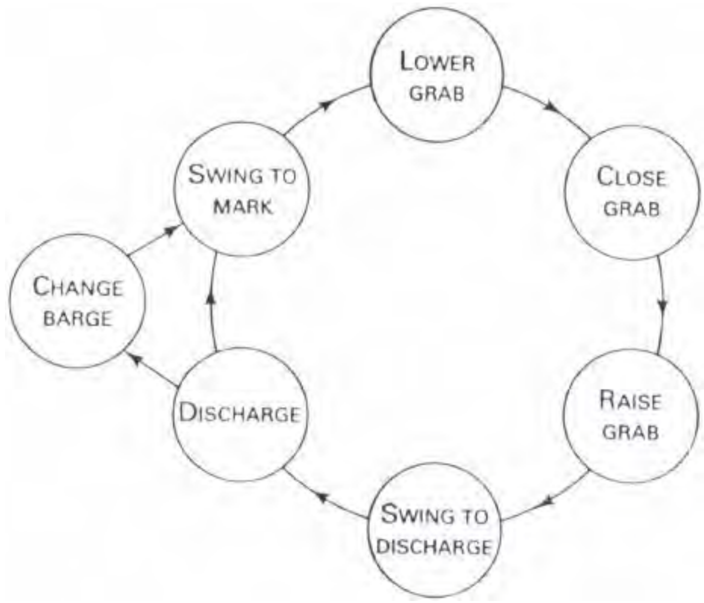


Figure 12. Operation cycle of grab dredger (Source Bray et al., 1997)

On the left side (see Figure 13) the clamshell is in the closed position and in the middle clamshell is a simple open bucket. The bucket is in the open position when it is dropped into the sediment. When it is lifted from the water, it has to be closed to retain the sediment. The clamshell is believed to be best soft sediments and in a difficult-to-access locations (Tsinker, 2004). Because the clamshell dredge is placed on a barge, it is capable of reaching many locations including difficult locations. However, because the clamshell uses mechanical cable, the length of the cable is the only thing that limits the depth of the operation.

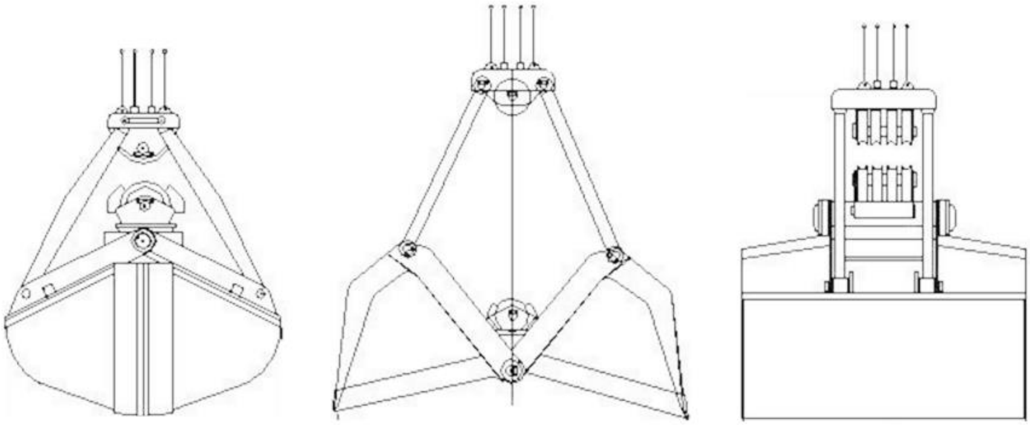


Figure 13. Clamshell bucket in operation (adapted from De Heer, 1989)

3.3.4. Estimation production of grab clamshell

The productivity of a clamshell grab dredger can be calculated by first determining several contributing factors in order to represent the actual performance of the dredgers. Bray et al. (1997) have simplified the calculation by providing a curve fitting to determine a nominal production (P_{nom}) which has been adjusted to the bucket fill factor or modification factor (f_m) and the basis of a productive unit (U_b) which represents the capacity of the bucket (C), which should be adjusted to the digability of the soil.

Table 11. Relationship between the type of grab bucket crane with dredged soil types

Bucket Type	Capacity
Mud	1.00 C
Sand/clay	0.72 C
Stones/rock	0.36 C

Further, the clamshell grab is not working by using the power of a heavy grab bucket; this is different from other types of mechanical dredger that works by using the power of the dredger itself. This is the reason why the bucket fill factor or modification factor (f_m) is lower than that of the other dredgers. Bray et al. (1997) has provided such factors in Table 12:

Table 12. Grab dredger, modification factor, f_m, for various soil types and bucket sizes

Soil type	Modification factor, f_m	
	2 m^3 bucket	4 m^3 bucket
Mud	0.75	0.80
Loose sand	0.70	0.75
Compact sand	0.60	0.70
Sand and Clay	0.50	0.60
Stones	0.35	0.45
Broken rock (Pre-treated)	0.20	0.30

Once the grab bucket capacity has been calculated, and the bucket fill factors are determined, they can be used as a supporting parameter in determining the nominal production (P_{nom}) through the following curve fitting;

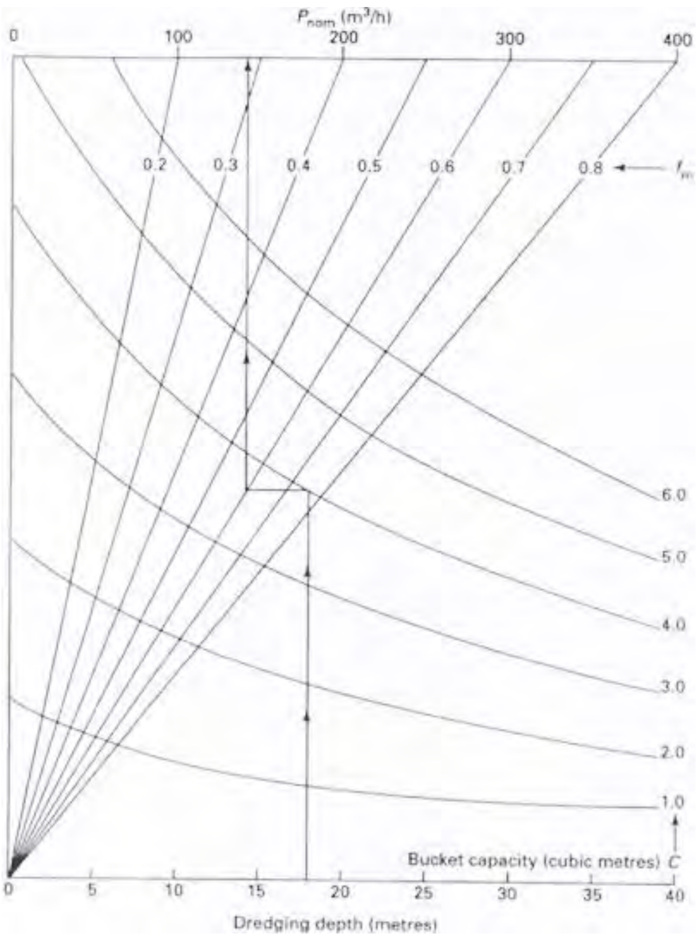


Figure 14. Grab clamshell: nominal output,P_{nom}, for various bucket sizes and dredger characteristics (Source Bray et al., 1997)

Furthermore, nominal production could be delayed due to several reasons such as the time required to advancing the dredger (f_a). Therefore, Bray et al. (1997) has defined this to be as follows;

$$f_a \quad \frac{1}{1 \quad \frac{t_a \text{ x } p_{nom}}{z}} \tag{5}$$

In the equation (5) above, A is the average area dredge, and z is the average thickness of the material, while tea is the time required (hours) to advance to the next dredging position and B is the bulking factor that is dependent on the sediment type and water content (see Table 12). Another delayed reason is the time for the changing hopper barge (f_h) and this is expressed in the following;

$$f_h \quad \frac{1}{1 \quad \underline{t_h \text{ x } f_a \text{ x } \;{}_{nom} \text{ x }}} \tag{6}$$

All of the parameters in equation (5) above are the same as in equation (6) by the addition of t_h is the time required (hours) to change hoppers, and the hopper capacity H in meters. After all the delay factors are (f_a, f_h) has been taken into account, then the maximum potential output (P_{max}) can be calculated using a nominal production (P_{nom}) as supporting parameters.

$${}_{max} \quad f_a \text{ x } f_h \text{ x } \;{}_{nom} \tag{7}$$

As already described in the equation (2) that P_{max} means maximum productivity with the circumstances under ideal conditions. Therefore, it should once again be corrected by considering the reduction factor, such as equipment malfunction, and the level of expertise the crew in order to find real productivity theory (P) that represent the actual conditions in the field. Thus, the Table 10 shows operational factors (f_o) and mechanical breakdown factors (f_b) to be considered, so that the calculation is as follows;

$$f_o \text{ x } f_b \text{ x } \quad {}_{max} \qquad (8)$$

Overall, this method works well, but only for small-sized buckets Therefore, another approach for larger bucket sizes is also needed. De Heer (1989) has another approach in calculating production of the clamshell grab with different supporting parameters. As for the calculations, it is as follows;

$$ {}_{nom} \quad \frac{\text{x } 3600}{T_{cycle} \text{ in sec.}} \qquad (9)$$

Where C is the bucket capacity, T_{cycle} is the total time needed to dredge of sedimentation until emptied and moved to another location to backfill the bucket to be emptied again (Adair, 2004). De Heer (1989) explains that for dredging depths up to 10 meters with a slewing angle of the crane by 180 degrees, the cycle time may be used for 90 seconds.

Furthermore, Adair (2004) has developed a calculation equation of bucket fill factor (f_m) for different size bucket adapted to various types of soil. as for hard soil sediment, or stone types, the calculation can as follows;

$$f_m \quad 0.1443 \text{ n} \qquad 0.25 \qquad (10)$$

Where Ln is the natural logarithm, which is the formula syntax in the calculation of aid programs such as Microsoft Excel, C is the capacity of the bucket, which is expressed in cubic meters. The bucket fill factor (f_m) for other soil types are summarized in Table 13;

Table 13. Summary of the grab clamshell, variety of bucket fill factor, f_m

Type of Soil	Range of bucket size (m^3)	Range of bucket fill factor	f_m
Mud	0 - 50	0.6 - 1	0.0474Ln(C)+0.7255
Loose Sand	0 - 50	0.6 - 1	0.0614Ln(C)+0.6607
Compact Sand	0 - 50	0.4 - 1	0.0933Ln(C)+0.5517
Sand and Clay	0 - 50	0.4 - 1	0.1228Ln(C)+0.4214
Stones	0 - 50	0 - 1	0.1443Ln(C)+0.25
Broken Rock	0 - 50	0 - 1	0.1443Ln(C)+0.1

Meanwhile, with the approach to the size of a large bucket (Adair, 2004), the nominal production (P_{nom}) in equation (9) is developed as follows;

$$ {}_{nom} \quad \frac{3600}{T_{cycle}} \, f_{m} \qquad (11)$$

3.4. Duration of the project

The productivity of the dredgers that have been obtained through the calculation of actual production was decisive in the proper length of the project (ideal) or known as productive duration. A mistake in the estimated productive duration (over-estimation) is a major cause of failure of a project (Turner, 1986). Ultimately, the actual production capacity theory will then be used as a basis for determining the approximate duration of the remaining projects, including the duration of the delay.

3.5. Dredging Cost Estimation

The productivity of each dredger, which has been obtained by calculating the actual production theory, will then be used in conjunction with a variety of price assumptions in order to estimate the cost of the dredging project alternatives. Based on the regulation of the Ministry of Transportation of the Republic of Indonesia No. KM. 70, 2010, the cost of dredging is broadly divided into two major components, namely the cost of operations and the cost of mobilization/demobilization. In addition, this ministerial regulation has also set the format of the calculation of each component cost estimates ranging from operating costs, mobilization/demobilization, crew and labor, fuel and lubricants, repair and maintenance, depreciation and insurance. In the case of the dredging operations in Indonesia, the authority has to abide to positive law of Indonesia. The considerations and additional information that are presented in this research are intended for comparative study and informational literature review.

3.5.1. Operating Cost

In the calculation of the cost of the dredging operation, it is important to know in advance the duration of the project. The real production level of dredgers are expressed in cubic meters per hour, and the volume to be dredged by each type of dredger. The cost of the dredging operation, it may consist of several factors such as the crew of the dredger, fuel, lubricants, and routine maintenance repairs, insurance, depreciation and profit (Tsinker, 2004). Then the cost of the various factors above is summed to obtain the operating costs.

3.5.2. Mobilization and Demobilization

Dredging costs of mobilization and demobilization depends on dredging fleet transportation costs to and from the project site. In fact, it is quite difficult to estimate the cost due to several factors that are not easy to be ascertained such as function of the distance itself, the crew and the lost cost resulting from the discontinuation of temporary to set-up. In addition, according to Randal (2000) in reality, no two dredgers that have to distance away to and from the project site are exactly the same.

3.5.3. Crew and Labor

In operating either the dredging operation and the operation of sailing dredgers, a reliable crew is necessary. The crew is a vital factor in a dredging project. Further, the type of crew was distinguished by its function in accordance with job placement, including personal deck and engineering, as well as a special operator for dredging.

As for the need for the number of crew, this depends on the type of dredger and the size of the vessel, automation equipment, and trip duration.

3.5.4. Fuel and Lubricants

The cost of fuel is very volatile in the marketplace. In addition, the cost factor has a fairly large portion of the cost calculation components and it is sensitive because it follows other factors such as distance and, the engine power to dredge and others. So it is necessary to limit well for the expenses of these factors. Furthermore, many different types of the machines, which work on dredgers and ancillary equipment in any dredging will cause the consumption of lubricant to be large as well. Generally argued by Tsinker (2004), in practice, the requirement for lubricant is calculated at 10% of the total cost of fuel.

3.5.5. Maintenance and Repair

Bray et al. (1997), described that by its nature maintenance is divided into two categories: routine maintenance and repairs. Tsinker (2004), however, argues that all necessary repairs during the duration of the project also included in the category of maintenance, such as replacing worn engine parts, damaged pipes, hoses, and electrical consumables. Lubrication of equipment is part of the maintenance repairs, which are minor maintenance. In addition, the major repair is anything that does not occur within the duration of the project but is still included in the contract with a small percentage of the actual maintenance costs. As to the daily cost of minor and major repairs for a trailing suction hopper dredge can be found by multiplying the capital cost of the dredge by 0.000135 and 0.000275 respectively (Bray et al., 1997).

3.5.6. Depreciation, Insurance, Overhead, Bonding and Profit

Depreciation is the reduction in the value of physical properties (dredger) over time of use and depends on the fiscal policy of the owner. According to Randall (2004) regarding the insurance of the dredger, an annual premium of 2.5 percent of insured plant value means that the daily insurance cost is the capital cost of the dredge multiplied by 0.025 and divided by the number of working days per year. Meanwhile, overhead is nine percent of the working costs already established to this point. Furthermore, Belesimo (2000), advises that project bonding may cost between 1.0 and 1.5 percent of the working cost. On the basis of these descriptions, overhead and bonding can be combined to an additional ten percent on top of the determined operating costs. Eventually, each individual contractor will determine its own profits in accordance with the type of work.

3.5.7. Additional Costs

Additional operational costs in the dredging project are reasonable as long as they do not fall into any of the above cost categories. Variations of these costs includes site surveys, environmental protection devices, and other miscellaneous items (Wowtschuk, 2016).

4. Data processing and analysis

In the dredger fleet for the dredging works of the port basin at Tanjung Perak Port, most of the dredgers will be procured domestically. The following Table 14 up to Table 17 gives the list of active dredgers owned and operated by PT RUKINDO, a state-owned dredging company.

Table 14. List of specification dredger types TSHD owned by PT Rukindo

No.	Name of Ship	Year Built	Length Overall (m)	Moulded Breadth (m)	Moulded Depth (m)	Loaded Draught (m)	Dredging Depth (m)	Hopper Capacity (m^3)
1	Bali II	1993	124.4	18.04	8.05	7	30	5,000
2	Aru II	1994	124.4	18.04	8.05	7	30	5,000
3	Irian Jaya	1981	109.88	18.04	8.05	6.33	20	4,000
4	Kalimantan II	1983	109.88	18.04	8.05	6.33	20	4,000
5	Sulawesi II	1974	92.5	16	8	7.33	20	2,900
6	Betuah	1978	92	16	8	7.33	20	2,900
7	Seram	1981	92	16	8	7.3	20	2,900
8	Halmahera	1983	92.5	16	8	7.33	20	2,900
9	Timor	1981	95	18.4	7	3	20	2,000
10	Banda	198	71.1	14	4.9	4.05	14	1,000
11	Natuna	1984	71.1	14	4.9	4.05	14	1,000

Table 15. List of specification dredger types clamshell owned by PT Rukindo

No.	Name of Ship	Year Built	Length Overall (m)	Moulded Breadth (m)	Moulded Depth (m)	Grab Capacity (m^3)	Dredging Depth (m)	Dredging Capacity (m^3)
1	Danau Laut Tawar	1974	54	23	4.5	20	25	-
2	Batur	1984	28	13	2.6	5.5	20	300
3	Ranau	1984	28	13	2.6	5.5	20	300
4	Poso	1984	28	13	2.6	5.5	20	300
5	Tondano	1984	28	13	2.6	5.5	20	300

Table 16. List of specification dredger types cutter suction owned by PT Rukindo

No.	Name of Ship	Year Built	Length Overall (m)	Moulded Breadth (m)	Moulded Depth (m)	Loaded Draught (m)	Dredging Depth (m)	Dredging Capacity (m^3/hr)
1	Batang Anai	1994	93	18.5	7	5	24	1,200
2	Kapuas 30	1976	43.17	13.41	2.9	1.9	17.68	600

Source: Website of PT (Persero) Pengerukan Indonesia, www.rukindo.co.id (2010).

The clamshell dredgers (Non-Hopper) is operated in the radius of 2.5 meters up to five meters from the edge of the wharf, while TSHD is operated beyond the limit of the clamshell dredgers.

Table 17. Auxiliary ship for dredgers owned by PT Rukindo

No.	Name of Ship	Hopper Capacity (m^3)	Speed (Knots)	LOA (m)	LBP (m)	Moulded Breadth	Height (m)
1	SB Seroja	500	5	46.58	44.52	9.75	3.66
2	SB 54	500	5	50.3	49.1	9.5	3.75

No.	Name of Ship	Draught (m)	Gross Tonnage (Tons)	Nett Tonnage	Main Engine (HP)	Depth Dredger (m)	Production Year
1	SB Seroja	1.8	518	156	2 x 480	10	1985
2	SB 54	2	528	158	2 x 370	10	1984

With regard to the types of soil in the dredging area of the port of Tanjung Perak, samples have been taken for laboratory test result (Appendix A, Table A-9). The result indicated that the silt content in the soil samples is 60%, sand content 5%, and clay content 35% with no evidence of gravel.

The grain size distribution test which was done in the laboratory using the soil samples taken coordinates 07°11.968'S and 112°43.722'E, shows that the soil predominantly consist of granules silts and clays.

Table 18. Predominant Soil Type

<table>
<tr><td colspan="2">Granules soil More than 35% where the smooth material is more than 0.06 cm</td></tr>
<tr><td>Granules silts and clays 65-100%.</td><td>Silt and clay, the gravel, sandy granules 35% - 65%</td></tr>
</table>

Table 19. Shear capacity for soil types

Silt type or silty sand	Quick Test
Loose	20^0 - 22^0
Dense	25^0 - 30^0
Clay (0^0 if saturate)	14^0 - 20^0

Table 18 shows that that strong value (N) of sediment in the port basin ranges from 4 s / d 10. The value indicated that the threshold for determining the dredging slope is between 1: 3 to 1: 4 (selected slope 1: 4).

4.1. Analysis of the Dredgers Productivity

At the port dredging project of Tanjung Perak in 2012, an outline of the work is divided into two which is based dredgers working on the location and amount of certain sedimentation stipulated in the employment contract. The number of as much as 907,049 m^3 of the sediment is carried by the type TSHD (Kalimantan II) with a capacity of 4,000 m^3 and other sediments of as much as 283,546 m^3 are carried by the clamshell dredger (Tondano) with a capacity of 5.5 m^3 with two ships assisted self-propelled hopper with a capacity of 500 m^3. Both are existing dredgers working on dredging in the port area of Tanjung Perak. The dredged area-adjusted with the results in 2012 included the sounding depth plan.

4.2. Kalimantan II

Kalimantan II is a type of dredger Trailing Suction Hopper Dredger (TSHD) which is a type of Hydraulic dredgers (Facts About: Trailing Suction Hopper Dredgers - IADC Dredging, 2014). Productivity is calculated in units of cubic meters per hour by considering transport capacity, sailing time, discharging time, unloading time, and several other reduction factors that can influence. However, in the calculation of this analysis, all the things that need to be considered in accordance with the literature review will be adjusted with the type and availability of data that have been obtained from the contractor from daily, weekly and monthly report projects. While there is a lack of data needed for this calculation, it will be overcame by assumption.

To find out more whether a dredger has been working in accordance with what has been planned by the contractor in order to complete the project, a comparison of real productivity theoretical performance and the initial calculated performance by the contractor is conducted.

Table 20. Estimates TSHD dredging cycle per day (based on estimated contractors)

No.	Dredging cycle	Time
1	Dredge	125 minutes
2	Sailed to the disposal site	72 minutes
3	Discharging	10 minutes
4	Sailed to the project site (empty condition)	60 minutes
5	Turning dredger	10 minutes
6	Number oc cycle time	277

Table 20 is the project information from the contractor, in determining the cycle time per day of TSHD, by using two pump units, then dredged material is accommodated in the hopper up to full for 125 minutes. Furthermore, when the hopper dredger is full, the pump is turned off, and the ladder lifted to be positioned on the deck, so that the ship can sail with the dredging materials to the disposal site with a time of about 72 minutes. After the dredger has arrived at the dumping site and dispose of the material by opening the bottom side of the dredger until completed and closed, this activity takes as long as 10 minutes. After the dredgers have turned and sailed back to the original location, which takes 60 minutes, they can start to perform further dredging. This is the cycle of dredging and disposal of material.

Based on the information obtained, the performance of the dredger can be determined through the calculation of productivity capacity dredgers that will be used in the project. First to determine the number of cycles (trip) in a day that can be achieved is by dividing the number of minutes in a day with the number of minutes to perform one cycle, and after the values are rounded then as many as 5 trips a day were shown, as in the following calculation;

$$\text{umbe r of trips a day} \quad \frac{\text{The amount of time in a day in minutes}}{\text{Number of cycle time}}$$

$$\text{umbe r of trips a day} \quad \frac{24 \text{ hours x } 60 \text{ minutes}}{277 \text{ minutes}} \quad 5.2 \quad 5 \text{ Tr ip}$$

Furthermore, the production capacity can be calculated by multiplying the number of trips and hopper capacity of 4,000 cubic meters, as well as the concentration of granules in a slurry of 40%, which the remaining amount of 60% is water. This is obtained through laboratory testing (in Appendix A-10) and can be described as follows;

roduction capacity The amount of trip x opper a pacity x of granules in the slurry

Then production capacity 5 x 4000 m^3 x 40 8,000 m^3/day

If divided by the number of hours in the day, the production capacity is as follows;

$$\text{roduction capacity} \quad \frac{8\ 000 \text{ m}^3/\text{day}}{24 \text{ hours}} \quad 333.33 \quad 333 \text{ m}^3/\text{hours}$$

The above equation shows the highest production with the number of trips that can be produced where it is assumed that the dredgers are working nonstop for 24 hours without stopping. Thus, it can simply be estimated that the to further the time required by the dredger in completing the work that is equal to 113 calendar days which is obtained by dividing the amount of sediment to be dredged and production capacity in a day.

The time of execution of the dredging project under the contract is 150 calendar days. Further, if it refers to the performance of TSHD, which had been planned by the contractor, the amount of 8,000 cubic meters per day, or equal to 333 cubic meters per hour, so that they can complete the job within 113 days or ahead of the time available. However, in reality it is different because, this can be known through daily and weekly reports that dredging work has been obtained, where up to week 17, the TSHDs are still working and there is still remaining work. This issue becomes quite interesting to explore as to how it was not achieved in accordance with what had been planned. In addition, the extent to which this can cause problems needs to be reviewed, especially from the viewpoint of IPC III as the operator of the port.

By knowing the production capacity in accordance with the design plan of work that has been determined by the contractor in the project contract documents. The next step is to figure out the real production capacity through an approach of project data available.

Table 21 is a summary of the weekly report of the project until week 17 (details in Appendix A, Table A-8), The data has provided a record of activities of the dredging cycle, either in the form of loading time, constrained time (delay), sailing time, discharging time, and number of trips. Thus, the calculation becomes easier by utilizing the availability of data. Furthermore, regarding the summary of the working time of the dredging project, the calculation parameters mentioned loading time (t_{load}), sailing time (t_{sail}), loading time (t_{load}), discharging time (t_d), and time delay (t_{delay}) and other reduction factors will be calculated as follows:

Table 21. Summary of work time dredging projects by Kalimantan II

	TSHD Kalimantan II						
	Loading	Delays	Sailing	Discharging	Amount of work	Productivity (m^3)	
Week	Hour	Hour	Hour	Hour	Trip	Weekly	Cumulative
1	9	20	42	1	5	8.000	-
2	15	108	43	2	14	22.400	30.400
3	27	68	69	4	23	36.800	67.200
4	22	89	53	3	18	28.800	96.000
5	39	30	94	5	32	51.200	147.200
6	30	74	62	4	20	32.000	179.200
7	44.32	18	99.75	5.5	33	52.800	232.000
8	32.33	57.83	73.67	4.17	25	40.000	272.000
9	45.17	6.92	109.75	6	37	59.200	331.200
10	27.25	67.67	69.42	3.67	22	35.200	366.400
11	21	88.08	55.75	3.17	19	30.400	396.800
12	35	42.08	86.08	4.83	29	46.400	443.200
13	31.5	47.67	84.17	4.67	28	44.800	488.000
14	31.5	51.83	80.17	4.33	27	43.200	531.200
15	42.17	11.58	108.42	6	36	57.600	588.800
16	22.17	75.42	67.25	3.17	19	30.400	619.200
17	9.33	133.58	23.75	1.33	8	12.800	632.000
Total	342	601	858.17	46.83	395		
Total hr/ total trip	1.22	2.51	3.09	0.17			

4.2.1. Loading time

Loading time (t_{load}) is obtained from the total hours of loading divided by the total number of trips in the amount of 1.22 hours.

4.2.2. Sailing time

Sailing time (t_{sail}) is obtained from the total hours of sailing divided by the total number of a sailing trip in the amount of 3.09 hours.

4.2.3. Discharging time

Discharging time (t_d) is obtained from total discharging hours divided by the total number of trips in the amount of $0.166 \approx 0.17$ hours.

4.2.4. Delay time

Delay time (t_{delay}) is time lost due to traffic, weather, and technical issues during working hour, which is obtained from the total time during the execution delayed until week 17 in the amount of 990.58 hours.

4.2.5. Delay factor

Delays need to be included in the consideration which will be adjusted with the data provided in the form of a daily report of the project. From the data, there are obstacles that led to stopped work, caused by factors including traffic, weather and other technical factors which have been represented by a total delay time (t_{delay}). In addition, total working time available until the week of the 17th amounted to 2,846 hours. Then by the using the equation number (4), delay factor into the calculation can be described as follows:

$$f_d \quad \frac{\text{Total working time available} \quad \text{time lost due to traffic during working hours}}{\text{Total working time available}} \qquad (4)$$

And so:

$$f_d \quad \frac{2\,856 \quad 990.58}{2\,856} \quad 0.65$$

4.2.6. Operational factor

According to Bray et al. (1997), the operational factor (f_o) can be seen in Tables 10 with the assumption that the influence of good management and a good crew, obtained operational factors valued at 0.9.

4.2.7. Mechanical breakdown factor

Mechanical reduction due to an engine failure or worn is 1% per year is calculated after the first 5 years. Further, the reduction factor for ships 20 years of age is equal to 0.85 (De Heer, 1989). Based on the ship particular document for dredgers types

TSHD, where the dredger was built in 1983 and the implementation of the project started in 2012, the mechanical breakdown factors (f_b) can be calculated as follows:

$$f_b \quad 100 \quad \left(\text{year dredging project} \quad (\text{year construction of dredgers} \quad 5\ \text{year})\right) \ 1$$

Then further calculations become;

$$f_b \quad 100 \quad - \left(1983 - (2012 - 5) \right) 1 \qquad 0.76$$

4.2.8. Maximum potential productivity

P_{max} means maximum productivity with the circumstances under ideal conditions. Then, after all, the parameters required in the computation have been obtained, by the using the equation number (2), so the maximum productivity can be explained to be as follows:

$$_{max} \quad \frac{f_e}{t_{load} \quad t_{turn} \quad t_{sail} \quad t_d} \tag{2}$$

And so:

$$_{max} \quad \frac{4\ 000\ m^3\ x\ 40}{1.1\ x \quad 1.22 \quad 3.09 \quad 0.17} \quad 324.\ 57\ m^3/hr$$

Where the t_{turn} has been identified as part of t_{sail} with t_{load} and t_d presented in the weekly report of the project, the bulking factor (B), according to Table 10 is obtained by 1.1 then the hopper capacity (C_H) amounted to 4,000 cubic meters and the proportion of hopper filled (f_e) according to the data available (can be found in Appendix B) is 40%.

4.2.9. Real productivity

Real production (P) is a productivity which was considered as a reduction factor that obviously occurs during the dredging process. Then by using an equation number (3) it can be explained to be:

$$_{max} \quad f_d \quad f_o \quad f_b \qquad (3)$$

Consequently:

$$324.57 \text{ x } 0.65 \text{ x } 0.9 \text{ x } 0.76 \quad 145.01 \text{ m}^3\text{/hr}$$

The value of 324.57 cubic meters per hour has been obtained from the calculation of P_{max} , as well as 0.65 which was obtained from the calculation of the delay factor (f_d) and 0.9 has been obtained from the calculation of operational factors (f_o) and 0.76 has been obtained from the calculation of the mechanical breakdown factor (f_b).

Based on the calculation above it can be seen that there are differences in estimates of production capacities ranging from the theoretical capacity (P_{nom}) which has been taken into account by the contractor and set forth in the employment contract that is equal to 333 cubic meters per hour. Then the value must be corrected by including parameters of working hours or cycles of dredging in order to represent the appropriate conditions by calculating P_{max} so then the results obtained amounted to 324.57 cubic meters per hour. However, P_{max} calculation applies only under ideal conditions where there is no hindrance at all. Thus the production capacity needs to be once again corrected by inserting some reduction factor in order to represent the real conditions, according to reality in projects such as the calculation of which the actual production amounted to 145.01 cubic meters per hours.

Table 22. Data entry section for Kalimantan II productivity

DESCRIPTION	RESULT	UNIT
Loading Time (t_{load})	1.22	hr
Sailing Time (t_{sail})	3.09	hr
Discharging Time (t_d)	0.17	hr
Total Delays Time (t_t)	990.58	hr
Buckling Factor (B)	1.1	-
Hopper Capacity (H)	4,000	m^3
Proportion of Hopper filled (f_e)	0.4	-
Delay Factor (f_d)	0.65	-
Operational Factor (f_o)	0.9	-
Mechanical Break Down Factor (f_b)	0.76	-
Maximum Potential Output (P_{max})	324.57	m^3 per hr
Output (P_{real})	145.01	m^3 per hr

Table 22 is the entry of data describing the results of calculations with the excel auxiliary program where the first column to the left is a description of factors that need to found. Then, continued in the second column in the middle is the result of the calculation and the last column on the right side is the unit of each factor counted.

4.2.10. Achievement of the project duration by the existing TSHD

The amount of volume to be dredged by TSHD is as much as 907,049 cubic meters and should be completed within 150 calendar days. If work has begun on 31 July 2012, the project will end on 27th December 2012. Meanwhile, referring to the daily and weekly reports of the project until week 17 or until 25 November 2012, TSHD has been working with the dredged material of 632,000 cubic meters. Based on this explanation, so that the time is left for TSHD project is only for 33-days calendar, and still leaves the volume of work amounted to 275,049 cubic meters. Further, if viewed from the planned production capacity by the contractor in the amount of 8,000 cubic meters per day, then the dredging project is able to be completed in only 113 calendar days or finished early in week 17 or on the 20 November 2012. This is obtained by dividing the total volume to be dredged with the planned production by the contractor. However, if viewed from the real productivity theory and the project require additional time during the 79 calendar days (or 46 calender days from 27th of December 2012); this is obtained by dividing the volume of the remaining work with real productivity theory and will be completed on 10 February 2013, of course, this is a delay in the work. Further, the explanation achievement of the time of this work can be simplified in the following illustration:

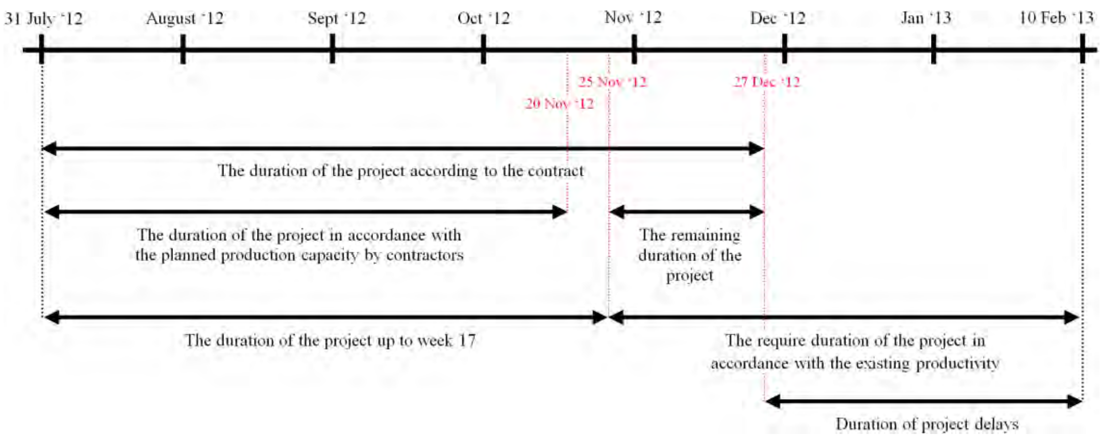


Figure 15. Timeline of dredging project by TSHD

On the other hand, apparently the result using the real productivity theory only amounted to 145.01 cubic meters per hour or approximately equivalent to 3,480.16 cubic meters per day (assuming worked nonstop for 24 hours a day). There are different estimates of production capacity significantly between the real productivity theory with the planned productivity by the contractor, in the amount of 4,519.84 cubic meters per day. This led to not achieving the production targets as planned and in the end, the project was not completed on time.

Table 23. Comparisons of estimates production capacity

TSHD Kalimantan II					
Week	The average real production capacity		Planned production capacity		Difference in production capacity
	Weekly (m^3)	Daily (m^3/hr)	Weekly (m^3)	Daily (m^3/hr)	Daily (m^3/hr)
(1)	(2)	(3)	(4)	(5)	(6)
1	8.000	48	56.000	333	286
2	22.400	133	56.000	333	200
3	36.800	219	56.000	333	114
4	28.800	171	56.000	333	162
5	51.200	305	56.000	333	29
6	32.000	190	56.000	333	143
7	52.800	314	56.000	333	19
8	40.000	238	56.000	333	95
9	59.200	352	56.000	333	(19)
10	35.200	210	56.000	333	124
11	30.400	181	56.000	333	152
12	46.400	276	56.000	333	57
13	44.800	267	56.000	333	67
14	43.200	257	56.000	333	76
15	57.600	343	56.000	333	(10)
16	30.400	181	56.000	333	152
17	12.800	76	56.000	333	257

In the implementation of dredging is shown Table 23. The real maximum productivity, can be achieved only on week 9 and week 15 with the amount of 352 and 343 cubic meters per hour respectively. However, in average, the productivity realization as presented by the contractor data is way below the target. It can be concluded that there is a gap between the productivity planned by the contractor and the actual production per hour for existing TSHD which evantually requires additional measures related to time and capacity so that the work can be completed on time.

4.2.11. Productivity of other alternative TSHD

The previous discussion information about the number, type, and specification fleet of dredgers owned by PT Rukindo as local contractors has been given. Therefore, the next step is to analyze the productivity of other TSHD. To estimate the real productivity, data and the same factors as in the previous calculations are required, as described in Table 24:

Table 24. Comparisonss of estimated production capacity

No.	Data calculation	Result	Unit
1	Hopper Capacity (H)	adjusted	m3
2	Buckling Factor (B)	1.1	-
3	Sailing Time (t_s)	3.09	hours
4	Loading Time (t_{load})	adjusted	hours
5	Discharging Time (t_d)	adjusted	hours
6	Proportion of Hopper filled (f_e)	0.4	-
7	Delay Factor (f_d)	0.65	-
8	Operasional Factor (f_o)	0.9	-
9	Mechanical Break Down Factor (f_b)	0.76	-

For simplification of the calculation, as shown in Table 24 defined points (2), (3), (6), (7), (8) and (9) are assumed to equal the values used by the calculation of TSHD Kalimantan II. Points (1) will depend on the specifications of the dredger, whereas points (4) and (5) will be put on the value of data that will be adjusted to TSHD Kalimantan II.

Further, in order to analyze all the alternatives productivity dredgers which are still of the same type as TSHD, some data from previous analyses of existing dredgers will be referenced and adapted to the capacity of other alternatives dredgers, calculation will start from the lowest-capacity hopper, namely TSHD 1000. Regarding the daily and weekly reports from the TSHD Kalimantan II, it is known that the dredger has a capacity of 4,000 cubic meters with a load time (t_{load}) of 1.22 hours, which means that the capacity TSHD 1000 is four times smaller than the existing THSD. Therefore, through the simple way of loading 1,000 cubic meters of dredging materials, it takes (t_{load}) 1.22 hours divided by 4 resulting in 0.306 hours. Whereas in terms of discharging, this will be adjusted to the previous calculation of TSHD; Therefore, it is known that the discharging time through the hopper is 0.17

hours or equal to 17 minutes per 4,000 cubic meters. So that to dispose of dredging material as much as 1,000 cubic meters will be required in discharging time (t_d) for 0.17 hours divided by 4 with a result of 0.042 hours which is equivalent to 2.5 minutes. Furthermore, parameters have been fulfilled, so the calculation of the maximum capacity (p_{max}) of TSHD 1000 could be estimated by equation (2). This is described as follows:

$$_{max} \quad \frac{f_e}{t_{load} \quad t_{turn} \quad t_{sail} \quad t_d} \qquad (2)$$

Consequently:

$$_{max} \quad \frac{4\,000 \text{ m}^3 \text{ x } 40}{1.1 \text{ x } \ 1.22 \quad 0.306 \quad 0.042} \quad 105.75 \text{ m}^3\text{/hr}$$

While the real production capacity (P) of TSHD 1000, then by the using the equation number (2), can be calculated to be as follow:

$$_{max} \quad f_d \quad f_o \quad f_b \qquad (3)$$

Consequently:

$$150.36 \text{ x } 0.65 \text{ x } 0.9 \text{ x } 0.76 \quad 47.24 \text{ m}^3\text{/hr}$$

As for the result, is a real productivity theory of TSHD 1000 amounted to 67.17 cubic meters per hour. While for other TSHDs, real productivity theory can be calculated in the same way and the results are shown in Table 25.

Table 25. Estimates of other alternative TSHD production capacity

No.	DESCRIPTION	UNIT	TSHD				
			1000 m3	2000 m3	2900 m3	4000 m3	5000 m3
1	Hopper Capacity (H)	m^3	1000	2000	2900	4000	5000
2	Buckling Factor (B)	-	1.1	1.1	1.1	1.1	1.1
3	Sailing Time (t_s)	hr	3.09	3.09	3.09	3.09	3.09
4	Loading Time (t_{load})	hr	0.306	0.612	0.887	1.22	1.530
5	Discharging Time (t_d)	hr	0.042	0.083	0.121	0.17	0.208
6	Proportion of Hopper filled (f_e)	-	0.4	0.4	0.4	0.4	0.4
7	Delay Factor (f_d)	-	0.65	0.65	0.65	0.65	0.65
8	Operasional Factor (f_o)	-	0.90	0.90	0.90	0.90	0.90
9	Mechanical Break Down Factor (f_b)	-	0.76	0.76	0.76	0.76	0.76
10	Maximum Potential Output (P_{max})	m^3 per hr	105.75	192.08	257.26	324.57	376.52
11	Real Capacity production (P)	m^3 per hr	47.24	85.81	114.94	145.01	168.21

Furthermore, the real productivity of each alternative TSHD has been obtained in accordance with the description of Table 25 and the comparison of each of productivity, is illustrated in Figure 16:

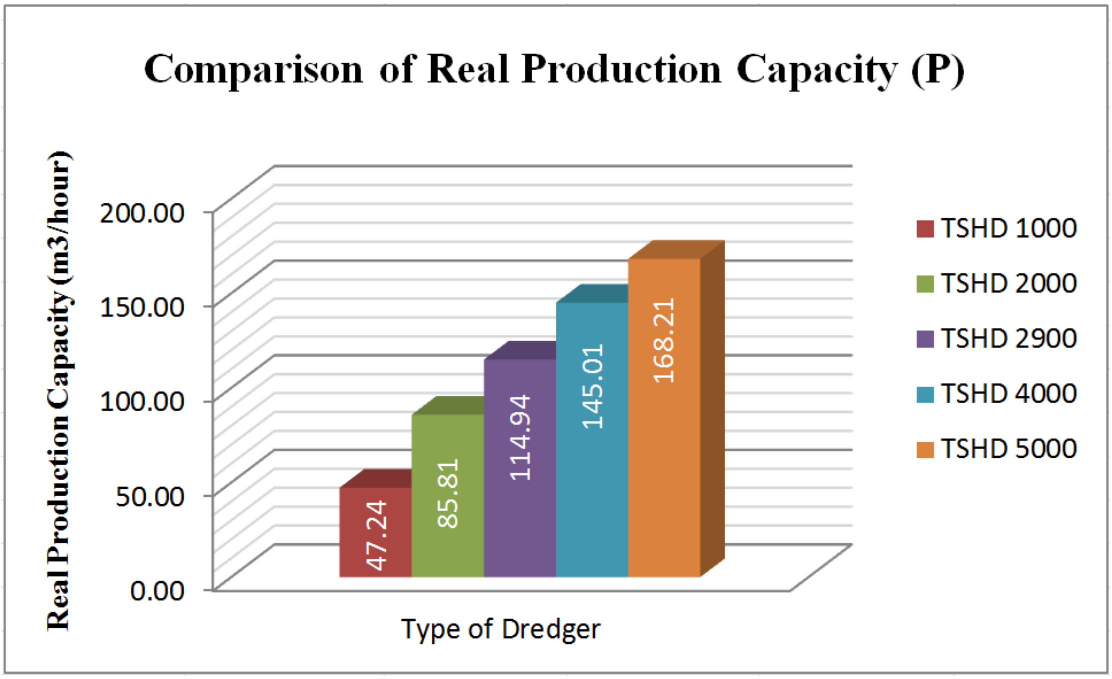


Figure 16. Comparison of other TSHD real production capacity theory

In the previous discussion, calculating the rest of the sediment to be dredged as 275,049 cubic meters divided by the remaining duration of the project (33 calendar days) resulted to 347 cubic meters per hour which is the real productivity needed to complete the work on time. This calculation is needed to support the decision to combine two TSHDs working at different locations, which remain in the same project area.

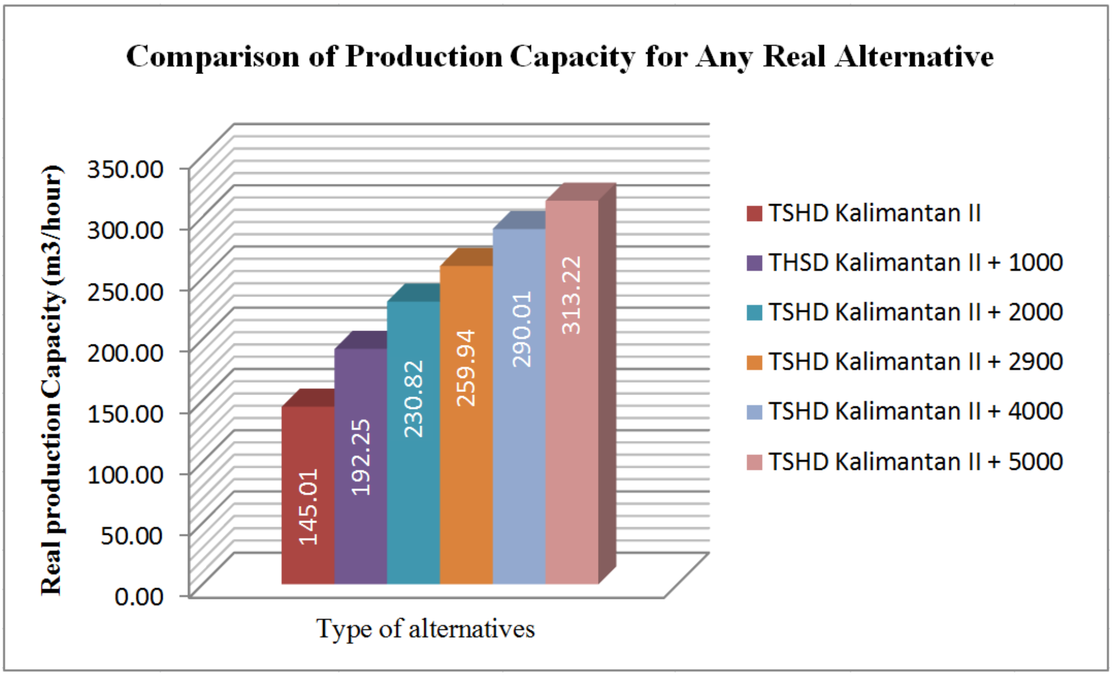


Figure 17. Comparison of production capacity for any real TSHD alternative

A combination, which is able to produce the highest productivity, is the existing TSHD with TSHD 5000 by real productivity theory of 313.22 cubic meters per hour as shown in Figure 17. With a combination of two TSHDs, the contractor was able to complete the project on 30 December 2012. Thus, the project contract for the duration of the project deadline was on 27 December 2012, so this alternative project will only be delayed for 3 calendar days. This happened because the minimum capacity required for the acceleration of production, there was still a difference of 34.07 cubic meters per hour. More than that, this combination is the most probable alternative solution by the contractor. However, the issue of costs needed has to be considered; because the project owner, who in this case is the port, will not provide additional cost for this issue. While accelerating the achievement of the project by another alternative, TSHD combinations can be seen in Figure 18. Further, calculation can be found in the Appendix B.

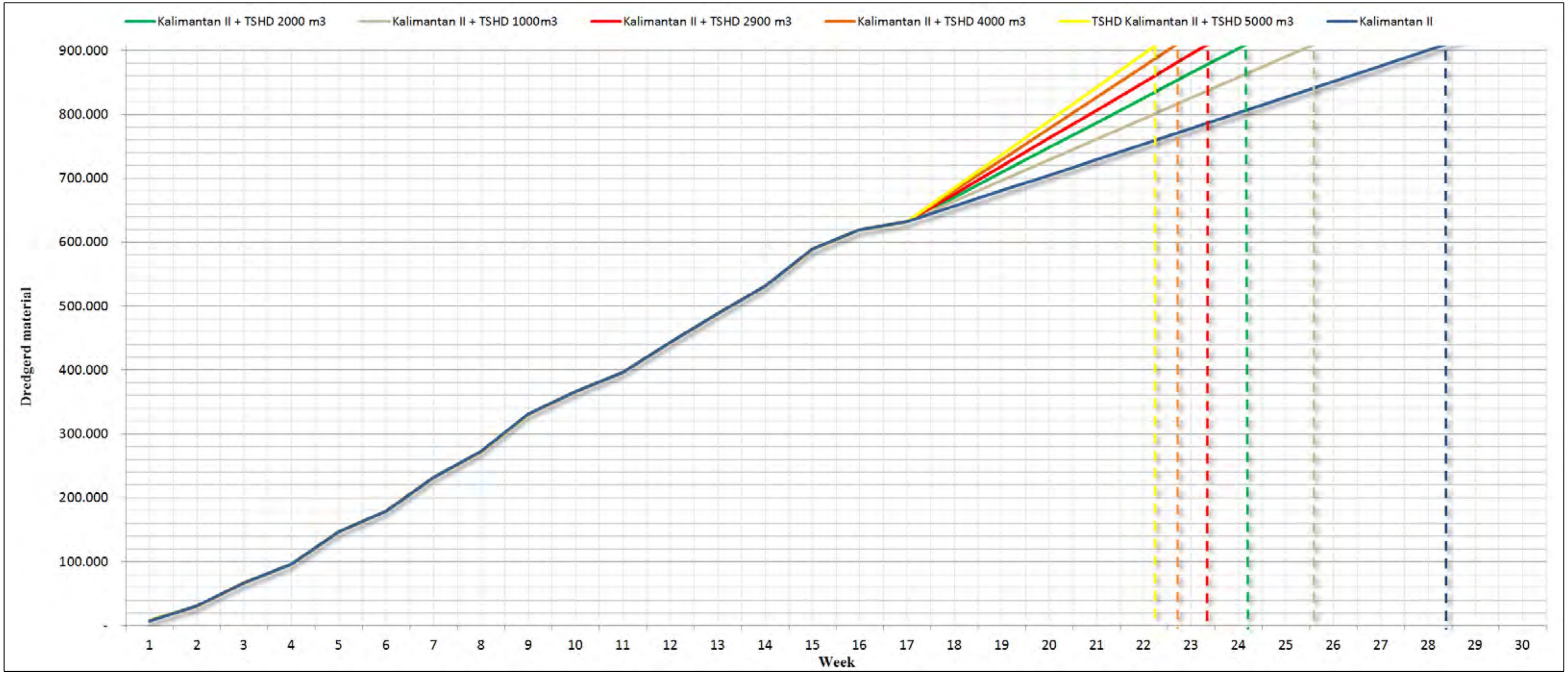


Figure 18. Comparison of production capacity for any real alternative

4.2.12. Delay factor Information of TSHD

Based on the summary of daily reports for delays in the project (Appendix A, Table A-8), factors causing delays during the project implementation are classified into six factors. As for the main cause is waiting for lubricant, have led the project to lose of time of 293.42 hours or approximately 12 calendar days. In addition, other causes of repair and maintenance of engine failure amounted to 265.08 hours, or approximately 11 calendar days. In addition, there are factors such as the time of prayer and religious holidays, waiting to re-fuel, waiting to recharge freshwater, and such others as bad weather, where the four last factors accounted for 413.42 hours of lost time, or approximately 17 calendar days. As for the details, these can be seen in Table 26:

Table 26. Factors causing delays

No.	DESCRIPTION	Time Delays		
		Hours	Days	%
1	Waiting for Lubricant	293.42	12.2	8.15%
2	Repair and Maintenance of Engine Failure	265.08	11.0	7.36%
3	The Time of Prayer & Religious Holidays	199.92	8.3	5.55%
4	Waiting for Refueling	158.67	6.6	4.41%
5	Waiting for Recharging of Freshwater	49.00	2.0	1.36%
6	Bad Weather	5.83	0.2	0.16%
	Total Time Lost	**971.92**	**40.5**	**27.00%**
	Total Time Available for the Project ; 150 Days Calender			

Further, from Table 26, for the factor number one up to number five, they can be categorized as project management issues, and factor number six as external factor (weather), which had contributed to lost time, overall, a total of approximately 40.05 calendar days equal to 27% of the project duration.

4.3. Tondano

After the previous analysis of the TSHD, analysis will now be given for the type of clamshell, through the approach of real productivity theory, which has been adjusted to the conditions of the project. Bray et al. (1997) have provided data for the fill factor through the curve fitting method. Furthermore, it is also necessary to know, in advance, how contractors plan and determine the production capacity and suitability in the field. Only, then can a comparison of productivity of both approaches be conducted an alternative solution given as to when the project has the potential to be late because there is a difference in productivity plans, in reality. In the context of the analysis, the real productivity of Tondano will be adjusted by the project data that has been obtained in the form of daily and weekly project reports.

Table 27. Estimates grab clamshell dredging cycle per day (based on estimated contractors)

No.	Dredging cycle	Time
1	Fill the bucket	136 minutes
2	Sailed to the disposal site	120 minutes
3	Discharging	10 minutes
4	Sailed to the project site (empty condition)	90 minutes
5	Manuevering/Turning dredger	20 minutes
6	Number of cycle time	376

Table 27 presents information that shows the project from the contractor estimate of the cycle time the clamshell with a capacity of 5.5 m^3 per day. Further, Tondano disposes of dredged materials into a hopper vessel with a capacity of 500 cubic meters, which is located next to them, and it takes 136 minutes. After that, the hopper will sail to the disposal site within 120 minutes and dispose of materials from the dredging within 10 minutes. Then, it goes back again to the project site for 90 minutes and later berthing next to the side of the clamshell while waiting to go back, because in this activity there are two ships hoppers, which take turns in working for Tondano.

Based on the information from these contractors, the next performance of Tondano can be determined by calculating the capacity of clamshell dredgers that will be used in the project. The first step is to determine if the number of cycles per day is achieved by dividing the time available in a day expressed in minutes and then divided by the amount of time in one cycle. Then the number of trips per day for 3 times is obtained. The explanation is as follows:

$$\text{umbe r of trips a day} \quad \frac{\text{24 hours x 60 minutes}}{\text{376 minutes}} \quad 3.12 \quad \text{3 Tr ip}$$

The use of two hoppers by Tondano, is certainly enough to affect the amount of the resulting productivity. The planned production capacity by the contractors can be calculated by multiplying these parameters, either the number of trips generated in one cycle, the hopper capacity of 500 cubic meters, the amount of the hopper, and the level of concentration of granules in a slurry of 40%. In which the remaining amount of 60%, which was obtained through laboratory testing (Appendix A, Table A-10). This is described as follows;

$$\text{roduction capacity} \quad \text{3 Trip x 500 m}^3 \text{ x 2 hopper x 80} \quad \text{2,400 m}^3\text{/day}$$

If divided by the number of hours in the day, the production capacity to be as follows;

$$\text{roduction capacity} \quad \frac{\text{2 400 m3/day}}{\text{24 hours}} \quad \text{100 m}^3\text{/hours}$$

The above equation shows the highest production with the number of trips that can be produced, where it is assumed that the dredgers are working nonstop for 24 hours without stopping. The performance of Tondano had been planned by the contractor in the amount of 100 cubic meters per hour, so the project could be finished within 118 days or ahead of the time available. However, in reality it is slightly different where real productivity is resulting smaller than planned by the contractor. Table 28 illustrates the known average productivity based on performance in the field.

Table 28. Summary progress of productivity Tondano

Week	Clamshell Tondano			
	Progress of work (%)		Progress of work (m^3)	
	%	%	m3	m3
	Weekly	Cumulative	Weekly	Cumulative
1	0.42%	0.42%	1.200	1.200
2	5.64%	6.07%	16.000	17.200
3	3.67%	9.73%	10.400	27.600
4	3.39%	13.12%	9.600	37.200
5	3.39%	16.51%	9.600	46.800
6	3.81%	20.31%	10.800	57.600
7	5.08%	25.39%	14.400	72.000
8	4.37%	29.77%	12.400	84.400
9	6.49%	36.26%	18.400	102.800
10	4.94%	41.19%	14.000	116.800
11	2.40%	43.59%	6.800	123.600
12	3.39%	46.98%	9.600	133.200
13	4.23%	51.21%	12.000	145.200
14	5.36%	56.57%	15.200	160.400
15	6.35%	62.92%	18.000	178.400
16	5.50%	68.42%	15.600	194.000
17	4.94%	73.36%	14.000	208.000
Average weekly production			12235.29	m^3/week
Average daily production			1.748	m^3/Day
Average real production capacity (P)			72.83	m^3/Hour

Table 28 is a summary of productivity progress of the Tondano until week 17 by the real average production by 72.83 cubic meters per hour. However, average production is in contrast with the theoretical calculation of actual production in order to illustrate the performance of dredgers in accordance with the reality of the project. Further, it is necessary to determine the duration of the project implementation. As in the calculation of TSHD before, there are some required parameters in determining the real productivity for the clamshell as described by Bray et al. (1997) that the reduction is an important factor to consider.

4.3.1. Productive Unit

The productive unit for the grab clamshell should be modified in accordance with the digability of the soil (Bray, 1997). The type of material sedimentation in front of the wharf is stones/rock, so the according to the Table 11, the bucket capacity is considered to be equal to 2 cubic meters obtained from the multiplication of the bucket capacity of 5.5 cubic meters multiplied by a factor of digging capacity that is equal to 0.36.

4.3.2. Modification Factor

The modification factor (f_m) is for the type of sand and clay. However, there is in fact more common hard soil, which is almost like a rock, so in this case it is assumed as a rock. Soil can be adjusted with table 12 is 0.45.

4.3.3. Nominal Production

Nominal production (uninterrupted output), P_{nom} is the production capacity by dredging cycle. P_{nom} can be calculated by the curve fitting provided by Bray et al. (1997), so that by entering parameters such as bucket capacity and modification factors, P_{nom} of 85 cubic meters per hour is obtained, as described in Figure 19:

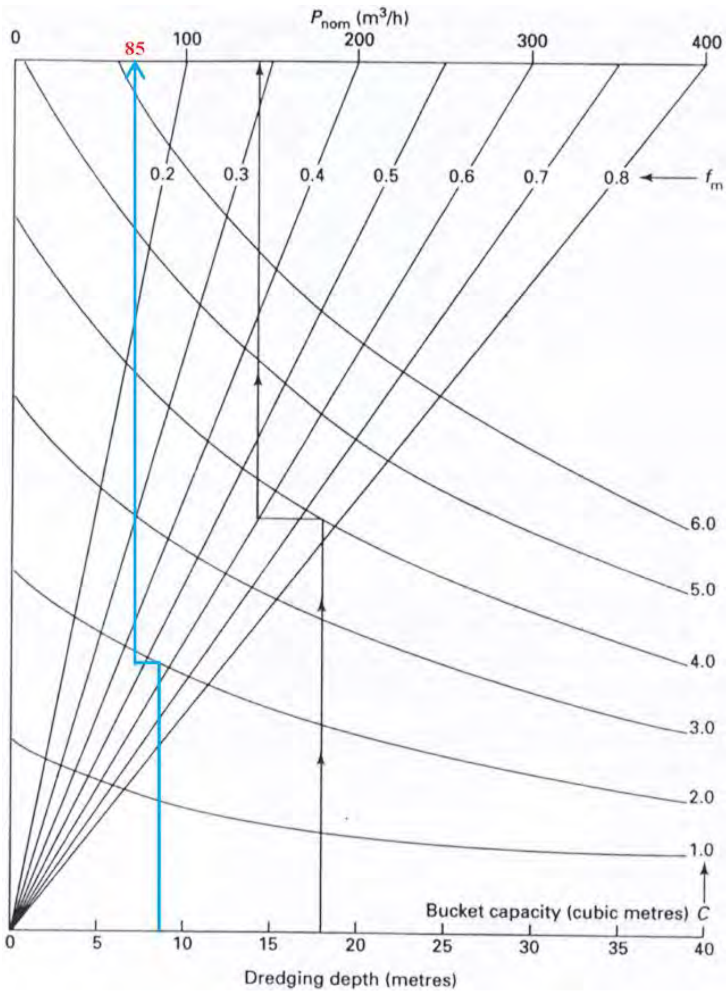


Figure 19. Grab dredger nominal output Pnom, for various bucket sizes and dredger characteristics (Source Bray et al., 1997)

4.3.4. Delay Factor

Bray et al. (1997) explained that it is important to know the delay factor due to advancing the dredger and the delay factor due to changing hoppers when they are full. Then by using the equation (5) and (6) respectively, both kinds of delay factors can be explained as is follows:

$$f_a \quad \frac{1}{1 \quad \frac{t_a \text{ x } p_{nom}}{z}} \tag{5}$$

Consequently:

$$f_a \quad \frac{1}{1 \quad \frac{0.45 \text{ x } 85}{10{,}000 \text{ x } 1}} \quad 0.996$$

While f_h can be calculated as is follow:

$$f_h \quad \frac{1}{1 \quad \underline{t_h \text{ x } f_a \text{ x } \quad _{nom} \text{ x }}} \tag{6}$$

And so:

$$f_h \quad \frac{1}{1 \quad \frac{1 \text{ x } 0.996 \text{ x } 85 \text{ x } 0.45}{500}} \quad 0.93 \tag{6}$$

Where (f_a) is the delay factor for advancing and (f_h) is the delay factor due to changing hoppers which are both reduction factors consisting of some calculation parameters, such as (t_a) or the time it takes to advance to the next dredging position and expressed in units of hours. Furthermore, where (t_h) or the time is needed to change hoppers, then P_{nom} was calculated previously, and afterwards there was (A), or the average area dredged by each crane in one dredging position and is expressed in units of square meters, while (z) is the average thickness of material to be dredged in one cut, and is expressed in units of meters. The hopper capacity (H) is expressed in cubic meter.

4.3.5. Maximum potential productivity

P_{max} means maximum productivity with the circumstances under ideal conditions. Then, after all, the parameters required in the calculation has been obtained, by using the equation number (7). The maximum productivity can be explained to be as follows:

$$_{max} \quad f_a \text{ x } f_h \text{ x } \quad _{nom} \qquad (7)$$

And so:

$$_{max} \quad 0.99 \text{ x } 0.93 \text{ x } 85 \leftrightarrow \quad _{max} \quad 78.68 \text{ m}^3\text{/hr}$$

4.3.6. Real productivity

Real production (P) is a productivity which was considered a reduction factor that obviously occurs during the dredging process. Then, assuming that the value of operational factors (f_o) and mechanical breakdown factor (f_b), is equal to TSHD, but for the delay, the factor will adjust the actual condition of the clamshell, so that real production can be explained as follows:

$$_{max} \quad f_d \quad f_o \quad f_b \qquad (3)$$

And so:

$$76.68 \text{ x } 0.9 \text{ x } 0.76 \quad 53.82 \text{ m}^3\text{/hr}$$

Based on the weekly production reports from Tondano as shown in table 28, real production capacity average is 72.83 cubic meters per hour. There is a difference of 19.01 cubic meters per hour between the average productivity with real productivity results of calculations using the theory or at 1.35 when both are divided. Table 29 the process of data entry and calculations for the Tondano productivity theory.

Table 29. Data entry section for Tondano productivity

DESCRIPTION	RESULT	UNIT
Bulking factor (B)	0.45	-
Bucket Capacity (C)	5.5	m^3
Productive unit (U_b)	2	-
Number of Grab Hopper (N)	2	-
Grab Hopper Capacity (H)	500	m^3
Average dredging depth (d)	8	
Average thickness of material to be dredged in one cut (z)	1	m^3
Average area dredged (A)	10000	m^2
Time required to advance to the next dredging position (t_a)	0.45	hrs
Time required to change hopper (t_h)	1	hrs
Nominal uninterrupted output (P_{nom})	85	m^3 per hr
Delay factor for advancing (f_a)	0.99	-
Delay factor due to changing hoppers (f_h)	0.93	-
Maximum potential productivity (P_{max})	78.68	m^3 per hr
Output (P_{real})	53.82	m^3 per hr

4.3.7. Achievement of the project duration by the existing grab clamshells

The volume to be dredged by grab clamshell is as much as 283,546 cubic meters and should be completed within 150 calendar days. If the work has begun on 31 July 2012, it will end on 27th December 2012. The daily and weekly reports of the project until week 17 or until 25 November 2012, the grab clamshell dredged 208,000 cubic meters. According to this data explanation, so that the time is left for TSHD project is only for 33-days calendar, and still left a volume amounting to 75.546 cubic meters. Further, if viewed from the planned production capacity by the contractor in the amount of 2,400 cubic meters per day, then the dredging project will be able to be completed in only 118 calendar days or will be finished 32 days ahead or on the 25 November 2012. However, if viewed from the real productivity theory and the project require additional time during the 58 calendar days (or 25 calender days from 27th of December 2012); this is obtained by dividing the volume of the remaining work with real productivity theory and will be completed on 20 January 2013.This is delayed in the work for 25-days. Further, the explanation of the achievement of the time of this work can be simplified in the following illustration;

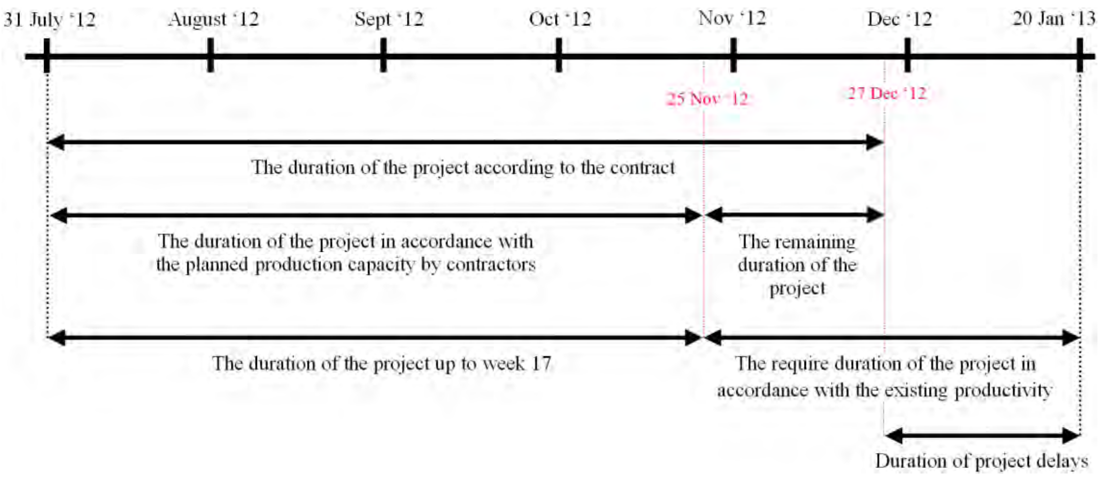


Figure 20. Timeline of dredging project by Clamshell

Table 30. Comparisons of estimates production capacity

Tondano - Clasmshell							
Week	The average real production capacity		Real production capacity theory		Planned production capacity		Difference in production capacity
	Weekly (m^3)	Daily (m^3/hr)	Weekly (m^3)	Daily (m^3/hr)	Weekly (m^3)	Daily (m^3/hr)	Daily (m^3/hr)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) = (7) - (3)
1	1.200	7.14	9041.28	53.82	2400	100	93
2	16.000	95.24	9041.28	53.82	2400	100	5
3	10.400	61.90	9041.28	53.82	2400	100	38
4	9.600	57.14	9041.28	53.82	2400	100	43
5	9.600	57.14	9041.28	53.82	2400	100	43
6	10.800	64.29	9041.28	53.82	2400	100	36
7	14.400	85.71	9041.28	53.82	2400	100	14
8	12.400	73.81	9041.28	53.82	2400	100	26
9	18.400	109.52	9041.28	53.82	2400	100	(9.52)
10	14.000	83.33	9041.28	53.82	2400	100	17
11	6.800	40.48	9041.28	53.82	2400	100	60
12	9.600	57.14	9041.28	53.82	2400	100	43
13	12.000	71.43	9041.28	53.82	2400	100	29
14	15.200	90.48	9041.28	53.82	2400	100	10
15	18.000	107.14	9041.28	53.82	2400	100	(7.14)
16	15.600	92.86	9041.28	53.82	2400	100	7
17	14.000	83.33	9041.28	53.82	2400	100	17

A comparison of the three methods of approach to estimate productivity results as shown in Table 16, where the week-9th and 15th, respectively generate 109.52 and 107.14 cubic meters per hour. Average productivity shows the progress of work exceeds that of planned productivity by contractors. However, from the perspective of the project owner (port), real productivity theory is more decisive to be considered as a productivity which represents the real performance in the field because it had been to consider the factor of reduction according to the conditions at the project site. in addition, productivity has a smaller value so that in the implementation of the project the contractor is expected to be better prepared, in providing the type of dredger and production capacity is well used.

4.3.8. Productivity of another alternative Clamshell

There is a significant difference between the real productivity theory and planneds contractor productivity caused by an estimated project delay by up to 25 calendar days. In addition, these conditions should be anticipated by accelerating the implementation of the project by an approximate calculation of the delay duration of the project by providing an alternative to another similar dredger with varying capacities. Furthermore, besides the clamshell bucket capacity of 5.5 cubic meters, the contractor also has a clamshell bucket capacity of 20 cubic meters as an alternative solution.

4.3.9. Productivity of Danau Laut Tawar

Danau Laut Tawar is the name of the type clamshell dredger bucket capacity of 20 cubic meters owned by PT Rukindo. Below is the calculation to determine the productivity theory required modification factor or bucket fill factor (f_m) which was obtained through the equation for the number (10):

$f_m \quad 0.1443 \text{ n} \qquad 0.25$ (10)

And so:

$f_m \quad 0.1443 \text{ x } \quad \text{n } 20 \qquad 0.25 \qquad f_m \quad 0.68$

While the nominal production can be calculated by an equation number (11) by first determining the productive unit (U_b) following table (11) at 0.36 C, so calculations be are as follows:

$$_{nom} \quad \frac{3600}{T_{cycle}} \text{ f }_{m} \qquad (11)$$

Consequently:

$$_{nom} \quad \frac{3600}{90} \text{x } 7.2 \text{ x } 0.68 \quad 196.50 \text{ m}^3\text{/ hrs}$$

Then by assuming that the value f_o and f_h are equal to Tondano, the P_{max} can be calculated to be the following:

$$_{max} \quad f_a \text{ x } f_h \text{ x } \;_{nom} \qquad (7)$$

And so:

$$_{max} \quad 0.996 \text{ x } 0.93 \text{ x } 196.50 \rightarrow \;_{max} \quad 181.89 \text{ m}^3\text{/ hrs}$$

Finally, the real production theory of the clamshell 20 cubic meters, can be calculated by taking into account the reduction factor for f_o and f_b which are assumed to be equal to the previous calculation. So the calculation is as follows:

$$f_o \text{ x } f_b \text{ x } \;_{max} \qquad (8)$$

And so:

$$0.90 \text{ x } 0.76 \text{ x } 181.89 \rightarrow \qquad 124.41 \text{ m}^3\text{/ hrs}$$

The real productivity theory of each variation clamshell has been taken into account and can be used as an alternative solution to meet the rest of the projected volume.

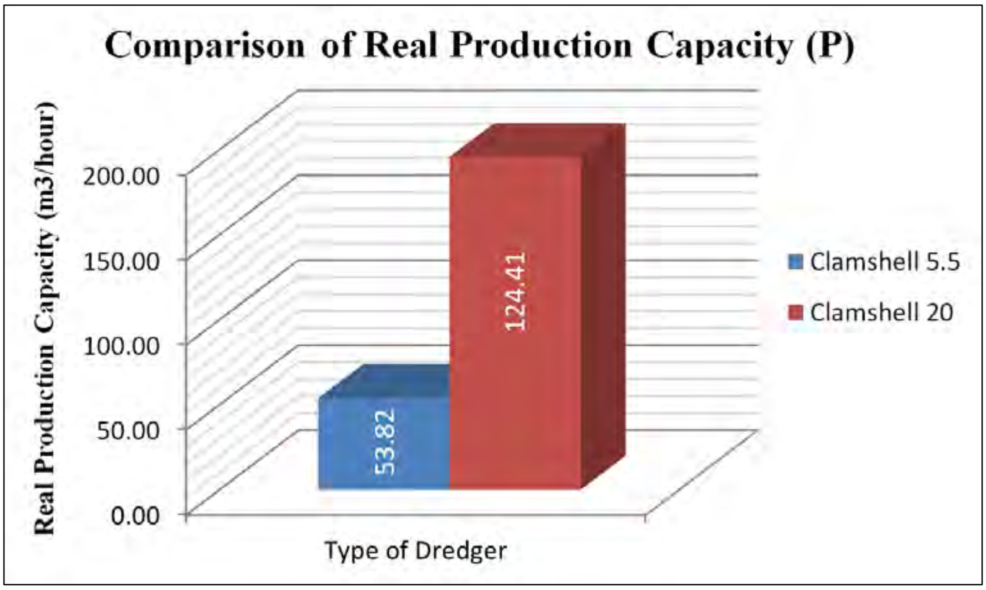


Figure 21. Comparison of other Clamshell real production capacity theory

In fulfilling the rest of the dredging volume with the remaining time available, the required minimum production capacity is 95.39 cubic meters per hour. Therefore, the combination of the two clamshell dredgers is necessary to be considered as an alternative in resolving the issue.

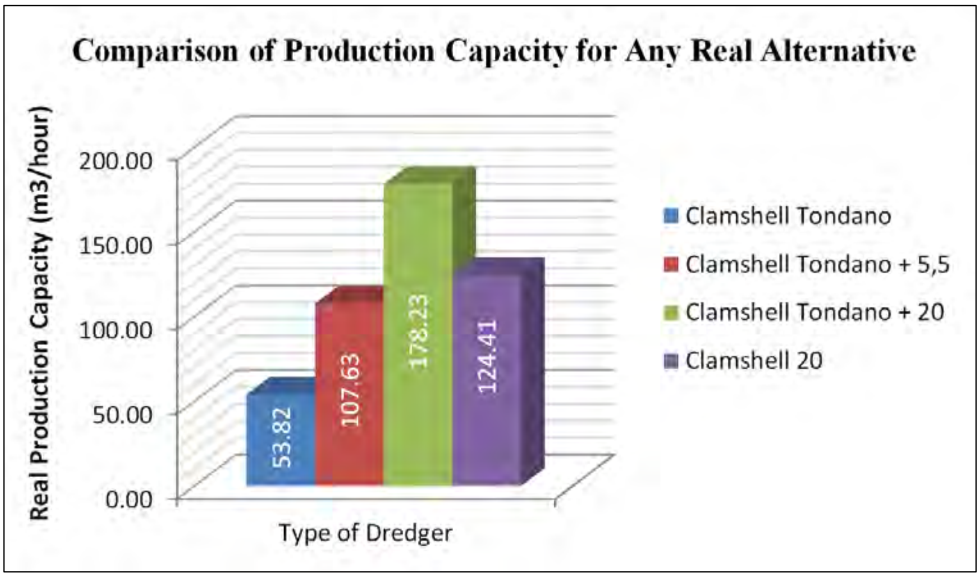


Figure 22. Comparison of production capacity for any real Clamshell alternative

Tondano combined with a clamshell bucket capacity of 20 cubic meters, has produced the highest productivity as shown in Figure 22. This implementation through a combination of dredgings can be completed during the period to 19 weeks with a productivity of 178.23 cubic meters per hour. However, the cost factor should be considered in order to set the optimal solution of the problem.

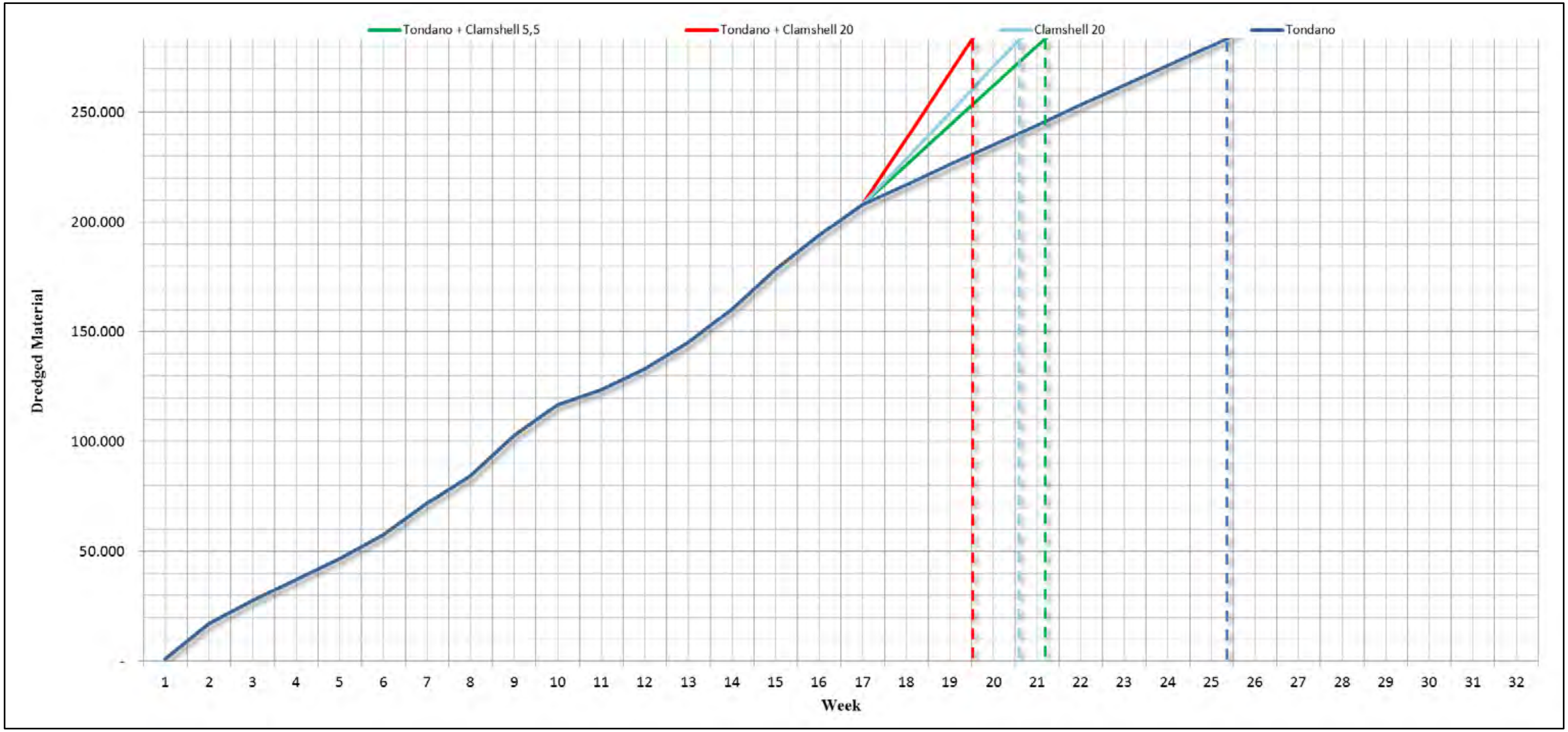


Figure 23. Comparison of production capacity for any real alternative

4.3.10. Delay factor Information of Grab Clamshell

Based on the summary of daily reports for delays in the project, the factors are classified into six factors that cause delays during the project implementation. As for the main causes are repair and maintenance of engine failure, have led the project a time lost of 288.83 hours or equal to 12 calendar days. In addition, other causes are waiting for lubricant amounted to 153.00 hours or approximately 6 calendar days. In addition, there are factors, such as the time of prayer and religious holidays, administrative issue, waiting for refueling, and movement the position of the dredger, where the four last factors is accounted for 198.42 hours of lost time or approximately 8 calendar days. The details can be seen in Table 31:

Table 31. Factors causing delays

No.	DESCRIPTION	Time Delays		
		Hours	Days	%
1	Repair and Maintenance of Engine Failure	288.83	12.0	8.02%
2	Waiting for Lubricant	153.00	6.4	4.25%
3	The Time of Prayer & Religious Holidays	144.00	6.0	4.00%
4	Administrative issues	24.83	1.0	0.69%
5	Waiting for Refueling	20.17	0.8	0.56%
6	Movement the Position of the Dredger	9.42	0.4	0.26%
	Total Time Lost	**640.25**	**26.7**	**17.78%**
	Total Time Available for the Project ; 150 Days Calender			

Further, from Table 31, for the factors number one up to number six, can be categorized as project management issues which had been contributed to losing time overall of approximately 26 calendar days or equal to 26.7% of the project duration.

5. Estimated cost of the dredging project

The total project cost under the contract amounted to IDR 60 billion, with a total volume of 1,190,595 cubic meters dredged, while the total volume of which has been dredged up to week 17, either by TSHD or clamshell respectively 632,000 and 208,000. So that the total volume of dredged by both types of dredgers amounted to 840,000 cubic meters or progress of the project's total equivalent to 70.55%. In other words, it can simply be assumed that the dredging project budget that has been absorbed by IDR 42,331,775,289 or calculated through the 70% multiplied by IDR 60 billion. So, the rest of the budget which has not been absorbed is equal to IDR 17,668,224,711. The cost required to accelerate the project is calculated by following regulation of the Minister of Transportation of the Republic of Indonesia No. KM. 70, 2010, regarding standard costs in 2011 in the ministry of transportation. As for the cost of the dredging project required acceleration of each type of dredger can be seen in Table 32 below and detailed calculations contained in the appendix B-1.

Table 32. The estimated cost of dredging alternatives

Type of Dredger	Productivity (m^3 per Days)	Dredging Work Unit Price (IDR)	The rest of Volume (m^3)	The Cost of Dredging work (IDR)	Cost Mobilization	Cost Demobilization	Total Cost (IDR)
(1)	(2)	(3)	(4)	(5) = (3) x (4)	(6)	(7)	(8) = (5) + (6) + (7)
Kalimantan II	3.480	88.812	275.049	24.427.651.788	-	-	24.427.651.788
Kalimantan II + TSHD 1000	4.614	269.026	275.049	73.995.332.274	684.392	684.392	73.996.701.058
Kalimantan II + TSHD 2000	5.540	217.392	275.049	59.793.452.208	976.399	976.399	59.795.405.006
Kalimantan II + TSHD 2900	6.239	195.646	275.049	53.812.236.654	1.076.633	1.076.633	53.814.389.920
Kalimantan II + TSHD 4000	6.960	177.624	275.049	48.855.303.576	1.151.578	1.151.578	48.857.606.732
Kalimantan II + TSHD 5000	7.517	174.059	275.049	47.874.753.891	1.502.564	1.502.564	47.877.759.019
Todano	1.292	48.501	75.546	3.664.056.546	-	-	3.664.056.546
Todano + Clamshell 5,5	2.583	97.002	75.546	7.328.113.092	453.974	453.974	7.329.021.040
Todano + Clamshell 20	4.278	79.479	75.546	6.004.320.534	795.905	795.905	6.005.912.344
Clamshell 20	2.986	30.978	75.546	2.340.263.988	795.905	795.905	2.341.855.798

The rest of the volume of TSHD and Clamshell respectively 275,049 and 75,546 cubic meters. As for the existing TSHD combination with TSHD 1000 will cost around IDR 73,9 billion, and combined with TSHD 2000 will cost around IDR 59,7 billion, the next combination is with TSHD 2900 at a cost of about IDR 53,8 billion is required, then combined with TSHD 4000 will cost around IDR 48,8 billion, and the latter is combined with TSHD and will cost at IDR 47,87 billion. In addition, the combination of the existing clamshell with a clamshell bucket capacity of 5.5 cubic meters will cost around IDR 7.3 billion, and when combined with a clamshell bucket capacity of 20 cubic meters it costs around IDR 6 billion. Furthermore, if the existing clamshell replaced with a clamshell bucket capacity of 20 cubic meters, the cost dibuthkan around IDR 2.3 billion.

6. Conclusion and Recommendation

6.1. Trailing Suction Hopper Dredger

The real productivity theories of the existing TSHD proved to be 145.01 cubic meters per hour or less than 4.6 times of the initial calculation by the contractor. The estimated time needed to conclude the dredging project of 907,049 cubic meters, Based on the real productivity theory calculation of TSHD will required 79 calender days which is 46 days more than the initial duration remaining calculation of the contract and can be considered as potential delay.

In order to anticipate the potential delay, an acceleration of the implementation of the project through an increase in real production is necessary. The acceleration can be done using alternative similar dredgers, namely TSHD 1000, TSHD 2900, TSHD 4000, and TSHD 5000.

The research has identified several problems in the dredging operation that hinder the project productivity. The Problems are classified into two categories, the project management issues (internal factor) and weather issue (external factor). Among the existing problems, the time needed to wait for lubricants is the most hindering factor which accounts up to 8.15% of the total time lost, followed by repair and maintenance of engine failure 7.36%, the time of prayer and religious holidays 5.55%, and waiting for refueling 4.41%. The weather is the only external issue identified only accounts for 0.16%. This has proved that the management issues should be taken into considerations to improve the productivity of the dredging operations.

Finally, from the perspective of alternative production capacity, the combination of existing TSHD with TSHD 5000 presents the greatest acceleration as well as a good solution to pursue potential delays in the project duration. Meanwhile, a real productivity theory is recommended to be used in determining the productivity of the dredger, because they represent the real conditions in the project and taking into account the circumstances as reduction factors.

6.2. Grab Clamshell Dredger

The real productivity theory of the grab clamshell dredger amounted to 53.82 cubic meters per hour, or 0.54 times smaller than the production plan. The contract volume, for sedimentation, which must be dredged, by the contractor, is 283,546 cubic meters within 150 calendar days and will expire at the end of week 22. In addition, according to the calculation of the real productivity theory of grab clamshell is required during 58 days than the rest of the project duration of the contract and can be considered as potential delay.

In order to address the issue of the potential delay in completion of the project, then considered to add other similar dredging fleet, with the same production capacity or replace existing dredger with a larger capacity. The clamshell grab with a bucket capacity of 5.5 and 20 cubic meters has become an alternative option.

The management issues came out to be the main problems in the dredging productivity in grab clamshell. The time needed for repair and maintenance of engine failure has acounted for 8.02% of the total time lost followed by waiting for the lubricant 4.25%, the time of prayer and religious holidays 4.0%, administrative issue 0.69%, waiting for refueling 0.56%, and movement the position of the dredger 0.26%. No external factor has been found in this case.

The research suggests the replacing of the existing grab clamshell with the clamshell bucket capacity of 20 cubic meters to pursue the potential delay. In addition, the rest of the volume to be dredged material is not too much. So does not require high real production capacity. The real productivity theory with some consideration of the reduction factor also need to be applied in determining the production capacity of the dredger to represents the actual conditions in the project dredging operation. The reduction factors such as the level of reliability of the management and crew, mechanical breakdown factor, and the delay factors for changing the hopper and advancing, also significantly reduce the production plans under ideal circumstances.

APPENDIX A
TRAILING SUCTION HOPPER DREDGE AND GRAB CLAMSHELL PRODUCTION

Analysis of the productivity of each dredger has been incorporated into one count of using the auxiliary program Microsoft Excel. This section will describe briefly the sequence of calculation of the productivity of each type of dredger including alternative productivity in which some calculation parameters are used such as data information from project reports, reduction factor, and a calculation equation referred to under of references provided. Meanwhile, if there is a lack of data availability as a parameter calculation, it will be solved by the logical assumption.

Table A-1. Project site information used in estimate dredger productivity

PROJECT INFORMATION - DAILY SUMMARY REPORT OF THE PROJECT BY TSHD							
	TSHD Kalimantan II						
	Loading	Delays	Sailing	Discharging	Amount of work	Productivity (m^3)	
Week	Hour	Hour	Hour	Hour	Trip	Weekly	Cumulative
1	9.00	20.00	42.17	0.83	5.00	8.000	-
2	15.17	107.58	42.92	2.33	14.00	22.400	30.400
3	26.83	68.42	68.92	3.83	23.00	36.800	67.200
4	22.17	89.42	53.42	3.00	18.00	28.800	96.000
5	38.67	30.17	93.83	5.33	32.00	51.200	147.200
6	29.92	74.33	61.58	3.50	20.00	32.000	179.200
7	44.32	18.00	99.75	5.50	33.00	52.800	232.000
8	32.33	57.83	73.67	4.17	25.00	40.000	272.000
9	45.17	6.92	109.75	6.00	37.00	59.200	331.200
10	27.25	67.67	69.42	3.67	22.00	35.200	366.400
11	21.00	88.08	55.75	3.17	19.00	30.400	396.800
12	35.00	42.08	86.08	4.83	29.00	46.400	443.200
13	31.50	47.67	84.17	4.67	28.00	44.800	488.000
14	31.50	51.83	80.17	4.33	27.00	43.200	531.200
15	42.17	11.58	108.42	6.00	36.00	57.600	588.800
16	22.17	75.42	67.25	3.17	19.00	30.400	619.200
17	9.33	133.58	23.75	1.33	8.00	12.800	632.000
Total	483.48	990.58	1221.00	65.67	395.00		
Total hr/ total trip	1.22	2.51	3.09	0.17			

Table A-1 provides a summary of daily reports the dredging project which presents data related to loading time, time delays, sailing time, discharging time and productivity which in has been recapitulated in the weekly. Furthermore, this data is required in the calculation of the estimated real productivity theory as a parameter that can represent the actual circumstances. Besides that as a comparison between the average productivity with real productivity theory, which then can be used as a reference in the calculation of the estimated duration of the remaining projects and was last used as a reference in determining the productivity of other dredgers.

Table A-2 below is a sequence of calculations where there are three columns. The first column on the left contains is a description of the items that have been determined and will be searched which are divided into four basic calculations such as the dredging operations, reduction factor, real productivity theory, and the duration of the project, including the parameters that have been obtained from the project data and assumptions. The second column in the middle is the result of each item searched from the first column. The third last column on the right is the unit of each parameter to be searched..

The next is Table A-3 which is an advanced calculation to find the real productivity theory, from each dredger alternative. There are five columns in this table where the first column on the left is a description of the parameters needed in the calculation. The second column to the fifth column is the value of the parameter that is searched for each capacity that has been adjusted for each type of alternative dredger. on the bottom line where green is the outcome of matter in the form of real productivity capacity of each alternative theory that has been determined namely TSHD with a hopper capacity of 4000 m^3, TSHD 1000 m^3, TSHD 2900 m^3 and 5000 m^3 TSHD.

Table A-4 is a summary of the results of the previous calculation which presented four dredgers with a different kind of hopper capacity as an alternative to problem solving of real productivity and potential delays in the project. The selection of four types of dredgers is based on the alternative dredging fleet ownership by PT Rukindo as the contractor, as well as adjusted to the ability for dredge sediment material types at the project site.

Table A-2. Summary of the Project calculation dredged by TSHD

DREDGE OPERATIONAL	RESULT	UNIT
Number working hour of 17 weeks	2856	hours
Loading Time (t_{load})	1.22	hours
Sailing Time (t_{sail})	3.09	hours
Discharging Time (t_d)	0.17	hours
Total Delays Time (t_t)	990.58	hours
Bulking Factor (B)	1.10	-
Hopper Capacity (H)	4000	m^3
Proportion of Hopper filled (f_e)	0.40	-
REDUCTION FACTOR	RESULT	UNIT
Delay Factor (f_d)	0.65	-
Operasional Factor (f_o)	0.90	-
Mechanical Break Down Factor (f_b)	0.76	-
PRODUCTION RATE	RESULT	UNIT
Maximum Potential Output (P_{max})	324.57	m^3 per hr
Output (P_{real})	145.01	m^3 per hr
TIME CALCULATION	RESULT	UNIT
Total volume of dredging	1.190.595	m^3
Volume derdging of TSHD	907.049	m^3
Volume dredging of Clamshell	283.546	m^3
Total volume dredged for 17 weeks	632.000	m^3
The remaining volume of dredging	275.049	m^3
Duration of project	150	Days Calender
Start	31/07/2012	Date
Finish / Last period of Project	27/12/2012	Date
Last of Week 17	25/11/2012	Date
Remaining time of project	33	Days Calender
Output expected (P_{should})	347	m^3 per hr
Time required according to real productivity	79	Days Calender
Estimate Duration of project delays	46	Days Calender

There is conducted a scenario combination of two TSHD working on the project (in table A-4). Each combination has resulted in an increase of real productivity for completing the project in accordance with the time remaining. In this regard presented two possibilities whether to add additional dredger or replaces the existing ones.

Table A-3. Summary of the project calculation Dredged

DESCRIPTION	TSHD				
	4000 m^3	1000 m^3	2000 m^3	2900 m^3	5000 m^3
Hopper Capacity (H)	4000	1000	2000	2900	5000
Loading Time (t_{load})	1.22	0.306	0.612	0.887	1.530
Sailing Time (t_s)	3.09	3.09	3.09	3.09	3.09
Discharging Time (t_d)	0.17	0.042	0.083	0.121	0.208
Buckling Factor (B)	1.10	1.10	1.10	1.10	1.10
Proportion of Hopper filled (f_e)	0.40	0.40	0.40	0.40	0.40
Maximum Potential Output (P_{max})	324.57	105.75	192.08	257.26	376.52
Number working hour of 17 weeks	2856	2856	2856	2856	2856
Total Delays Time (t_t)	990.58	990.58	990.58	990.58	990.58
Delay Factor (f_d)	0.65	0.65	0.65	0.65	0.65
Operasional Factor (f_o)	0.90	0.90	0.90	0.90	0.90
Mechanical Break Down Factor (f_b)	0.76	0.76	0.76	0.76	0.76
Output (P_{real})	145.01	47.24	85.81	114.94	168.21

Table A-4. Comparison of alternative productivity

Summary of Real Productivity		
Type of Dredger	(P_{real})	Unit
TSHD 1000	47.24	m^3 per hour
TSHD 2000	85.81	m^3 per hour
TSHD 2900	114.94	m^3 per hour
TSHD 4000	145.01	m^3 per hour
TSHD 5000	168.21	m^3 per hour
Alternative Productivity		
Type of Dredger	Prod. Capacity	Unit
TSHD Kalimantan II	145.01	m^3 per hour
THSD Kalimantan II + 1000	192.25	m^3 per hour
TSHD Kalimantan II + 2000	230.82	m^3 per hour
TSHD Kalimantan II + 2900	259.94	m^3 per hour
TSHD Kalimantan II + 4000	290.01	m^3 per hour
TSHD Kalimantan II + 5000	313.22	m^3 per hour

Table A-5. Analysis for accelerating achievement of the project by TSHD

Type of Dredger	(P_{real})	Unit
TSHD 1000	47.24	m^3 per hour
TSHD 2000	85.81	m^3 per hour
TSHD 2900	114.94	m^3 per hour
TSHD 4000	145.01	m^3 per hour
TSHD 5000	168.21	m^3 per hour

ANALYSIS DURATION FOR ACCELERATING ACHIEVEMENT OF THE PROJECT

Total sedimentation of the project	1.190.595	m^3
Total sediment dredged by TSHD of	907.049	m^3

	TSHD Kalimantan II				TSHD Kalimantan + TSHD 1000 m3			
	Progress of work (%)		Progress of work (m3)		Progress of work (%)		Progress of work (m3)	
	%	%	m^3	m^3	%	%	m^3	m^3
Week	Weekly	Cumulative	Weekly	Cumulative	Weekly	Cumulative	Weekly	Cumulative
1	0.88%	0.88%	8.000	8.000	0.88%	0.88%	8.000	8.000
2	2.47%	3.35%	22.400	30.400	2.47%	3.35%	22.400	30.400
3	4.06%	7.41%	36.800	67.200	4.06%	7.41%	36.800	67.200
4	3.18%	10.58%	28.800	96.000	3.18%	10.58%	28.800	96.000
5	5.64%	16.23%	51.200	147.200	5.64%	16.23%	51.200	147.200
6	3.53%	19.76%	32.000	179.200	3.53%	19.76%	32.000	179.200
7	5.82%	25.58%	52.800	232.000	5.82%	25.58%	52.800	232.000
8	4.41%	29.99%	40.000	272.000	4.41%	29.99%	40.000	272.000
9	6.53%	36.51%	59.200	331.200	6.53%	36.51%	59.200	331.200
10	3.88%	40.39%	35.200	366.400	3.88%	40.39%	35.200	366.400
11	3.35%	43.75%	30.400	396.800	3.35%	43.75%	30.400	396.800
12	5.12%	48.86%	46.400	443.200	5.12%	48.86%	46.400	443.200
13	4.94%	53.80%	44.800	488.000	4.94%	53.80%	44.800	488.000
14	4.76%	58.56%	43.200	531.200	4.76%	58.56%	43.200	531.200
15	6.35%	64.91%	57.600	588.800	6.35%	64.91%	57.600	588.800
16	3.35%	68.27%	30.400	619.200	3.35%	68.27%	30.400	619.200
17	1.41%	69.68%	12.800	632.000	1.41%	69.68%	12.800	632.000
18	2.69%	72.36%	24.361	656.361	3.56%	73.24%	32.298	664.298
19	2.69%	75.05%	24.361	680.722	3.56%	76.80%	32.298	696.596
20	2.69%	77.73%	24.361	705.083	3.56%	80.36%	32.298	728.894
21	2.69%	80.42%	24.361	729.445	3.56%	83.92%	32.298	761.192
22	2.69%	83.11%	24.361	753.806	3.56%	87.48%	32.298	793.491
23	2.69%	85.79%	24.361	778.167	3.56%	91.04%	32.298	825.789
24	2.69%	88.48%	24.361	802.528	3.56%	94.60%	32.298	858.087
25	2.69%	91.16%	24.361	826.889	3.56%	98.16%	32.298	890.385
26	2.69%	93.85%	24.361	851.250	3.56%	101.72%	32.298	922.683
27	2.69%	96.53%	24.361	875.611	3.56%	105.28%	32.298	954.981
28	2.69%	99.22%	24.361	899.972	3.56%	108.85%	32.298	987.279
29	2.69%	101.91%	24.361	924.334	3.56%	112.41%	32.298	1.019.577
30	2.69%	104.59%	24.361	948.695	3.56%	115.97%	32.298	1.051.875
	acceleration of the project by ;			1.00	*acceleration of the project by ;*			1.33

	TSHD Kalimantan + TSHD 2000 m3				TSHD Kalimantan + TSHD 2900 m3			
	Progress of work (%)		Progress of work (m3)		Progress of work (%)		Progress of work (m3)	
	%	%	m^3	m^3	%	%	m^3	m^3
Week	Weekly	Cumulative	Weekly	Cumulative	Weekly	Cumulative	Weekly	Cumulative
1	0.88%	0.88%	8.000	8.000	0.88%	0.88%	8.000	8.000
2	2.47%	3.35%	22.400	30.400	2.47%	3.35%	22.400	30.400
3	4.06%	7.41%	36.800	67.200	4.06%	7.41%	36.800	67.200
4	3.18%	10.58%	28.800	96.000	3.18%	10.58%	28.800	96.000
5	5.64%	16.23%	51.200	147.200	5.64%	16.23%	51.200	147.200
6	3.53%	19.76%	32.000	179.200	3.53%	19.76%	32.000	179.200
7	5.82%	25.58%	52.800	232.000	5.82%	25.58%	52.800	232.000
8	4.41%	29.99%	40.000	272.000	4.41%	29.99%	40.000	272.000
9	6.53%	36.51%	59.200	331.200	6.53%	36.51%	59.200	331.200
10	3.88%	40.39%	35.200	366.400	3.88%	40.39%	35.200	366.400
11	3.35%	43.75%	30.400	396.800	3.35%	43.75%	30.400	396.800
12	5.12%	48.86%	46.400	443.200	5.12%	48.86%	46.400	443.200
13	4.94%	53.80%	44.800	488.000	4.94%	53.80%	44.800	488.000
14	4.76%	58.56%	43.200	531.200	4.76%	58.56%	43.200	531.200
15	6.35%	64.91%	57.600	588.800	6.35%	64.91%	57.600	588.800
16	3.35%	68.27%	30.400	619.200	3.35%	68.27%	30.400	619.200
17	1.41%	69.68%	12.800	632.000	1.41%	69.68%	12.800	632.000
18	4.28%	73.95%	38.778	670.778	4.81%	74.49%	43.670	675.670
19	4.28%	78.23%	38.778	709.556	4.81%	79.31%	43.670	719.341
20	4.28%	82.50%	38.778	748.334	4.81%	84.12%	43.670	763.011
21	4.28%	86.78%	38.778	787.112	4.81%	88.93%	43.670	806.681
22	4.28%	91.05%	38.778	825.890	4.81%	93.75%	43.670	850.351
23	4.28%	95.33%	38.778	864.668	4.81%	98.56%	43.670	894.022
24	4.28%	99.60%	38.778	903.446	4.81%	103.38%	43.670	937.692
25	4.28%	103.88%	38.778	942.224	4.81%	108.19%	43.670	981.362
26	4.28%	108.15%	38.778	981.001	4.81%	113.01%	43.670	1.025.032
27	4.28%	112.43%	38.778	1.019.779	4.81%	117.82%	43.670	1.068.703
28	4.28%	116.70%	38.778	1.058.557	4.81%	122.64%	43.670	1.112.373
29	4.28%	120.98%	38.778	1.097.335	4.81%	127.45%	43.670	1.156.043
30	4.28%	125.25%	38.778	1.136.113	4.81%	132.27%	43.670	1.199.713
	acceleration of the project by ;			1.59	*acceleration of the project by ;*			1.79

	TSHD Kalimantan + TSHD 4000 m3				TSHD Kalimantan II + TSHD 5000 m3			
	Progress of work (%)		Progress of work (m3)		Progress of work (%)		Progress of work (m3)	
	%	%	m^3	m^3	%	%	m^3	m^3
Week	Weekly	Cumulative	Weekly	Cumulative	Weekly	Cumulative	Weekly	Cumulative
1	0.88%	0.88%	8.000	8.000	0.88%	0.88%	8.000	8.000
2	2.47%	3.35%	22.400	30.400	2.47%	3.35%	22.400	30.400
3	4.06%	7.41%	36.800	67.200	4.06%	7.41%	36.800	67.200
4	3.18%	10.58%	28.800	96.000	3.18%	10.58%	28.800	96.000
5	5.64%	16.23%	51.200	147.200	5.64%	16.23%	51.200	147.200
6	3.53%	19.76%	32.000	179.200	3.53%	19.76%	32.000	179.200
7	5.82%	25.58%	52.800	232.000	5.82%	25.58%	52.800	232.000
8	4.41%	29.99%	40.000	272.000	4.41%	29.99%	40.000	272.000
9	6.53%	36.51%	59.200	331.200	6.53%	36.51%	59.200	331.200
10	3.88%	40.39%	35.200	366.400	3.88%	40.39%	35.200	366.400
11	3.35%	43.75%	30.400	396.800	3.35%	43.75%	30.400	396.800
12	5.12%	48.86%	46.400	443.200	5.12%	48.86%	46.400	443.200
13	4.94%	53.80%	44.800	488.000	4.94%	53.80%	44.800	488.000
14	4.76%	58.56%	43.200	531.200	4.76%	58.56%	43.200	531.200
15	6.35%	64.91%	57.600	588.800	6.35%	64.91%	57.600	588.800
16	3.35%	68.27%	30.400	619.200	3.35%	68.27%	30.400	619.200
17	1.41%	69.68%	12.800	632.000	1.41%	69.68%	12.800	632.000
18	5.37%	75.05%	48.722	680.722	5.80%	75.48%	52.621	684.621
19	5.37%	80.42%	48.722	729.445	5.80%	81.28%	52.621	737.242
20	5.37%	85.79%	48.722	778.167	5.80%	87.08%	52.621	789.862
21	5.37%	91.16%	48.722	826.889	5.80%	92.88%	52.621	842.483
22	5.37%	96.53%	48.722	875.611	5.80%	98.68%	52.621	895.104
23	5.37%	101.91%	48.722	924.334	5.80%	104.48%	52.621	947.725
24	5.37%	107.28%	48.722	973.056	5.80%	110.29%	52.621	1.000.346
25	5.37%	112.65%	48.722	1.021.778	5.80%	116.09%	52.621	1.052.966
26	5.37%	118.02%	48.722	1.070.500	5.80%	121.89%	52.621	1.105.587
27	5.37%	123.39%	48.722	1.119.223	5.80%	127.69%	52.621	1.158.208
28	5.37%	128.76%	48.722	1.167.945	5.80%	133.49%	52.621	1.210.829
29	5.37%	134.13%	48.722	1.216.667	5.80%	139.29%	52.621	1.263.450
30	5.37%	139.51%	48.722	1.265.389	5.80%	145.09%	52.621	1.316.070
	acceleration of the project by ;			2.00	*acceleration of the project by ;*			2.16

Table A-5 is the end product of a real theory THSD productivity calculation and estimation of the possibility of accelerating the achievement of the project duration. There are two main categories, namely calculation progress of work which is expressed in percentage and in the number of cubic meters. The main categories is subdivided into two sub-categories, a weekly progress of work and the progress of work cumulative, either in percentage or in cubic meters**.** As for the yellow color on the line above, is a recapitulation of productivity of a daily report of the project, in which data are available up to week 17 with the total sediment dredged as 632,000 cubic meters or equivalent to 69.68% of the amount of sediment by TSHD (amounting to 907,049 cubic meters). Hereinafter, weekly and cumulative productivity calculation will be based on real productivity preconceived theories, including the combination of alternatives where each alternative calculations would give a scale of the acceleration of project completion.

Referring to the employment contract, the project was due to expire at week 22. Furthermore, for the TSHD Kalimantan II with real productivity theory capable of completing the project up to weeks 29 with a cumulative result of dredging sediment of 924,334 cubic meters or equivalent to 101.91% of the total sediment dredged by TSHD. Then for the combination of TSHD 1000 and the existing TSHD able to complete projects up to 26 weeks with a cumulative result of dredging sediment of 922.683 cubic meters or equivalent to 101.72% and provide accelerated project completion, at 133 times faster, which is calculated by dividing productivity real alternatives and real productivity for the TSHD existing theories. Next the combination of TSHD 2000 and the existing TSHD is able to complete projects up to 26 weeks with a cumulative result of dredging sediment of 942,224 cubic meters or equivalent to 103.88% and provide accelerated project completion, at 1.59 times faster. Likewise, the combination TSHD 2900 and the existing TSHD is able to complete projects up to weeks 25 with a cumulative result of dredging sediment of 937,692 cubic meters or equivalent to 103.38% and provides accelerated completion of the project amounted to 1.79 times faster. Meanwhile, with TSHD 4000 and TSHD existing, as well as TSHD 5000 and the existing TSHD which provides acceleration of 2.0 times, and 2.16 times faster respectively. As for the achievement of this project has been illustrated in figure 17.

Table A-6 below is a sequence of calculations of the grab clamshell. Similar to the explanation in Table A-2, where the first column to the left is a description of the items that have been determined and will be searched which are divided into four basic calculation that the operational dredging, reduction factor, real productivity theory, and the duration of the project. However, there are additional items of the reduction factor for adjusting the work methods of dredging equipment. The additional reduction factor in the calculation is the delay factor for advancing (f_a) and the delay factor for changing the hoppers (f_h). These two explanations can be found in the chapter reviews of the production rate for grab clamshell. The second column in the middle is the result of each item searched from the first column while the third last column on the right is the unit of each parameter to be searched. The parameters presented in this calculation are obtained from the project data and the researcher assumptions.

Table A-6. Summary of the project calculation dredged by clamshell

DREDGE OPERATIONAL PLAN	RESULT	UNIT
Bucket Capacity, C	5.50	m^3
Productive unit, U_b	2.00	m^3
Number of Grab Hopper	2.00	unit
Grab Hopper Capacity, H	500	m^3
Average dredging depth, d	8.00	m
Average thickness of material to be dredged in one cut, z	1.00	m
Average area dredged, A	10.000	m
Time required to advance to the next dredging position, t_a	0.45	hrs
Time required to change hopper, t_h	1.00	m^2
REDUCTION FACTOR	RESULT	UNIT
Bulking factor, B	0.45	-
Delay factor for advancing, f_a	0.996	-
Delay factor due to changing hoppers, f_h	0.93	-
Operasional Factor (f_o)	0.90	-
Mechanical Break Down Factor (f_b)	0.76	-
PRODUCTION RATE	RESULT	UNIT
Nominal Production, P_{nom}	85.00	m^3 per hrs
Maximum Potential Output (P_{max})	78.68	m^3 per hrs
Output (P_{real})	53.82	m^3 per hrs
TIME CALCULATION	RESULT	UNIT
Total volume of dredging	1.190.595	m^3
Volume derdging of TSHD	907.049	m^3
Volume dredging of Clamshell	283.546	m^3
Total volume dredged for 17 weeks	208.000	m^3
The remaining volume of dredging	75.546	m^3
Duration of project	150	Days Calender
Start	31/07/2012	Date
Finish / Last period of Project	27/12/2012	Date
Last of Week 17	25/11/2012	Date
Remaining time of project	33	Days Calender
Output expected (P_{should})	95.39	m^3 per hr
Time required according to real productivity	58	Days Calender
Estimate duration of project delays	25	Days Calender
Duration of project according to planned productivity by contractor	31	Days Calender

Table A-7. Analysis for accelerating achievement of the project by clamshell

Type of Dredger	(P_{real})	Unit
Clamshell Tondano 5,5	53.82	m^3 per hour
Clamshell 5,5	53.82	m^3 per hour
Clamshell 20	124.411	m^3 per hour

ANALYSIS DURATION FOR ACCELERATING ACHIEVEMENT OF THE PROJECT

Total sedimentation of the project	1190595	m^3
Total sediment dredged by Clamshell of	283.546	m^3

	Clamshell Tondano				Clamshell Tondano + Clamshell 5,5				Clamshell Tondano + Clamshell 20				Clamshell 20			
	Progress of work (%)		Progress of work (m3)		Progress of work (%)		Progress of work (m3)		Progress of work (%)		Progress of work (m3)		Progress of work (%)		Progress of work (m3)	
	%	%	m^3	m^3	%	%	m^3	m^3	%	%	m^3	m^3	%	%	m^3	m^3
Week	Weekly	Cumulative	Weekly	Cumulative	Weekly	Cumulative	Weekly	Cumulative	Weekly	Cumulative	Weekly	Cumulative	Weekly	Cumulative	Weekly	Cumulative
1	0.42%	0.42%	1.200	1.200	0.42%	0.42%	1200	1.200	0.42%	0.42%	1.200	1.200	0.42%	0.42%	1.200	1.200
2	5.64%	6.07%	16.000	17.200	5.64%	6.07%	16.000	17.200	5.64%	6.07%	16.000	17.200	5.64%	6.07%	16.000	17.200
3	3.67%	9.73%	10.400	27.600	3.67%	9.73%	10.400	27.600	3.67%	9.73%	10.400	27.600	3.67%	9.73%	10.400	27.600
4	3.39%	13.12%	9.600	37.200	3.39%	13.12%	9.600	37.200	3.39%	13.12%	9.600	37.200	3.39%	13.12%	9.600	37.200
5	3.39%	16.51%	9.600	46.800	3.39%	16.51%	9.600	46.800	3.39%	16.51%	9.600	46.800	3.39%	16.51%	9.600	46.800
6	3.81%	20.31%	10.800	57.600	3.81%	20.31%	10.800	57.600	3.81%	20.31%	10.800	57.600	3.81%	20.31%	10.800	57.600
7	5.08%	25.39%	14.400	72.000	5.08%	25.39%	14.400	72.000	5.08%	25.39%	14.400	72.000	5.08%	25.39%	14.400	72.000
8	4.37%	29.77%	12.400	84.400	4.37%	29.77%	12.400	84.400	4.37%	29.77%	12.400	84.400	4.37%	29.77%	12.400	84.400
9	6.49%	36.26%	18.400	102.800	6.49%	36.26%	18.400	102.800	6.49%	36.26%	18.400	102.800	6.49%	36.26%	18.400	102.800
10	4.94%	41.19%	14.000	116.800	4.94%	41.19%	14.000	116.800	4.94%	41.19%	14.000	116.800	4.94%	41.19%	14.000	116.800
11	2.40%	43.59%	6.800	123.600	2.40%	43.59%	6.800	123.600	2.40%	43.59%	6.800	123.600	2.40%	43.59%	6.800	123.600
12	3.39%	46.98%	9.600	133.200	3.39%	46.98%	9.600	133.200	3.39%	46.98%	9.600	133.200	3.39%	46.98%	9.600	133.200
13	4.23%	51.21%	12.000	145.200	4.23%	51.21%	12.000	145.200	4.23%	51.21%	12.000	145.200	4.23%	51.21%	12.000	145.200
14	5.36%	56.57%	15.200	160.400	5.36%	56.57%	15.200	160.400	5.36%	56.57%	15.200	160.400	5.36%	56.57%	15.200	160.400
15	6.35%	62.92%	18.000	178.400	6.35%	62.92%	18.000	178.400	6.35%	62.92%	18.000	178.400	6.35%	62.92%	18.000	178.400
16	5.50%	68.42%	15.600	194.000	5.50%	68.42%	15.600	194.000	5.50%	68.42%	15.600	194.000	5.50%	68.42%	15.600	194.000
17	4.94%	73.36%	14.000	208.000	4.94%	73.36%	14.000	208.000	4.94%	73.36%	14.000	208.000	4.94%	73.36%	14.000	208.000
18	3.19%	76.55%	9.041	217.041	6.38%	79.73%	18.083	226.083	10.56%	83.92%	29.942	237.942	7.37%	80.73%	20.901	228.901
19	3.19%	79.73%	9.041	226.083	6.38%	86.11%	18.083	244.165	10.56%	94.48%	29.942	267.885	7.37%	88.10%	20.901	249.802
20	3.19%	82.92%	9.041	235.124	6.38%	92.49%	18.083	262.248	10.56%	105.04%	29.942	297.827	7.37%	95.47%	20.901	270.703
21	3.19%	86.11%	9.041	244.165	6.38%	98.87%	18.083	280.330	10.56%	115.60%	29.942	327.769	7.37%	102.84%	20.901	291.604
22	3.19%	89.30%	9.041	253.206	6.38%	105.24%	18.083	298.413	10.56%	126.16%	29.942	357.712	7.37%	110.21%	20.901	312.505
23	3.19%	92.49%	9.041	262.248	6.38%	111.62%	18.083	316.495	10.56%	136.72%	29.942	387.654	7.37%	117.58%	20.901	333.406
24	3.19%	95.68%	9.041	271.289	6.38%	118.00%	18.083	334.578	10.56%	147.28%	29.942	417.597	7.37%	124.96%	20.901	354.308
25	3.19%	98.87%	9.041	280.330	6.38%	124.38%	18.083	352.660	10.56%	157.84%	29.942	447.539	7.37%	132.33%	20.901	375.209
26	3.19%	102.05%	9.041	289.372	6.38%	130.75%	18.083	370.743	10.56%	168.40%	29.942	477.481	7.37%	139.70%	20.901	396.110
27	3.19%	105.24%	9.041	298.413	6.38%	137.13%	18.083	388.826	10.56%	178.96%	29.942	507.424	7.37%	147.07%	20.901	417.011
28	3.19%	108.43%	9.041	307.454	6.38%	143.51%	18.083	406.908	10.56%	189.52%	29.942	537.366	7.37%	154.44%	20.901	437.912
29	3.19%	111.62%	9.041	316.495	6.38%	149.88%	18.083	424.991	10.56%	200.08%	29.942	567.308	7.37%	161.81%	20.901	458.813
30	3.19%	114.81%	9.041	325.537	6.38%	156.26%	18.083	443.073	10.56%	210.64%	29.942	597.251	7.37%	169.18%	20.901	479.714
	acceleration of the project by ;			1.00	*acceleration of the project by ;*			2.00	*acceleration of the project by ;*			3.31	*acceleration of the project by ;*			2.31

Table A-7 is the end product of the calculation of the real productivity theory of the grab clamshell and the estimation of the possibility of accelerating the achievement of the project duration with the same assumptions uses in the previous table A-5. The total sedimentation in front of the wharf at seven terminals amounted to 283,546 meters and should be completed within 150 calendar days or 22 weeks. Using the real production capacity theory of 53.82 cubic meters per hour, the existing clamshell dredger is capable of completing the job entirely up to week 26, with the total achievement of the project of 102.5% or equivalent to 289,372 cubic meters at week 26. This means that the project is late for approximately four weeks. Therefore, refers to the calculation in the previous chapter, it is required to accelerate the achievement of the project through a combination of adding more dredger or replacing existing dredger with the one with a higher production capacity.

The first alternative is to bring in grab clamshell with a capacity bucket of 5.5 cubic meters to work with the existing dredger. Consequently, the two dredgers can generate twice 53.82 cubic meters per hour and are able to complete the project until week 22, with the total sediment dredged as 298,413 cubic meters or equivalent to 105.24%. This combination of two dredgers with the same capacity has resulted in 2.00 times acceleration. The second alternative is to add another grab clamshell with the bucket capacity of 20 cubic meters to work with the existing dredgers and generate real production theory of 178.23 cubic meters per hour resulted in the completion of the project in the week 20, with the total sediment dredged as 297.87 cubic meters or equivalent to 105.04%. This combination of two different bucket dredger capacity is capable of providing accelerated completion of the project amounted to 3.31 times faster. The last alternative is to replace the existing grab clamshell, with a grab clamshell bucket capacity of 20 cubic meters. This alternative theory is capable of producing real production amounted to 124.411 cubic meters per hour and were able to complete the project up to week 21, with total sediment dredged as 291.604 cubic meters or equivalent to 102.84% and provides to 2.31 times acceleration.

Table A-8. Summary of daily reports for time delays project of TSHD

DATE / WEEK	TRIP	DREDGING LOCATION		DREDGING PROCESS			SAILING-OUT			DISCHARGING			SAILING-IN			OBSTRACTION / DELAYS			WEATHER	INFORMATION
		FROM	TO	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE		
Week-1 /																				
03/08/2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	00.00	20.00	1200	-	Dredger anchored in rede Port of Tanjung Perak; waiting instructions of project manager (1200)
Week-2 /																				
06/08/2012	1	Turning Basin		-	-	-	00.00	01.30	90	01.30	01.40	10	01.40	04.45	185	04.45	24.00	1155	Sunny	Dredger anchored in rede Port of Tanjung Perak; waiting for refueling (1155')
07/08/2012	1	Turning Basin		-	-	-	-	-	-	-	-	-	-	-	-	00.00	24.00	1440	Sunny	Dredger anchored in rede Port of Tanjung Perak; Right bulbous repairs and waiting for recharging of freshwater. (1440')
08/08/2012	1	Turning Basin		-	-	-	-	-	-	-	-	-	-	-	-	00.00	24.00	1440	Sunny	Dredger anchored in rede Port of Tanjung Perak; Right bulbous repairs and waiting for recharging of freshwater. (1440')
09/08/2012	1	Turning Basin		-	-	-	-	-	-	-	-	-	-	-	-	00.00	24.00	1440	Sunny	Dredger anchored in rede Port of Tanjung Perak; waiting for 200 tons recharging of freshwater. (1440')
10/08/2012					-	-	-	-	-	-	-	-	-	-	-	00.00	16.20	980		Dredger anchored in rede Port of Tanjung Perak; waiting for lubricant (980')
					-	-	-	-	-	-	-	-	16.20	17.10	50	-	-	-		-
	1	Turning Basin-Mirah		17.10	18.20	70	18.20	19.50	90	1190	1200	10	20.00	21.40	100	-	-	-	Sunny	-
	#	Turning Basin-Mirah		21.40	22.50	70	22.50	24.00	70	-	-		-	-		-	-	-		-
Week-3 /													00.00	01.30	90					
17/08/2012	1	Turning Basin-Mirah		-	-	-	00.00	01.25	85	01.25	01.35	10	01.35	03.35	120	03.35	24.00	1225	Sunny	Dredger anchored in rede Port of Tanjung Perak; revision of machines and maintenance dredging tool (1225')
18/08/2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	00.00	24.00	1440		Dredger anchored in rede Port of Tanjung Perak; revision of machines and maintenance dredging tool (1440')
19/08/2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	00.00	24.00	1440		Dredger anchored in rede Port of Tanjung Perak; Celebrete Eid Al-Fitr (1440')
Week-4 /																				
20/08/2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	00.00	24.00	1440		Dredger anchored in rede Port of Tanjung Perak; Celebrete Eid Al-Fitr (1440')
21/08/2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	00.00	24.00	1440	Sunny	Dredger anchored in rede Port of Tanjung Perak; Celebrete Eid Al-Fitr (1440')
22/08/2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	00.00	24.00	1440	Sunny	Dredger anchored in rede Port of Tanjung Perak; Celebrete Eid Al-Fitr (1440')
23/08/2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	00.00	17.25	1045	-	Dredger anchored in rede Port of Tanjung Perak; waiting to permit movement of the port authority (1440')
	-	-	-	-	-	-	-	-	-	-	-	-	17.25	18.00	35	-	-	-	-	-
	1	Turning Basin-Mirah		18.00	19.10	70	19.10	20.30	80	20.30	20.40	10	20.40	22.10	90				Sunny	-
	#	Turning Basin-Mirah		22.10	23.20	70	23.20	24.00	40	-	-		-	-						-
Week-5 /																				
27/08/2012	1	Turning Basin-Mirah		-	-	-	00.00	01.20	80	01.20	01.30	10	01.30	03.00	90				Sunny	-
	2	Turning Basin-Mirah		03.00	04.10	70	04.10	05.30	80	05.30	05.40	10	05.40	07.10	90				Sunny	-
	3	Turning Basin-Mirah		07.10	08.20	70	08.20	09.40	80	09.40	09.50	10	09.50	11.20	90				Sunny	-
	4	Turning Basin-Mirah		11.20	12.30	70	12.30	13.50	80	13.50	14.00	10	-	-	-	14.00	17.15	195	Sunny	Dredger anchored in the dumping area; Fixing dry tank left side (195')
	-	-	-	-	-	-	-	-		-	-	-	17.15	18.40	85				-	-
	5	Turning Basin-Mirah		18.40	19.50	70	19.50	21.15	85	21.15	21.25	10	21.25	23.00	95				Sunny	-
	#	Turning Basin-Mirah		23.00	24.00	60	-	-		-	-	-	-	-		-	-	-	-	-
28/08/2012	1	Turning Basin-Mirah		00.00	00.10	10	00.10	01.30	80	01.30	01.40	10	01.40	03.10	90	-	-	-	Sunny	-
	2	Turning Basin-Mirah		03.10	04.20	70	04.20	05.40	80	05.40	05.50	10	05.50	07.20	90	-	-	-	Sunny	-
	3	Turning Basin-Mirah		07.20	08.30	70	08.30	09.50	80	09.50	10.00	10	10.00	11.30	90	-	-	-	Sunny	-
	4	Turning Basin-Mirah		11.30	12.40	70	12.40	14.00	80	14.00	14.10	10	14.10	15.40	90	-	-	-	Sunny	-
	5	Turning Basin-Mirah		15.40	16.50	70	16.50	18.10	80	18.10	18.20	10	18.20	19.55	95	-	-	-	Sunny	-
	6	Turning Basin-Mirah		19.55	21.05	70	21.05	22.30	85	22.30	22.40	10	-	-	-	22.40	24.00	80	Sunny	Dredger anchored in the dumping area; Seawater cooling repair mains engines right side and left side (80')
29/08/2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	00	06.30	390	Sunny	Dredger anchored in the dumping area; Seawater cooling repair mains engines right side and left side (390')
	-	-	-	03.10	-	-	-	-	-	-	-	-	06.30	08.45	135	-	-	-	Sunny	-
	1	Turning Basin-Mirah		08.45	09.55	70	09.55	11.15	80	11.15	11.25	10	11.25	12.55	90	-	-	-	Sunny	-
	2	Turning Basin-Mirah		12.55	14.05	70	14.05	15.25	80	15.25	15.35	10	15.35	17.05	90	-	-	-	Sunny	-
	3	Turning Basin-Mirah		17.05	18.15	70	18.15	19.35	80	19.35	19.45	10	19.45	21.20	95	-	-	-	Sunny	-
	4	Turning Basin-Mirah		21.20	22.30	70	22.30	23.50	80	23.50	24.00	10	-	-	-	-	-	-	Sunny	-
31/08/2012	1	Turning Basin-Mirah		-	-	-	00.00	01.15	75	01.15	01.25	10	01.25	03.00	95	-	-	-	Sunny	
	2	Turning Basin-Mirah		03.00	04.10	70	04.10	05.35	85	05.35	05.45	10	05.45	07.20	95	-	-	-	Sunny	
	3	Turning Basin-Mirah		07.20	08.30	70	08.30	09.50	80	09.50	10.00	10	-	-	-	10.00	16.15	375	Sunny	Dredger anchored in the dumping area; Fixing dry tank left side (375')
	-			-	-	-	-	-	-	-	-	-	16.15	17.50	95	-	-	-	-	
	4	Turning Basin-Mirah		17.50	19.00	70	19.00	20.20	80	20.20	20.30	10	20.30	22.05	95	-	-	-	Sunny	
	#	Turning Basin-Mirah		22.05	23.15	70	23.15	24.00	45	-	-	-	-	-	-	-	-	-		
01/09/2012	1	Turning Basin-Mirah		-	-	-	00.00	00.35	35	00.35	00.45	10	00.45	02.20	95				Sunny	
	2	Turning Basin-Mirah		02.20	03.30	70	03.30	04.50	80	04.50	05.00	10	05.00	06.40	100				Sunny	
	3	Turning Basin-Mirah		06.40	07.50	70	07.50	09.15	85	09.15	09.25	10	09.25	10.55	90				Sunny	
	4	Turning Basin-Mirah		10.55	12.05	70	12.05	13.25	80	13.25	13.35	10	13.35	15.10	95				Sunny	
	5	Turning Basin-Mirah		15.10	16.20	70	16.20	17.45	85	17.45	17.55	10				17.55	23.15	320	Sunny	Dredger anchored in the dumping area; transfer of fuel to Split Barge 54 as much as 5000 liters (320')
	-	-	-	-	-	-	-	-	-	-	-	-	23.15	24.00	45	-	-	-		
02/09/2012	-	-	-										00.00	00.50	50					
	1	Turning Basin-Mirah		00.50	02.20	90	02.20	03.40	80	03.40	03.50	10	-	-	-	03.50	11.20	450	Sunny	Dredger anchored in the dumping area; Fixing dry tank left side (450')
	-	-	-	-	-	-	-	-	-	-	-	-	11.20	12.55	95	-	-	-		
	2	Turning Basin-Mirah		12.55	14.25	90	14.25	15.45	80	15.45	15.55	10	15.55	17.30	95	-	-	-	Sunny	
	3	Turning Basin-Mirah		17.30	19.00	90	19.00	20.25	85	20.25	20.35	10	20.35	22.05	90	-	-	-	Sunny	
	#	Turning Basin-Mirah		22.05	23.35	90	23.35	24.00	25	-	-	-	-	-	-	-	-	-		

Table A-8. Continued

DATE / WEEK	TRIP	DREDGING LOCATION		DREDGING PROCESS			SAILING-OUT			DISCHARGING			SAILING-IN			OBSTRACTION / DELAYS			WEATHER	INFORMATION
		FROM	TO	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE		
Week-6 /									00			00			00					
05/09/2012	-	-	-	-	-	-	-	-	-	-	-	-	00.00	00.15	15	-	-	-		
	1	Turning Basin-Berlian Timur		00.15	01.45	90	01.45	03.15	90	03.15	03.25	10	03.25	05.00	95	-	-	-	Sunny	
	2	Turning Basin-Berlian Timur		05.00	06.25	85	06.25	07.50	85	07.50	08.00	10	08.00	09.55	115	09.55	24.00	845	Sunny	Dredger anchored in rede Port of Tanjung Perak; revise ME and refueling (845')
06/09/2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	00.00	24.00	1440	-	Dredger anchored in rede Port of Tanjung Perak; revise ME and refueling (1440')
07/09/2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	00.00	24.00	1440	-	Dredger anchored in rede Port of Tanjung Perak; revise ME and refueling (1440')
08/09/2012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	00.00	04.35	275		Dredger anchored in rede Port of Tanjung Perak; fixing hydraulic pipes (275')
	1	Turning Basin-Berlian Timur		04.35	06.05	90	06.05	07.30	85	07.30	07.40	10	07.40	07.55	15	07.55	10.20	145	Sunny	Dredger anchored in rede Maspion; fixing gearbox ME right side (145')
	-	-	-	-	-	-	-	-	-	-	-	-	10.20	11.55	95	-	-	-		
	2	Turning Basin-Berlian Timur		11.55	13.25	90	13.25	14.50	85	14.50	15.00	10	15.00	16.35	95	-	-	-	Sunny	
	3	Turning Basin-Berlian Timur		16.35	18.05	90	18.05	19.25	80	19.25	19.35	10	19.35	21.05	90	-	-	-	Sunny	
	-			21.05	22.35	90	22.35	24.00	85	-	-	-	-	-	-	-	-	-		
09/09/2012	1	Turning Basin-Berlian Timur		-	-	-	-	-	-	00.00	00.10	10	00.10	01.45	95	-	-	-	Sunny	
	2	Turning Basin-Berlian Timur		01.45	03.15	90	03.15	04.50	95	04.50	05.00	10	05.00	06.35	95	-	-	-	Sunny	
	3	Turning Basin-Berlian Timur		06.35	08.05	90	08.05	09.35	90	09.35	09.45	10	09.45	11.35	110	11.35	15.30	235	Sunny	Dredger anchored in rede Port of Tanjung Perak; waiting for recharging of freshwater. (235')
	-	-	-	-	-	-	-	-	-	-	-	-	15.30	15.45	15	-	-	-		
	4	Turning Basin-Berlian Timur		15.45	17.15	90	17.15	18.50	95	18.50	19.00	10	19.00	20.35	95	-	-	-	Sunny	
	5	Turning Basin-Berlian Timur		20.35	22.05	90	22.05	23.35	90	23.35	23.45	10	23.45	24.00	15	-	-	-	Sunny	
Week-7 /																				
10/09/2012	-	-	-	-	-	-	-	-	-	-	-	-	00.00	01.25	85	-	-	-		
	1	Turning Basin-Berlian Timur		01.25	02.55	90	02.55	04.15	80	04.15	04.25	10	04.25	05.55	90	-	-	-	Sunny	
	2	Turning Basin-Berlian Timur		05.55	07.25	90	07.25	08.45	80	08.45	08.55	10	08.55	10.35	100	10.35	15.10	275	Sunny	Dredger anchored in rede Port of Tanjung Perak; waiting for recharging of freshwater. (275')
	-	-	-	-	-	-	-	-	-	-	-	-	15.10	15.25	15	-	-	-		
	3	Turning Basin-Berlian Timur		15.25	16.55	90	16.55	18.15	80	18.15	18.25	10	18.25	20.00	95	-	-	-	Sunny	
	4	Turning Basin-Berlian Timur		20.00	21.30	90	21.30	22.55	85	22.55	23.05	10	23.05	24.00	55	-	-	-	Sunny	
13/09/2012	-	-	-	-	-	-	-	23.40	-	-	-	-	00.00	01.20	80	-	-	-		
	1	Turning Basin-Berlian Timur		01.20	02.50	90	02.50	04.15	85	04.15	04.25	10	04.25	05.55	90	-	-	-	Sunny	
	2	Turning Basin-Berlian Timur		05.55	07.25	90	07.25	08.55	90	08.55	09.05	10	09.05	09.10	05	09.10	16.20	430	Sunny	Dredger anchored in rede Maspion; fixing the pump housing right side, broken of bolt wearing plates (145')
	-	-	-	-	-	-	-	-	-	-	-	-	16.20	17.55	95	-	-	-		
	3	Turning Basin-Berlian Timur		17.55	19.20	85	19.20	20.50	90	20.50	21.00	10	21.00	22.30	90	-	-	-	Sunny	
	-	Turning Basin-Berlian Timur		22.30	24.00	90	-	-	-	-	-	-	-	-	-	-	-	-		
14/09/2012	1	Turning Basin-Berlian Timur					00.00	01.25	85	01.25	01.35	10	01.35	03.10	95				Sunny	
	2	Turning Basin-Berlian Timur		03.10	04.25	75	04.25	05.45	80	05.45	05.55	10	05.55	07.25	90				Sunny	
	3	Turning Basin-Berlian Timur		07.25	08.40	75	08.40	10.00	80	10.00	10.10	10	10.10	11.40	90	11.40	15.30	230	Sunny	Anchoring on Tg. Perak's basin for repairing loading Valve gate and Friday pray (230')
	-												15.30	15.45	15					
	4	Turning Basin-Berlian Timur		15.45	17.00	75	17.00	18.20	80	18.20	18.30	10	18.30	20.00	90				Sunny	
	5	Turning Basin-Berlian Timur		20.00	21.15	75	21.15	22.35	80	22.35	22.45	10	22.45	24.00	75				Sunny	
Week-8 /																				
17/09/2012	1	Turning Basin-Berlian Timur		00.00	01.15	75	01.15	02.35	80	02.35	02.45	10	02.45	04.15	90				Sunny	
	2	Turning Basin-Berlian Timur		04.15	05.30	75	05.30	06.50	80	06.50	07.00	10	07.00	08.35	95				Sunny	
	3	Turning Basin-Berlian Timur		08.35	09.50	75	09.50	11.15	85	11.15	11.25	10	11.25	12.55	90	12.55	16.30	215	Sunny	Anchoring at Tg. Perak's Basin for waiting procurenment and repairment of Turbo filter charge generator no. 2 (215')
													16.30	16.45	15				Sunny	
	4	Turning Basin-Berlian Timur		16.45	18.00	75	18.00	19.25	85	19.25	19.35	10	19.35	21.05	90				Sunny	
	5	Turning Basin-Berlian Timur		21.05	22.20	75	22.20	23.30	70	23.30	23.40	10	23.40	00.00	20				Sunny	
18/09/2012													00.00	01.10	70					
	1	Turning Basin-Berlian Timur		01.10	02.25	75	02.25	03.50	85	03.50	04.00	10	04.00	05.35	95				Sunny	
	2	Turning Basin-Berlian Timur		05.35	06.50	75	06.50	08.15	85	08.15	08.25	10	08.25	10.10	105	10.10	00.00	830	Sunny	Anchoring at Tg. Perak basin for waiting lubricant (830')
19/09/2012																00.00	00.00	1440		Anchoring at Tg. Perak basin for waiting lubricant (1440')
20/09/2012																00.00	13.50	830		Anchoring at Tg. Perak basin for waiting lubricant (830')
21/09/2012	1	Turning Basin-Berlian Timur					00.00	01.20	80	01.20	01.30	10	01.30	03.00	90				Sunny	
	2	Turning Basin-Berlian Timur		03.00	04.15	75	04.15	05.35	80	05.35	05.45	10	05.45	07.20	95				Sunny	
	3	Turning Basin-Berlian Timur		07.20	08.35	75	08.35	10.00	85	10.00	10.10	10	10.10	11.40	90	11.40	14.15	155	Sunny	Anchoring at Tg. Perak's basin for Friday pary (155')
													14.15	14.30	15					
	4	Turning Basin-Berlian Timur		14.30	15.45	75	15.45	17.05	80	17.05	17.15	10	17.15	18.50	95				Sunny	
	5	Turning Basin-Berlian Timur		18.50	20.05	75	20.05	21.30	85	21.30	21.40	10	21.40	23.10	90				Sunny	
		Turning Basin-Berlian Timur		23.10	24.00.00	50														

Table A-8. Continued

DATE / WEEK	TRIP	DREDGING LOCATION		DREDGING PROCESS			SAILING-OUT			DISCHARGING			SAILING-IN			OBSTRACTION / DELAYS			WEATHER	INFORMATION
		FROM	TO	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE		
Week-9 /																				
25/09/2012	-												00.00	01.05	65					
	1	Turning Basin-Berlian Timur		01.05	02.20	75	02.20	03.45	85	03.45	03.55	10	03.55	05.30	95				Sunny	
	2	Turning Basin-Berlian Timur		05.30	06.45	75	06.45	08.10	85	08.10	08.20	10	08.20	09.50	90	09.50	12.20	150	Sunny	Anchoring at Maspion's basin for repair parent engine cooling pump (150')
	-												12.20	13.50	90					
	3	Turning Basin-Berlian Timur		13.50	15.05	75	15.05	16.25	80	16.25	16.35	10	16.35	18.10	95					
	4	Turning Basin-Berlian Timur		18.10	19.25	75	19.25	20.50	85	20.50	21.00	10	21.00	22.35	95				Sunny	
	-	Turning Basin-Berlian Timur		22.35	23.50	75	23.50	24.00.00	10										Sunny	
28/09/2012	1	Turning Basin-Mirah					00.00	01.05	65	01.05	01.15	10	01.15	02.50	95				Sunny	
	2	Turning Basin-Mirah		02.50	04.05	75	04.05	05.30	85	05.30	05.40	10	05.40	07.10	90				Sunny	
	3	Turning Basin-Mirah		07.10	08.25	75	08.25	09.50	85	09.50	10.00	10	10.00	11.35	95	11.35	16.00	265	Foggy	anchoring at Tg perak Basin for changging left wire rope trunion, & Friday pray (265')
	-												16.00	16.15	15					
	4	Turning Basin-Mirah		16.15	17.30	75	17.30	18.55	85	18.55	19.05	10	19.05	20.40	95				Sunny	
	5	Turning Basin-Mirah		20.40	21.55	75	21.55	23.15	80	23.15	23.25	10	23.25	24.00.00	35				Sunny	
Week-10 /																				
02/10/2012	-									00.00	01.25	85	01.25	24.00.00	1355					Ship anchoring at Tg Perak's basin for ME revision, drigging member and refueling
03/10/2012													00.00	24.00.00	1440					Ship anchoring at Tg Perak's basin for ME revision, drigging member and refueling and refueling fresh water
04/10/2012	-															00.00	16.30	990		Ship anchoring at Tg Perak's basin for refueling fresh water (990')
	-												16.30	16.45	15					
	1	Turning Basin-Berlian Timur		16.45	17.55	70	17.55	19.20	85	19.20	19.30	10	19.30	21.00	90				Sunny	
	2	Turning Basin-Berlian Timur		21.00	22.10	70	22.10	23.30	80	23.30	23.40	10	23.40	24.00.00	20				Sunny	
05/10/2012	-												00.00	01.15	75					
	1	Turning Basin-Berlian Timur		01.15	02.25	70	02.25	03.55	90	03.55	04.05	10	04.05	05.40	95				Sunny	
	2	Turning Basin-Berlian Timur		05.40	06.50	70	06.50	08.15	85	08.15	08.25	10	08.25	10.15	110	10.15	14.50	275	Sunny	Ship anchoring ata tg. Perak's basin for drop in oxygen bottle and Friday pray (275')
	-												14.50	15.05	15					
	3	Turning Basin-Berlian Timur		15.05	16.15	70	16.15	17.40	85	17.40	17.50	10	17.50	19.25	95				Sunny	
	4	Turning Basin-Berlian Timur		19.25	20.35	70	20.35	22.00	85	22.00	22.10	10	22.10	23.45	95				Sunny	
	-	Turning Basin-Berlian Timur		23.45	24.00.00	15									00					
Week-11 /																				
11/10/2012	1	Turning Basin-Jamrud selatan		00.00	00.25	25	00.25	01.45	80	01.45	01.55	10	01.55	03.25	90				Sunny	
	2	Turning Basin-Jamrud selatan		03.25	04.35	70	04.35	06.00	85	06.00	06.10	10	06.10	07.55	105	07.55	24.00.00	965	Sunny	Anchoring at Tg Perak's Basin for waiting lubricant oil (965')
12/10/2012																00.00	24.00.00	1440		Anchoring at Tg Perak's Basin for waiting lubricant oil (1440')
13/10/2012																00.00	24.00.00	1440		Anchoring at Tg Perak's Basin for waiting lubricant oil (1440')
14/10/2012																00.00	24.00.00	1440		Anchoring at Tg Perak's Basin for waiting lubricant oil (1440')
Week-12 /																				
15/10/2012																00.00	24.00.00	1440		Anchoring at Tg Perak's Basin for waiting lubricant oil (1440')
16/10/2012																00.00	14.20	860		Anchoring at Tg Perak's Basin for waiting lubricant oil (860')
													14.20	14.35	15					
	1	Turning Basin-Jamrud selatan		14.35	15.45	70	15.45	17.20	95	17.20	17.30	10	17.30	19.00	90				Sunny	
	2	Turning Basin-Jamrud selatan		19.00	20.10	70	20.10	21.40	90	21.40	21.50	10	21.50	23.20	90				Sunny	
	-	Turning Basin-Jamrud selatan		23.20	24.00.00	40														
19/10/2012	1	Turning Basin-Jamrud selatan					00.00	00.20	20	00.20	00.30	10	00.30	01.55	85				Sunny	
	2	Turning Basin-Jamrud selatan		01.55	03.05	70	03.05	04.30	85	04.30	04.40	10	04.40	06.10	90				Sunny	
	3	Turning Basin-Jamrud selatan		06.10	07.20	70	07.20	08.40	80	08.40	08.50	10	08.50	10.30	100	10.30	14.15	225	Sunny	Anchoring at Tg Perak's Basin for repairment of right loading valve & Hyd. Bottom door no. 7 left side (225')
													14.15	14.45	30					
	4	Turning Basin-Jamrud selatan		14.45	15.55	70	15.55	17.30	95	17.30	17.40	10	17.40	19.10	90				Sunny	
	5	Turning Basin-Jamrud selatan		19.10	20.20	70	20.20	21.50	90	21.50	22.00	10	22.00	23.25	85				Sunny	
	-	Turning Basin-Jamrud selatan		23.25	24.00.00	35														

Table A-8. Continued

DATE / WEEK	TRIP	DREDGING LOCATION		DREDGING PROCESS			SAILING-OUT			DISCHARGING			SAILING-IN			OBSTRACTION / DELAYS			WEATHER	INFORMATION
		FROM	TO	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE		
Week-13 /																				
24/10/2012	1	Turning Basin-Berlian Timur					00.00	00.45	45	00.45	00.55	10	00.55	02.25	90				Sunny	
	2	Turning Basin-Berlian Timur		02.25	03.35	70	03.35	05.00	85	05.00	05.10	10	05.10	06.45	95				Sunny	
	3	Turning Basin-Berlian Timur		06.45	07.55	70	07.55	09.25	90	09.25	09.35	10	09.35	11.35	120	11.35	15.50	255	Sunny	Anchoring at Tg, Perak's Basin for repairment of left dredging pump and refueling (255')
													15.50	16.25	35					
	4	Turning Basin-Berlian Timur		16.25	17.35	70	17.35	19.00	85	19.00	19.10	10	19.10	20.40	90				Sunny	
	5	Turning Basin-Berlian Timur		20.40	21.50	70	21.50	23.10	80	23.10	23.20	10	23.20	24.00.00	40				Sunny	
25/10/2012	-												00.00	00.55	55					
	1	Turning Basin-Jamrud selatan		00.55	02.05	70	02.05	03.25	80	03.25	03.35	10	03.35	05.05	90				Sunny	
	2	Turning Basin-Jamrud selatan		05.05	06.15	70	06.15	07.40	85	07.40	07.50	10	07.50	09.25	95				Sunny	
	3	Turning Basin-Jamrud selatan		09.25	10.35	70	10.35	12.00	85	12.00	12.10	10	12.10	14.10	120	14.10	24.00.00	590	Sunny	Anchoring at Tg, Perak's Basin for repairment of left dredging pump and refueling (590')
26/10/2012																00.00	24.00.00	1440		Anchoring at Tg, Perak's Basin, National holiday for Idul Adha 1433 H (1440')
27/10/2012																00.00	09.35	575		Anchoring at Tg, Perak's Basin,preparation for dredging operation (575')
													09.35	10.05	30					
	1	Turning Basin-Jamrud selatan		10.05	11.15	70	11.15	12.35	80	12.35	12.45	10	12.45	14.15	90				Sunny	
	2	Turning Basin-Jamrud selatan		14.15	15.25	70	15.25	16.50	85	16.50	17.00	10	17.00	18.35	95				Sunny	
	3	Turning Basin-Jamrud selatan		18.35	19.45	70	19.45	21.10	85	21.10	21.20	10	21.20	22.50	90				Sunny	
	-	Turning Basin-Jamrud selatan		22.50	24.00.00	70														
Week-14 /																				
02/11/2012	1	Turning Basin-Mirah					00.00	00.30	30	00.30	00.40	10	00.40	02.10	90				Sunny	
	2	Turning Basin-Mirah		02.10	03.20	70	03.20	04.40	80	04.40	04.50	10	04.50	06.25	95				Sunny	
	3	Turning Basin-Mirah		06.25	07.35	70	07.35	09.00	85	09.00	09.10	10	09.10	10.50	100	10.50	14.05	195	Cloudy	Ship anchoring at Tg. Perak's basin for Friday pray (195')
	-												14.05	14.20	15					
	4	Turning Basin-Mirah		14.20	15.30	70	15.30	16.50	80	16.50	17.00	10	17.00	18.35	95				Sunny	
	5	Turning Basin-Mirah		18.35	19.45	70	19.45	21.10	85	21.10	21.20	10	21.20	23.25	125	23.25	24.00.00	35	Sunny	Ship anchoring at Tg. Perak's basin for ME revision and dredging members (35')
03/11/2012																00.00	24.00.00	1440		Ship anchoring at Tg. Perak's basin for ME revision, dredging members and refueling bunker and fresh water (1440')
04/11/2012																00.00	24.00.00	1440		Ship anchoring at Tg. Perak's basin for ME revision, dredging members and refueling bunker and fresh water (1440')
Week-15 /																				
05/11/2012																00.00	05.50	350		Ship anchoring at Tg. Perak's basin due to high wind (350')
													05.50	06.10	20					
	1	Turning Basin- Nilam Timur		06.10	07.20	70	07.20	08.40	80	08.40	08.50	10	08.50	10.20	90				Cloudy	
	2	Turning Basin- Nilam Timur		10.20	11.30	70	11.30	12.55	85	12.55	13.05	10	13.05	14.40	95				Cloudy	
	3	Turning Basin- Nilam Timur		14.40	15.50	70	15.50	17.10	80	17.10	17.20	10	17.20	18.50	90				Cloudy	
	4	Turning Basin- Jamrud Selat		18.50	20.00	70	20.00	21.25	85	21.25	21.35	10	21.35	23.10	95				Sunny	
	-	Turning Basin- Nilam Timur		23.10	24.00.00	50														
09/11/2012	1	Turning Basin- Jamrud Selatan					00.00	00.50	50	00.50	01.00	10	01.00	02.30	90				Cloudy	
	2	Turning Basin- Jamrud Selat		02.30	03.40	70	03.40	05.05	85	05.05	05.15	10	05.15	06.50	95				Cloudy	
	3	Turning Basin- Nilam Timur		06.50	08.00	70	08.00	09.20	80	09.20	09.30	10	09.30	11.10	100	11.10	14.30	200	Cloudy	Ship anchoring at Tg. Perak's Basin for Friday pray and lifting lubricant oil (200")
	-												14.30	14.45	15					
	4	Turning Basin- Nilam Timur		14.45	15.55	70	15.55	17.20	85	17.20	17.30	10	17.30	19.05	95				Sunny	
	5	Turning Basin- Nilam Timur		19.05	20.15	70	20.15	21.40	85	21.40	21.50	10	21.50	23.25	95				Sunny	
	-	Turning Basin- Jamrud Selat		23.25	24.00.00	35														
11/11/2012	-												00.00	01.00	60					
	1	Turning Basin- Jamrud Selat		01.00	02.10	70	02.10	03.35	85	03.35	03.45	10	03.45	05.15	90				Cloudy	
	2	Turning Basin- Nilam Timur		05.15	06.25	70	06.25	07.45	80	07.45	07.55	10	07.55	09.30	95				Cloudy	
	3	Turning Basin- Nilam Timur		09.30	10.40	70	10.40	12.05	85	12.05	12.15	10	12.15	12.35	20	12.30	14.55	145	Cloudy	Anchoring at Maspion basin for changing lubricant oil of generator no. 2 & repair pneumatic systems (145')
	-												14.55	16.30	95					
	4	Turning Basin- Jamrud Selat		16.30	17.40	70	17.40	19.05	85	19.05	19.15	10	19.15	20.00	45				cloudy	
	5	Turning Basin- Jamrud Selat		20.50	22.00	70	22.00	23.25	85	23.25	23.35	10	23.35	24.00.00	25				cloudy	

Table A-8. Continued

DATE / WEEK	TRIP	DREDGING LOCATION		DREDGING PROCESS			SAILING-OUT			DISCHARGING			SAILING-IN			OBSTRACTION / DELAYS			WEATHER	INFORMATION
		FROM	TO	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE	START	STOP	MINUTE		
Week-16 /																				
	1	Turning Basin-	Nilam Timur				00.00	00.50	50	00.50	01.00	10	01.00	06.15	315				Sunny	
	2	Turning Basin-	Nilam Timur	06.15	07.25	70	07.25	08.50	85	08.50	09.00	10	09.00	10.30	90				Cloudy	
14/11/2012	3	Turning Basin-	Nilam Timur	10.30	11.40	70	11.40	13.05	85	13.05	13.15	10	13.15	14.45	90				Cloudy	
	4	Turning Basin-	Nilam Timur	14.45	15.55	70	15.55	17.15	80	17.15	17.25	10	17.25	19.00	95				Cloudy	
	5	Turning Basin-	Jamrud Selat	19.00	20.10	70	20.10	21.35	85	21.35	21.45	10	21.45	23.35	110	23.35	24.00.00	25	Cloudy	Anchoring at Tg. Perak's basin for celebrating new islamic year 1434 Hijriyah (25')
15/11/2012																00.00	24.00.00	1440		Anchoring at Tg. Perak's basin for celebrating new islamic year 1434 Hijriyah (1440')
													00.00	00.55	55					
	1	Turning Basin-	Jamrud Selat	00.55	02.05	70	02.05	03.40	95	03.40	03.50	10	03.50	05.25	95					
16/11/2012	2	Turning Basin-	Nilam Timur	05.25	06.35	70	06.35	08.05	90	08.05	08.15	10	08.15	10.40	145	10.40	13.20	160		Anchoring at Tg. Perak's basin for Friday pray (160')
	-												13.20	14.00	40					
	3	Turning Basin-	Jamrud Selat	14.00	15.10	70	15.10	16.45	95	16.45	16.55	10	16.55	18.30	95					
	4	Turning Basin-	Nilam Timur	18.30	19.40	70	19.40	21.10	90	21.10	21.20	10	21.20	23.40	140	23.40	24.00.00	20		Anchoring at Tg. Perak's basin for prepare engine revision and deck department (20')
17/11/2012																00.00	24.00.00	1440		Anchoring at Tg. Perak's basin for ME revision, dredging personel and waiting for refueling bunker (1440')
18/11/2012																00.00	24.00.00	1440		Anchoring at Tg. Perak's basin for ME revision, dredging personel and waiting for refueling bunker (1440')
Week-17 /																				
19/11/2012																00.00	24.00.00	1440		Anchoring at Tg. Perak's basin for ME revision, dredging personel and waiting for refueling bunker (1440')
20/11/2012																00.00	24.00.00	1440		Anchoring at Tg. Perak's basin for waiting procurement of lubricant oil (1440')
21/11/2012																00.00	24.00.00	1440		Anchoring at Tg. Perak's basin for waiting procurement of lubricant oil (1440')
22/11/2012																00.00	24.00.00	1440		Anchoring at Tg. Perak's basin for waiting procurement of lubricant oil (1440')
23/11/2012																00.00	24.00.00	1440		Anchoring at Tg. Perak's basin for waiting procurement of lubricant oil (1440')
	-															00.00	13.35	815		Anchoring at Tg. Perak's basin for waiting procurement of lubricant oil (815')
	-												13.35	13.50	15					
24/11/2012	1	Turning Basin-	Nilam Timur	13.50	15.00	70	15.00	16.25	85	16.25	16.35	10	16.35	18.10	95				Cloudy	
	2	Turning Basin-	Nilam Timur	18.10	19.20	70	19.20	20.45	85	20.45	20.55	10	20.55	22.25	90				Cloudy	
	-	Turning Basin-	Nilam Timur	22.25	23.35	70	23.35	24.00.00	25											

Table A-8 is a summary of daily reports for time delays project of TSHD where previously had been filtering and only on the date and time delays in project implementation. These data are useful in identifying the dominant cause of delays, which is expected to be given a completion of the issue based on required by the project. The results can be seen in Table 26.

Table A-9. Results of laboratory test for the type of soil in the dredging project

INSTITUT TEKNOLOGI SEPULUH NOPEMBER
FAKULTAS TEKNIK SIPIL DAN PERENCANAAN
JURUSAN TEKNIK SIPIL
LABORATORIUM KEAIRAN DAN TEKNIK PANTAI
Kampus ITS – Sukolilo – Surabaya 60111
Telp : (031) 5928602 - 5946094 - 5947284 Fax : (031) 5947284 – 5928602 e-mail : hidroits@sby.centrin.net.id

Berat total (gram) 270
Berat tempat (gram) 41
Berat contoh (gram) 229

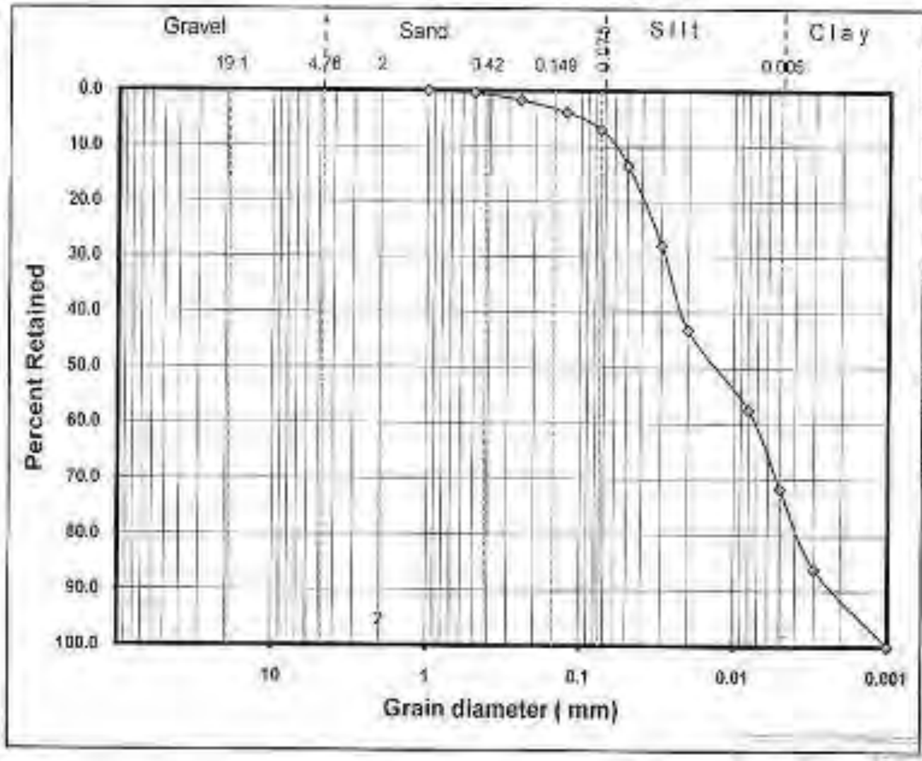
Proyek : Pelabuhan Perak
River Pelabuhan
Location : Perak Surabaya

Sample No. : II
Date of sampling :20-10-2011
Jam :

Tested by Laborant
Date of testing : 28-10-2011

GRAIN SIZE DISTRIBUTION

Diameter	Tertahan			
	Berat		Prosen	
	Total	Contoh		Σ
(mm)	(gram)	(gram)	(%)	(%)
19.06	41	0	0	0
12.7	41	0	0	0.0
7.9	41	0	0	0.0
4.76	41	0	0	0.0
3.36	41	0	0	0.0
2	41	0	0	0.0
1	41	0	0	0.0
0.5	42	1	0.4367	0.4
0.25	44	3	1.31	1.7
0.125	48	5	2.1834	3.9
0.075	49	7	3.0568	7.0
0.05	56	15	6.5502	13.5
0.03	74	33	14.41	27.9
0.02	76	35	15.284	43.2
0.008	74	33	14.41	57.6
0.005	73	32	13.974	71.6
0.003	74	33	14.41	86.0
0.001	73	32	13.974	100.0



Grain Diameter :

D 90		mm
D 65		mm
D 50		mm
D mean		mm

Description of soil

Gravel	%	0.00
Sand	%	7.00
Silt	%	64.00
Clay	%	29.00

GS = 2.8402

Table A-10. Results of laboratory test for the concentration of silt

PT. (Persero) RUKINDO JAKARTA

KK. " KALIMANTAN II "

PENGUKURAN KADAR LUMPUR DALAM BAK

LEMBAR No : 23

HARI	:	SABTU
TANGGAL	:	25-Aug-12
JAM	:	09.30 LT
KAPAL KERUK	:	KK. " KALIMANTAN II "
LOKASI	:	KOLAM PELABUHAN TG. PERAK SURABAYA
SPOT	:	TURNING BASIN S/D MIRAH
JENIS TANAH	:	TANAH LIAT DAN LUMPUR

1	Berat Jenis air	:	1.025	Gram/ml
2	Berat Gelas Kosong	:	506	Gram
3	Volume	:	1000	ml
4	Pengambilan lumpur di bak	:	Muka, tengah, belakang	

No	Berat dalam Gram		Volume (ml)	BJ Lumpur (Gram/ml)	Keterangan
	Gelas + Lumpur	Lumpur			
1	1665	1159	1000	1.159	
2	1662	1156	1000	1.156	
3	1658	1152	1000	1.152	
4	1662	1156	1000	1.156	
5	1663	1157	1000	1.157	
6	1659	1153	1000	1.153	

Jumlah Berat Jenis = 6.933 Gram / ml

Berat Jenis Lumpur Rata rata = $\frac{\text{Jumlah BJ}}{6}$ = $\frac{6.933}{6}$

= 1.156 Gram / ml

5 Berat Jenis Tanah Dasar.

Berat Gelas	506	Gram
Beras Gelas + Air	1114	Gram
Berat Gelas + Air + Tanah Dasar	1384	Gram
Berat Tanah Dasar	270	Gram
Volume Air (dalam gelas)	600	ml
Volume Air + Tanah Dasar	800	ml
Volume Tanah Dasar	200	ml

BJ Tanah Dasar = $\frac{\text{Berat Tanah Dasar}}{\text{Volume Tanah Dasar}}$ = $\frac{270 \text{ Gram}}{200 \text{ ml}}$

= 1.35 Gram / ml

Konsentrasi kadar lumpur dalam bak.

$$\frac{\text{BJ Lumpur - BJ Air X 100 \%}}{\text{BJ Tanah Dasar - BJ Air}} = \frac{1.156 - 1.025}{1.350 - 1.025} \times 100\ \%$$

= 0.4015 = **40%**

MANAGER

APPENDIX B

TRAILING SUCTION HOPPER DREDGE AND GRAB CLAMSHELL COST ESTIMATION

Table B-1. Results of laboratory test for the concentration of silt

Estimates of Fuel Consumption for Daily Operations													
Dredger Types of TSHD													
1.	**TSHD Type 5.000 m3**												
	a. Main Engine :	2	x	3.950	HP x	170	gr/HP/hr x	24	Hours :	0.85	=	37.920.00	Ltr
	b. Dredge Pump :	(di couple dengan Main Engine)											
	c. Generator :	3	x	670	HP x	165	gr/HP/hr x	24	Hours :	0.85	=	9.364.24	Ltr
												47.284.24	Ltr
							The assumption of an average en			40%	=	18.913.69	Ltr
								rounded			=	**19.000.00**	Ltr
	Mob/Demob												
	a. Main Engine :	2	x	3.950	HP x	170	gr/HP/hr x	24	Hours :	0.85	=	37.920.00	Ltr
	b. Dredge Pump :												
	c. Generator :	2	x	670	HP x	165	gr/HP/hr x	24	Hours :	0.85	=	6.242.82	Ltr
											=	44.162.82	Ltr
							The assumption of an average en			40%	=	**17.665.13**	Ltr
								rounded			=	**17.700.00**	Ltr
2.	**TSHD Type 4.000 m3**												
	a. Main Engine :	2	x	1.795	HP x	170	gr/HP/hr x	24	Hours :	0.85	=	17.232.00	Ltr
	b. Dredge Pump :	2	x	898	HP x	163	gr/HP/hr x	8	Hours :	0.85	=	2.755.28	Ltr
	c. Generator :	2	x	544	HP x	165	gr/HP/hr x	24	Hours :	0.85	=	5.068.80	Ltr
												25.056.08	Ltr
				The assumption of an average engine power						65%	=	16.286.45	Ltr
								rounded			=	**16.280.00**	Ltr
	Mob/Demob												
	a. Main Engine :	2	x	1.795	HP x	170	gr/HP/hr x	24	Hours :	0.85	=	17.232.00	Ltr
	b. Dredge Pump :	0	x	898	HP x	163	gr/HP/hr x	8	Hours :	0.85	=	0.00	Ltr
	c. Generator :	1	x	544	HP x	165	gr/HP/hr x	24	Hours :	0.85	=	2.534.40	Ltr
											=	19.766.40	Ltr
				The assumption of an average engine power					65%		=	**12.848.16**	Ltr
						rounded					=	**12.848.00**	Ltr

At this stage, dredging cost estimate is calculated by following the regulations of the Indonesian republic transport ministry. Because some cost parameters that have been set in advance, and force in 2011, such as vessel rental costs, amounting to IDR 18,233,539 (this includes insurance costs, an estimate of depreciation, and salaries of the crew of the dredger). The next is the price of fuel amounting to IDR 9.664 per litre, the price of lubricants amounted to IDR 50,000 per litre, the number of working days in a year of 216 calendar days, costing over dredging of 20%, assuming an average power ship engines, costs P & I insurance, H & M insurance, crew salary, etc.

Table B-1. Continued

3.	**TSHD Type 2900 m3**												
	a. Main Engine :	2	x	2.100	HP x	170	gr/HP/hr x	24	Hours :	0.85	=	20.160.00	Ltr
	b. Dredge Pump :	2	x	820	HP x	163	gr/HP/hr x	8	Hours :	0.85	=	2.515.95	Ltr
	c. Generator :	2	x	820	HP x	165	gr/HP/hr x	24	Hours :	0.85	=	7.640.47	Ltr
												30.316.42	Ltr
			The assumption of an average engine power							50%	=	15.158.21	Ltr
							rounded				=	**15.158.00**	Ltr
	Mob/Demob												
	a. Main Engine :	2	x	2.100	HP x	170	gr/HP/hr x	24	Hours :	0.85	=	20.160.00	Ltr
	b. Dredge Pump :												
	c. Generator :	1	x	820	HP x	165	gr/HP/hr x	24	Hours :	0.85	=	3.820.24	Ltr
											=	23.980.24	Ltr
			The assumption of an average engine power					50%			=	**11.990.12**	Ltr
							rounded				=	**11.990.00**	Ltr
4.	**TSHD Type 2000 m3**												
	a. Main Engine :	2	x	2.100	HP x	170	gr/HP/hr x	24	Hours :	0.85	=	20.160.00	Ltr
	b. Dredge Pump :	2	x	550	HP x	163	gr/HP/hr x	8	Hours :	0.85	=	1.687.53	Ltr
	c. Generator :	2	x	729	HP x	165	gr/HP/hr x	24	Hours :	0.85	=	6.792.56	Ltr
											=	28.640.09	Ltr
			The assumption of an average engine power							45%	=	12.888.04	Ltr
							rounded				=	**12.800.00**	Ltr
	Mob/Demob												
	a. Main Engine :	2	x	2.100	HP x	170	gr/HP/hr x	24	Hours :	0.85	=	20.160.00	Ltr
	b. Dredge Pump :												
	c. Generator :	1	x	729	HP x	165	gr/HP/hr x	24	Hours :	0.85	=	3.396.28	Ltr
											=	23.556.28	Ltr
			The assumption of an average engine power					45%			=	**10.600.33**	Ltr
						rounded					=	**10.600.00**	Ltr
5.	**TSHD Type 1000 m3**												
	a. Main Engine :	2	x	846	HP x	170	gr/HP/hr x	24	Hours :	0.85	=	8.121.60	Ltr
	b. Dredge Pump :	1	x	400	HP x	163	gr/HP/hr x	8	Hours :	0.85	=	613.65	Ltr
	c. Generator :	2	x	300	HP x	165	gr/HP/hr x	24	Hours :	0.85	=	2.795.29	Ltr
												11.530.54	Ltr
						The assumption of an average en				70%	=	8.071.38	Ltr
							rounded				=	**8.070.00**	Ltr
	Mob/Demob												
	a. Main Engine :	2	x	846	HP x	170	gr/HP/hr x	24	Hours :	0.85	=	8.121.60	Ltr
	b. Dredge Pump :												
	c. Generator :	1	x	300	HP x	165	gr/HP/hr x	24	Hours :	0.85	=	1.397.65	Ltr
											=	9.519.25	Ltr
					The assumption of an average engine power						=	**6.663.47**	Ltr
					rounded						=	**6.663.00**	Ltr

Table B-1. Continued

Dredger Types of Clamshell												
1.	**Clamshell Type 5,5 m3**											
	a. Main Engine :	1	x	400	HP x	180	gr/HP/hr x	18	Hours :	0.85 =	1.524.71	Ltr
	b. Gen. Crane :	1	x	100	HP x	170	gr/HP/hr x	24	Hours :	0.85 =	480.00	Ltr
	c. Hydraulic :	1	x	50	HP x	170	gr/HP/hr x	18	Hours :	0.85 =	180.00	Ltr
	d. 2 Split Barge:	4	x	290	HP x	170	gr/HP/hr x	9	Hours :	0.85 =	2.088.00	Ltr
	e. 1 Tug Boat :	1	x	290	HP x	180	gr/HP/hr x	9	Hours :	0.85 =	552.71	Ltr
											4.825.41	Ltr
					The assumption of an average engine power					75% =	3.619.06	Ltr
								rounded		=	**3.620.00**	Ltr
	Mob/Demob											
	a. Main Engine :	2	x	290	HP x	170	gr/HP/hr x	24	Hours :	0.85 =	2.784.00	Ltr
	b. Generator Crane :	1	x	50	HP x	170	gr/HP/hr x	24	Hours :	0.85 =	240.00	Ltr
	e. 1 Tug Boat :	1	x	350	HP x	180	gr/HP/hr x	9	Hours :	0.85 =	667.06	Ltr
										=	3.691.06	Ltr
					The assumption of an average engine				75%	=	**2.768.29**	Ltr
								rounded		=	**2.768.00**	Ltr
2.	**Clamshell Type 20 m3**											
	a. Main Engine :	1	x	1.139	HP x	180	gr/HP/hr x	18	Hours :	0.85 =	4.341.60	Ltr
	b. Generator Crane :	1	x	100	HP x	170	gr/HP/hr x	24	Hours :	0.85 =	480.00	Ltr
	c. 2 Split Barge:	4	x	350	HP x	170	gr/HP/hr x	9	Hours :	0.85 =	2.520.00	Ltr
	d. 1 Tug Boat :	2	x	350	HP x	180	gr/HP/hr x	9	Hours :	0.85 =	1.334.12	Ltr
											8.675.72	Ltr
					The assumption of an average engine power					75% =	6.506.79	Ltr
								rounded		=	**6.506.00**	Ltr
	Mob/Demob											
	a. Main Engine :	2	x	1.139	HP x	170	gr/HP/hr x	24	Hours :	0.85 =	10.934.40	Ltr
	b. Gen. Crane :	1	x	100	HP x	170	gr/HP/hr x	24	Hours :	0.85 =	480.00	Ltr
	d. 1 Tug Boat :	2	x	350	HP x	180	gr/HP/hr x	9	Hours :	0.85 =	1.334.12	Ltr
										=	12.748.52	Ltr
				The assumption of an average engine power					75%	=	**9.561.39**	Ltr
							rounded			=	**9.561.00**	Ltr

Table B-2. Results of laboratory test for the concentration of silt

Estimates of Lubricants Consumption for Daily Operations											
Dredger Types of TSHD											
1. TSHD 5000											
a. Main Engine	2	x	3.950	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	777.36	Ltr
b. Dredge Pump	(di couple dengan Main Engine)										
c. Generator	3	x	670	HP x	0.0033	Ltr/HP/Hours x	24	Hours	=	159.19	Ltr
									=	936.55	
	The assumption of an average engine power						40%		=	374.62	Ltr
				rounded					**=**	**375.00**	**Ltr**
Mobilization/Demobilization TSHD 5000											
a. Main Engine	2	x	3.950	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	777.36	Ltr
b. Dredge Pump	(di couple dengan Main Engine)										
c. Generator	2	x	670	HP x	0.0033	Ltr/HP/Hours x	24	Hours	=	106.13	Ltr
									=	883.49	Ltr
		The assumption of an average engine power					40%		=	353.40	Ltr
						rounded			**=**	**353.00**	**Ltr**
2. TSHD 4000											
a. Main Engine	2	x	1.795	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	353.26	Ltr
b. Dredge Pump	2	x	898	HP x	0.0033	Ltr/HP/Hours x	8	Hours	=	47.41	Ltr
c. Generator	2	x	544	HP x	0.0033	Ltr/HP/Hours x	24	Hours	=	86.17	Ltr
										486.84	Ltr
		The assumption of an average engine power					65%		=	316.45	Ltr
						rounded			**=**	**310.00**	**Ltr**
Mobilization/Demobilization TSHD 4000											
a. Main Engine	2	x	1.795	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	353.26	Ltr
b. Dredge Pump	0	x	898	HP x	0.0033	Ltr/HP/Hours x	8	Hours	=	0.00	Ltr
c. Generator	2	x	544	HP x	0.0033	Ltr/HP/Hours x	24	Hours	=	86.17	Ltr
									=	439.43	Ltr
		The assumption of an average engine power					65%		=	285.63	Ltr
						rounded			**=**	**280.00**	**Ltr**
3. TSHD 2900											
a. Main Engine	2	x	2.100	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	413.28	Ltr
b. Dredge Pump	2	x	820	HP x	0.0033	Ltr/HP/Hours x	8	Hours	=	43.30	Ltr
c. Generator	2	x	820	HP x	0.0033	Ltr/HP/Hours x	24	Hours	=	129.89	Ltr
										586.46	Ltr
		The assumption of an average engine power					50%		=	293.23	Ltr
						rounded			**=**	**294.00**	**Ltr**
Mobilization/Demobilization TSHD 2900											
a. Main Engine	2	x	2.100	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	413.28	Ltr
b. Dredge Pump											
c. Generator	1	x	820	HP x	0.0033	Ltr/HP/Hours x	24	Hours	=	64.94	Ltr
									=	478.22	Ltr
	The assumption of an average engine power						50%		=	239.11	Ltr
						rounded			**=**	**230.00**	**Ltr**

Table B-2. Continued

4.	**TSHD 2000**											
	a. Main Engine	2	x	2.100	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	413.28	Ltr
	b. Dredge Pump	2	x	550	HP x	0.0033	Ltr/HP/Hours x	8	Hours	=	29.04	Ltr
	c. Generator	2	x	729	HP x	0.0033	Ltr/HP/Hours x	24	Hours	=	115.47	Ltr
											557.79	Ltr
		The assumption of an average engine power						45%		=	251.01	Ltr
							rounded			**=**	**252.00**	**Ltr**
	Mobilization/Demobilization TSHD 2000											
	a. Main Engine	2	x	2.100	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	413.28	Ltr
	b. Dredge Pump											
	c. Generator	1	x	729	HP x	0.0033	Ltr/HP/Hours x	24	Hours	=	57.74	Ltr
										=	471.02	Ltr
		The assumption of an average engine power						45%		=	211.96	Ltr
							rounded			**=**	**210.00**	**Ltr**
5.	**TSHD 2000**											
	a. Main Engine	2	x	846	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	166.49	Ltr
	b. Dredge Pump	1	x	400	HP x	0.0033	Ltr/HP/Hours x	8	Hours	=	10.56	Ltr
	c. Generator	2	x	300	HP x	0.0033	Ltr/HP/Hours x	24	Hours	=	47.52	Ltr
											224.57	Ltr
		The assumption of an average engine power						70%		=	157.20	Ltr
							rounded			**=**	**157.00**	**Ltr**
	Mobilization/Demobilization TSHD 2000											
	a. Main Engine	2	x	846	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	166.49	Ltr
	b. Dredge Pump											
	c. Generator	1	x	300	HP x	0.0033	Ltr/HP/Hours x	24	Hours	=	23.76	Ltr
										=	190.25	Ltr
		The assumption of an average engine power						70%		=	133.18	Ltr
							rounded			**=**	**130.00**	**Ltr**

				Dredger Types of Clamshell								
1.	**Clamshell 5.5 M^3**											
	a. Main Engine	1	x	300	HP x	0.0041	Ltr/HP/Hours x	18	Hours	=	22.14	Ltr
	b. Generator	1	x	100	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	9.84	Ltr
	c. Hydraulic	1	x	50	HP x	0.0033	Ltr/HP/Hours x	18	Hours	=	2.97	Ltr
	d. 2 Split Barge	4	x	290	HP x	0.0041	Ltr/HP/Hours x	9	Hours	=	42.80	Ltr
	e. 1 Tug Boat	1	x	290	HP x	0.0041	Ltr/HP/Hours x	9	Hours	=	10.70	Ltr
											88.46	Ltr
		The assumption of an average engine power						75%		=	66.34	Ltr
							rounded			**=**	**67.00**	**Ltr**
	Mobilization/Demobilization Clamshell 5.5 M^3											
	b. Generator	1	x	100	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	9.84	Ltr
	e. 1 Tug Boat	1	x	290	HP x	0.0041	Ltr/HP/Hours x	9	Hours	=	10.70	Ltr
										=	20.54	Ltr
		The assumption of an average engine power						75%		=	15.41	Ltr
							rounded			**=**	**10.00**	**Ltr**

Table B-2. Continued

2.	**Clamshell 20 M^3**											
	a. Main Engine	1	x	1.139	HP x	0.0036	Ltr/HP/Hours x	18	Hours	=	73.81	Ltr
	b. Generator	1	x	100	HP x	0.0036	Ltr/HP/Hours x	24	Hours	=	8.64	Ltr
	c. Hydraulic	1	x	50	HP x	0.0033	Ltr/HP/Hours x	18	Hours	=	2.97	Ltr
	d. 2 Split Barge	4	x	290	HP x	0.0036	Ltr/HP/Hours x	9	Hours	=	37.58	Ltr
	e. 1 Tug Boat	1	x	290	HP x	0.0036	Ltr/HP/Hours x	18	Hours	=	18.79	Ltr
										=	141.79	Ltr
			The assumption of an average engine power					75%		=	106.34	Ltr
							rounded			**=**	**106.00**	**Ltr**
	Mobilization/Demobilization Clamshell 20 M^3											
	b. Generator	1	x	100	HP x	0.0041	Ltr/HP/Hours x	24	Hours	=	9.84	Ltr
	e. 1 Tug Boat	1	x	290	HP x	0.0041	Ltr/HP/Hours x	9	Hours	=	10.70	Ltr
										=	20.54	Ltr
			The assumption of an average engine power					75%		=	15.41	Ltr
							rounded			**=**	**10.00**	**Ltr**

Table B-3. Analysis unit price of dredging by TSHD

TSHD 4000										
No.	**TYPES OF COST**	**CALCULATION**							**AMOUNT**	
1	*2*								*4*	
I	**Production per day**									**3.480 m3**
II	**Cost per day**									
1	Fuel operation		**16.280**	**Ltr**	x	IDR	9.664		IDR	157.337.533
2	Lubricants operations		**316**	**Ltr**	x	IDR	50.000		IDR	15.822.300
3	Rental of vessel	Rp.	18.233.539.527		/		216		IDR	84.414.535
	Amount of costs								IDR	**257.574.367**
III	**Unit Price**									
1	Per cubic meters	Rp.	257.574.367		/		3.480	m3	IDR	74.011
2	**Unit Price Dredging Project**			1.20	x	IDR	74.011		IDR	**88.813**
	Rounded								**IDR**	**88.810**

An estimation of the fuel requirements (Table B-1) and lubricants (Table B-2) has been accounted based on the rules of The Ministry of Transportation, including for each type of dredger with a capacity variation of productivity, to simplify the calculations used. The amount of fuel and lubricants will be used in the calculation of unit price dredging as seen respectively in Table B-3 and Table B-4, where the unit price of the dredging project by TSHD amounting to IDR 88,810 per cubic meter and for clamshell amounting to IDR 48,501 per cubic meter.

Table B-4. Analysis unit price of dredging by Clamshell

CLAMSHELL 5,5			
No.	**JENIS BIAYA**		**JUMLAH**
1	2		4
I	**Production per day**		**1.292 m3**
II	**Cost per day**		
1	Fuel operation	**3.620** **Ltr** x Rp. 9.664.47	IDR 34.985.373
2	Lubricants operations	**67** **Ltr** x Rp. 50.000.00	IDR 3.350.000
3	Rental of vessel	IDR 4.813.900.344 / 198	IDR 24.312.628
	Amount of costs		**IDR 62.648.001**
III	**Unit Price**		
1	Per cubic meters	IDR 62.648.001 / 1.292 m3	IDR 48.501
2	**Unit Price Dredging Project**		IDR **48.501**
	Rounded		IDR **48.501**

Table B-5. The estimated cost of mobilization/demobilization by TSHD

No.	**TYPES OF COST**	**CALCULATION**	**AMOUNT OF**
1	2		4
1.	Fuel	**12.848** **Ltr** x IDR 9.664	IDR 124.169.080
2.	Lubricants	**280** **Ltr** x IDR 50.000	IDR 14.000.000
3.	Supporting operational costs	1.00 x IDR 27.658.191	IDR 27.658.191
4.	Sailing costs		IDR 165.827.271
5.	Sailing speed (Knot)		6
6.	The distance of-per-day (N Mil)	6 x 24	144
7.	**Cost per Mil-N**	IDR 165.827.271 / 144	IDR 1.151.578
		Mobilization	**IDR 1.151.578**
		Demobilization	**IDR 1.151.578**

Table B-6. The estimated cost of mobilization/demobilization by Clamshell

CLAMSHELL 5,5			
No.	**TYPES OF COST**		**AMOUNT**
1	2		4
1.	Fuel per day	**2768.0.00** **Ltr** x IDR 9.664	IDR 26.751.246
2.	Lubricants per day	**10.0.00** **Ltr** x IDR 50.000	IDR 500.000
3.	Supporting operational costs	1.00 x IDR 59.911.812	IDR 59.911.812
4.	Sailing costs per day		IDR 87.163.058
5.	Sailing speed (Knot)		4.00
6.	The distance of-per-day (N Mil)	4.00 x 24	96
7.	Cost of Mob/Demob per-N Mil		
	a. pull - tandem	1.00 / 96.00 x Rp. 87.163.058	IDR **907.949**
	amount		IDR **907.949**
	rounded		**907.948**
	b. Unaccompanied	1.00 / 2.00 x 907.948	IDR **453.974**
	rounded		IDR **453.974**

Table B-3 accounted for TSHD fuel costs amounting to IDR 157,337,553 which is obtained by multiplying the amount of fuel needed for 16,280 litres and multiplied by the price of fuel amounting to IDR 9,664 per litres. Likewise, the cost of lubricants obtained through the multiplication of the number of lubricants amounted to 316 litres multiplied by the price per litres lubricant for IDR 50,000. The next parameter is the cost of the rental price dredgers that have been set in 2011 by the government with an estimate of IDR 18,233,539,527 and an effective number of working days of the 216 calendar days in a year. The cost for renting the TSHD dredger amounted to IDR 84,414,535 resulting to the total cost of IDR 257,574,367 and is divided by a real productivity theory which has been calculated at the beginning of 3,480 m3 per day; the result is the cost per cubic meter dredging amounted to IDR 74.011. Eventually, by the consideration of over-dredging at 1,20 (or approximately 20%), the final of unit cost of dredging per cubic is obtained by multiplying factor over dredging 1.20 and the cost of dredging which is IDR 74.011. The final cost per cubic meter of IDR 88.810. The next thing to be taken into account is the unit cost of dredging for clamshell type dredger, it is calculated in the same way as in Table B-4.

Table B-5 is a calculation for mobilization and demobilization costs where the calculation is done in the same way with the calculation of unit cost of dredging. However, there are other additional parameters such as speed sailing of each type of dredger which to TSHD estimated at 6 Knots. In addition, the parameters for a distance of dumping calculated by multiplying the speed of 6 knots sailing and then multiplied with the amount of time available in a day (24 hours), so the distance covered in each one-day dredging cycle is equal to 144 nautical miles. Mobilization and demobilization costs are eventually calculated by multiplying the cost of sailing needs, amounting to IDR 165,827,271 with the distance required to sail for one day (144), the result amounted to IDR 1,151,578. The next thing to be taken into account is the unit cost of dredging for clamshell type dredger done in the same way as in Table B-6.

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