# 128 - Development of waterway transport on the Musi River, South Sumatra

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ABSTRACT: The Musi River in South Sumatra is a natural river without any engineering intervention measures taken. Due to the areas abundant natural resources, barging is expected to increase in coming decades. This study investigated various options for improving the navigability of the Musi River, in cooperation with users and the government of Indonesia. Conclusions show that with simple measures, the logistics can be greatly improved on the short term and forms a win-win situation for all parties involved. On the mid-term and long-term, capital investments into river improvement and transhipment are necessary, provided parties involved can join forces to secure sufficient transport volume to recover costs.

## 1 INTRODUCTION

Southern Sumatra is one of the main centres of natural resources in Indonesia, with many palm oil and rubber plantations and large reserves of coal. There are two coal mining areas in Southern Sumatra. Each mining area is connected by rivers to Palembang. The Musi and Rawas River from the northern mine area and the Lematang River from the southern mining area (Muara Enim). Coal is transported from the Southern area by rail to Palembang as well as to South Sumatra. Currently, a small number of coal jetties have been constructed along the Musi River, but large scale barge transport is not yet being done. Transport by road is often expensive and not allowed on public roads due to safety, unless a dedicated coal hauling road is used. Rail is being utilized as well, but investments are lacking to increase the railroad capacity. Therefore expanding barging on the Musi River is an interesting option to unlock greater potential for exporting resources. Objective of this study was to investigate various options for improvement of the river navigability to provide cost effective barging for the users. This paper shows a very practical case study of implementing simple measures with significant benefits.

## .2 MUSI RIVER LOGISTICS AND DEMAND

### 2.1 *Introduction*

The Musi River system comprises of the Musi River, navigable from Lakitan about 390km upstream of the river mouth, the Rawas River, having its bifurcation point 370km upstream of the river mouth, and the Lematang River, about 190km from the river mouth.

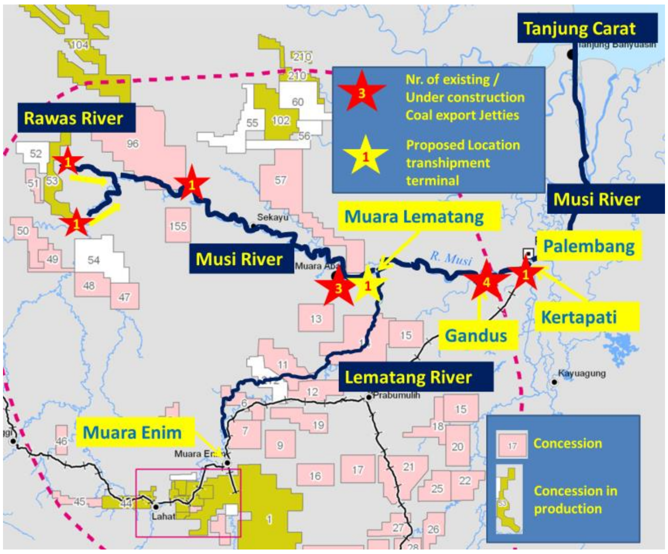



Figure 1: Musi River network with its tributaries and mine concessions

### 2.2 Capacity demand for coal transport

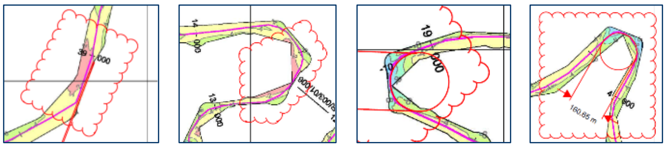
The maximum coal export potential from the Musi River area depends on the international coal market and the demand for coal coming from the South Sumatra region. A pre-feasibility study carried out in 2010 (BMT 2010), estimated the coal export growth from the South Sumatra region as presented in Table 1 below. Several plans for more power plants in the south Sumatra region are developed as an alternative destination for coal, such as Bangko Tengah (SS-8) near the Bukit Assam mine. About 25% of the production in the area is used for local consumption (BMT 2010). Total coal resources in South Sumatera are estimated at 24.59 billion tons, of which 94% is low to medium quality and 6% high to very high quality. Measured coal reserves are approximately 2.74 billion, of which 95% low to medium quality and 5% high to very high quality. South Sumatera coal resources account for approximately 41% of total Indonesian coal resources, see (BMT 2010). Over the last 5 years, the coal prices dropped and the export volumes have not increased as much as previously forecasted. The export volumes have been extrapolated to 2050.

Table 1: Expected Musi River output demand for coal on the Musi River (BMT 2010).

| BMT Argoss | 2020 | 2025 | 2035 | 2040 | *2050* |
|---|---|---|---|---|---|
| Total export Volume | 22 MT | 26 MT | 27 MT | 29 MT | *40 MT (extra-polated)* |

### 2.3 *Navigation on the Musi River and its branches*

The Musi River is influenced by the tides up to Muara Lematang (190km upstream) with water depth for barging throughout the year for barges up to 7,500 DWT. Detailed bathymetric maps show that at very few locations during the dry season, barges would require to wait for high tides on this section. Bends are in general very gentle, with only 1 bend which is too sharp to be safely passed by a 7,500 DWT barge. The river width is not sufficient to allow for 2-way traffic on various sections. Upstream of Muara Lematang, the river depth decreases and becomes more seasonal influenced by run-off than by tidal variations. The maximum barge size on these sections decrease to 1,000 DWT on the upstream Musi River and Rawas River sections to 2,000 DWT intermediately. Year-round barging is not possible.



| Chainage 39,000: limited water depth | Chainage 13,500: limited water depth in bend | Chainage 19,000: cut-off corner | Chainage 4,000: cut corner (see below) |
|---|---|---|---|

Figure 2: Bend radius calculations from bathymetries

At Muara Lematang, the Lematang River flows into the Musi River. This branch is not being used for barging at present due to strong seasonal influences by run-off. A site visit and bathymetric survey campaign was carried out. From this analysis, it was concluded that in its present situation the river would only be capable of barge traffic for several months only, and for very limited barge sizes (250DWT barges maximum).

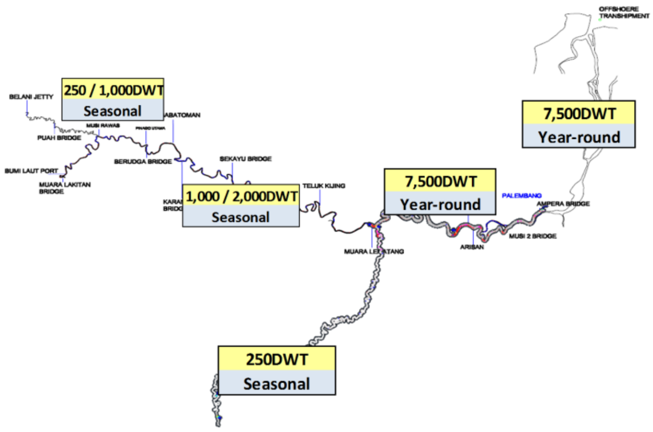



Figure 3: Musi River maximum barge size of its branches

Figure 4: Top RoRo barges. Second: 7,500 DWT barge passing Ampera Bridge in Palembang. Third: Bridge passing upstream Musi River section. Bottom: Musi River typical 7,500 DWT barge and 2400 Hp tug combination parked and waiting for being loaded.

## 2.4 *Musi River logistics and capacity*

Logistics and capacity calculations have been made for barging on the Musi River and its branches. Capacity calculations have been based on:

- Traffic speed
- Barge sizes
- Distance between barges
- Waiting times at 1-way sections
- Waiting times and capacity of bridges (especially the Ampera Bridge at Palembang)
- Information collected during various site visits

Based on this, the following was observed:

- Capacity on the river between Muara Lematang and the river mouth is limited by several 1-way sections.
- The barge size is limited by depth and bend radius to 7,500 DWT or 300ft barges.
- Upstream of Muara Lematang, the capacity is limited by several 1-way sections, narrow bends and seasonal water level variations.
- The Lematang River capacity is limited by bend radii and water depth during the dry season.

As a result of the above, the capacity of the Musi River in its current situation is as Figure 6 below, which presents the maximum capacity along the Musi River

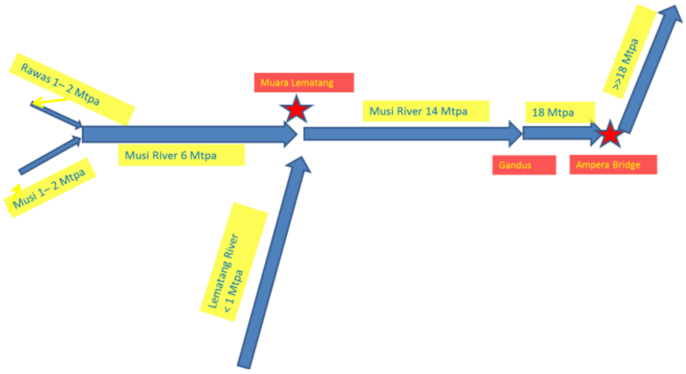



Figure 6: Musi River capacity of its branches

## 2.5 Comparison of demand and capacity for transportation

Figure 7 below summarizes the future demand and present capacity of the Musi River. From this it can be concluded that in the future the demand will likely exceed the river capacity in its current capacity. Before the capacity is reached, barging costs will increase, due to queuing and increased waiting times at 1-way sections. In addition, barging traffic might become dangerous because unless measures are taken, bend passages may result in collisions, especially where houses are built in the outer bend, see below Figure 8 for an example.

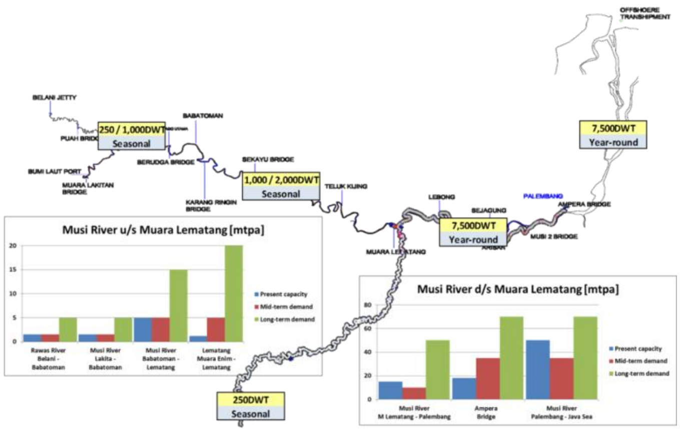



Figure 7: Musi River capacity of its branches and the future demand

Figure 8: Houses in the outer bend as depicted in Figure 5

## 3 MUSI RIVER IMPROVEMENTS

### 3.1 Musi River from Muara Lematang to the river mouth improvement measures and its barging cost implications

Several measures have been reviewed for increasing the capacity of the Musi River, using a simple logistics model taking into account sailing speed, tides, waiting times at 1-way section, bridges etc. using queuing theory. The following measures have been considered for measures to be taken to increase the capacity:

- Allow for night barging:
- Convoy barging, meaning that for a certain period (typically 6 hours) barges will go only upstream in a convoy closely following each other, and for the remainder of the time, barges will go only downstream in a convoy closely following each other.
- Several river works to reduce the bottlenecks:
  - Dredging
  - Removal of the long 1-way stretch
  - Bend Cuts
- Improve capacity at critical passes of narrow sections such as the Ampera bridge by convoy barging, training of tug captains, allow and provide for night barging.

To allow for night barging, several Aids to Navigation need to be installed to improve the navigation safety. In addition the following would be required:

- Chainage indication to facilitate easy communication with river users
- Indication of waiting sections at one way sections, sharp bends and other obstacles
- Markers and buoys along the river
- Each tug should be equipped with an AIS system

To allow for convoys, a clear set of regulations and management procedures is required, for instance indicating who is responsible for managing the convoy hours, how information is directed to Musi River users and what will happen if the regulations are not being followed.

The impact on the river capacity of various improvement measures for the section Muara Lematang to Palembang, is presented in Table 2 below.

Table 2: Musi River in between Muara Lematang and Palembang after implementing various measures

| Volume (Mtpa) | Present | Night Barging | Convoys | Convoys + Night barging | River works |
|---|---|---|---|---|---|
| Annual volume | 14 | 27 | 25 | 50 | 34 |

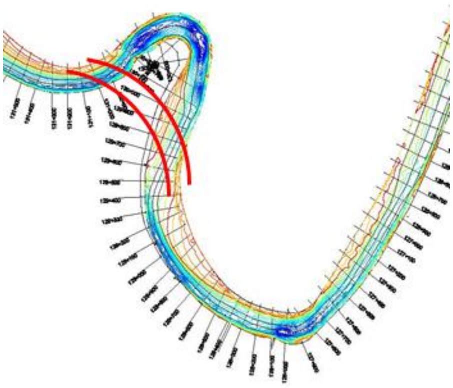


Figure 9: Bend cut as a river improvement measure on the Musi River.

From the above table 2, it can be seen that without complicated measures the capacity of the Musi River can be doubled easily . The capacity of the river is concluded to be sufficient to meet near future demands, provided the management measures are implemented.

### 3.2 *Cost implication of Musi River Improvements*

The costs of measures for expanding the capacity of the Musi River, have been compared to the actual barging costs on the Musi River from Muara Lematang to the mouth of the river, accounting for the number of barges required, barge rental costs, fuel, personal etc. The various river management measures have been reviewed and potential cost savings have been calculated.

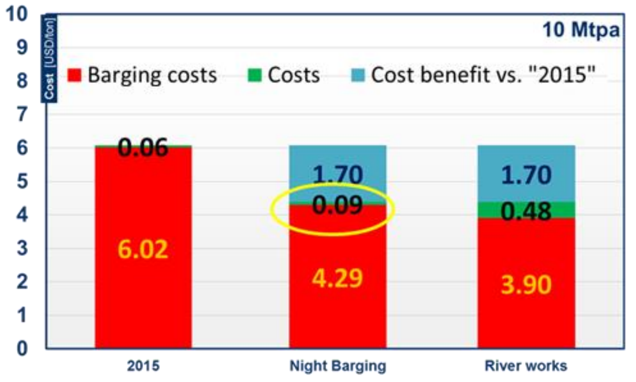



Figure 10 Cost reduction of implementing night barging or river works in USD/t coal transported from Muara Lematang to a sea going vessel offshore. The cost figures are for 10 Mtpa export of coal.

### 3.2 Musi River upstream sections

Without further management, it is likely that the capacity of the river (6 Mtpa) will be reached with forecasted coal transportation volumes on this section up to 20Mtpa in the most optimistic scenario in 2050. To increase the capacity, night barging can be authorized. In addition, from earlier studies (see DHV 2010) it was concluded that barges of 2,000 DWT could potentially navigate from Babatoman at least for most of the year if some limited dredging would be done. This would increase the total capacity of the Musi River from Babatoman to Muara Lematang, The future capacity of the upstream sections can therefore be improved to at least 12 Mtpa, which would be sufficient to serve upstream users for a long period of time. The most upstream section of the Musi River up to Lakitan, as well as the Rawas River, can potentially allow for more barges when management measures are applied too. Without measures to control the water level though, these sections will always be limited to seasonal barging as insufficient run-off is present to guarantee sufficient water depth.

## 4 LEMATANG RIVER IMPROVEMENTS: CANALIZATION

### 4.1 *Introduction*

The transport capacity of the Lematang River in its current status is rather limited and has been estimated at 0.3 Mtpa for daytime navigation and at 0.6 Mtpa in case of day and night time navigation (excluding the dry – non-navigable – season).

However, the potential export coal volume from Muara Enim and Lahat mining areas is significant. Total coal reserves in South Sumatera area are reported to exceed 120,000 MT of which many concessions can be found in Muara Enim area.

The key issue is how these coal reserves can be unlocked for export using the Lematang River and whether it is competitive to other modes of transport. This study presents a very high assessment on measures required to improve Lematang River so it will become suitable for year-round 2,000 DWT barging operations, which is found to be the most cost effective barge size; larger barges do not fit the natural width of the river channel and would require significant widening of the river.

### 4.2 *Ship locks*

The required number of shipping locks in Lematang River depends on two main factors; the water elevation (available depth) along the river and the river slope. These values have been defined based on surveys undertaken for this study. The shipping locks need to be provided with additional water control structures, such as a weir or movable structures, to manage water levels in the dry season and in the wet season when discharge is high. A total number of 3 shipping locks is required.

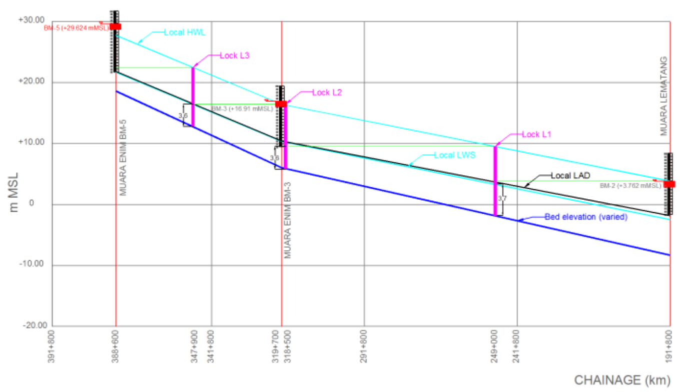



Figure 11 River cross section with indicative locations of ship locks to manage the water level in the dry season.

### 4.3 *Bend cuts*

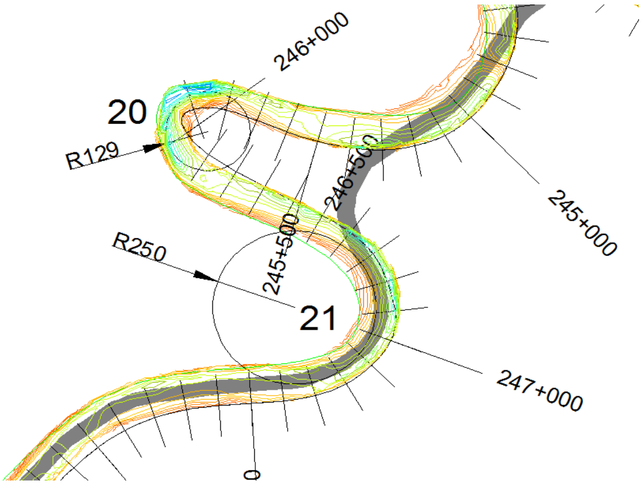



Figure 12: Example of the total of 32 bend cuts to be made on the Lematang River.

Many bends are too sharp for a 2,000 DWT barge to pass. The canal layout needs to be made such that the number of bend cuts is minimized. Also the bend cuts itself need to be as short as possible to minimise costs for excavation and slope protection works. Canal cut locations are determined at sharp bends with less than 250 m radius to provide sufficient space for barges to pass the bend. Figure 11 shows an example of how the canal is rerouted to avoid the bends that have a radius less than specified. Further detailed review on how the bend cuts would impact the morphological aspects of the river will need to be assessed and a proper strategy relating to the artificial cut-off should be developed from the point of view of sustainable development.

### 4.4 Cost evaluation of canalization of the Lematang River

The investment costs for improving the Lematang River with 3 ship lock weir combinations, bend cuts and other necessary costs are estimated to be in total 400 Million USD, with annual recurring costs of 8 Million USD for maintenance and operations. A very high level comparison with building and operating roads and rail has been made, using typical costs for these other modes of transport from other similar projects. From this, it can be concluded that for low export volumes, the investment into canalization of the Lematang River is not competitive to other modes of transport from a direct cost perspective. For 20Mtpa export volume or larger, the option is more cost effective than rail or road.

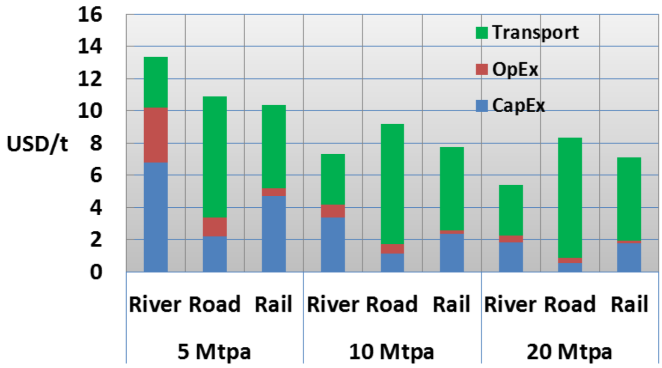



Figure 13 Cost comparison of river transport with rail and road for various throughput scenarios.

The above implicates that the export volume should be sufficiently large to recover costs for the investment costs. The total export volume depends on the international coal market demand and other export opportunities of the coal miners. Therefore, a first step before realizing this project is an agreement with coal miners to discuss and agree on future transport volumes.

## 5 TRANSSHIPMENT TERMINAL

To reduce costs for users of the Musi River, coal being transported from upstream Musi River sections and the Lematang River will require transhipment from smaller 1,000 DWT or 2,000 DWT barges to 7,500 DWT barges. This will reduce the barging costs as the costs per ton of transporting coal by a 7,500 DWT barge is substantially lower. From user feedback carried out during the study, it was understood that upstream users are very interested to share the facility, provided that cost effective logistics can be guaranteed. A location at Muara Lematang is found to be the most promising location, as the Lematang River is nearby and this location is accessible for barges of 7,500 DWT.

Figure 14 Concept layout of river berth front of the transhipment terminal with several small berths for the incoming 2,000 DWT barges and berths for large barges 7,500 DWT for export for 20 Mtpa.

A detailed calculation of the CapEx and OpEx of the multi-user transhipment terminal shows that the terminal can be operated using a fee for users, which is competitive compared to operating terminals by single users. A breakeven for operating the terminal would however be found around operating for more than 10 Mtpa. Investment into the coal transhipment terminal is therefore only found feasible when export volumes from upstream sections and/or the Lematang River can be realized.

## 6 VISION FOR 2050 AND ACTION PLAN

### 6.1 Introduction

An action plan to implement a vision for development of the Musi River up to 2050, covers 4 focal points. Below table provides a high level time path for implementation of various sections of the Musi River:

Table 3 Overview of strategic action plan for coming decades.

| Measures / Implementation year | Short Term | Mid term | Long term |
|---|---|---|---|
| Musi River Muara Lematang to Palembang | x | x | x |
| Musi River Upstream from Muara Lematang | | x | x |
| Transhipment Terminal | | x | x |
| Lematang River | | x | x |

### 6.2 Immediate Actions (short term) on the Musi River

The following activities are required on the short term to make implementation of managing the Musi River a success:

- Prepare a legal framework to allow night navigation and define the specific roles and obligations of relevant organizations on the Musi River, in particular IPC Pelindo (acting port authority), the local South Sumatra Government and any other local stakeholders.
- Issue electronic river navigation maps to barging companies for inclusion into AIS systems on barges and resurvey on bi-annual basis. This should be combined with installation of a basic water level measurement network.
- Procurement and installation in the river chainage signs, navigation signs and buoys at narrow and shallow sections and other Aids to Navigation
- Implement tariff for Muara Lematang to Palembang to cover costs for the investment and maintenance.

### 6.2 Midterm/Longterm Actions on the Musi River

Following the immediate actions as stipulated above, the following can be done:

- Preparation of MoU of involved parties with specific agreements for transhipment and investments.
- Survey campaign for locations which are considered for bend cuts and locks on Musi River and Lematang River and the location for the transhipment terminal.
- Extend river management scope to upstream sections of the Musi and Rawas River
- Investment and procurement of construction works and river management in
  - the upstream sections of the Musi River,
  - Lematang River as well as into
  - the coal transhipment terminal.

## 7 CONCLUSION

The coal transport capacity of the Musi River on the downstream section from Muara Lematang to Palembang in its present way of operating is smaller than expected coal export volumes in the future.
This will initially result in congestion and consequently higher barging costs for users, and ultimately limit export volumes. Additional river transport capacity can be provided to barging companies by managing the traffic on the Musi River without high investments, thereby keeping barging costs at acceptable levels. The following vessel traffic management (VTS) measures can be applied to increase the transport capacity on the Musi River system:

- Allow night barging;
- Apply one-way direction timeslots at critical river sections (convoy barging): for example barges are sailing upstream in convoys for a period of 6hrs followed by barges downstream again in convoys during a timeslot period of 6 hours;
- Operating a VTS system which will benefit traffic planning and can also be used to monitor barges and collect fees;
- Install Aids to Navigation at critical river spots;

Upstream of Muara Lematang, the Musi River and its branches Lematang River and Rawas River have limited capacity due to seasonal depth restrictions as a result of large water level variations. Also for these sections, it is however with simple measures feasible to increase the capacity.

To further increase the potential of the Musi River system, the results show that from an economic point of view it seems feasible to canalize the Lematang River to unlock potential at the Muara Enim area. This option would however require a sufficiently large export volume to be cost effective. To achieve this, agreements with potential users are necessary.

A coal transhipment terminal is required to tranship coal from upstream or Lematang River 2,000 DWT barges to 7,500 DWT barges to reduce barging costs to acceptable levels. It is concluded that this provides a feasible business case, when export volumes of 10 Mtpa or more are reached. Therefore it is concluded that investment in a transhipment terminal is only interesting when the coal export volume from upstream sections or the Lematang River can be increased to achieve this throughput volume.

From this, it can be concluded that managing the Musi River would be an interesting business case, as investments are relatively limited and benefits for users can become substantial in the near future when 10 Mtpa of coal is transported on the Musi River. On long term when export volumes increase further, additional investment in river works and a transhipment terminal become feasible and beneficial too.

This case study shows that with simple and easy measures, the Musi River is a good example how rivers can be improved to allow for large volumes of transport. Key factor in success for long term developments and investments however will be the joint cooperation of the government investing in the river, and river users to use the river for their export covering for the investment costs.

Authors would like to acknowledge IPC Pelindo in guiding, supporting and contributing to make this study a success.

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