FINAL REPORT

# Transportation Study on the Grain Market Segment and the Panama Canal

## Volume 1: Main Report

**SUBMITTED TO**
Autoridad del Canal de Panamá

**SUBMITTED BY**
Nathan Associates Inc.,
Arlington Virginia

**IN ASSOCIATION WITH**
Richardson Lawrie Associates,
London

**UNDER CONTRACT NO.**
SAA-81851

September 9, 2003

NATHAN
ASSOCIATES INC.

**www.nathaninc.com**

FINAL REPORT

# Transportation Study on the Grain Market Segment and the Panama Canal

## Volume 1: Main Report

**SUBMITTED TO**
Autoridad del Canal de Panamá

**SUBMITTED BY**
Nathan Associates Inc.,
Arlington Virginia

**IN ASSOCIATION WITH**
Richardson Lawrie Associates,
London

**UNDER CONTRACT NO.**
SAA-81851

September 9, 2003

# Contents

# ILLUSTRATIONS

## Tables

## Figures

# Executive Summary

Agricultural commodities are one of the important products in world trade that are also shipped extensively through the Panama Canal. In 2001, nearly 39 million metric tons of grains and oilseeds were shipped through the Panama Canal comprising 18 percent of world trade for these commodities.

## OBJECTIVE AND SCOPE

The Transportation Study on the Grain Market Segment and the Panama Canal is part of a larger set of studies to examine the feasibility of expanding the capacity of the existing Canal to permit the transit of larger vessels. The grains market segment study will:

- Assess the Canal's potential market for grains trade,
- Determine the economic advantages of using the Canal versus existing and expected alternative transport options,
- Devise a market strategy that attracts the grains business to the extent that the Canal's earnings are maximized under existing and expanded lock conditions, and
- Forecast traffic, transit, and revenue flows through 2025, and associated risks, for the Existing and Expanded Canal.

## WORLD GRAIN TRADE FORECAST

### Macroeconomic Scenarios

The study has been conducted using three global macroeconomic and trade scenarios to the year 2025 prepared by DRI-WEFA for the Autoridad de Canal de Panamá.[1] The macroeconomic scenarios provide forecasts of GDP, population, per capita income, government and private consumption, investment, and trade of goods and services. The three macroeconomic scenarios—most probable case scenario, best case and worst case—incorporate varying assumptions on world economic performance, geopolitical conditions, international trade policies, and environmental issues.

### Future North America Production Levels and Patterns

There are numerous factors impacting changes in production in the next 25 years. These include: changes in yield (in response to technical improvements) and changes in area planted in part in

[1] DRI-WEFA, Global Macroeconomic and Trade Scenarios to 2025, Volume I: Most Probable Case, prepared for the Panama Canal Authority (Contract No. SAA75897BGP), March 2002.

response to farm programs and returns per acre. During this period it is expected that area planted will evolve gradually toward those crops providing the greatest returns per acre.

Data on yields and acres were projected by year to 2025 and used to derive production estimates and changes in production by region and crop to 2025. Some of the important findings are:

- Corn production is expected to increase mostly in the three dominate regions: Eastern Corn Belt (increase of 9 million metric tons from 2002), Western Corn Belt (increase of 7.5 million metric tons) and the Central Plains (increase of 5 million metric tons). Soybeans will increase primarily in the Eastern Corn Belt (increase of 6 million metric tons) and the Western Corn Belt (increase of 5.3 million metric tons). Wheat will increase in each of Saskatchewan, Central Plains and the Northern Plains by about 2 million metric tons each.
- Changes in production in all other crops and regions are expected to be minimal and typically in the range of less than 1 million metric tons.

An important change in US consumption is that related to corn use for ethanol. This industry has been expanding during the past decade, and its rate of expansion is expected to accelerate in the coming decade. These results indicate that as a result of the accelerated ethanol demand for corn, that

- Corn consumption will increase another 13 percent by 2010 and 11 percent by 2025, versus what would otherwise be natural consumption growth;
- Most of the growth in ethanol consumption will be concentrated in Central and Northern Plains, and the Western Corn Belt.

## Brazil Soybean Production Trends

Soybean production in Brazil has expanded rapidly in the traditional southern production region, increasing from less than 2 million hectares in 1970, to nearly 8 million hectares in 1975. Since then, area planted in this region has remained in the 6-7 million hectares level. The regions in which most of the expansion is occurring is in the Central West, and North. Area planted in these regions has increased from nil through the mid-1970s, and now has more than 7 million hectares planted, exceeding that in the traditional south. The average level of production in these regions during the period 1995-1999 was: Brazil South, 14 million metric tons; Brazil Center-West, 12 million metric tons; and Brazil North, 3 million metric tons.

- Production is expected to increase from 31 million metric tons in 1999 to 50 million metric tons in 2003 and to 108 million metric tons by 2020.
- Most of the increase in production is due to the prospect of increasing area under production, i.e., by bringing new lands under cultivation.
- Most of the increase is expected to be concentrated in the Northerly states in Brazil. Specifically, production is expected to increase by 66 percent in 2005 in Brazil North, and by 31 percent in Brazil South. By 2020, these values would represent increases in production of 467 percent and 157 percent respectively.

## World Grain Import Demand

Key findings regarding forecast of grain import demand include:

- ***World import demand*** for all grains is expected to increase about 47 percent for the 2000-2025 period. The increase in world import demand is due mainly to what would appear to be optimistic projections of world income growth for the period by DRI-WEFA.

- ***Barley.*** Aggregate import demand for barley is expected to increase 55 percent for the 2001-2025 period. Increases in individual country's import demand ranges from 6 percent in Korea to 1800 percent in other South America. Import demand for barley is the largest in Middle East with an increase of 31 percent, followed by China with an increase of 119 percent.

- ***Corn.*** Aggregate import demand for corn is expected to increase about 26 percent for the 2001-2025 period. Japan is the largest importer of corn, followed by North Africa and S. Korea in 2001. However, China will be the second largest importer in 2025 with an import of 9.9 million metric tons. It is expected that Japan and South. Korea will import more meat rather than feed grains to raise livestock for the period. Under a freer trade environment, beef production in the countries may not be competitive. China is expected to produce as much meat as possible to meet rapidly increasing domestic demand for meat rather than importing the shortages from major meat producing countries. Because of this, China's imports of corn are expected to increase rapidly.

- ***Rice.*** Aggregate import demand for rice is expected to increase much faster than those for barley and corn. Average increase in rice consumption would be 51 percent over the 2001-2025 period. This is due to (1) increasing trend in consumers' preference and taste of rice over wheat, and (2) much higher income elasticity on rice. Middle East is the largest rice importing region with an increase of 81 percent for the period, followed by West Africa with an increase of 58 percent. Under a freer trade environment, Philippines, Korea and Malaysia are expected to increase their imports faster than other countries for the period.

- ***Sorghum.*** As a minor crop, major importers are Mexico and Japan. Mexico is the largest importer, followed by Japan. These countries' imports are expected to increase 63 percent and 20 percent, respectively, for the 2001-2025 period. Average increase in import demand is 45 percent for the period.

- ***Soybean.*** Average increase in import demand for soybeans is expected to be about 49 percent for the 2001-2025 period. The largest soybean importer was the EU, followed by Japan. However, China will be the largest importer of soybeans in 2025. China is expected to import about 30 million metric tons of soybeans in 2025. China is expected to produce as much meat as possible to meet its rapidly increasing domestic demand for meat rather than importing meet directly from major exporters. The European Union was the largest importer of soybeans in 2001, but the second largest importer with import volume of 19.9 million metric tons in 2025.

- ***Wheat.*** Aggregate import demand for wheat is expected to increase over 61 percent for the 2001- 2025 period. Largest importers are Middle East, followed by North Africa for the 2001-2025 period. However, China's import will increase faster than other countries and will be the third largest importer of wheat in 2025, with an import volume of about

15.7 million metric tons. This is mainly due to continuous decrease in wheat production in China rather than increase in consumption.

## POTENTIAL PANAMA CANAL TRANSITS

Table E-1 summarizes potential laden transits in terms of cargo tons, DWT, numbers of transits and PCUMS for both the Existing and Expanded Canals and for all cases. For the Most Probable Cases, grains cargo transits for the Existing Canal are estimated to increase by 67 percent from 47 million tons in 2001 to over 79 million tons in 2025 and for the Expanded Canal by 77 percent to almost 84 million tons. For the Existing Canal similar percentage increases are projected for transits in terms of DWT and PCUMS. However because of the expected continuing trend towards the utilization of larger vessels, the total number of transits is forecast to increase by about 54 percent for the Existing Canal, from 1,205 in 2001 to 1,852 in 2025.

**Table E-1. Potential Laden Transits in Cargo Tons, DWT, Number of Transits and PCUMS, Existing and Expanded Canal, No Tolls, All Cases**

| | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Case | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **Cargo (000 long tons)** | | | | | | | | | | |
| Most Probable | 47,400.1 | 48,305.0 | 62,195.0 | 66,576.1 | 73,130.2 | 79,230.6 | 64,210.2 | 69,858.8 | 77,547.1 | 83,941.2 |
| Best | 47,400.1 | 49,438.9 | 63,819.7 | 70,929.1 | 75,947.1 | 83,133.5 | 65,425.3 | 72,780.7 | 81,737.2 | 87,768.2 |
| Worst | 47,400.1 | 53,691.1 | 56,098.7 | 59,579.9 | 58,626.5 | 60,824.0 | 57,559.8 | 60,259.3 | 62,573.9 | 62,233.0 |
| **Vessel Size (000 dwt)** | | | | | | | | | | |
| Most Probable | 57,204.3 | 58,204.9 | 75,217.5 | 80,636.5 | 88,651.1 | 96,104.7 | 73,778.5 | 80,208.5 | 89,006.3 | 96,284.7 |
| Best | 57,204.3 | 59,581.6 | 77,215.3 | 85,932.7 | 92,259.4 | 100,948.8 | 75,177.4 | 83,575.8 | 93,837.9 | 100,687.5 |
| Worst | 57,204.3 | 65,070.2 | 68,020.6 | 72,151.6 | 71,090.3 | 74,000.6 | 66,048.3 | 69,080.9 | 71,712.1 | 71,322.4 |
| **Transits (no.)** | | | | | | | | | | |
| Most Probable | 1,205.1 | 1,216.4 | 1,505.5 | 1,577.1 | 1,721.7 | 1,851.8 | 1,467.8 | 1,559.0 | 1,751.5 | 1,910.0 |
| Best | 1,205.1 | 1,245.3 | 1,549.2 | 1,706.4 | 1,776.5 | 1,963.2 | 1,499.9 | 1,651.5 | 1,859.6 | 2,028.4 |
| Worst | 1,205.1 | 1,278.3 | 1,292.8 | 1,357.6 | 1,305.5 | 1,333.2 | 1,238.5 | 1,281.7 | 1,300.5 | 1,263.1 |
| **PCUMS (000)** | | | | | | | | | | |
| Most Probable | 28,828.0 | 29,436.1 | 37,871.5 | 40,482.5 | 44,470.6 | 48,195.2 | 37,162.0 | 40,249.9 | 44,692.5 | 48,382.4 |
| Best | 28,828.0 | 30,126.6 | 38,860.4 | 43,142.1 | 46,159.3 | 50,583.3 | 37,858.3 | 41,979.0 | 47,045.6 | 50,578.9 |
| Worst | 28,828.0 | 32,561.5 | 34,051.4 | 36,167.7 | 35,563.1 | 36,890.7 | 33,088.2 | 34,651.4 | 35,858.6 | 35,546.8 |

Source: Richardson Lawrie Associates

For the Expanded Canal the projected growth in transits in terms of DWT and PCUMS remains at around 68 percent. This is less than the rate of growth in cargoes of 77 percent because of the improved utilization that would result from an enlarged Canal. The number of transits would grow by 59 percent overall as the result of both greater utilization levels and the trend towards larger vessel sizes.

The most salient features of the southbound transits are the stronger than average increases in the 50,000-60,000 DWT size range encompassing the modern Handymax sizes and in the 70,000-80,000 DWT size range encompassing the modern Panamax and representing the limit of most grain port capabilities. Specifically:

- The substitution of vessels in the 20,000-30,000 DWT size ranges by, in the first instance vessels of 30,000-50,000 DWT.
- After 2010 vessels of 30,000-40,000 DWT decline year on year at an accelerating rate while transits of vessels between 40,000 and 50,000 DWT continue to increase at numbers which are similar to the overall average.
- Meanwhile, the DWT of vessels of 50,000-60,000 DWT incorporating the newer Handymax sizes are forecast to increase substantially. This trend is at its most acute in the short term as transits through the Canal reflect more closely changes in the world fleet and thereafter growth rates which vary between nearly twice and 3.5 times the average DWT growth.
- As would be expected the share of the traditional Panamax size range of 60,000 - 70,000 DWT declines - from 33 percent to 23 percent - as the share of the 70,000 - 80,000 DWT range consequently increases from 21 percent to 36 percent.

In the case of the Expanded Canal, despite the likelihood that larger vessels will transit the Canal in this case, total DWT actually declines in the earlier years of the forecast compared to the Existing Canal case as the utilization levels of size ranges up to 80,000 DWT improve and inefficiencies are removed from the global shipping system. In the second half of the forecast period, the total DWT through the Canal southbound increases compared to the Existing Canal with increased use of vessels up to 100,000 DWT. Specifically:

- While there are fluctuations in individual time periods, the overall usage of the 60,000-70,000 DWT size range is fairly flat;
- While the share of the 70,000-80,000 DWT range continues to increase, this is to a lesser degree than in the Existing Canal as this is the size range which benefits most from improvements in vessel utilization.
- Vessels in excess of 80,000 DWT would be expected to land cargo in the Far East, particularly in China, South Korea and Taiwan.

## COMPARISON OF ACP REPORTED GRAIN TRAFFIC WITH STUDY ESTIMATES

The forecasts of potential Panama Canal grain trade presented in this Volume are not directly comparable to ACP reported grain traffic for several reasons. First, as already mentioned the definition of potential Panama Canal grain trade is based on the assumption of no Panama Canal tolls. Second, the forecast of potential transits is for dry bulk vessels only and does not include grains that may transit the Canal on non-dry bulk vessels2.

---

[2] However, we have prepared and provided the ACP with a forecast of such cargo carried aboard non-dry bulk vessels to be incorporated in other market segment studies.

It is important to recognize that this study was designed not to prepare independent forecasts of potential Panama Canal grain trade. Accordingly, the study did not use ACP-reported Canal traffic as the basis of the forecast. Rather the study developed the potential trade forecast from other sources of production, consumption and trade of each grain.

Table E-2 presents a comparison of ACP reported grain traffic for 2001 with forecasts prepared in this study. The upper portion of the table shows that in 2001 total ACP reported grain traffic was 38.5 million tons. To be comparable to the study's forecast, the amount of grain carried on non-dry bulk vessels is subtracted (1.6 million tons in 2001). The remaining ACP-reported grain traffic on dry bulk vessels totaled 36.9 million tons in 2001.

**Table E-2. Comparison of ACP Reported Grains Traffic with Study Forecasts, 2001 (thousands of long tons)**

| Item | 2001 |
|---|---|
| **Grains Trade from ACP data** | |
| ACP reported grains commodities traffic a/ | 38,489 |
| Less: Grain commodities on non-dry bulk vessels b/ | 1,599 |
| Subtotal grains traffic from RLA | 36,890 |
| | |
| **Grains Trade prepared by Study** | |
| Potential Canal grain trade forecast with zero tolls c/ | 48,459 |
| Less: Grains trade in non-dry bulk carriers d/ | 1,059 |
| Potential Canal grains trade in dry bulk vessels | 47,400 |
| Less: Traffic diverted with actual ACP tolls e/ | 9,266 |
| Forecast of grains bulk traffic on dry bulk vessels | 38,134 |

a/ From Volume 2, Appendix K, Table K-1.
b/ From Volume 2, Appendix K, Table K-1.
c/ From Grains Transit model, Table XB1graintradeforecast.xls
d/ From Grains Transit model, Table XB3grains.xls
e/ From Volume 4, Table 4-2.

Source: as noted.

The lower portion of Table E-2 shows the estimates of grain trade prepared by the study. From the global trade forecasts prepared by the study, we identified the amount of grain trade on trade routes where the Panama Canal is the least-cost routing assuming no Canal tolls. The result is the forecast of potential Panama Canal grain trade with zero tolls of 47.4 million tons as reported in this volume.

However, again this estimate includes grain trade carried on non-dry bulk vessel (1.1 million tons in 2001). Also to be compared with ACP-reported traffic, the amount of potential dry bulk trade that is not captured due to Panama Canal tolls needs to be subtracted (79.3 million tons in 2001). The result is an estimate of 38.1 million tons of grains on dry bulk vessels that would use the Panama Canal. This is 1.2 million tons or 3.4 percent above the figure derived from ACP records. The results are quite close given the entirely independent and separate method used to prepare the forecast.

## WORLD FLEET DEVELOPMENT BY SIZE

The potential growth in the world fleet and the potential impact of an Expanded Canal on its development are important background to the projection of changes in the allocation of cargo to different size ranges of vessel in the Canal transit forecasts. Forecasts of the world fleet by size range for the Existing and Expanded Canals have been developed based on future expectations of world trade growth in dry bulk commodities, changing preferences for ordering particular vessel sizes, the age distribution of the existing fleet and projected scrapping by size range.

The main difference between the Existing and Expanded Canal conditions is that under the latter conditions, the 70,000–80,000 DWT size range would be expected to peak at around 79 million DWT in 2018 before declining to just under 65 million DWT in 2025. This compares with a steady rise to nearly 109 million DWT under Existing Canal conditions. In contrast, with an Expanded Canal, the 80,000–90,000 DWT size range would increase to 54 million DWT instead of about 5 million DWT in the former case. There would also be an approximately 4 million DWT increase in the size of the 90,000–100,000 DWT size range by the end of the forecast period.

## ANALYSIS OF FUTURE SHIP COSTS AND FREIGHT COSTS

For the purpose of this study we define freight costs as the freight paid by the shipper to the ship owner or operator. While these represent the cost to the shipper these are not the same as operating costs (capital, fixed and variable) borne by the owner. Capital costs comprise capital repayments plus interest charges. Fixed operating costs include manning, repairs and maintenance, insurance, stores and supplies and overheads. Variable costs cover bunkers, port charges and Canal dues, where applicable.

Estimates of freight costs—expressed in terms of US$ per cargo ton—have been developed through voyage estimates by route and deadweight (DWT) size range for:

- All vessels transiting the Canal,
- By pass routes
- Routes that represent alternatives to the Existing Canal, and
- Routes where cargo moves in vessels that could transit the Existing Canal but are precluded from so doing by current toll policies.

Freight costs by vessel size and trade have been calculated for all grains movements involving transit of the Panama Canal (excluding tolls) together with the costs for alternative routes and by pass routes via the Suez Canal, Cape of Good Hope and Cape Horn for all years from 2000 through 2025. The main differences in the rates between the Existing and Expanded Canals are, of course, the use of larger vessels on certain routes and improved utilization in the latter case.

- In comparing the Canal with least cost alternative routes under Existing Canal conditions, weighted average freight costs from the US Gulf to the Far East through the Canal have an approximately $2.65 per ton to $5.00 per ton advantage.

- The greatest saving is for Japan, then South Korea, China and Taiwan. By contrast, a similar comparison for exports from North Brazil indicates differentials in favor of the Canal ranging from just $0.16 per ton to $2.50 per ton.
- For exports to South East Asia from the US Gulf the Canal enjoys an advantage of between $0.10 per ton and about $2.40 per ton although only into the Philippines is the differential significant and for Malaysia the Canal would not be the favored route even at zero tolls.
- For North Brazil the Canal is not competitive at all for exports to South East Asia. Not surprisingly, the Canal is most competitive for relatively short hauls on intra Western Hemisphere trades.

For the Expanded Canal the conclusions tend to be broadly the same, except that the differentials are, if anything, slightly smaller.

- Expansion of the Panama Canal would reduce weighted average freight costs from the US Gulf to the Far East by between $1.00 per ton and $1.60 per ton. Similar reductions would be seen from the US Gulf to South East Asia. These generally represent the greatest savings offered by an Expanded Canal. Freight costs from Brazil to the Far East would be reduced by around $0.50 per ton.

## ECONOMIC VALUE OF THE PANAMA CANAL

The determination of the economic value of the Canal involves comparing the total cost of transporting grain commodities over routes transiting the Panama Canal and over alternative routes. For each potential Canal route involving grain commodities, we first identified all current and projected viable alternative routes and then identified the least cost alternative route.

The definition of the least-cost alternatives takes into account the following factors:

- Mileage, if necessary, at a port level where more than one port might be considered representative of a particular origin or destination.
- Size and characteristics of vessels forecast to be operating on specific commodity–route pairs for all-water alternative routes
- Current and projected draft of ports that serve the Canal and alternative routes. These include the ports of origin and destination, as well as intermediate ports.
- Current and projected capacity constraints in the transportation system, including bottlenecks and congestion at ports, limits of the land transport system, and the capacity of the Panama Canal under Existing and Expanded Canal scenarios.
- Commodity market forecasts that look at production and consumption trends and developments that will help identify current and future geographic and product competition.
- Timing. Route structures may change during the projection period, as improvements in the transportation system and other developments are implemented. Typically, if one expects trade on a specific route to grow over the forecast period, then, all other things being equal, cargo sizes will increase and there is also the possibility that the incidence of

"parceling" of cargoes will increase to the utilization of larger vessels as has been seen in the coal and iron ore trades.

- Typical cargo sizes that may be determined not by transportation considerations but by industrial requirements and trade volumes.
- Inventory costs for the additional time required for shipping over the longer distances associated with least cost alternative routes.

Table E-3 summarizes the total economic values calculated for both the Existing and Expanded Canal, through to 2025. Under Existing Canal conditions, the economic value of the Canal is estimated to remain within the range of the equivalent of $4.93 per ton to $5.67 per ton in $2002 terms. Translated into total economic value, this results in a steady increase from $259 million in 2001 to $390 million in 2025.

**Table E-3. Summary of Economic Value of Existing and Expanded Panama Canal, Most Probable Case, Selected Years 2001-2025**

| | Existing Canal | | | | Expanded Canal | | | | Margin Expanded vs. Existing Canal | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Potential Panama Canal Transits | Potential Panama Canal cargo (tons 000s) | Economic Value of Canal ($/ton | Economic Value of Canal ($000s) | Potential Panama Canal Transits | Potential Panama Canal cargo (tons 000s) | Economic Value of Canal ($/ton) | Economic Value of Canal ($000s) | Economic Value of Canal ($/ton) | Economic Value of Canal ($000s) |
| 2001 | 1,202 | 47,339 | 5.48 | 259,522 | | | | | | |
| 2005 | 1,213 | 48,238 | 5.67 | 273,674 | | | | | | |
| 2010 | 1,502 | 62,114 | 5.21 | 323,405 | 1,464 | 63,186 | 6.01 | 379,903 | 0.81 | 56,498 |
| 2015 | 1,573 | 66,490 | 5.13 | 340,865 | 1,555 | 68,731 | 5.96 | 409,510 | 0.83 | 68,645 |
| 2020 | 1,717 | 73,036 | 5.06 | 369,893 | 1,748 | 77,449 | 6.05 | 468,557 | 0.99 | 98,664 |
| 2025 | 1,847 | 79,133 | 4.93 | 389,775 | 1,906 | 83,841 | 6.13 | 513,845 | 1.20 | 124,071 |

Source: Nathan Associates Inc.

For the Expanded Canal, the economic value is projected to increase from the equivalent of $6.01 per ton in 2010 to $6.13 per ton in 2025. Total economic value would rise from $380 million to $514 million. The margins between the Expanded Canal and the Existing Canal from 2010 to 2025 are estimated to increase from $0.81 per ton to $1.20 per ton, or from $56 million to $124 million.

## ALTERNATIVE PANAMA CANAL MARKETING STRATEGIES

The terms of reference for the study state that the marketing strategy shall pursue the following objectives:

- Maximize Canal's earnings
- Maximize the canal market share for the dry bulk segment, and
- Be non-discriminatory within the dry bulk segment

Based on our review of the Panama Canal Neutrality Treaty and of toll policies at comparable facilities, we believe there is ample scope to differentiate Panama Canal tolls by size of vessel and commodity. Accordingly, we identified alternative toll pricing options for analysis that had tolls

varying by size of vessel, and by commodity[3]. Toll options were also analyzed with tolls assessed by PCUMS and by ton of cargo carried. Toll pricing options included ACP tolls in effect prior to October 2002, from October 2002 through June 2003 and ACP tolls to take effect in July 1, 2003. The ACP tolls as of July 1, 2003 were used as the basis for examining a series of toll increases at 25 percent intervals from 25 percent increase through a 150 percent increase.

The detailed review of the Canal toll pricing options revealed the following findings.

- Approximately 15 percent of the potential transits (with no tolls) would be diverted to alternative routes once any non-insignificant Canal tolls were imposed. These involved routes North America Gulf to South East Asia, from Brazil North to Japan, and from South America East to South America West.
- A sizable number of transits and cargo would be diverted at certain pricing points for particular commodity-route pairs.
- After certain levels of toll increases, Canal revenues decline as the loss of toll revenue due to diverted transits is not offset by toll increases for the remaining Panama Canal transits.

Table E-4 presents summarized results of the 14 Canal toll pricing options for the Existing Canal and Expanded Canal, Most Probable Case for 2011. This table clearly shows the potential for the Panama Canal to increase toll revenues. In 2011, estimated Canal toll revenues for dry bulk vessels in the grain market segment under July 1, 2003 toll rates total $86.5 million. The Canal captured 81 percent of potential transits in this market segment and 79 percent of potential grain dry bulk cargo. However, the Canal toll revenues of $86.5 million only accounted for 26 percent of the estimated economic value of the Canal of $327million. If tolls rate from July 1, 2003 were doubled, toll revenues for 2011 traffic would be $150.4million, an increase of 74 percent. Even with tolls doubled, the Canal would still only capture 46 percent of the total economic value of the Canal[4].

The demand for Canal services is inelastic relative to tolls. That is, a given percentage increase in tolls would result in a smaller percentage decrease in Canal transits and would generate higher Canal toll revenues. A review of Table E-4 provides an indication of the price inelasticity of demand. A 75 percent increase in tolls from July 1, 2003 levels reduces the forecast of Canal grain bulk transits in

---

[3] As this market segment only deals with dry bulk carriers, Panama Canal toll pricing options by type of vessel were not analyzed.

[4] For the Canal to capture 100 percent of the economic value of the Canal, it would have to have a toll pricing policy that charged each vessel transiting the full benefit of using the Canal over alternative routings. Such a policy is not administratively practical, nor consistent with the Panama Canal Neutrality Treaty.

**Table E-4. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2011**

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| **Existing Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 |
| Potential Panama Canal Cargo (ton 000s) | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 |
| Forecast Panama Canal Transits (no.) | 1,233 | 1,233 | 1,233 | 1,198 | 1,198 | 1,198 | 1,106 | 1,095 | 1,095 | 945 | 1,143 | 1,197 | 1,143 | 1,106 |
| Percent of Potential Transits | 81.2% | 81.2% | 81.2% | 78.9% | 78.9% | 78.9% | 72.8% | 72.1% | 72.1% | 62.2% | 75.2% | 78.8% | 75.2% | 72.8% |
| Forecast Panama Canal Cargo (ton 000s) | 49,900 | 49,900 | 49,900 | 48,283 | 48,283 | 48,283 | 43,183 | 42,786 | 42,786 | 34,571 | 45,249 | 48,209 | 45,266 | 43,183 |
| Percent of Potential Cargo | 79.1% | 79.1% | 79.1% | 76.6% | 76.6% | 76.6% | 68.5% | 67.8% | 67.8% | 54.8% | 71.7% | 76.4% | 71.8% | 68.5% |
| Economic Value of Canal for Potential Transits ($000s) | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 9,997 | 9,997 | 9,997 | 13,182 | 13,182 | 13,182 | 29,125 | 30,623 | 30,623 | 63,595 | 22,799 | 13,416 | 22,742 | 29,125 |
| Forecast Panama Canal Revenues ($000S) | 76,337 | 82,591 | 86,490 | 104,622 | 125,546 | 146,471 | 150,358 | 167,532 | 178,701 | 150,329 | 154,416 | 153,675 | 149,652 | 149,280 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 70 | 87 | 105 | 122 | 136 | 153 | 163 | 159 | 135 | 128 | 131 | 135 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.53 | 1.66 | 1.73 | 2.17 | 2.60 | 3.03 | 3.48 | 3.92 | 4.18 | 4.35 | 3.41 | 3.19 | 3.31 | 3.46 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 |
| Potential Panama Canal Cargo (ton 000s) | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 |
| Forecast Panama Canal Transits (no.) | 1,183 | 1,183 | 1,183 | 1,149 | 1,149 | 1,141 | 1,058 | 1,034 | 963 | 912 | 1,097 | 1,140 | 1,122 | 1,058 |
| Percent of Potential Transits | 79.8% | 79.8% | 79.8% | 77.5% | 77.5% | 76.9% | 71.3% | 69.7% | 64.9% | 61.5% | 74.0% | 76.9% | 75.6% | 71.3% |
| Forecast Panama Canal Cargo (ton 000s) | 49,861 | 49,861 | 49,861 | 48,260 | 48,260 | 47,641 | 42,599 | 41,208 | 37,088 | 33,887 | 44,980 | 47,576 | 46,511 | 42,599 |
| Percent of Potential Cargo | 77.6% | 77.6% | 77.6% | 75.1% | 75.1% | 74.1% | 66.3% | 64.1% | 57.7% | 52.7% | 70.0% | 74.0% | 72.4% | 66.3% |
| Economic Value of Canal for Potential Transits ($000s) | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 9,855 | 9,855 | 9,855 | 12,933 | 12,933 | 14,555 | 28,737 | 33,618 | 48,739 | 60,299 | 22,174 | 14,741 | 17,825 | 28,737 |
| Forecast Panama Canal Revenues | 72,774 | 78,733 | 82,447 | 99,708 | 119,649 | 137,865 | 142,312 | 154,891 | 149,908 | 142,718 | 146,604 | 144,658 | 146,429 | 141,224 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 70 | 87 | 104 | 121 | 134 | 150 | 156 | 156 | 134 | 127 | 131 | 133 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.46 | 1.58 | 1.65 | 2.07 | 2.48 | 2.89 | 3.34 | 3.76 | 4.04 | 4.21 | 3.26 | 3.04 | 3.15 | 3.32 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

2011 from 1,233 vessels to 1,198 vessels, or only 2.9 percent. A 100 percent increase in tolls reduces the forecast of Canal grain bulk transits to 1,106 vessels or 10.3 percent.

Appendix C presents results of the Canal toll pricing options for both the Existing Canal from 2001-2025 and the Expanded Canal from 2010-2025. For all years and pricing options, the Existing Canal scenario is shown to generate more toll revenues than the Existing Canal for the grains market segment. While these results initially seem counter-intuitive, there are three factors that together fully explain these findings.

First, the total potential Panama Canal grain cargo under the Expanded Canal scenario of 63.3 million tons in 2010 is only slightly higher than the Existing Canal scenario of 62.2 million tons. Thus, the introduction of the Expanded Canal does not significantly impact the volume of grain trade that could potentially use the Canal.

Second, with the Expanded Canal, there is a trend toward using larger vessels and hence the number of grain vessels needed is reduced. The Expanded Canal scenario is shown to have 1,468 potential transits in 2010 versus 1,506 potential transits for the Existing Canal. As Canal tolls provide discounted rates for larger vessels, Canal toll revenues for the same annual volume of grain cargo will be less for the Expanded Canal versus the Existing Canal.

Third, the Expanded Canal is shown to have a smaller total economic value than the Existing Canal. In 2010, the Expanded Canal has a total economic value of $310.6 million as compared to $323.4 million for the Existing Canal. The economic value of the Canal defined for study purposes is the transportation cost savings of the use of the Canal as compared to the least-cost alternative routing. Decisions on whether to use the Canal or an alternative route are made taking into account the shipping characteristics and corresponding costs of each routing. For the Existing Canal scenario, the decision is based on the shipping characteristics and costs associated with that scenario. These were described fully in *Volume 3: Vessel Transit and Fleet Analysis*. With the Expanded Canal scenario, again decisions to use the Canal are determined by the shipping characteristics and costs for the Canal and alternative routings associated with that scenario.

The reason that the economic value of the Canal is lower for the Expanded Canal scenario is that the cost differentials between the Expanded Canal and its least-cost alternative routings are lower than those estimated for the Existing Canal. With the Expanded Canal, there will be a trend toward use of larger vessels and some originating and receiving ports will develop facilities to accommodate the larger vessels. However, the use of larger vessel will reduce the transport cost of both Canal and least-cost alternative routings. As the mileages for the least-cost alternative routings are greater than for Canal routes, the cost saving of using larger vessels is greater in absolute terms. Thus the Expanded Canal has a smaller transportation cost differential or economic value between the Canal and the least-cost alternative routing[5].

---

[5] Please note that the treatment of economic used herein for the toll pricing analysis differs from that presented in *Volume 4: Economic Value of Panama Canal*. In Volume 4, the terms of reference called for a direct comparison of the economic value of the Existing Canal and Expanded Canal. Thus for that analysis, transportation costs of routes through the Existing and Expanded Canals were both compared to the transportation costs of the alternative routes under the Existing Canal scenario.

This finding directly impacts the results of the Canal toll pricing options for the Expanded Canal as more traffic is shown to be diverted from the Canal to alternative routings compared to the same toll level for the Existing Canal.

## IDENTIFICATION OF PREFERRED PANAMA CANAL TOLL PRICING

All of the tolls pricing options analyzed were considered to be non-discriminatory within the grain bulk segment. Precedents set at comparable facilities allow for differentiation of tolls by size of vessel and by commodity as long as they are applied to all such vessels on a consistent basis. First priority was given to maximization of toll revenues, closely followed by maximization of Canal market share. A preferred Canal toll pricing option was identified for each year and each Canal scenario (Table E-5).

### Existing Canal

For the Existing Canal, the preferred option for all years is PCUMS Option 3 which corresponds to Panama Canal tolls increased by 75 percent from July 1, 2003 levels. This pricing option allows the Canal to retain approximately 80 percent of total potential transits as compared to 83 percent under current tolls. Panama Canal toll revenues, however, increase by nearly 70 percent under PCUMS Option 3.

**Table E-5. Preferred and Alternative Canal Toll Pricing Options, Existing and Expanded Canal , Most Probable Case, 2001-2025**

| | Existing Canal | | Expanded Canal | |
|---|---|---|---|---|
| Year | Preferred Toll Pricing Option | Alternative Toll Pricing Option | Preferred Toll Pricing Option | Alternative Toll Pricing Option |
| 2001-2009 | PCUMS Option 3 (75% increase) | Commodity Option 2 tolls (100% increase with 10% discount for wheat and corn) | n.a. | n.a. |
| 2010-2011 | PCUMS Option 3 (75% increase) | Commodity Option 2 tolls (100% increase with 10% discount for wheat and corn) | Commodity Option 3 tolls (100% increase with 10% discount for wheat and 5% discount for corn) | PCUMS Option 3 (75% increase) |
| 2012–2019 | PCUMS Option 3 (75% increase) | Commodity Option 3 tolls (100% increase with 10% discount for wheat and 5% discount for corn) | Commodity Option 3 tolls (100% increase with 10% discount for wheat and 5% discount for corn) | PCUMS Option 3 (75% increase) |
| 2020-2024 | PCUMS Option 3 (75% increase) | Commodity Option 3 tolls (100% increase with 10% discount for wheat and 5% discount for corn) | Commodity Option 4 tolls (100% increase with 5% discount for wheat) | PCUMS Option 3 (75% increase) |
| 2025 | PCUMS Option 3 (75% increase) | Commodity Option 4 tolls (100% increase with 5% discount for wheat) | Commodity Option 4 tolls (100% increase with 5% discount for wheat) | PCUMS Option 3 (75% increase) |

Source: Appendix C.

The preferred option is PCUMS Option 3 which corresponds to Panama Canal tolls increased by 75 percent from July 1, 2003 levels. This pricing option allows the Canal to retain approximately 80

percent of total potential transits (with not tolls) and in fact has additional diversions of around 3 percent of the forecasted transits under July 1, 2003 tolls. Panama Canal revenues, however, increase by nearly 70 percent under PCUMS Option 3.

While there are other Canal pricing options that yield up to 20 percent more revenue, they involve much higher levels of toll increases (140 percent increase over July 1, 2003 rates) and result in additional diversion of at least 10 percent more of potential transits.

Consideration for the preferred Canal pricing option was given to Panama Canal tolls with a 100 percent increase over July 1, 2003 rates. This generates up to 5 percent more revenue but also results in additional diversions of more than 6 percent of potential cargo. The dual objectives of maximizing earnings while maximizing Canal market share led us to select the 75 percent increase option as the preferred Canal pricing option.

### Expanded Canal

For the Expanded Canal, the preferred option for 2010-2019 is Commodity Option 3 which corresponds to Panama Canal tolls increased by 100 percent from July 1, 2003 levels with a 10 percent discount for wheat and 5 percent discount for corn. This pricing option allows the Canal to retain approximately 72 percent of total potential transits in 2011 as compared to 77 percent under current tolls. Panama Canal toll revenues, however, increase by nearly 78 percent under Commodity Option 3.

From 2020-2025, Commodity Option 4 (100 percent increase with a 5 percent discount for wheat) was selected as the preferred Canal toll pricing option. During these years, the elimination of the discount for corn and the reduction in the discount for wheat from 10 percent to 5 percent generates additional Canal toll revenue without no further diversion of transits[6].

## FORECAST OF PANAMA CANAL TRANSITS, TOLL REVENUE AND CARGO

Table E-6 and Table E-7 present comparisons of Panama Canal transits, cargo and laden toll revenues under the preferred toll pricing option and current Panama Canal tolls for the Existing Canal and Expanded Canal scenarios.

For the Existing Canal under the preferred toll pricing option, forecasted Canal transits increase from 968 vessels in 2001 to 1,188 vessels in 2010 and reach 1,365 vessels by 2025. Forecasted canal revenues increase from $112 million in 2001 to $144 million in 2010 and $170 million by 2025. Throughout the period Canal toll revenues under the preferred toll pricing option are approximately 70 percent above those forecast under current Canal tolls.

---

[6] The only minor exception is in 2020, when 17 transits are diverted under Commodity Option 4 as compared to Commodity Option 3. However, toll revenues are still higher under Commodity Option 4 that year.

## Table E-6. Panama Canal Laden Transits, Cargo and Revenue under Preferred Toll Option and Current Canal Tolls Existing Canal, Most Probable Case, 2001-2025

| Year | Forecast with Preferred Tolls | | | Forecast with Current Tolls | | |
|---|---|---|---|---|---|---|
| | Transits (no.) | Cargo (ton 000s) | Toll Revenue ('$000) | Transits (no.) | Cargo (ton 000s) | Toll Revenue ('$000) |
| 2001 | 968 | 36,792 | 112,202 | 1,001 | 38,314 | 66,749 |
| 2002 | 973 | 37,102 | 113,131 | 1,006 | 38,633 | 67,295 |
| 2003 | 979 | 37,411 | 114,092 | 1,013 | 38,951 | 67,860 |
| 2004 | 985 | 37,720 | 115,049 | 1,019 | 39,270 | 68,422 |
| 2005 | 991 | 38,029 | 116,002 | 1,025 | 39,588 | 68,983 |
| 2006 | 1,030 | 39,941 | 121,694 | 1,064 | 41,512 | 72,255 |
| 2007 | 1,070 | 41,854 | 127,391 | 1,104 | 43,436 | 75,530 |
| 2008 | 1,110 | 43,766 | 133,093 | 1,144 | 45,360 | 78,808 |
| 2009 | 1,150 | 45,678 | 138,802 | 1,184 | 47,284 | 82,090 |
| 2010 | 1,188 | 47,590 | 144,497 | 1,223 | 49,208 | 85,364 |
| 2011 | 1,198 | 48,283 | 146,471 | 1,233 | 49,900 | 86,490 |
| 2012 | 1,209 | 48,976 | 148,445 | 1,244 | 50,592 | 87,616 |
| 2013 | 1,219 | 49,669 | 150,419 | 1,254 | 51,285 | 88,743 |
| 2014 | 1,230 | 50,362 | 152,393 | 1,265 | 51,977 | 89,869 |
| 2015 | 1,241 | 51,055 | 154,366 | 1,276 | 52,669 | 90,995 |
| 2016 | 1,256 | 51,831 | 156,621 | 1,292 | 53,507 | 92,388 |
| 2017 | 1,273 | 52,606 | 158,931 | 1,310 | 54,345 | 93,814 |
| 2018 | 1,292 | 53,382 | 161,286 | 1,330 | 55,183 | 95,264 |
| 2019 | 1,311 | 54,157 | 163,644 | 1,350 | 56,021 | 96,717 |
| 2020 | 1,330 | 54,933 | 166,006 | 1,371 | 56,859 | 98,172 |
| 2021 | 1,337 | 55,235 | 166,913 | 1,379 | 57,275 | 98,883 |
| 2022 | 1,343 | 55,537 | 167,823 | 1,388 | 57,692 | 99,596 |
| 2023 | 1,350 | 55,838 | 168,736 | 1,397 | 58,108 | 100,310 |
| 2024 | 1,357 | 56,140 | 169,651 | 1,407 | 58,524 | 101,026 |
| 2025 | 1,365 | 56,442 | 170,569 | 1,416 | 58,940 | 101,744 |

Source: Appendix C.

For the Expanded Canal under the preferred toll pricing option, forecasted Canal transits increase from 1,074 vessels in 2010 to 1,380 vessels by 2025. Forecasted canal revenues increase $138 million in 2010 to $184 million by 2025. Canal toll revenues under the preferred toll pricing option are approximately 70 percent above those forecast under current Canal tolls in 2010 increasing to 83 percent above current tolls by 2025.

## Table E-7. Panama Canal Laden Transits, Cargo and Revenue under Preferred Toll Option and Current Canal Tolls Expanded Canal, Most Probable Case, 2010-2025

| Year | Forecast with Preferred Toll Pricing Option | | | Forecast with Current Canal Tolls | | |
|---|---|---|---|---|---|---|
| | Transits (no.) | Cargo (ton 000s) | Toll Revenue ('$000) | Transits (no.) | Cargo (ton 000s) | Toll Revenue ('$000) |
| 2010 | 1,074 | 43,516 | 137,899 | 1,174 | 49,176 | 81,428 |
| 2011 | 1,122 | 46,511 | 146,429 | 1,183 | 49,861 | 82,447 |
| 2012 | 1,131 | 47,195 | 148,457 | 1,193 | 50,545 | 83,467 |
| 2013 | 1,141 | 47,878 | 150,484 | 1,202 | 51,230 | 84,487 |
| 2014 | 1,151 | 48,562 | 152,511 | 1,212 | 51,915 | 85,507 |
| 2015 | 1,164 | 49,244 | 154,543 | 1,235 | 53,155 | 87,395 |
| 2016 | 1,203 | 51,067 | 160,072 | 1,260 | 54,166 | 89,045 |
| 2017 | 1,228 | 51,874 | 162,656 | 1,288 | 55,177 | 90,718 |
| 2018 | 1,253 | 52,681 | 165,249 | 1,317 | 56,188 | 92,395 |
| 2019 | 1,279 | 53,488 | 167,849 | 1,347 | 57,199 | 94,077 |
| 2020 | 1,290 | 54,217 | 174,334 | 1,377 | 59,141 | 95,765 |
| 2021 | 1,321 | 55,630 | 178,665 | 1,394 | 59,748 | 96,739 |
| 2022 | 1,334 | 56,020 | 179,936 | 1,411 | 60,356 | 97,716 |
| 2023 | 1,349 | 56,410 | 181,216 | 1,430 | 60,964 | 98,698 |
| 2024 | 1,364 | 56,801 | 182,505 | 1,448 | 61,572 | 99,683 |
| 2025 | 1,380 | 57,191 | 183,804 | 1,468 | 62,180 | 100,674 |

Source: Appendix C.

# 1. Introduction

Agricultural commodities are one of the important products in world trade that are also shipped extensively through the Panama Canal. In 2001, nearly 39 million metric tons of grains and oilseeds were shipped through the Panama Canal comprising 18 percent of world trade for these commodities.

International trade of grains and oilseeds are influenced by many factors. These include agricultural production, consumption which is impacted by tastes, population and income growth; as well as agricultural and trade policies. In addition, the relative costs of production interior shipping, handling and ocean shipping costs all impact the volume of world trade and the use of the Panama Canal. Changes in any of these variable costs will impact the international distribution of grains and oilseeds and shipments through the Panama Canal.

## OBJECTIVE AND SCOPE

The Transportation Study on the Grain Market Segment and the Panama Canal is part of a larger set of studies to examine the feasibility of expanding the capacity of the existing Canal to permit the transit of larger vessels. The grains market segment study will:

- Assess the Canal's potential market for grains trade,
- Determine the economic advantages of using the Canal versus existing and expected alternative transport options,
- Devise a market strategy that attracts the grains business to the extent that the Canal's earnings are maximized under existing and expanded lock conditions, and
- Forecast traffic, transit, and revenue flows through 2025, and associated risks, for the Existing and Expanded Canal.

## REPORT ORGANIZATION

The Draft Final Report of the *Transportation Study on the Grain Market Segment and the Panama Canal* consists of the following six volumes:

- Volume 1: Main Report
- Volume 2: Panama Canal's Potential Market
- Volume 3: Vessel Transit and Fleet Analysis
- Volume 4: Economic Value of the Panama Canal
- Volume 5: Marketing Strategy
- Volume 6: Forecast of Panama Canal Cargo, Transits and Toll Revenue

The organization of this Volume *1: Main Report* generally follows the structure of the study's analyses presented in detail in Volume 2 through Volume 6.

Following this introductory section, Section 2 presents the approach methodology and results of the forecast of world demand, supply and trade for each of the dry bulk commodities. Section 3 present a review of historical Panama dry bulk trade and the forecast of potential Panama Canal trade through 2025.

Section 4 provides the analysis and forecast of the global vessel fleet for the Existing and Expanded Canal cases and a description of the ocean voyage estimation model and other inputs used to develop forecast of ocean freight rates for Panama Canal routes and alternative routes.

The forecast of potential canal transits and the determination of the economic value of the Panama Canal are presented in Section 5. The development and recommendation of a preferred Panama Canal toll strategy and the resulting forecast of canal transits and revenues are described in Section 6.

# 2. World Grain Trade Forecast

This section presents the assessment of the Canal's potential market for grains trade.[1] It is important to note that for purposes of this study the term "Canal's potential market" represents our estimate of the maximum market share that the Canal could capture of world trade assuming a value of zero for Panama Canal tolls. Section 5 on Panama Canal market strategy and pricing identifies and analyzes the impact of alternative Canal toll structures and rates on forecast traffic volume.

## APPROACH

In general, the world grain trade is characterized as highly substitutable. Some classes of Australian wheat, for example, can be substituted for the same classes of wheat from North America, while Argentinean corn can substitute for U.S. corn. Product supplies notwithstanding, the ability of producers to compete for consumer markets depends greatly on the competitiveness of their total transport and logistics costs as well as the price of the commodity itself.

Given that grain is a relatively low-value commodity, transport costs constitute a significant component of the final delivered price. The use of the Canal is an important part of grain transportation. This point is underscored when considering how dependent the grain business is on the Canal. According to OECD figures, about 70 percent of waterborne grain shipments originate in North and South America—and the Panama Canal handles about 50 percent of North American grain shipments. Ports in the U.S. Gulf handle about 85 percent of U.S. grain exports (largely destined for Southeast and East Asian markets).[2] Grain in turn is one of the Panama Canal's most important commodity groups.

### Macroeconomic Scenarios

The study has been conducted using three global macroeconomic and trade scenarios to the year 2025 prepared by DRI-WEFA for the Autoridad de Canal de Panamá.[3] The macroeconomic

---

[1]The analysis and findings in this section were largely prepared by Dr. William W. Wilson, Dr. Won Koo, Bruce Dahl and Skip Taylor of the Department of Agribusiness and Applied Economics, North Dakota State University. These individuals were retained as Principal Consultants by Nathan Associates Inc and the corresponding report represents the findings of Nathan Associates Inc. and the Principal Consultants, and not necessarily that of North Dakota State University.

[2] Japan, South Korea, and Taiwan are the United States' largest corn markets, representing 85 percent, 57 percent, and 94 percent of imported corn in those countries, respectively. U.S. soybean producers also represent substantial portions of soybean imports to Japan and Taiwan—75 percent and 80 percent, respectively.

[3] DRI-WEFA, Global Macroeconomic and Trade Scenarios to 2025, Volume I: Most Probable Case, prepared for the Panama Canal Authority (Contract No. SAA75897BGP), March 2002.

scenarios provide forecasts of GDP, population, per capita income, government and private consumption, investment, and trade of goods and services. The three macroeconomic scenarios—most probable case scenario, best case and worst case—incorporate varying assumptions on world economic performance, geopolitical conditions, international trade policies, and environmental issues.

## Grain Production and Consumption

Historical consumption and production data are based on information from organizations such as the International Grain Council, U.S. Grains Council, Agriculture and Agri-Food Canada, Foreign Agricultural Service and the Agricultural Marketing Service of the U.S. Department of Agriculture, FAPRI Outlook reports at the University of Missouri, and individual grain shippers. Cross-checking data from different sources has enabled us to determine which provide the most consistently reliable data. The data sources used are described in the descriptions in Appendix A, C and E.

We have developed a simple forecasting model to forecast import demand in major importing countries for individual commodities. The model consists of the following two procedures:

- ***Estimate per capita import demand for individual commodities in importing countries.*** There are two fundamental sets of assumptions implicit in the econometric analysis used in these studies. One is farming technology, the other consumer preferences. Farming technology refers to yields per hectare, or productivity. These are captured in the econometric equations. The assumption is that the yield per hectare growth rate will continue as that projected using historical data, albeit at an exponential rate. The other is consumer preferences. In our consumption equations, we estimate the relationship between per capita consumption and income and trend. The latter reflects the impacts of changes in consumption habits over time. Again, both these are captured exponentially. Further, for projection purposes, the income projections are those from WEFA. Thus, these are the explicit assumptions.[4]

For this, we assume that neither farming technology nor consumer preferences will change appreciably during the 25-year forecast horizon and will thus continue to maintain the trend that an importing country has experienced in the past. For future growth, import demand for a commodity in an importing country is defined as a function of the economic conditions unique to that country and the trend. "Import" is the difference between domestic supply (production plus carry-in stock) and domestic consumption. Thus, the trend variable in import demand represents both farming

---

[4] Of these two variables, our view is that the more critical variable is income. We used per capita income estimates provided by WEFA-DRI, and these seem to be fairly optimistic relative to what has transpired. This is particularly true for China. Given these have a dramatic impact on consumption, their impact is important. Second, it should be important to monitor yields and production costs in critical regions, notably soybeans in US and Brazil. Production costs derived from WEFA data suggest that the US is currently the low -cost producer, but this situation may be changing. In addition, the viability of much of the expanded growth in export potential from Brazil is dependent in part on transportation projects being adopted. The progress toward these should be monitored.

technology and consumer preferences. Per capita consumption of a commodity in a country is expressed as a function of per capita disposable income, trend, and other exogenous variables.

- ***Estimate aggregate import demand for individual commodities in the countries.*** The total import of a commodity is calculated by multiplying the per capita import by population in the country.

### Projected Grain Trade Flows

An analytical model of the world grain trade was developed for purposes of evaluating current competitiveness of the Panama Canal in grains and oilseeds shipments, to assess impacts of critical variables on its competitiveness, and to project changes in flows through the year 2025. These have been projected with and without an expansion of the Canal.

The model projects trade flow among importing and exporting grain countries. The model uses a variety of inputs, including grain flows by type of grain; shipping, handling, and storage costs; shipping practices; port restrictions/constraints; and various assumptions about the Panama Canal scenarios. The model is a spatial equilibrium model based on a linear programming algorithm. The model minimizes handling, transportation and related costs and tariffs for grain shipment from the major producing countries and regions to the primary and targeted importing countries and regions. Major exporting countries, such as Argentina, Australia, Brazil, Canada, the EU, and the United States, are included in the model to evaluate the impacts of Panama Canal scenarios on exporting countries' market shares in importing countries. The model will include all grains (as specified in the proposal, in aggregate), shipping and handling costs, shipping practices, port restrictions/constraints and assumptions about the Panama Canal scenarios.

## COMPARISON OF ACP REPORTED GRAIN TRAFFIC WITH STUDY ESTIMATES

The forecasts of potential Panama Canal grain trade presented in this Volume are not directly comparable to ACP reported grain traffic for several reasons. First, as already mentioned the definition of potential Panama Canal grain trade is based on the assumption of no Panama Canal tolls. Second, the forecast of potential transits is for dry bulk vessels only and does not include grains that may transit the Canal on non-dry bulk vessels5.

It is important to recognize that this study was designed not to prepare independent forecasts of potential Panama Canal grain trade. Accordingly, the study did not use ACP-reported Canal traffic as the basis of the forecast. Rather the study developed the potential trade forecast from other sources of production, consumption and trade of each grain.

Table 2-1 presents a comparison of ACP reported grain traffic for 2001 with forecasts prepared in this study. The upper portion of the table shows that in 2001 total ACP reported grain traffic was 38.5 million tons. To be comparable to the study's forecast, the amount of grain carried on non-dry bulk vessels is subtracted (1.6 million tons in 2001). The remaining ACP-reported grain traffic on dry bulk vessels totaled 36.9 million tons in 2001.

---

[5] However, we have prepared and provided the ACP with a forecast of such cargo carried aboard non-dry bulk vessels to be incorporated in other market segment studies.

**Table 2-1. Comparison of ACP Reported Grains Traffic with Study Forecasts, 2001 (thousands of long tons)**

| Item | 2001 |
|---|---|
| **Grains Trade from ACP data** | |
| ACP reported grains commodities traffic a/ | 38,489 |
| Less: Grain commodities on non-dry bulk vessels b/ | 1,599 |
| Subtotal grains traffic from RLA | 36,890 |
| | |
| **Grains Trade prepared by Study** | |
| Potential Canal grain trade forecast with zero tolls c/ | 48,459 |
| Less: Grains trade in non-dry bulk carriers d/ | 1,059 |
| Potential Canal grains trade in dry bulk vessels | 47,400 |
| Less: Traffic diverted with actual ACP tolls e/ | 9,266 |
| Forecast of grains bulk traffic on dry bulk vessels | 38,134 |

a/ From Volume 2, Appendix K, Table K-1.
b/ From Volume 2, Appendix K, Table K-1.
c/ From Grains Transit model, Table XB1graintradeforecast.xls
d/ From Grains Transit model, Table XB3grains.xls
e/ From Volume 4, Table 4-2.

Source: as noted.

The lower portion of Table 2-1 shows the estimates of grain trade prepared by the study. From the global trade forecasts prepared by the study, we identified the amount of grain trade on trade routes where the Panama Canal is the least-cost routing assuming no Canal tolls. The result is the forecast of potential Panama Canal grain trade with zero tolls of 47.4 million tons as reported in this volume.

However, again this estimate includes grain trade carried on non-dry bulk vessel (1.1 million tons in 2001). Also to be compared with ACP-reported traffic, the amount of potential dry bulk trade that is not captured due to Panama Canal tolls needs to be subtracted (79.3 million tons in 2001). The result is an estimate of 38.1 million tons of grains on dry bulk vessels that would use the Panama Canal. This is 1.2 million tons or 3.4 percent above the figure derived from ACP records. The results are quite close given the entirely independent and separate method used to prepare the forecast.

## NORTH AMERICA GRAIN PRODUCTION

Production of grains and oilseeds in the United States and Canada are distributed throughout the Midwest and western regions. Maps of production and density for the top the three grains and oilseeds in the United States are shown in Figures 2-1 through 2-3 (and in more detail in *Volume 2: Panama Canal's Potential Market*, Appendix A). Some of the important findings include:

- The largest volume of production in North America is corn produced in the Eastern Corn Belt, Central Plains and the Western Corn Belt. These have current production in the 85 million metric tons, 70 million metric tons and 45 million metric tons, respectively.
- This is followed by soybeans in the Eastern Corn Belt, and Western Corn Belt with projection in the 23-25 million metric tons area.
- Wheat follows in importance with production in the 10 million metric tons range in Saskatchewan, Central and Northern Plains with numerous other regions being of substantially lesser importance.
- The remaining crops, barley, rice and sorghum are of lesser importance with production in even the largest regions at less than 5 million metric tons.

**Figure 2-1. United States Corn Production, 2001**

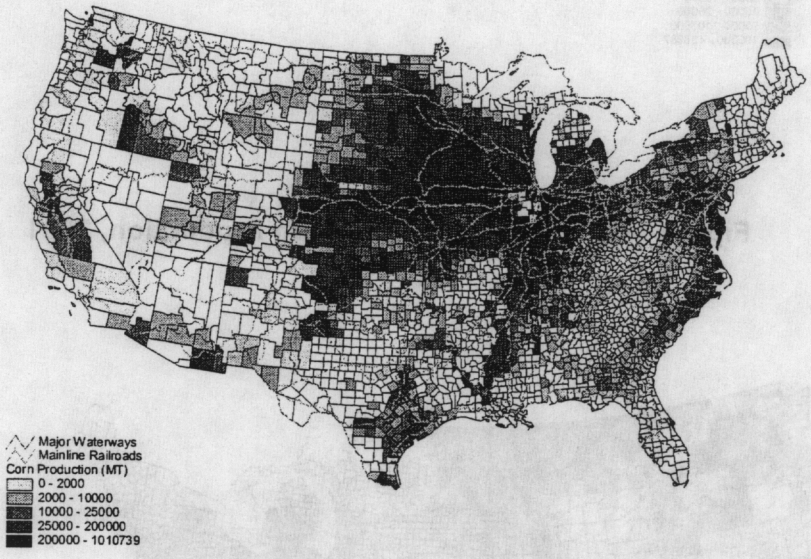


**Figure 2-2. United States Wheat Production, 2001**

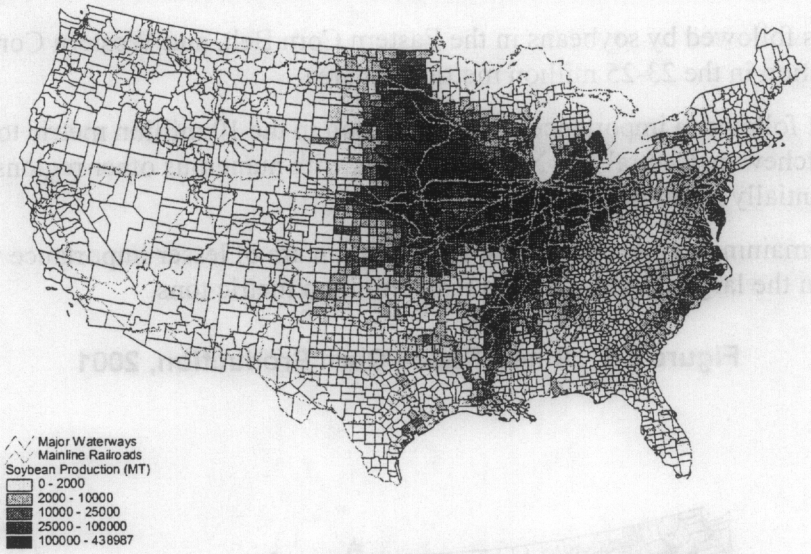
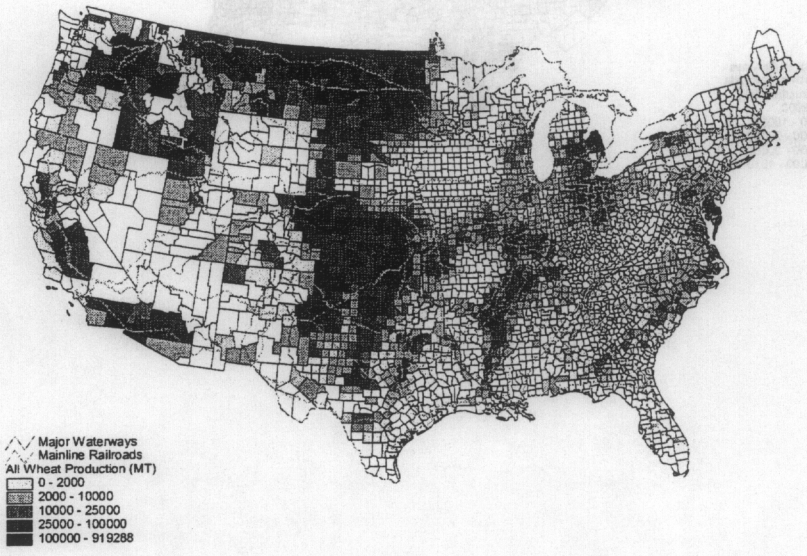



**Figure 2-3. United States Soybean Production, 2001**



## Determinants of Future Production Levels and Patterns

There are numerous factors impacting changes in production in the next 25 years. These include: changes in yield (in response to technical improvements) and changes in area planted in part in response to farm programs and returns per acre. During this period it is expected that area planted will evolve gradually toward those crops providing the greatest returns per acre.

Data on yields and acres were projected by year to 2025 and used to derive production estimates and changes in production by region and crop to 2025. Some of the important findings are:

- In the period through 2010, increases in production should occur in most regions. However, these will be concentrated mostly in soybeans. Most all of these increases are due to acre shifts and yield increases.
- In the period through 2025 the changes are primarily due to productivity increases. These will result in increases in production in all crops, but, dominated by far in corn and soybeans.
- Corn production is expected to increase mostly in the three dominate regions: Eastern Corn Belt (increase of 9 million metric tons from 2002), Western Corn Belt (increase of 7.5 million metric tons) and the Central Plains (increase of 5 million metric tons). Soybeans will increase primarily in the Eastern Corn Belt (increase of 6 million metric tons) and the Western Corn Belt (increase of 5.3 million metric tons). Wheat will increase in each of Saskatchewan, Central Plains and the Northern Plains by about 2 million metric tons each.
- Changes in production in all other crops and regions are expected to be minimal and typically in the range of less than 1 million metric tons.

### *Effect of Increase in U.S. Domestic Corn Demand for Ethanol*

An important change in US consumption is that related to corn use for ethanol. This industry has been expanding during the past decade, and its rate of expansion is expected to accelerate in the coming decade. These types of increases will impact demand for domestic consumption of corn in future. To account for this in the analysis and to illustrate its importance, potential increases in demand were estimated and converted to a corn equivalent to reflect increased demand.

Results from two separate studies were used to form projections on future ethanol capacity and corn consumption. Guebert[6] cites industry projections for total ethanol demand for ethanol in 2012 will be 5,500 million gallons/year. The California Energy Commission[7] surveyed current and prospective firms on plans for ethanol capacity to the year 2005 and derived expected plant capacity by region in 2005. Using these projections and some technical assumptions[8] we derived the projected

---

[6] Guebert, Alan. 2002. "ADM positions to dominate ethanol market." *The Western Producer*, Sept. 26.

[7] California Energy Commission. 2001. *U.S. Ethanol Industry Production Capacity Outlook: Results of a Survey Conducted by the California Energy Commission*. State of California, Energy Commission. August, Staff Paper P600-01-017.

[8] See *Volume 2: Panama Canal's Potential Market,* Appendix A for a description of technical assumptions.

consumption of corn by producing/consumption regions for the year 2005 and 2010. This procedure resulted in the added corn required to meet expected ethanol production demands over that in the current year for both 2010 and 2025 and are shown in Table 2-2.[9]

These results indicate that as a result of the accelerated ethanol demand for corn, that

- Corn consumption will increase another 13 percent by 2010 and 11 percent by 2025, versus what would otherwise be natural consumption growth;
- Most of the growth in ethanol consumption will be concentrated in Central and Northern Plains, and the Western Corn Belt.

**Table 2-2. Estimated Change Corn Consumption Due to Increased Ethanol Production, 2010 and 2025 (thousands of metric tons)**

| Region | Demand with No Addition for Increased Ethanol | Added Demand For Ethanol | Total Demand With Ethanol Increase |
|---|---|---|---|
| **2010** | | | |
| Central Plains | 27,622 | 6,565 | 34,187 |
| Delta | 7,830 | 0 | 7,830 |
| Eastern Corn Belt | 65,467 | 2,243 | 67,710 |
| North East | 8,917 | 404 | 9,321 |
| Northern Plains | 9,135 | 5,214 | 14,349 |
| Pacific Northwest | 1,957 | 17 | 1,974 |
| South East | 20,445 | 67 | 20,511 |
| Southern Plains | 11,527 | 543 | 12,070 |
| West Coast | 6,090 | 4,693 | 10,783 |
| West Central | 58,942 | 8,319 | 67,261 |
| Total | 216,932 | 28,063 | 245,996 |
| **2025** | | | |
| Central Plains | 32,087 | 6,565 | 38,652 |
| Delta | 9,096 | 0 | 9,096 |
| Eastern Corn Belt | 79,049 | 2,243 | 78,292 |
| North East | 10,359 | 404 | 10,753 |
| Northern Plains | 10,611 | 5,214 | 15,825 |
| Pacific Northwest | 2,274 | 17 | 2,290 |
| South East | 23,749 | 67 | 23,816 |
| Southern Plains | 13,391 | 543 | 13,934 |
| West Coast | 7,074 | 4,693 | 11,767 |
| West Central | 68,469 | 8,319 | 76,788 |
| Total | 256,159 | 28,063 | 281,213 |

Source: Prepared by Dr. William Wilson and D. Won Koo.

### *Implications for the Panama Canal*

Given that grain production in North America is one of the major sources for Panama Canal trade, the changes in North American production discussed above have important implications for the Canal. Those identified here of particular importance include:

- The large positive changes in production in corn and soybeans are notable relative to all the other grains.

[9] Projections exist for growth through 2010. The same growth is assumed to occur through 2025 (there are no projections to our knowledge for ethanol to that year). This would imply a slower growth rate in those more later years–specifically, the growth rate would be two-third of that which is expected to occur to 2010.

- Most of the positive changes in production are expected to occur in the Northern and Central Plains, and the Western Corn belt.
- Increases in ethanol demand for corn will increase domestic corn consumption. Increases in demand over current projected consumption would be largely (in rank order) in the Western Corn Belt, Central and Northern Plains, Western U.S., and Eastern Corn Belt. For each of these regions, this increase in domestic demand will reduce their exportable surplus, which otherwise would have been shipped off-shore.

## BRAZIL SOYBEAN PRODUCTION AND EXPORT POTENTIAL[10]

Soybean production and productivity in Brazil is changing and has potentially important impacts on future shipments through the Canal.

### Soybean Production Trends

Production has traditionally been concentrated in the Southern states of Brazil and the Central West regions. These regions are frequently referred as Parana in the south and Mato Grosso in the Central West. Soybean production in Brazil has traditionally been in the Southern regions. These were typically used for domestic crushing and the production of soybean oil and meals which were used locally for food and/or feeds, or were exported as products; or, the soybeans were exported directly. Typically, these soybeans and related infrastructure were exported from the Southern ports of Santos, Paranagua and Rio Grande.

Soybean production has expanded rapidly in the traditional southern production region, increasing from less than 2 million hectares in 1970, to nearly 8 million hectares in 1975. Since then, area planted in this region has remained in the 6-7 million hectares level. The regions in which most of the expansion is occurring is in the Central West, and North. Area planted in these regions has increased from nil through the mid-1970s, and now has more than 7 million hectares planted, exceeding that in the traditional south. The average level of production in these regions during the period 1995-1999 was: South 14 million metric tons; Center-West 12 million metric tons; and North 3 million metric tons.

Results from our meetings with senior industry and government officials are summarized below. Officials with the National Agency of Waterways and Ports (ANTAQ) provided detailed data and maps of their expected changes in production and exports of soybeans. There seemed to be a consensus that there was room for substantial growth in soybean production from the 2002 production level of 50 million metric tons. The range of upside potential was for soybean production to approach 92-100 million metric tons during the period 2010 to 2020 (Table 2-3).

Key observations include:

- Production is expected to increase from 31 million metric tons in 1999 to 50 million metric tons in 2003 and to 108 million metric tons by 2020.

---

[10] A more extensive discussion of changes in production, exports and transport logistical costs for Brazilian soybeans is presented in *Volume 2: Panama Canal's Potential Market*, Appendix I.

- Most of the increase in production is due to the prospect of increasing area under production, i.e., by bringing new lands under cultivation.
- Most of the increase is expected to be concentrated in the Northerly states in Brazil. Specifically, production is expected to increase by 66 percent in 2005 in Brazil North, and by 31 percent in Brazil South. By 2020, these values would represent increases in production of 467 percent and 157 percent respectively.

The cost of production in Brazil was included in our analysis and based on WEFA estimates. It is important that these are estimates and provide a consistent basis across countries and throughout the forecast period; and, in general, they are consistent with other published studies (e.g. USDA and University of Illinois) during the same period. An important area of uncertainty is the prospective production costs in the land yet to be introduced in production in the Northerly regions. In our estimates, these were based on per hectare costs and WEFA assumptions on costs for Brazil.

Results of the Brazil trip indicated that by 2020 exports could expand to 50 million metric tons (Table 2-4). This would result in Brazil's exports exceeding those of the United States, the current dominant exporter. Most of the growth would come from increased area brought under production in more northerly regions. For comparison, a recent ProX report[11] analysis shows a sharp uptrend, but less than that of USDA, with Brazilian exports stabilizing around 25 million metric tons by 2008.

In the past, Brazil has crushed most of their soybeans, and exported oil, meal and soybeans. This was facilitated in part by the neutral export taxes, by the reduced cost of shipping products, the composition of import markets and the need or meal in the domestic feeding industry. This regime has now changed due to the adoption of a value added tax favoring soybean exports. In addition, the new importers, notably China and Japan, have incentives to induced domestic processing.

The consensus view is that soybean production and therefore exports would expand much faster than exports of oil and meal.

[11] A U.S-based agri-business consulting firm that provides regular outlook reports for the agricultural and financial communities

## Table 2-3 Brazil Soybean Production Potential, Actual 1999 and Projected 2005 and 2020

| State | Region N/S | Area 1999 | Yield 1999 | Production 1999 | Area Potential | Production Potential | Estimated Prod. 2005 | Estimated Prod. 2020 | percent Change 2005 | percent Change 2020 | percent Potential 2005 | percent Potential 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ɔnia | N | 7.8 | 2.064 | 16 | 1771 | 7196 | 160 | 7004 | 144 | 6988 | 0.02 | 0.97 |
| | N | 0.1 | 3 | 0 | 20 | 76 | 0.4 | 0.9 | 0 | 1 | 0.01 | 0.01 |
| onas | N | 1.1 | 1.364 | 2 | 18 | 49 | 2.9 | 35.2 | 1 | 34 | 0.06 | 0.72 |
| ɪa | N | 0 | 0 | 0 | 1205 | 2859 | 1.9 | 86 | 2 | 86 | 0.00 | 0.03 |
| | N | 1.2 | 2.167 | 3 | 5991 | 24912 | 23.8 | 3594 | 21 | 3591 | 0.00 | 0.14 |
| ɪtins | N | 46.3 | 2.449 | 113 | 3902 | 18224 | 283 | 3527 | 170 | 3414 | 0.02 | 0.19 |
| ɪhao | N | 166.9 | 2.451 | 409 | 730 | 3759 | 791 | 3103 | 382 | 2694 | 0.21 | 0.83 |
| | N | 32.2 | 2.568 | 83 | 739 | 3451 | 229 | 2215 | 146 | 2132 | 0.07 | 0.64 |
| | N | 580 | 1.983 | 1150 | 7409 | 28927 | 2333 | 6363 | 1183 | 5213 | 0.08 | 0.22 |
| ; Gerais | S | 575.3 | 2.328 | 1339 | 1839 | 7781 | 1811 | 3396 | 472 | 2057 | 0.23 | 0.44 |
| ılo | S | 520.5 | 2.73 | 1421 | 3790 | 10347 | 1193 | 896 | -228 | -525 | 0.12 | 0.09 |
| ıa | S | 2788.1 | 2.782 | 7756 | 2230 | 12597 | 8619 | 11826 | 863 | 4070 | 0.68 | 0.94 |
| ı Catarina | S | 220.1 | 2.143 | 472 | 1661 | 7008 | 638 | 1359 | 166 | 887 | 0.09 | 0.19 |
| rande do Sul | S | 3050.5 | 1.464 | 4466 | 4266 | 9173 | 5909 | 8669 | 1443 | 4203 | 0.64 | 0.95 |
| Grosso do Sul | S | 1073.8 | 2.607 | 2799 | 12950 | 43643 | 3786 | 7669 | 987 | 4870 | 0.09 | 0.18 |
| Grosso | N | 2635 | 2.836 | 7473 | 11588 | 54117 | 11516 | 26469 | 4043 | 18996 | 0.21 | 0.49 |
| | S | 1334.1 | 2.563 | 3419 | 12721 | 47576 | 6406 | 21984 | 2987 | 18565 | 0.13 | 0.46 |
| ɛderal | S | 28.4 | 2.31 | 66 | 62 | 280 | 108 | 137 | 42 | 71 | 0.39 | 0.49 |
| | | 13,061 | 2.4 | 30,987 | 72,892 | 281,975 | 43,811 | 108,333 | 41 | 250 | 0.17 | 0.44 |
| N | | 3,471 | 2.1 | 9,249 | 33,373 | 143,570 | 15,341 | 52,397 | 66 | 467 | | |
| S | | 9,591 | 2.4 | 21,739 | 39,519 | 138,405 | 28,470 | 55,936 | 31 | 157 | | |

SOURCE: Governo Federal "Corredores Estrategiocos de Desenvolvimento" Jan 2002

**Table 2-4. Projected Soybeans Exports, 2005 and 2020 (million metric tons)**

| Exporter | 2005 | 2020 | Change | % Change |
|---|---|---|---|---|
| United States | 26.00 | 41.00 | 15.00 | 58 |
| Argentina | 4.80 | 9.80 | 5.00 | 104 |
| Brazil | 15.80 | 50.20 | 34.40 | 218 |
| Canada | 0.30 | 0.05 | _0.25 | _83 |
| China | 0.15 | 0.03 | _0.13 | _83 |
| EU | 0.40 | 0.72 | 0.32 | 80 |
| Other (Americas) | 3.15 | 5.30 | 2.15 | 68 |
| Other | 0.20 | 4.50 | 0.25 | 123 |
| Total | 50.80 | 107.54 | 56.74 | 112 |

Source: Neto, F. Corredores Estrategicos de Desenvolvimento, Ministerio Dos Transportes, September 2001.

## WORLD GRAIN IMPORT DEMAND[12]

Import demand for a commodity in a country is defined as the difference between domestic demand and domestic supply of the commodity in the country under an assumption that carry-over stock remains constant over time. Domestic demand for the commodity in the country is affected by per capita income and consumer preference and tastes in the country, while domestic production is influenced by advancement in farming technology.

In this study, demand and supply of individual commodities were estimated by using econometric techniques with time series data from 1970 to 2000. In estimating demand for individual commodities in each country, per capita consumption of a commodity is estimated using variables such as per capita income and the trend. We used the trend variable to represent consumer preference and taste. Then total consumption of a commodity in a country is estimated by multiplying the estimated per capita consumption of the commodity by population in the country. Therefore, demand for a commodity in a country is influenced by per capita income, population, and a trend variable representing consumer preference and taste. Since domestic supply in a country is relatively stable with an increasing trend in farming technology, import demand for a commodity depends upon growth in per capita income and population. These were then combined with the DRI-WEFA forecast for income and population in each country/region to derive projected consumption and also used to derive projected imports.

Results are shown in Tables 2-5 through 2-11 and Figure 2-4. Highlights of these results are summarized below:

- ***World Import Demand.*** World import demand for all grains is expected to increase about 47 percent for the 2000-2025 period. The increase in world import demand is due mainly to what would appear to be optimistic projections of world income growth for the period by DRI-WEFA.

[12]Volume 2: *Panama Canal's Potential Market,* Appendix E contains detailed description of the data and econometric procedures used in the analysis of import demand.

- ***Fast growth market.*** Pakistan will have the fastest growth in import demand for all grains (322 percent 662 thousand tons in 2001 to 2.8 million tons in 2025), followed by China (217 percent from 19.8 million tons in 2001 to 62.6 million tons in 2025).
- ***Slow growth markets.*** Japan and the EU will have the slowest growth in import demand (less than 1 percent). Among crops, import demand for wheat is expected to grow slightly faster than other crops.
- ***China.*** Expected increases in China's import demand for corn and soybeans for the 2001-2025 period will increase traffic volume of these two crops through Panama Canal. China's import demand for all grains and oilseeds are expected to increase about 217 percent, which could be a main factor affecting grain traffic through Panama Canal.

The 2003 USDA Agricultural Baseline Projections suggested Chinese imports of wheat would increase from 1.5 million metric tons in 2003/04 to 9.1 million metric tons by 2012/2013. They cite land use competition and increasing water limitations in China as factors leading to an increase in China's wheat imports[13]. The 2003 USDA Outlook conference provided a China outlook. USDA sees the sharp uptrend in Chinese imports continuing unabated for the next 10 years, eventually rising above 25 million metric tons by 2011. However, ProX labeled this projection "not remotely plausible", instead seeing Chinese imports stabilizing between 16-18 million metric tons over the next 10 years.

- ***Other Asian countries,*** e.g., Korea and Japan, traditionally have imported over 45 million metric tons of grains and soybean from the United States through the Panama Canal. However, their import demand for grains and oilseed are expected to increase less than 10 percent for the period, indicating that these countries are not main factors affecting increases in grain traffic through Panama Canal.
- ***Middle East, North Africa, and the EU*** are major importers of grains and oilseeds and their import demand are expected to increase about 48 percent for the period. However, these shipments do not affect traffic volume through Panama Canal.
- ***Barley.*** Aggregate import demand for barley is expected to increase 55 percent for the 2001-2025 period (Table 2-4). Increases in individual country's import demand ranges from 6 percent in Korea to 1800 percent in other South America. Import demand for barley is the largest in Middle East with an increase of 31 percent, followed by China with an increase of 119 percent.
- ***Corn.*** Aggregate import demand for corn is expected to increase about 26 percent for the 2001-2025 period (Table 2-5). Japan is the largest importer of corn, followed by North Africa and S. Korea in 2001. However, China will be the second largest importer in 2025 with an import of 9.9 million metric tons. It is expected that Japan and South. Korea will import more meat rather than feed grains to raise livestock for the period. Under a freer trade environment, beef production in the countries may not be competitive. China is expected to produce as much meat as possible to meet rapidly increasing domestic demand for meat rather than importing the shortages from major meat producing countries. Because of this, China's imports of corn are expected to increase rapidly.

---

[13] *Milling and Baking News*, February 18, 2003, p. 39.

- ***Rice.*** Aggregate import demand for rice is expected to increase much faster than those for barley and corn. Average increase in rice consumption would be 51 percent over the 2001-2025 period (Table 2-6). This is due to (1) increasing trend in consumers' preference and taste of rice over wheat, and (2) much higher income elasticity on rice. Middle East is the largest rice importing region with an increase of 81 percent for the period, followed by West Africa with an increase of 58 percent. Under a freer trade environment, Philippines, Korea and Malaysia are expected to increase their imports faster than other countries for the period.

- ***Sorghum.*** As a minor crop, major importers are Mexico and Japan. Mexico is the largest importer, followed by Japan. These countries' imports are expected to increase 63 percent and 20 percent, respectively, for the 2001-2025 period (Table 2-7). Average increase in import demand is 45 percent for the period.

- ***Soybean.*** Average increase in import demand for soybeans is expected to be about 49 percent for the 2001-2025 period (Table 2-8). The largest soybean importer was the EU, followed by Japan. However, China will be the largest importer of soybeans in 2025. China is expected to import about 30 million metric tons of soybeans in 2025. China is expected to produce as much meat as possible to meet its rapidly increasing domestic demand for meat rather than importing meet directly from major exporters. The European Union was the largest importer of soybeans in 2001, but the second largest importer with import volume of 19.9 million metric tons in 2025.

- ***Wheat.*** Aggregate import demand for wheat is expected to increase over 61 percent for the 2001- 2025 period (Table 2-9). Largest importers are Middle East, followed by North Africa for the 2001-2025 period. However, China's import will increase faster than other countries and will be the third largest importer of wheat in 2025, with an import volume of about 15.7 million metric tons. This is mainly due to continuous decrease in wheat production in China rather than increase in consumption.

## Table 2-5. All Grains: Import Demand, Actual 2001 and Projected 2005-2025, 1,000 Mt

| | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | percent change |
|---|---|---|---|---|---|---|---|
| Africa East | 4,770 | 5,306 | 5,843 | 6,970 | 8,097 | 9,224 | 0.93 |
| Africa North | 26,664 | 28,370 | 30,077 | 33,391 | 36,705 | 40,019 | 0.50 |
| Africa South | 2,263 | 2,423 | 2,583 | 2,832 | 3,081 | 3,330 | 0.47 |
| Africa West | 7,054 | 7,780 | 8,507 | 9,607 | 10,707 | 11,807 | 0.67 |
| Brazil | 9,196 | 11,058 | 12,358 | 13,367 | 11,626 | 13,702 | 0.49 |
| Canada | 4,055 | 4,294 | 4,532 | 4,977 | 5,422 | 5,868 | 0.45 |
| Caribbean | 4,505 | 4,681 | 4,857 | 5,120 | 5,383 | 5,645 | 0.25 |
| Chile | 2,046 | 2,158 | 2,271 | 2,466 | 2,661 | 2,856 | 0.40 |
| China | 19,793 | 26,638 | 44,213 | 50,098 | 56,457 | 62,648 | 2.17 |
| East Europe | 567 | 1,052 | 1,570 | 2,433 | 3,138 | 4,012 | 6.08 |
| European U | 20,907 | 19,157 | 19,516 | 19,908 | 20,202 | 20,701 | -0.01 |
| FSU | 667 | 780 | 821 | 903 | 986 | 1,069 | 0.60 |
| India | 0 | 2,655 | 4,287 | 203 | 171 | 134 | |
| Indonesia | 9,924 | 10,309 | 10,694 | 11,324 | 11,954 | 12,584 | 0.27 |
| Japan | 31,381 | 31,546 | 31,711 | 31,869 | 32,027 | 32,186 | 0.03 |
| Korea | 13,609 | 13,870 | 14,132 | 14,266 | 14,400 | 14,534 | 0.07 |
| Malaysia | 4,644 | 4,918 | 5,192 | 5,633 | 6,073 | 6,513 | 0.40 |
| Mexico | 17,725 | 19,301 | 20,877 | 22,614 | 24,352 | 26,089 | 0.47 |
| Middle East | 37,722 | 40,788 | 43,854 | 48,530 | 53,206 | 57,883 | 0.53 |
| Other South Am | 14,850 | 15,153 | 15,455 | 16,222 | 16,989 | 17,756 | 0.20 |
| Pakistan | 662 | 1,197 | 1,733 | 2,087 | 2,441 | 2,795 | 3.22 |
| Philippines | 4,865 | 5,433 | 6,001 | 6,953 | 7,905 | 8,857 | 0.82 |
| Singapore | 660 | 688 | 715 | 752 | 789 | 826 | 0.25 |
| Taiwan | 8,572 | 8,800 | 9,028 | 9,410 | 9,792 | 10,174 | 0.19 |
| Thailand | 7,134 | 7,285 | 7,617 | 8,099 | 8,573 | 9,065 | 0.27 |
| Venezuela | 2,445 | 2,550 | 2,655 | 2,843 | 3,030 | 3,218 | 0.32 |
| Viet Nam | 680 | 768 | 991 | 1,153 | 1,336 | 1,490 | 1.19 |
| Total | 269,364 | 290,988 | 324,147 | 346,119 | 369,621 | 397,131 | 0.47 |

Source: Estimates derived from USDA Economic Research Service data base: Production, Supply and Demand (PS&D)

## Table 2-6. Barley: Import Demand, Actual 2001 and Projected 2005-2025, 1,000 Mt

| | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | percent change |
|---|---|---|---|---|---|---|---|
| Africa East | 139 | 170 | 202 | 273 | 344 | 415 | 1.99 |
| Africa North | 1,795 | 1,960 | 2,125 | 2,405 | 2,685 | 2,965 | 0.65 |
| Africa South | 126 | 133 | 141 | 151 | 161 | 172 | 0.37 |
| Africa West | 0 | 0 | 0 | 0 | 0 | 0 | |
| Brazil | 126 | 0 | 0 | 0 | 0 | 0 | -1.00 |
| Canada | 0 | 0 | 0 | 0 | 0 | 0 | |
| Caribbean | 0 | 0 | 0 | 0 | 0 | 0 | |
| Chile | 55 | 64 | 73 | 89 | 105 | 121 | 1.19 |
| China | 2,862 | 3,444 | 4,120 | 5,089 | 6,074 | 7,062 | 1.47 |
| East Europe | 223 | 562 | 1,171 | 1,884 | 2,598 | 3,311 | 13.85 |
| European U | 1,421 | 0 | 0 | 0 | 0 | 0 | -1.00 |
| FSU | 0 | 0 | 0 | 0 | 0 | 0 | |
| India | 0 | 13 | 36 | 47 | 64 | 73 | |
| Indonesia | 0 | 0 | 0 | 0 | 0 | 0 | |
| Japan | 1,508 | 1,536 | 1,565 | 1,596 | 1,628 | 1,660 | 0.10 |
| Korea | 217 | 219 | 221 | 224 | 227 | 230 | 0.06 |
| Malaysia | 0 | 0 | 0 | 0 | 0 | 0 | |
| Mexico | 185 | 209 | 233 | 254 | 275 | 296 | 0.60 |
| Middle East | 7,320 | 7,858 | 8,397 | 8,784 | 9,171 | 9,559 | 0.31 |
| Other South Am | 268 | 301 | 335 | 379 | 422 | 466 | 0.74 |
| Pakistan | 3 | 16 | 29 | 40 | 50 | 61 | 18.00 |
| Philippines | 0 | 0 | 0 | 0 | 0 | 0 | |
| Singapore | 0 | 0 | 0 | 0 | 0 | 0 | |
| Taiwan | 186 | 190 | 194 | 199 | 205 | 210 | 0.13 |
| Thailand | 0 | 0 | 0 | 0 | 0 | 0 | |
| Venezuela | 0 | 0 | 0 | 0 | 0 | 0 | |
| Viet Nam | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | 18,434 | 18,681 | 20,853 | 23,430 | 26,030 | 28,625 | 0.55 |

Source: Estimates derived from USDA Economic Research Service data base: Production, Supply and Demand (PS&D)

## Table 2-7. Corn: Import Demand, Actual 2001 and Projected 2005-2025, 1,000 Mt

| | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | percent change |
|---|---|---|---|---|---|---|---|
| Africa East | 659 | 663 | 667 | 678 | 690 | 701 | 0.06 |
| Africa North | 8,235 | 8,237 | 8,238 | 8,634 | 9,030 | 9,426 | 0.14 |
| Africa South | 0 | 0 | 0 | 0 | 0 | 0 | |
| Africa West | 154 | 156 | 158 | 159 | 159 | 160 | 0.04 |
| Brazil | 1,683 | 3,263 | 4,163 | 4,594 | 2,258 | 3,776 | 1.24 |
| Canada | 2,096 | 2,115 | 2,134 | 2,263 | 2,392 | 2,521 | 0.20 |
| Caribbean | 1,404 | 1,412 | 1,420 | 1,471 | 1,523 | 1,574 | 0.12 |
| Chile | 1,268 | 1,295 | 1,321 | 1,383 | 1,445 | 1,506 | 0.19 |
| China | 0 | 1,369 | 12,719 | 11,709 | 11,278 | 9,964 | |
| East Europe | 0 | 0 | 0 | 0 | 0 | 0 | |
| European U | 691 | 0 | 0 | 0 | 0 | 0 | -1.00 |
| FSU | 0 | 0 | 0 | 0 | 0 | 0 | |
| India | 0 | 0 | 0 | 0 | 0 | 0 | |
| Indonesia | 1,226 | 1,242 | 1,258 | 1,340 | 1,421 | 1,502 | 0.23 |
| Japan | 16,351 | 16,352 | 16,354 | 16,374 | 16,394 | 16,414 | 0.00 |
| Korea | 8,115 | 8,119 | 8,123 | 8,181 | 8,240 | 8,299 | 0.02 |
| Malaysia | 2,322 | 2,361 | 2,400 | 2,542 | 2,685 | 2,828 | 0.22 |
| Mexico | 5,300 | 5,298 | 5,297 | 5,314 | 5,332 | 5,349 | 0.01 |
| Middle East | 5,428 | 5,430 | 5,432 | 5,723 | 6,015 | 6,306 | 0.16 |
| Other South Am | 2,727 | 2,643 | 2,560 | 2,687 | 2,813 | 2,940 | 0.08 |
| Pakistan | 3 | 9 | 16 | 31 | 46 | 61 | 18.06 |
| Philippines | 475 | 515 | 554 | 567 | 580 | 593 | 0.25 |
| Singapore | 45 | 45 | 45 | 47 | 50 | 52 | 0.14 |
| Taiwan | 4,925 | 4,966 | 5,006 | 5,193 | 5,380 | 5,567 | 0.13 |
| Thailand | 4,359 | 4,543 | 4,726 | 4,990 | 5,253 | 5,517 | 0.27 |
| Venezuela | 1,133 | 1,159 | 1,185 | 1,268 | 1,351 | 1,435 | 0.27 |
| Viet Nam | 0 | 31 | 198 | 298 | 419 | 507 | |
| Total | 70,599 | 73,228 | 85,983 | 87,463 | 86,775 | 89,023 | 0.26 |

Source: Estimates derived from USDA Economic Research Service data base: Production, Supply and Demand (PS&D)

## Table 2-8. Rice: Import Demand, Actual 2001 and Projected 2005-2025, 1,000 Mt

| | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | percent change |
|---|---|---|---|---|---|---|---|
| Africa East | 785 | 895 | 1,006 | 1,195 | 1,384 | 1,573 | 1.00 |
| Africa North | 0 | 0 | 0 | 0 | 0 | 0 | |
| Africa South | 989 | 1,080 | 1,171 | 1,298 | 1,424 | 1,551 | 0.57 |
| Africa West | 3,470 | 3,789 | 4,109 | 4,566 | 5,024 | 5,482 | 0.58 |
| Brazil | 988 | 1,002 | 1,011 | 1,050 | 1,117 | 1,147 | 0.16 |
| Canada | 314 | 349 | 384 | 433 | 483 | 533 | 0.70 |
| Caribbean | 902 | 977 | 1,051 | 1,145 | 1,239 | 1,333 | 0.48 |
| Chile | 74 | 85 | 95 | 110 | 125 | 140 | 0.89 |
| China | 0 | 233 | 1,292 | 691 | 136 | 0 | |
| East Europe | 344 | 350 | 356 | 364 | 372 | 380 | 0.10 |
| European U | 492 | 521 | 551 | 576 | 605 | 630 | 0.28 |
| FSU | 611 | 623 | 634 | 671 | 707 | 744 | 0.22 |
| India | 0 | 0 | 0 | 0 | 0 | 0 | |
| Indonesia | 3,164 | 3,177 | 3,191 | 3,208 | 3,225 | 3,242 | 0.02 |
| Japan | 821 | 824 | 828 | 838 | 848 | 859 | 0.05 |
| Korea | 89 | 187 | 284 | 248 | 213 | 178 | 0.99 |
| Malaysia | 651 | 755 | 859 | 996 | 1,132 | 1,269 | 0.95 |
| Mexico | 450 | 516 | 582 | 667 | 751 | 836 | 0.86 |
| Middle East | 5,011 | 5,620 | 6,230 | 7,178 | 8,126 | 9,074 | 0.81 |
| Other South Am | 842 | 844 | 846 | 848 | 850 | 852 | 0.01 |
| Pakistan | 0 | 0 | 0 | 0 | 0 | 0 | |
| Philippines | 680 | 903 | 1,126 | 1,608 | 2,091 | 2,573 | 2.79 |
| Singapore | 346 | 361 | 376 | 394 | 411 | 429 | 0.24 |
| Taiwan | 0 | 0 | 0 | 0 | 0 | 0 | |
| Thailand | 0 | 0 | 0 | 0 | 0 | 0 | |
| Venezuela | 0 | 0 | 0 | 0 | 0 | 0 | |
| Viet Nam | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | 23,023 | 25,096 | 27,990 | 30,099 | 32,283 | 34,847 | 0.51 |

Source: Estimates derived from USDA Economic Research Service data base: Production, Supply and Demand (PS&D)

## Table 2-9. Sorghum: Import Demand, Actual 2001 and Projected 2005-2025, 1,000 Mt

| | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | percent change |
|---|---|---|---|---|---|---|---|
| Africa East | 187 | 117 | 47 | 107 | 166 | 226 | 0.21 |
| Africa North | 45 | 69 | 93 | 138 | 184 | 229 | 4.06 |
| Africa South | 0 | 0 | 0 | 0 | 0 | 0 | |
| Africa West | 0 | 7 | 14 | 46 | 78 | 110 | |
| Brazil | 229 | 270 | 312 | 367 | 419 | 472 | 1.06 |
| Canada | 31 | 44 | 57 | 74 | 91 | 108 | 2.50 |
| Caribbean | 2 | 3 | 3 | 5 | 7 | 9 | 3.00 |
| Chile | 0 | 0 | 0 | 0 | 0 | 0 | |
| China | 0 | 148 | 0 | 0 | 0 | 15 | |
| East Europe | 0 | 0 | 0 | 0 | 1 | 1 | |
| European U | 149 | 149 | 150 | 152 | 37 | 154 | 0.04 |
| FSU | 0 | 0 | 0 | 0 | 0 | 0 | |
| India | 0 | 49 | 98 | 0 | 0 | 0 | |
| Indonesia | 0 | 0 | 0 | 0 | 0 | 0 | |
| Japan | 2,229 | 2,342 | 2,454 | 2,530 | 2,605 | 2,680 | 0.20 |
| Korea | 3 | 3 | 3 | 3 | 3 | 3 | 0.19 |
| Malaysia | 0 | 0 | 0 | 0 | 0 | 0 | |
| Mexico | 4,738 | 5,346 | 5,954 | 6,540 | 7,126 | 7,712 | 0.63 |
| Middle East | 147 | 181 | 216 | 271 | 326 | 381 | 1.59 |
| Other South Am | 91 | 96 | 102 | 104 | 107 | 110 | 0.21 |
| Pakistan | 26 | 34 | 42 | 45 | 48 | 52 | 1.02 |
| Philippines | 0 | 0 | 0 | 0 | 0 | 0 | |
| Singapore | 0 | 0 | 0 | 0 | 0 | 0 | |
| Taiwan | 43 | 44 | 45 | 46 | 46 | 46 | 0.07 |
| Thailand | 155 | 170 | 186 | 212 | 227 | 263 | 0.70 |
| Venezuela | 0 | 0 | 0 | 0 | 0 | 0 | |
| Viet Nam | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | 10,075 | 11,078 | 11,785 | 12,653 | 13,489 | 14,595 | 0.45 |

Source: Estimates derived from USDA Economic Research Service data base: Production, Supply and Demand (PS&D)

## Table 2-10. Soybeans: Import Demand, Actual 2001 and Projected 2005-2025, 1,000 Mt

| | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | percent change |
|---|---|---|---|---|---|---|---|
| Africa East | 6 | 8 | 11 | 18 | 25 | 33 | 4.45 |
| Africa North | 598 | 669 | 741 | 869 | 998 | 1,127 | 0.88 |
| Africa South | 220 | 219 | 218 | 245 | 271 | 298 | 0.35 |
| Africa West | 13 | 19 | 26 | 43 | 60 | 76 | 5.00 |
| Brazil | 0 | 0 | 0 | 0 | 0 | 0 | |
| Canada | 262 | 294 | 327 | 375 | 423 | 471 | 0.80 |
| Caribbean | 116 | 120 | 125 | 130 | 135 | 141 | 0.21 |
| Chile | 60 | 64 | 68 | 73 | 78 | 83 | 0.39 |
| China | 11,979 | 14,560 | 17,228 | 21,420 | 25,657 | 29,831 | 1.49 |
| East Europe | 0 | 82 | 43 | 184 | 167 | 320 | |
| European U | 18,154 | 18,486 | 18,816 | 19,181 | 19,560 | 19,916 | 0.10 |
| FSU | 57 | 156 | 187 | 233 | 279 | 325 | 4.70 |
| India | 0 | 271 | 0 | 157 | 0 | 61 | |
| Indonesia | 1,587 | 1,713 | 1,840 | 2,021 | 2,201 | 2,382 | 0.50 |
| Japan | 5,009 | 5,025 | 5,041 | 5,059 | 5,078 | 5,096 | 0.02 |
| Korea | 1,522 | 1,559 | 1,595 | 1,614 | 1,634 | 1,654 | 0.09 |
| Malaysia | 497 | 546 | 596 | 661 | 726 | 791 | 0.59 |
| Mexico | 4,485 | 4,896 | 5,307 | 5,794 | 6,281 | 6,768 | 0.51 |
| Middle East | 1,838 | 2,198 | 2,557 | 3,024 | 3,491 | 3,958 | 1.15 |
| Other South Am | 2,220 | 1,962 | 1,705 | 1,540 | 1,375 | 1,210 | -0.45 |
| Pakistan | 138 | 147 | 155 | 176 | 196 | 217 | 0.57 |
| Philippines | 510 | 567 | 623 | 710 | 797 | 884 | 0.73 |
| Singapore | 39 | 42 | 44 | 48 | 52 | 55 | 0.41 |
| Taiwan | 2,343 | 2,456 | 2,569 | 2,659 | 2,750 | 2,841 | 0.21 |
| Thailand | 1,764 | 1,684 | 1,784 | 1,928 | 2,074 | 2,219 | 0.26 |
| Venezuela | 444 | 477 | 510 | 556 | 602 | 647 | 0.46 |
| Viet Nam | 24 | 27 | 30 | 18 | 6 | 0 | -1.00 |
| Total | 55,888 | 60,254 | 64,152 | 70,751 | 76,937 | 83,427 | 0.49 |

Source: Estimates derived from USDA Economic Research Service data base: Production, Supply and Demand (PS&D)

**Table 2-11. Wheat: Import Demand, Actual 2001 and Projected 2005-2025, 1,000 Mt**

| | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | percent change |
|---|---|---|---|---|---|---|---|
| Africa East | 2,994 | 3,453 | 3,911 | 4,700 | 5,489 | 6,278 | 1.10 |
| Africa North | 15,991 | 17,435 | 18,880 | 21,344 | 23,807 | 26,271 | 0.64 |
| Africa South | 929 | 991 | 1,053 | 1,138 | 1,224 | 1,310 | 0.41 |
| Africa West | 3,417 | 3,808 | 4,200 | 4,793 | 5,386 | 5,979 | 0.75 |
| Brazil | 6,170 | 6,523 | 6,872 | 7,356 | 7,832 | 8,307 | 0.35 |
| Canada | 1,353 | 1,492 | 1,631 | 1,832 | 2,033 | 2,234 | 0.65 |
| Caribbean | 2,080 | 2,169 | 2,258 | 2,368 | 2,479 | 2,589 | 0.24 |
| Chile | 589 | 651 | 714 | 811 | 908 | 1,006 | 0.71 |
| China | 4,951 | 6,883 | 8,854 | 11,188 | 13,312 | 15,776 | 2.19 |
| East Europe | 0 | 58 | 0 | 0 | 0 | 0 | |
| European U | 0 | 0 | 0 | 0 | 0 | 0 | |
| FSU | 0 | 0 | 0 | 0 | 0 | 0 | |
| India | 0 | 2,323 | 4,153 | 0 | 107 | 0 | |
| Indonesia | 3,947 | 4,176 | 4,405 | 4,756 | 5,107 | 5,458 | 0.38 |
| Japan | 5,464 | 5,466 | 5,469 | 5,471 | 5,474 | 5,476 | 0.00 |
| Korea | 3,662 | 3,784 | 3,906 | 3,995 | 4,083 | 4,171 | 0.14 |
| Malaysia | 1,174 | 1,256 | 1,339 | 1,434 | 1,529 | 1,625 | 0.38 |
| Mexico | 2,567 | 3,035 | 3,504 | 4,045 | 4,586 | 5,128 | 1.00 |
| Middle East | 17,978 | 19,500 | 21,022 | 23,550 | 26,078 | 28,607 | 0.59 |
| Other South Am | 8,702 | 9,305 | 9,908 | 10,665 | 11,421 | 12,178 | 0.40 |
| Pakistan | 492 | 991 | 1,491 | 1,795 | 2,100 | 2,404 | 3.89 |
| Philippines | 3,200 | 3,449 | 3,698 | 4,067 | 4,437 | 4,806 | 0.50 |
| Singapore | 230 | 240 | 250 | 263 | 277 | 290 | 0.26 |
| Taiwan | 1,075 | 1,144 | 1,213 | 1,312 | 1,411 | 1,509 | 0.40 |
| Thailand | 857 | 889 | 921 | 970 | 1,019 | 1,067 | 0.25 |
| Venezuela | 869 | 914 | 960 | 1,019 | 1,077 | 1,136 | 0.31 |
| Viet Nam | 656 | 710 | 764 | 837 | 910 | 983 | 0.50 |
| Total | 91,346 | 102,651 | 113,384 | 121,724 | 134,107 | 146,613 | 0.61 |

Source: Estimates derived from USDA Economic Research Service data base: Production, Supply and Demand (PS&D)

## WORLD GRAIN TRADE FLOWS

World grain trade in 2000/2001 was about 210 million metric tons, of which approximately 158 million metric tons originates from North America, Brazil and Argentina (Table 2-12).

- The largest single origin is the U.S. Gulf with 85 million metric tons. Next is the U.S. West coast at 20 million metric tons. This is followed distantly by Argentina at 21million metric tons, Canada, the EU and Australia each at about 16-17 million metric tons, China and Brazil at 9 million metric tons.
- The largest importing regions are East Asia (59 million metric tons), followed by Latin America (43 million metric tons), Africa (32 million metric tons) and the Middle East (29million metric tons).
- The largest flows are through the U.S. Gulf with shipments to Japan, Africa, and the Middle East. Exports from the United States and Canada West Coast are largely to South and East Asia; those from Brazil are largely to Europe; Argentina to China, the Middle East and Africa; Australia is mostly to Asia, Middle East and Africa.

Appendix A, Tables A-1 through A-6 show world trade for 2000/2001 for each of the six commodities.

## Table 2-12. All Grains: World Grain Trade, 2000/2001 (thousands of metric tons)

| Importing Country/Region | Exporting Country/Region | | | | | | | | Other | | | | | | | | Total Trade |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | United States | | | Canada | | Brazil | Argentina | Total | EU | Australia | China | Thailand | Vietnam | Mexico | Peru | Chile | |
| | East C. | West C. | Gulf | East | West | | | | | | | | | | | | |
| E. Europe | 0 | 0 | 68 | 22 | 0 | 75 | 10 | 175 | 703 | 0 | 127 | 30 | 98 | 0 | 0 | 0 | 1,133 |
| Western Europe ((EU) | 3,370 | 5 | 6,172 | 1,093 | 48 | 7,271 | 2,918 | 20,878 | 25 | 357 | 0 | 278 | 9 | 0 | 0 | 0 | 21,547 |
| FSU | 7 | 84 | 1,841 | 4 | 0 | 2 | 85 | 2,023 | 791 | 0 | 241 | 7 | 46 | 0 | 0 | 0 | 3,108 |
| *East Asia* | 1,176 | 15,860 | 27,695 | 407 | 3,132 | 1,051 | 1,871 | 51,193 | 348 | 3,388 | 3,373 | 449 | 10 | 0 | 0 | 0 | 58,761 |
| China/Hong Kong | 347 | 1,265 | 4,825 | 335 | 1,057 | 621 | 1,040 | 9,489 | 118 | 191 | 0 | 275 | 0 | 0 | 0 | 0 | 10,073 |
| Japan | 747 | 8,202 | 15,189 | 72 | 1,941 | 364 | 682 | 27,197 | 1 | 2,038 | 151 | 144 | 10 | 0 | 0 | 0 | 29,540 |
| S. Korea | 82 | 3,487 | 3,387 | 0 | 134 | 54 | 56 | 7,200 | 229 | 1,159 | 3,222 | 31 | 0 | 0 | 0 | 0 | 11,841 |
| Taiwan | 0 | 2,906 | 4,295 | 0 | 0 | 12 | 93 | 7,306 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7,306 |
| *S. Asia* | 0 | 597 | 763 | 102 | 96 | 0 | 182 | 1,740 | 571 | 2,166 | 0 | 0 | 63 | 0 | 0 | 0 | 4,540 |
| India | 0 | 0 | 3 | 0 | 0 | 0 | 84 | 87 | 385 | 326 | 0 | 0 | 0 | 0 | 0 | 0 | 798 |
| Pakistan | 0 | 432 | 0 | 0 | 0 | 0 | 0 | 432 | 7 | 1,285 | 0 | 0 | 0 | 0 | 0 | 0 | 1,724 |
| Bangladesh | 0 | 165 | 268 | 102 | 96 | 0 | 98 | 729 | 166 | 453 | 0 | 0 | 63 | 0 | 0 | 0 | 1,411 |
| Other | 0 | 0 | 492 | 0 | 0 | 0 | 0 | 492 | 13 | 102 | 0 | 0 | 0 | 0 | 0 | 0 | 607 |
| *SE Asia* | 278 | 2,913 | 2,743 | 0 | 1,580 | 115 | 524 | 8,154 | 356 | 3,172 | 3,238 | 871 | 1,454 | 0 | 0 | 0 | 17,245 |
| Indonesia | 137 | 223 | 1,170 | 0 | 700 | 0 | 80 | 2,311 | 314 | 1,917 | 1,184 | 250 | 563 | 0 | 0 | 0 | 6,540 |
| Malaysia | 19 | 17 | 493 | 0 | 366 | 59 | 78 | 1,032 | 0 | 793 | 1,771 | 330 | 133 | 0 | 0 | 0 | 4,060 |
| Philippines | 57 | 2,057 | 742 | 0 | 365 | 0 | 0 | 3,221 | 0 | 379 | 280 | 27 | 746 | 0 | 0 | 0 | 4,653 |
| Singapore | 0 | 53 | 0 | 0 | 10 | 0 | 0 | 63 | 0 | 83 | 2 | 263 | 11 | 0 | 0 | 0 | 423 |
| Thailand | 65 | 537 | 332 | 0 | 139 | 57 | 320 | 1,450 | 0 | 250 | 0 | 0 | 0 | 0 | 0 | 0 | 1,700 |
| Vietnam | 0 | 26 | 5 | 0 | 0 | 0 | 46 | 77 | 42 | 246 | 4 | 1 | 0 | 0 | 0 | 0 | 371 |
| *Middle East* | 260 | 146 | 7,120 | 520 | 3,842 | 110 | 1,452 | 13,450 | 6,970 | 5,539 | 480 | 1,407 | 665 | 28 | 0 | 0 | 28,538 |
| *Africa* | 1,026 | 658 | 11,537 | 2,341 | 686 | 106 | 2,781 | 19,134 | 6,236 | 2,041 | 1,286 | 2,533 | 736 | 497 | 0 | 0 | 32,463 |
| North Africa | | | | | | | | | | | | | | 497 | 0 | 0 | 497 |
| East Africa | | | | | | | | | | | | | | 0 | 0 | 0 | 0 |
| West Africa | | | | | | | | | | | | | | 0 | 0 | 0 | 0 |
| South Africa | | | | | | | | | | | | | | 0 | 0 | 0 | 0 |
| *Latin America* | 216 | 20 | 26,813 | 1,290 | 1,922 | 182 | 11,066 | 41,510 | 898 | 0 | 268 | 2 | 146 | 88 | 37 | 27 | 42,975 |
| Mexico | 41 | 0 | 13,213 | 129 | 708 | 0 | 25 | 14,116 | 35 | 0 | 0 | 0 | 0 | 88 | 0 | 0 | 14,239 |
| Caribbean | 12 | 0 | 4,344 | 284 | 1 | 11 | 20 | 4,671 | 622 | 0 | 248 | 2 | 146 | 0 | 0 | | 5,688 |
| E.C. Cen America | 0 | 0 | 596 | 0 | 0 | 26 | 0 | 622 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 622 |
| W. C. Central America | 39 | 0 | 2,476 | 0 | 0 | 0 | 122 | 2,637 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,643 |
| E.C. S. America | 0 | 0 | 345 | 16 | 215 | 30 | 8,380 | 8,986 | 58 | 0 | 21 | 0 | 0 | 0 | 0 | 27 | 9,092 |
| W. C. S. America | 85 | 0 | 3,445 | 75 | 700 | 116 | 1,283 | 5,703 | 121 | 53 | 0 | 0 | 0 | 0 | 0 | 0 | 5,877 |
| Chile | 0 | 20 | 838 | 0 | 216 | 0 | 1,044 | 2,119 | 57 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2,175 |
| Venezuela | 40 | 0 | 1,555 | 786 | 83 | 0 | 192 | 2,655 | 0 | 0 | 12 | 0 | 0 | 0 | 37 | | 2,704 |
| Total Exports from Above | 6,334 | 20,283 | 84,752 | 5,778 | 11,306 | 8,913 | 20,890 | 158,256 | 16,898 | 16,662 | 9,014 | 5,578 | 3,225 | 613 | 37 | 27 | 210,310 |
| Panama Shipments | 0 | 91 | 35,058 | 623 | 649 | 179 | 0 | 36,600 | 36 | 0 | 265 | 0 | 130 | 613 | 37 | 27 | 37,707 |
| Panama share | 0 | 0 | 41 | 11 | 6 | 2 | 0 | 23 | 0 | 0 | 3 | 0 | 4 | 100 | 100 | 100 | 18 |

Source: Prepared by Dr. William Wilson and D. Won Koo using data on international trade from: International Grains Council (London) World Grain Trade; United Nations Food and Agriculture Organization (New York); Canada Grains Council Statistical Handbooks (Winnipeg), USDA Federal Grains Inspection Service.

# 3. Potential Panama Canal Grain Trade

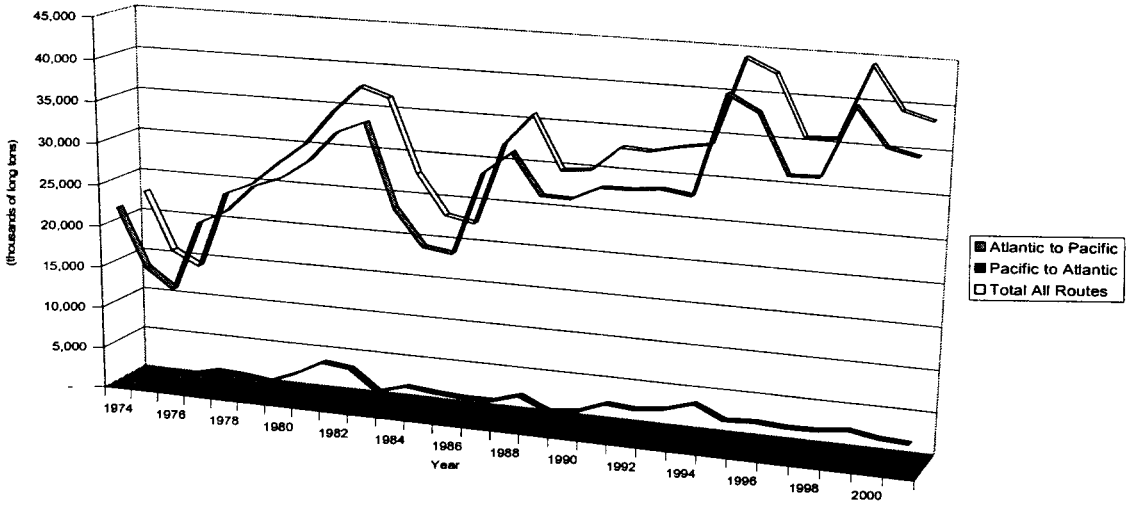
This section presents the assessment of the Canal's potential market for dry bulk trade. The section commences with a review of historical Panama Canal trade by route and commodity followed by a forecast of potential Panama Canal Trade through 2025. It is important to note that for purposes of this study the term "Canal's potential market" represents our estimate of the maximum market share that the Canal could capture of world trade assuming a value of zero for Panama Canal tolls. Section 6 on Canal toll pricing strategy identifies and analyzes the impact of alternative Canal toll structures and rates on forecast traffic volume.

## HISTORICAL PANAMA CANAL GRAIN TRADE

### Trade by Direction of Canal Transit and Route

Nearly 90 percent of grain trade through the Panama Canal has historically been on Atlantic to Pacific routes (Figure 3-1). In 2001 grain trade on Atlantic to Pacific Routes totaled 35.8 million tons or 93 percent of total Canal grain trade. Further detail on Panama Canal grain trade by direction of transit and route is presented in Table 3-1 for the 1995-2001 period.

**Figure 3-1. All Grains: Panama Canal Trade by Direction of Transit, 1974–2001**




Source: Table 3-1.

## Table 3-1. All Grains: Panama Canal Trade by Direction and Route, 1995 through 2001 (thousands of long tons)

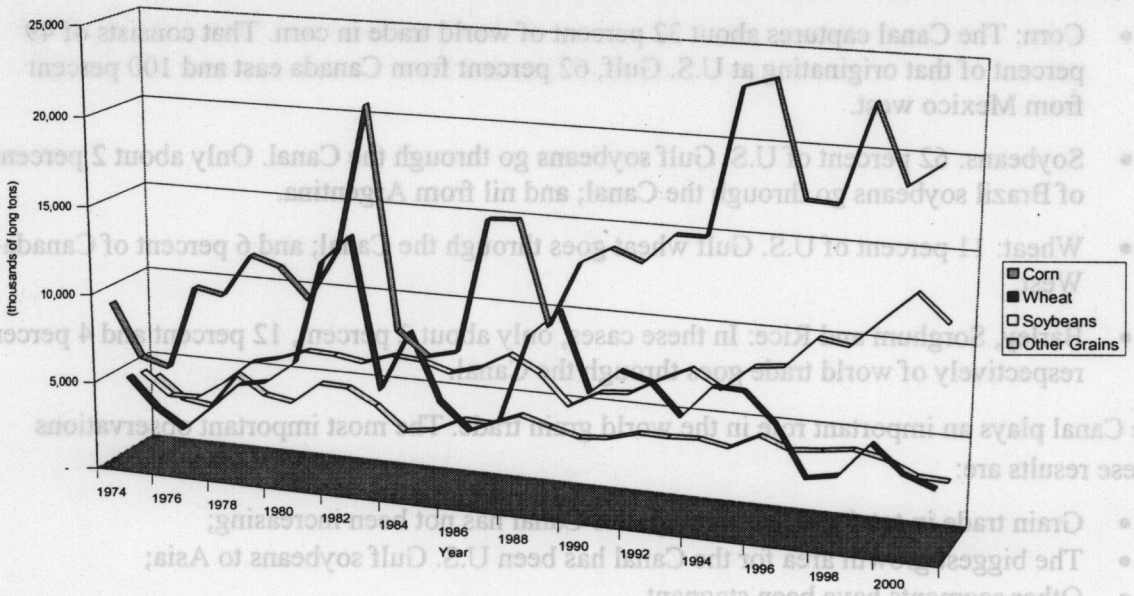
| Origin | Destination | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Average Annual Growth Rate 1995-2001 |
|---|---|---|---|---|---|---|---|---|---|
| **Atlantic to Pacific Routes** | | | | | | | | | |
| North America Gulf | Far East | | | | | | | | |
| North America Gulf | Japan | 17,874 | 16,389 | 16,225 | 16,929 | 17,852 | 15,166 | 15,725 | (2.1) |
| North America Gulf | China | 7,340 | 4,424 | 2,492 | 2,985 | 2,716 | 4,217 | 3,554 | (11.4) |
| North America Gulf | S Korea | 3,334 | 4,745 | 3,167 | 3,025 | 4,327 | 2,737 | 2,868 | (2.5) |
| North America Gulf | Taiwan | 3,458 | 5,346 | 3,165 | 2,458 | 4,867 | 3,757 | 4,023 | 2.6 |
| North America Gulf | Other Far East | 223 | 69 | 191 | 208 | 303 | 63 | 34 | (26.9) |
| Subtotal | | 32,228 | 30,972 | 25,240 | 25,606 | 30,065 | 25,941 | 26,203 | (3.4) |
| North America Gulf | Central America West | 2,382 | 2,841 | 2,266 | 2,359 | 2,676 | 2,967 | 3,488 | 6.6 |
| North America Gulf | South America West | 2,856 | 2,961 | 2,371 | 2,860 | 4,310 | 3,308 | 2,490 | (2.3) |
| North America East | Far East | | | | | | | | |
| North America East | Japan | 1,048 | 408 | 492 | 433 | 766 | 467 | 953 | (1.6) |
| North America East | China | 441 | 141 | 190 | 102 | 348 | 581 | 112 | (20.4) |
| North America East | S Korea | 107 | 145 | 100 | - | 459 | 264 | 159 | 6.8 |
| North America East | Taiwan | 19 | 56 | - | - | 56 | 400 | 201 | 47.6 |
| North America East | Other Far East | 27 | - | - | - | - | - | 0 | (59.4) |
| Subtotal | | 1,643 | 750 | 782 | 535 | 1,630 | 1,712 | 1,425 | (2.3) |
| North America Gulf | South East Asia | 843 | 1,050 | 1,011 | 761 | 1,339 | 1,884 | 1,205 | 6.1 |
| South America East | Far East | | | | | | | | |
| Brazil | Japan | - | - | 71 | 53 | 37 | 179 | 268 | n.a. |
| North America East | South America West | 171 | 207 | 269 | 179 | 120 | 102 | 190 | 1.8 |
| North America East | South East Asia | 21 | - | 31 | 42 | 40 | 39 | 113 | 32.7 |
| North America East | Central America West | 104 | 103 | 148 | 27 | 95 | 130 | 65 | (7.4) |
| North America Gulf | Oceania | 602 | 254 | 150 | 20 | 204 | 85 | 65 | (31.0) |
| North America East | Oceania | 12 | 8 | - | 56 | - | - | - | n.a. |
| Other Atlanticto Pacific Routes | | 258 | 210 | 307 | 277 | 282 | 230 | 332 | 4.2 |
| Total Atlantic to Pacific Routes | | 41,121 | 39,355 | 32,647 | 32,775 | 40,799 | 36,578 | 35,845 | (2.3) |
| **Pacific to Altlantic Routes** | | | | | | | | | |
| North America West | Africa | 722 | 859 | 633 | 1,207 | 1,556 | 1,158 | 795 | 1.6 |
| Central America West | Africa | 258 | 48 | 70 | 49 | 312 | 524 | 408 | 7.9 |
| Central America West | Central America East | - | 177 | 584 | 407 | 136 | 88 | 309 | n.a. |
| North America West | Europe | 562 | 635 | 384 | 205 | 365 | 154 | 239 | (13.3) |
| Far East | Caribbean Basin | 10 | 20 | 36 | 118 | 327 | 261 | 202 | 65.5 |
| South America West | South America East | 2 | 12 | 27 | 6 | 5 | 102 | 142 | 109.1 |
| South East Asia | Caribbean Basin | 128 | 310 | 189 | 26 | 174 | 179 | 141 | 1.6 |
| North America West | Central America East | 386 | 67 | 35 | 215 | 97 | 139 | 71 | (24.6) |
| North America West | South America East | 507 | 843 | 429 | 294 | 266 | 194 | 48 | (32.5) |
| Oceania | South America East | 91 | 42 | 99 | 26 | - | - | 58 | (7.1) |
| Central America West | Europe | 222 | 26 | 187 | 146 | - | - | - | n.a. |
| Other Pacific to Atlantic Routes | | 48 | 117 | 240 | 279 | 200 | 43 | 230 | 29.9 |
| Total Pacific to Atlantic Routes | | 2,935 | 3,155 | 2,912 | 2,976 | 3,438 | 2,842 | 2,643 | (1.7) |
| **Total All Routes** | | 44,056 | 42,511 | 35,559 | 35,751 | 44,237 | 39,420 | 38,489 | (2.2) |

Source: Autoridad de Canal de Panama.

## Trade by Commodity

Figure 3-2 shows grain trade through the Panama Canal from 1974 through 2001 for corn, wheat, soybeans and other grains. During this period total Panama Canal grain trade ranged from a low of 14.1 million tons in 1976 to a high of 44.2 million tons in 1999. Corn was the dominant grain commodity moving through the Canal each year except for 1981, 1982 and 1989 when wheat trade slightly exceeded corn trade.

**Figure 3-2. All Grains: Panama Canal Trade by Commodity, 1974-2001**




Source: Panama Canal Authority.

Since 1991, Panama Canal trade of corn and soybeans has shown a general increase (despite annual fluctuations) while wheat and other grains have shown a declining trend. *Volume 2: Panama Canal's Potential Market*, Appendix C presents a detailed review of the Panama Canal grain trade volumes. Key observations include:

- Grain trade through the Canal seems to be stable at about 35-40 million metric tons, though it appears to be declining in the more recent years.
- The dominant grain going through the Canal is corn, followed by soybeans, and then distantly wheat. Rice, sorghum, barley and oats are of substantially lesser importance.
- The dominant destination is Asia-NPAC comprising 85 percent of the transits in recent year.
- Among the grains, shipments of corn seem stable at about 20 million metric tons, soybeans had been increasing at least through 99/00 to 13 million metric tons; but wheat seems to have been declining from about 7.5 million metric tons to about 3 million metric tons with most of that loss from shipments to Asia-NPAC; rice trade does not appear trending and remains at about 900,000 metric tons; shipments of both sorghum and barley are minor and have been declining.

- The largest movement is of corn from U.S. Gulf to Japan, followed by soybeans to Japan and soybeans to China.
- Wheat shipments are largely U.S. Gulf to Philippines, Peru, Columbia, Costa Rica, and other Central American countries. Other notable wheat shipments are from the United States and Mexico West and Canada to Africa.

## PANAMA CANAL AND WORLD GRAIN TRADE

Canal shipments for each grain type relative to world trade.

- Corn: The Canal captures about 32 percent of world trade in corn. That consists of 49 percent of that originating at U.S. Gulf, 62 percent from Canada east and 100 percent from Mexico west.
- Soybeans: 62 percent of U.S. Gulf soybeans go through the Canal. Only about 2 percent of Brazil soybeans go through the Canal; and nil from Argentina.
- Wheat: 11 percent of U.S. Gulf wheat goes through the Canal; and 6 percent of Canada-West.
- Barley, Sorghum and Rice: In these cases, only about 2 percent, 12 percent and 4 percent respectively of world trade goes through the Canal.

The Canal plays an important role in the world grain trade. The most important observations from these results are:

- Grain trade in total and that through the Canal has not been increasing;
- The biggest growth area for the Canal has been U.S. Gulf soybeans to Asia;
- Other segments have been stagnant.
- These have been declining notably include corn, wheat and the minor grains;
- Only a small amount of Brazil soybeans uses the Canal currently.

## NORTH AMERICAN RAIL FLOWS

North American rail flows were summarized for 2000. Exports of grains were analyzed by port area and composition of exports by crop for specific port areas. Rail shipments for specific crops were then evaluated to determine which ports they shipped to. This provides some perspective on rail flows for each crop.

- The largest export port for U.S. grains is the Gulf with 70 million metric tons or exports, followed distantly by the Pacific at 20 million metric tons. All other ports are virtually inconsequential with less than 2 million metric tons each.
- The largest volume grains are: corn and soybeans through the U.S. Gulf at 35 million metric tons and 20 million metric tons respectively. Shipments of these grains through other ports are of minor importance.
- Wheat exports are about 20 million metric tons with the majority going through the U.S. Gulf and a slightly lesser amount through the Pacific Northwest.
- A large number of regions ship corn and soybeans primarily to the U.S. Gulf). However, those regions in Minnesota and Iowa can/do ship to several competing regions including

the Pacific Northwest, St. Louis (Gulf), Minneapolis and Duluth. The same is true for soybeans.

- Interior wheat shipments are more disperse. Central regions are mostly to the U.S. Gulf, Western to the Pacific Northwest, but a large number of Northern Plains regions can and do ship to both the U.S. Gulf, the Pacific Northwest and to other port areas.
- Interior shipments of barley are largely domestic.
- Interior shipments of sorghum are nearly all to/through the U.S. Gulf, or used domestically.

## NORTH AMERICAN INTERIOR SHIPPING COSTS

Interior shipping costs were derived from the major producing regions in the United States, to major consumption regions, and to export ports. These were done for both rail and for barges from the primary barge origin points.

For shipments from Eastern and Western Corn Belts and Northern Plains to export ports, an additional shipping alternative was added for shipment via barge to the U.S. Gulf.[14] An estimated $11.52 per metric ton differential in rail shipping costs for delivery to Minneapolis versus St. Louis exists between Western Corn Belt and Northern Plains origins. Differences between barge rates from Minneapolis and St. Louis to the U.S. Gulf averaged $7 per metric ton from Jan 2001 to Sept, 2002. These differentials were applied to estimate shipping costs using the alternative barge location for Minneapolis from these two origins. For the Eastern Corn Belt, farmer delivery to a barge terminal was assumed and rates were assigned as the average differential for Illinois River barge rates over St. Louis barge rates (Differential averaged $2 per metric ton from Jan 2001 to Sept, 2002 which results in an average shipping cost of $8.03).

Results are summarized in Table 3-2[15] and implications for the Canal and study are described below. The directional flows of grains within North America have an important impact on flows through the Canal. These are largely impacted by interior shipping costs and demand for shipments at ports. Interior shipping costs within North America are complex and of particular importance involve rail and barge competition, and intermarket competition.

---

[14] Barge rates were initially assumed to reflect rail shipment to St. Louis and then via barge to gulf ports. Due to the importance of these barge movements, alternative barge shipments reflecting movements from the Northern Plains and Western Corn Belt through upper Mississippi River barge loading facilities were added as well as a rate for Eastern Corn Belt movements through barge loading facilities at Peoria, IL.

[15] Detailed rates, manipulations for each grain and origin are shown in *Volume 2: Panama Canal's Potential Market*, Appendix B.

**Table 3-2 Average Shipping Costs, from U.S. Production Regions to Export Ports**

| | US East (Great Lakes) | US West Coast (Pacific Northwest) | US Gulf Rail to St. Louis + Barge | US Gulf Alt. Barge Locations1 | US Gulf Min Rail Texas Gulf, LA Gulf | Mexico |
|---|---|---|---|---|---|---|
| Central Plains | -- | 26.65 | 20.09 | -- | 19.83 | 28.15 |
| Delta | -- | 41.46 | -- | -- | 9.08 | 20.29 |
| Eastern Corn Belt | -- | 34.05 | 13.08 | 8.03 | 10.40 | 27.63 |
| Northeast | -- | -- | -- | -- | -- | -- |
| Northern Plains | 27.93 | 32.17 | 29.30 | 25.18 | 26.28 | 37.96 |
| Pacific Northwest | 58.61 | 14.69 | 36.83 | -- | -- | -- |
| Southeast | -- | -- | -- | -- | -- | -- |
| Southern Plains | -- | -- | -- | -- | 14.62 | 17.63 |
| West | -- | 18.54 | 40.38 | -- | 31.23 | -- |
| Western Corn Belt | 18.45 | 30.49 | 16.58 | 12.06 | 20.39 | 28.88 |

* Note: - - denotes no shipments for designated origin to destination

[1] Assumes Eastern Corn Belt delivery to Illinois River Terminal and Barge shipment to Gulf, Northern Plains and Western Corn Belt assume Rail costs for shipment to Minneapolis plus Barge shipment from Minneapolis to Gulf.

**Includes 8$ per metric ton for shipping, Great Lakes to St. Lawrence

Some of the important findings from these data include:

- The most important rates and rate differentials impacting movements through the Canal are the intermarket differences for shipments going to the West Coast versus the U.S. Gulf.
- These intermarket differences of particular interest are: Rail shipments from the Central and Northern Plains to the Pacific Northwest versus the U.S. Gulf. The average differences between these are in the area of $2-$4 per metric ton. Thus, with all else being the same, these regions have the greatest ability to shift movements from West to U.S. Gulf, and from U.S. Gulf to Pacific Northwest.
- All other rates impact the results in terms of distribution within North America. However, they are likely of lesser importance on the distribution through the Gulf versus Pacific Northwest ports. As examples:
- Shipments from the Delta and Eastern Corn belt are largely dedicated to the U.S. Gulf;
- Shipments from the Pacific Northwest and Western regions are largely dedicated to the Pacific Northwest;
- Barges play an important role and are an alternative to rail to the U.S. Gulf and/or to the Pacific Northwest. As illustrated, shipments involving barges are within 1-4$ per metric ton of direct rail shipments. Barges are most competitive for rail/barge combinations for grain originating from the Western Corn Belt.
- Mexico: Shipments to Mexico can occur through the U.S. center gulf with barges or rail; or by direct rail shipment, in this case via Laredo and Eagle Pass, with interior Mexico shipping by rail. Since NAFTA a greater portion of the grain has been imported directly.
- Canada: Rail rates for grains are regulated differently than for other traffic and have an important impact on the spatial flows. These results indicate that in virtually all cases shipment of grain from Canada is lowest cost moving through Canada (Table B2.3). Shipments via Vancouver or Thunder Bay typically have an advantage of $15-20 per

metric ton versus shipments through the U.S. system (direct rail or rail/barge combinations) to the U.S. Gulf. This is notable for the Canal for two reasons:

- The prospect of inducing shipments through the Gulf to go through the Canal are not great;
- The low cost of Vancouver (Prince Rupert) is such that grain moving west to go through the Canal to Africa and other selected regions (e.g. Venezuela) is potentially a viable shipment.

The implications of these differences on North American and International spatial competition are investigated further in *Volume 2: Panama Canal's Potential Market*, Appendixes G and I.

## BRAZIL SOYBEAN EXPORTS AND INTERIOR SHIPPING COSTS

### Soybean Exports

Brazil exports soybeans, as well as its products of meal and oil. Soybean exports have traditionally been exported through the southern ports of Parana and Rio Grande. Brazil has also announced the construction of the largest grain terminal in the Port of Santos at a cost of $58 million. This will have the capacity to handle 10 million metric tons upon completion.[16] The distribution of Brazilian soybean exports by port area in 1998/99 is shown in Table 3-3

**Table 3-3. Brazil Soybean Exports, By Port, 1998/99**

| Port | Volume (000 metric tons) |
|---|---|
| *Southern Ports* | |
| Paranagua | 3734 |
| Rio Grande | 1641 |
| Santos | 1897 |
| Others | 1300 |
| *Amazon River: Itacoatiara* | 584 |
| *Parana-Paragua Waterway: Caceres/Corumba* | 118 |
| Total | 9313 |

Source:Neto, F. Corredores Estrategicos de Desenvolvimento, Ministerio Dos Transportes, September 2001

### Interior Shipping

It is well recognized that the high cost of interior shipping has inhibited low cost access to world markets. Navigable waterways in the Center-West all flow west and south (with exception of the Sao Francisco River). Only in the recent years have Amazon tributaries become viable for exports. The railways are thought to be highly inefficient and costly to upgrade. In response the railways are being privatized.

[16] World Grain, "Latin Americas Biggest Grain Terminal Under Construction." Oct. 2002.

There have been several interior projects aimed to improve access to ports (Figure 4-3). These include: the Madeira-Amazon water (1997) which is the newest river system and used to ship soybeans in Western Mato Grosso via the Amazon. Soybeans are trucked to Porto Velho and then barged down the Madeira River to Amazon port of Itacoatiara (1000 km upriver from the mouth of the Amazon). From here a floating elevator loads Panamax sized ocean vessels. Exports via this route are expected to increase. Similar projects are underway in the Tiete-Parana waterway and Parana-Paraguay waterway.

Efforts have been made to lower the costs of interior shipping with some success. The interior spread between production regions and ports has declined from about $76 per metric ton to $47 between the early and later 1990s.

A recent study evaluated the potential cost reductions associated with these projects[17]. Results indicated cost reductions in the area of: $8 per metric ton on the Parana-Paraguay waterway from Mato Grosso to lower Parana; Mato Grosso via the Madeira-Amazon by $11 per metric ton; and rail shipping costs by about 40 percent.

### Interior Shipping Costs

Major changes are occurring in shipping economics within Brazil. This section first summarizes current shipping practices, proposed projects and then their likely impact on shipping costs.

There are numerous interior infrastructure projects underway, being planned, and/ or being discussed. All of these are focused on developing lower costs means of exporting soybeans, generally through the Northerly ports. Below is a summary of these projects:

- Truck to Puerto Velho, water to Itacoatiara and Santarém. This is completed and is being fully utilized now.
- BR163: This is a highway to Santarém which is currently paved to the Mato Grosso border. Further north, it is not paved and is in need of at least 50 bridges to complete the project.
- Tapajos Waterway: This would be development of a waterway serving the Port of Santarém, and originating soybeans from a very large productive area. This waterway would be parallel to the BR163 project.

In addition to these are a number of other projects that are being planned and analyzed. These were not discussed further since it appears the above are the most imminent and would have the greatest impact on soybean production and trade.

There were differing views on the timing, practicality, and cost savings on each of these projects:

- There are immense economic, political and environmental issues associated with each of these projects. Hence, their evolution will be uncertain;
- Most thought that is adopted, it was entirely possible that cost savings in the area of $10 per metric ton could be achieved.

---

[17] Fuller, S., L. Fellin, A. Lalor, and K. Klindworth. Effect of Improving South American Transportation Systems on US and South American Corn and Soybean Economies. USDA Ag. Marketing Service, October 2000.

- ANTAQ indicated the following regarding the projects. Their opinions were:
  - — BR163. This is a road that is already paved to the border of Para state. Beyond that it is not paved and is in very poor condition. However, there have already been placed 51 bridges completed on this road. ANTAQ indicated that since this goes through the heart of the Amazon region, the environmental implications of a road and subsequent high likelihood of human settlement in this area.
  - — The waterway is viewed as highly favorable because it would go to the heart of a very large producing region for soybeans. It has been preliminarily approved as a project by Avanca Brasil, but is lacking funding. There remains still significant environmental, engendering, social (it goes through an Indian reservation) and coordination issues (i.e. with the hydro-energy sector) prior to this moving forward. Estimated costs are $200 million and would take 3-4 years to complete.
  - — The area around Santarém is already expanding and within 3 years is expecting 11/2 million metric tons of soybeans to be produced in this region.

Important changes are occurring in Brazil which may impact shipments of soybeans through the Canal. Most important amongst these include:

- The rapid expansion of soybean production in the Central and North of Brazil;
- Infrastructure projects involving reductions in the interior cost of shipping;
- A prospective shift to result in increased exports from the Northern ports. Currently shipping costs from Mato Grosso via the northern ports have an advantage versus those going through the traditional Southern Ports. The advantage of northern shipments is expected to expand to other producing regions if/as some of the infrastructural projects are completed. In most cases the Northern shipments of soybeans from Brazil would be natural tributary to Rotterdam, the traditional market, or to Asia and China via the Canal. Both of these would be considered non-traditional import markets.

### Shipping/Handling Costs

ANTAQ (Brazil's National Agency of Waterways and Ports) provided detailed data and maps of their analysis of shipping costs from different origins through different ports to off-shore designations. These are summarized in Tables 4-3 and 4-4. A summary of the prospective changes in shipping costs are contained in *Volume 2: Panama Canal's Potential Market,* Appendix I. For planning, it is expected that these would occur by about 2010.

The tables show the components of shipping costs from different representative regions and routes, to Rotterdam and Shanghai respectively. Different origins and routes are shown, and cost projections are made for current and 2015 to be reflective if the impacts of alternative routes. Finally, the advantage to Brazil North versus Santos is derived, and, the change in advantage.

The results show individual components of shipping costs and are interpreted here directly. Costs are shown for four origin regions, moving from North to Southern regions. Results are shown in each case for shipments via a northerly route, and via a southerly or conventional route. Costs are also shown for the year 2015 considering the prospect of adopting the proposed transportation projects.

Important conclusions from these are:

- Currently, shipments from Campo Novo do Parecis favors a northerly routing through Port Velho and exported from Itacoatiara and Santarém. All other origins favor shipments through the more southerly port of Santos or Vitoria. These are true for both shipments to Rotterdam and to China.
- By 2015, shipments from both Campo Novo do Parecis and Sorriso favor moving through the northerly routes and exported out of Santarém. The reason for this is due to the adoption of the proposed transportation project resulting in reduced interior shipping costs going north. The other southerly origins would still favor routes through the traditional ports.
- The results also indicated a change in the advantage in shipping north. In 2000 the advantage of shipping north to China from Campo Novo do Parecis is $17 per metric ton, but will decline to $1 in 2015. For shipments from Sorriso, the advantage goes from a disadvantage of $1 per metric ton to an advantage of $10 per metric ton by 2015. Thus, the advantage for the more central regions of Sorrisso increase by about $11 per metric ton., whereas the advantage of Campo Novo do Parecis declines due to other transportation effects.

## SPATIAL ARBITRAGE AND COMPARISON OF COSTS AMONG COMPETING ROUTES

Ultimately many cost elements affect the spatial distribution of grains. These include production costs (in order to derive landed or delivered costs at the point of import), interior shipping costs, handling and other logistics costs, and ocean shipping costs. The analysis reported in this section is of intermarket competition and the spatial distribution of grains. The intent is to identify the impact of individual costs elements relative to other costs, and relative to competing regions, and how they affect shipments through the Canal. Two separate analyses were conducted. The first focuses on shipments from individual BEA regions in the United States, between the U.S. Pacific Northwest and U.S. Gulf, for ultimate shipment to Asian markets. The second examined the intermarket competitiveness among U.S. regions and those in South America, again, for shipments to Japan. Thus, these should be viewed as microscopic analysis of shipments from some of the most important origins to the most important destinations for Canal swing traffic.

### Analysis of U.S. Production Regions for Shipment to Asia

An analysis of shipment by crop from individual U.S. origin regions to Asia either through the canal or direct shipment from Pacific Northwest ports was evaluated. Total costs inclusive of interior shipping, handling costs, added interest costs an ocean shipping costs were derived for each origin through different routes to selected primary Asian markets. The comparative advantage of shipping through the canal for an origin was derived relative to other origins and routes. These comparative advantage values by BEA and crop were then mapped for wheat, corn, and soybeans (Figure 3-3 through Figure 3-5) and are summarized in Table 3-4. The results can be used to identify those regions that are natural tributary to the U.S. Gulf and the Canal, versus to the competing market, the Pacific Northwest in this case. In addition, the results can be used to identify those regions which are potentially swing areas in that they could easily shift interior distribution channels if/as economic variables changes.

**Table 3-4 Intermarket Arbitrage for U.S. Shipments via the Gulf and Canal**

| Grain | Natural Tributary for Gulf/Canal Shipments | Swing Origins |
|---|---|---|
| Wheat | North Dakota, South Dakota, Western Minnesota, Colorado, Kansas | Western regions of North Dakota, South Dakota and Nebraska |
| Corn | Minnesota | Southwestern Iowa and Southeastern Nebraska |
| Soybeans | South Dakota, Iowa | -NA- |

Source: Prepared by Dr. William Wilson and D. Won Koo

These results indicated that:

- Wheat: Gulf shipments to Asia have a competitive advantage for origins in North Dakota, South Dakota, Western Minnesota, Colorado and Kansas.
- Corn: Origins with competitive advantages are in South Dakota and Iowa.
- Soybeans: Shipments via the Gulf have advantages for shipment from Minnesota.

These results illustrate regions where there is competition between Pacific Northwest and Gulf port shipments and where Gulf port shipments to Asia have a competitive advantage.

**Figure 3-3. Advantage for Shipping Wheat From BEA Regions to Asian Markets From U.S. Gulf via Canal over Direct Shipment from Pacific Northwest ($ per metric ton)**

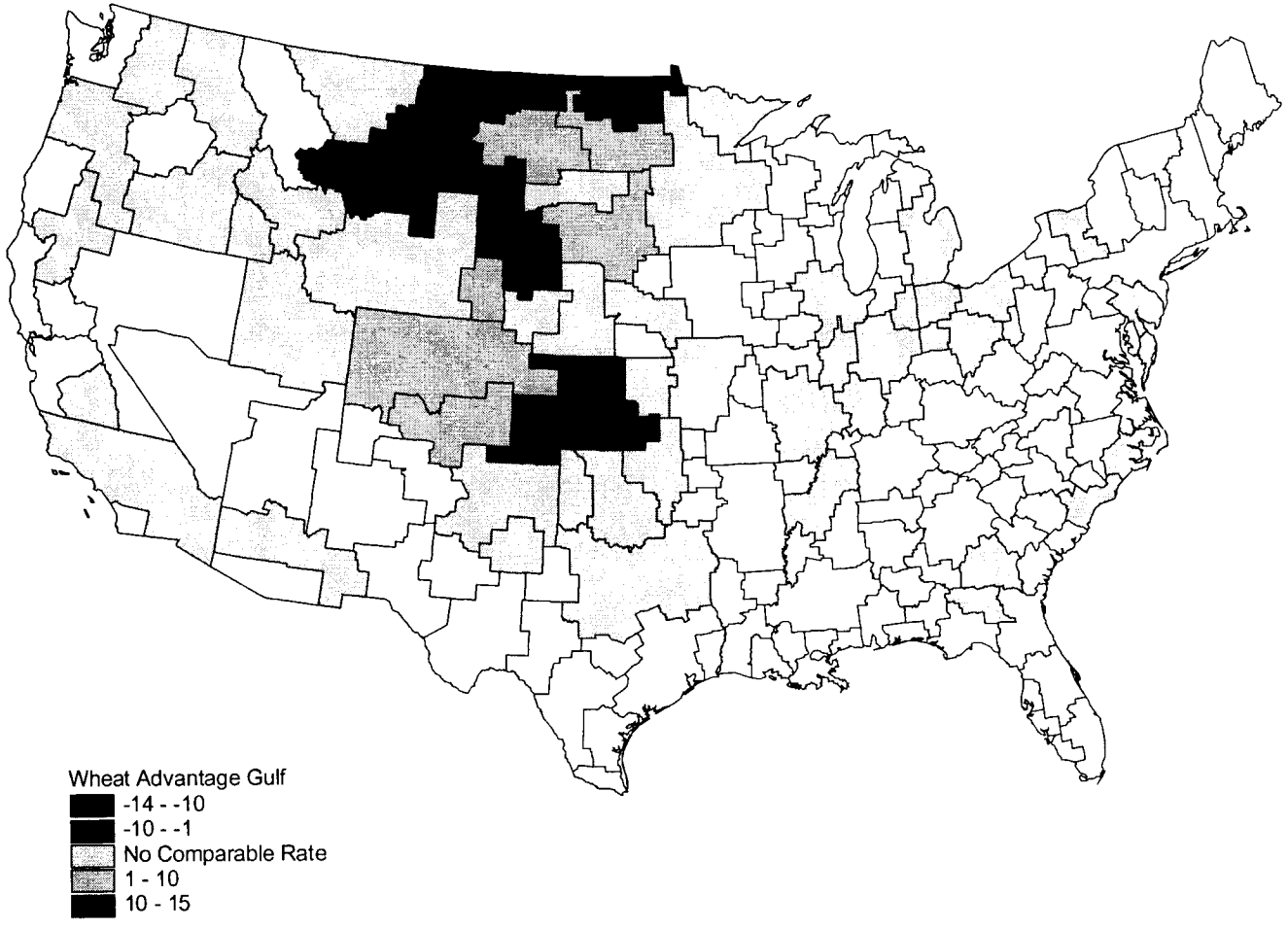


**Figure 3-4. Advantage for Shipping Corn From BEA Regions to Asian Markets From U.S. Gulf via Canal over Direct Shipment from Pacific Northwest ($ per metric ton)**

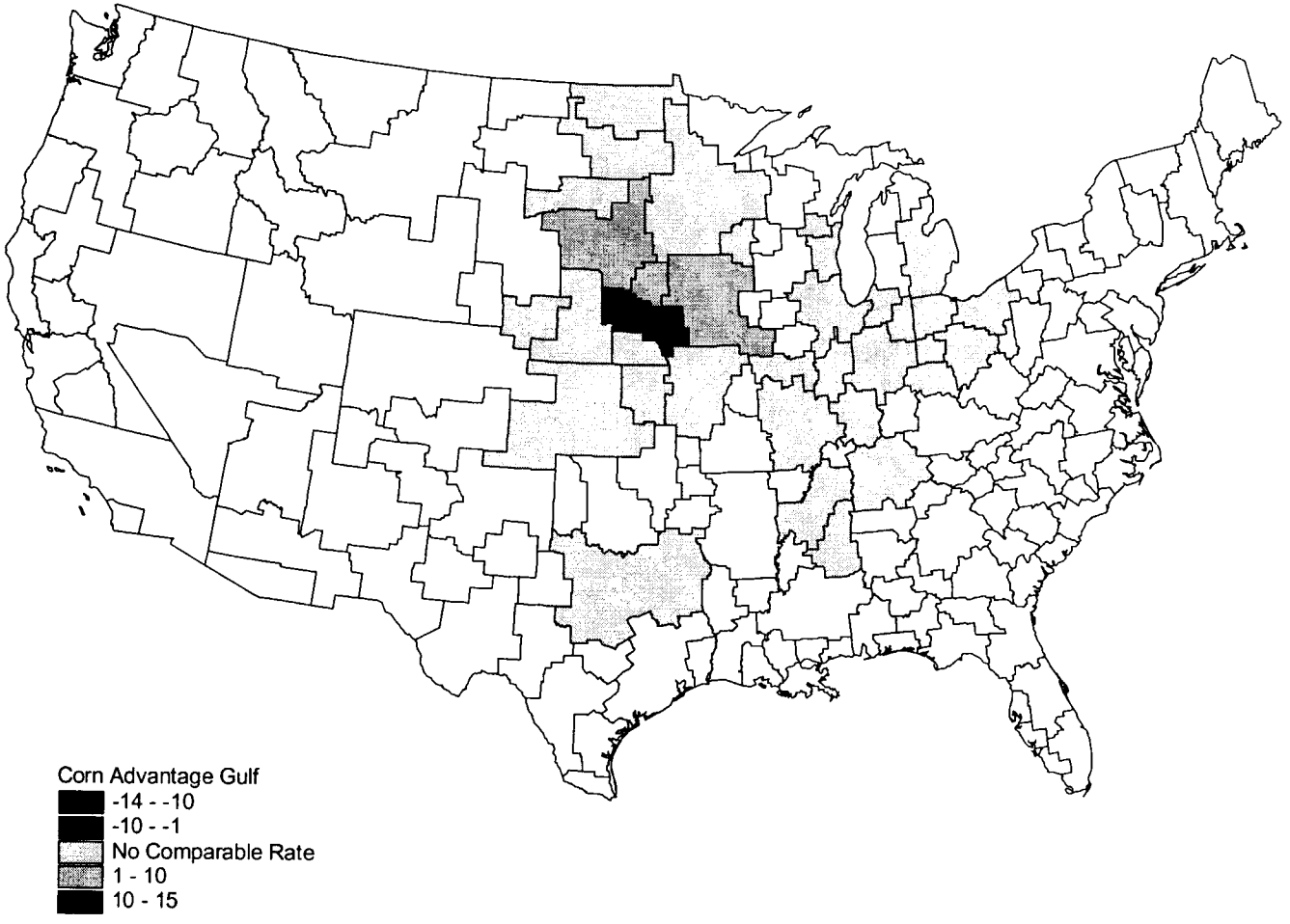
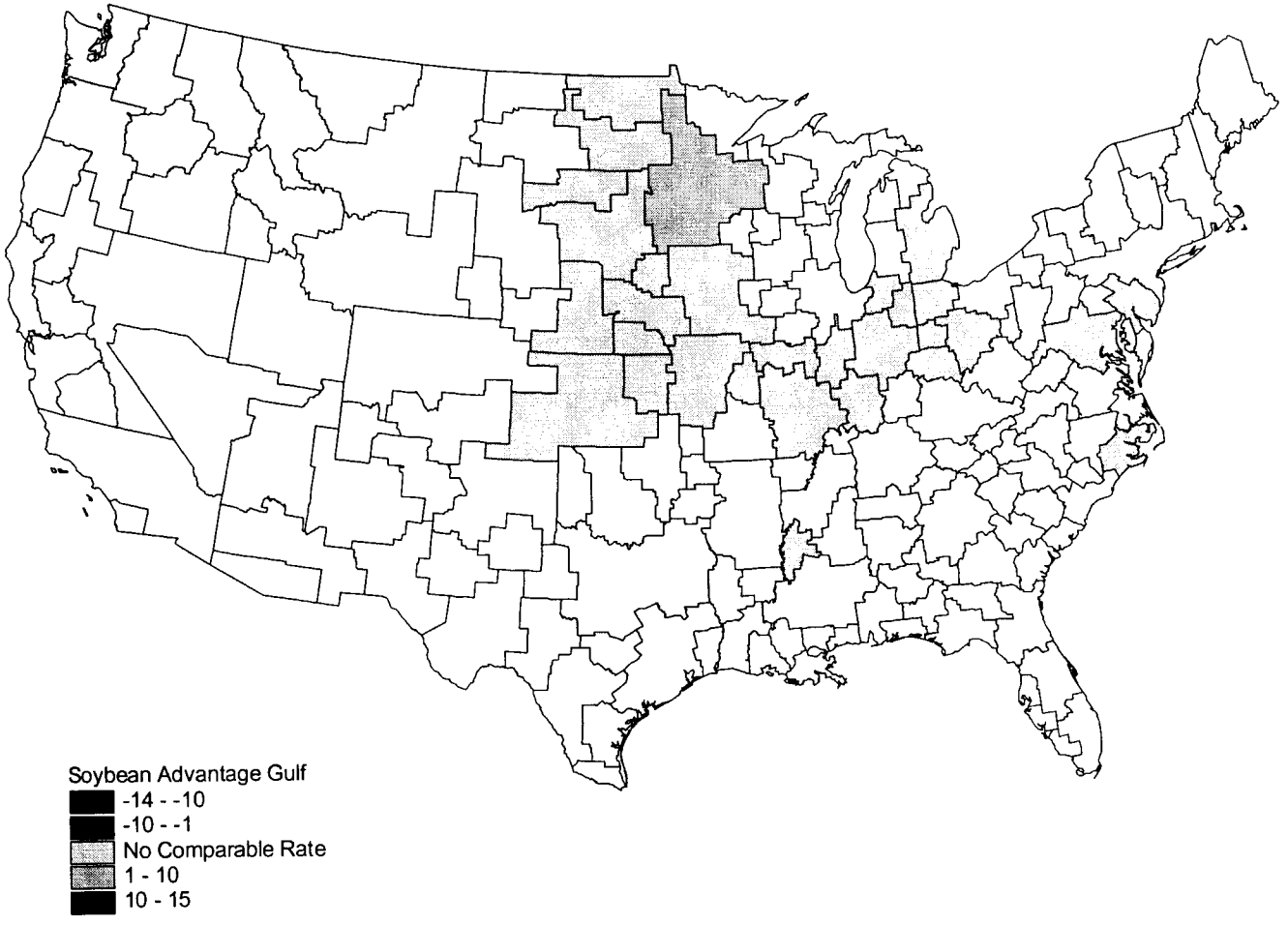


**Figure 3-5. Advantage for Shipping Soybeans From BEA Regions to Asian Markets From U.S. Gulf via Canal over Direct Shipment from Pacific Northwest ($ per metric ton)**



## Advantage of Shipment via Panama Canal versus Alternative Routes for Shipment to Asia

All of these data were incorporated into an analysis to assess the advantage of shipping via the Canal versus alternative routes for soybeans, corn and wheat. Routes compared included shipments from U.S., Canada, Brazil, and Argentina production regions to Asia. Costs of movements were estimated for movements through the canal and contrasted to alternative routes (via the capes or direct shipment from Western U.S. and Canadian ports).[18]
Costs included production costs, internal shipment to ports, terminal and port charges, ocean freight, canal charges where applicable, and interest costs.

- Cost of production was derived for each crop and production area from 2002 using yields for 2002, to arrive at a cost of production in U.S. dollars per metric tons.
- Internal U.S. shipping costs by crop were taken from Appendixes B for U.S. production regions to Gulf and Pacific Northwest ports; and from Appendix I for Brazil.
- Terminal and port costs used were: U.S. $1 per metric ton; $8 per metric ton for Canada; $10-$11 per metric ton for Brazil; and $4 per metric ton for Argentine.
- Canal toll charges were assumed at $2 per metric ton and applied to all shipments through the canal.
- Interest charges where applied to shipments via the Cape at 10 percent annual interest rate for 14 days.

Within the United States grains can easily shift to the U.S. Gulf or Pacific Northwest depending on the cumulative cost of shipping from origin to destinations. Similarly, within Brazil, though soybeans are traditionally exported through the southern ports which gives those port areas an advantage via Cape shipments, the prospect of exporting via Northern ports may yield advantages to the Canal. This analysis investigated the elements of costs that impact these decisions.

### *Spatial Arbitrage in the United States*

Some regions within the United States have a large advantage going to Asia through the U.S. Gulf and Canal, while others have a large advantage of going through the Pacific Northwest ports, by-passing the Canal. Based on these results the greatest opportunities/threats include:

- ***Corn to Japan:*** U.S. corn is far lower cost going to Asia than any alternative. Argentina has a cost disadvantage relative to the U.S. origins by about $30-$50 per metric ton.
- ***Corn to Japan:*** For shipments from the United States, shipments from the U.S. Gulf are generally lower cost. For those that compete directly the cost advantage going through the Canal is in the area of $2.16, $4.95 and $10.84 per metric ton for the Northern Plains, Central Plains and Western Corn belt respectively.
- ***Soybeans to Japan and China:*** Most of the United States has a production cost advantage relative to Brazil, and the interior shipping costs from the United States are substantially lower than those from Brazil. In addition, the ocean shipping costs from

[18]These are shown in detail in Volume 2, Chapter 4 and Appendix G.

Brazil are greater than from the United States. Taken together, the United States has a cost advantage in serving Japan and China in the area of $20-$30 per metric ton.

- ***Soybeans within the United States:*** The U.S. Gulf has an advantage relative to Pacific Northwest shipments to Japan in the area of $10-$28 per metric ton for most regions. The exceptions are from the Central and Northern Plains from which the Canal advantage is in the area of $0.01 to $0.61 per metric ton. Thus, these regions should be viewed as important sensitive areas for Canal competition.
- ***Soybeans from Brazil to Japan*** The U.S. is the low cost supplier to Japan relative to Brazil. Brazil South is always lowest cost by-passing the Canal by about $3 per metric ton. Brazil North has an advantage going through the Canal by $0.84 per metric ton which is the lowest cost routing from this origin.
- ***Soybeans from Brazil to China:*** The conclusions above also apply to soybean shipments to China. However, in this case shipments from Brazil-North to China through the Canal are higher cost by $0.10 per metric ton.

These results show that shipments from Brazil are very sensitive. The fundamental elements of these are that:

- The US is the low cost producer
- The US is the low cost supplier to China, by about $20-$30/mt.
- Japan would have an advantage of gravitating toward greater exports from Brazil-South
- Thus, China would end up being served first from the United States, and then from Brazil-North. Once the US supplies are exhausted, China would shift its marginal imports to be served from Brazil-North.

China imports of soybeans expand over time for both the United States and Brazil. However, there is greater growth from Brazil (from near nil to10 million metric tons in 2025), versus from the US growing from 4.4 million metric tons to 11.4 million metric tons. Part of the reason for this is that China trade from Brazil is new and in fact we are observing this emergence in this current year.

- **Wheat shipments:** Inter-market competition in the wheat market is less interesting. These results show that in going to Japan, the U.S. Gulf via the Canal would be the lowest cost origin in most cases, relative to United States or Canadian Pacific Northwest, and relative to Argentina. However, in going to this market there are strong preferences for Japan to buy the wheat of the quality exported from the Pacific Northwest. Hence, the model was restricted to preclude non-Pacific Northwest (Canada and United States) shipments to this market (as well as to the other Asian high quality markets). In contrast wheat going to China is lower cost via the U.S. Gulf which is the primary origin for shipments to that country. And, in contrast to other countries, we did not impose restrictions on this flow.

## FORECAST OF CANAL'S POTENTIAL MARKET

A large number of factors impact world grain trade and the distribution of shipments and shipments through the Panama Canal. These include supply and demand in individual countries and regions,

production costs, trade and agricultural policies, interior shipping and handling costs and ocean shipping costs. To analyze these effects on the Panama Canal, a spatial optimization model of world grain trade was developed. The spatial optimization model was used to evaluate the effect of changes in factors affecting grains shipments through the Canal.[19]

### Simulation Procedures and Assumptions

The *Grain Spatial Optimization Model* was used to generate forecasts for Canal shipments in 5-year increments to the year 2025. The *Grain Spatial Optimization Model* has the objective of minimizing costs of world grain trade, subject to meeting demands at importing countries and regions, available supplies and production potential in each of the exporting countries and regions, and currently available shipping costs and technologies. The model is solved jointly for each of the 6 grains. The costs included in the model are:

- Production costs for each grain in each exporting region
- Interior shipping and handling cost for each grain in each exporting region
- Ocean shipping costs
- Canal tolls for shipments through the Panama Canal. In the base case, these are assumed at $0 per metric ton for the potential Canal market forecasts

The base case uses values for the 2000/2001 world crops marketing year for calibrating domestic consumption and production, as well as for interior and international shipping costs. In addition to the restrictions implied above, some selected restrictions were imposed on the model. Table 3-5 describes the restriction applied, the grain and countries involved, the impacts on Canal shipments and the year in which it was relaxed, if any. In general, these were applied in order to capture some of the peculiarities associated with world grain shipments. As example, rice is shipped through the Canal to Cuba even though it would be lower cost for that shipment to be from the United States. This is due to current and past trade policy considerations. In this case, they will likely be relaxed in the coming years. There are a multitude of these types of trade and marketing practices which are not naturally captured in the basic specification of the model. Thus, these are implemented in the model as restrictions, the purpose being to assure the types of flows occur in the model as are observed in the data.

Most of these restrictions affect the wheat sector and relate to costs and quality differences among suppliers and importers. The purposes of the restrictions are due in part that there are numerous suppliers that are much lower cost than North America. However, at least currently, importers have entrenched purchasing and import practices to import from these regions mostly due to quality differences, despite that they are higher cost. As example, India (amongst others including the FSU) is a class of new and emerging exporters with low costs in production and shipping costs to

[19] Technical details of the model are presented in Volume 2, Appendix H.

## Table 3-5. Constraints Imposed on Model: Market and Trade Policy Restrictions

| Exporter | Importer | Grain | Restriction | Reason | Impact | Duration |
|---|---|---|---|---|---|---|
| US | Cuba | All grains (rice) | No trade | Trade policy restriction | Maintained assumption. Rice is imported from China | Relaxed in 2005 forward |
| US Ethanol | None | Corn | None | Accelerated expansion. Reduced exportable supplies concentrated in western regions | Exports favored from eastern regions through US Gulf to Asia, versus US PNW | Commencing in base case with existing production; expanding in 2010 |
| US West Coast | China | Wheat | Not allowed | TCK Smut | Forces China wheat to US Gulf relax in 2005 | Relaxed in 2005 forward |
| US/Canada West Coast | Japan, Korea, Philippines, Singapore, Thailand | Wheat | Only allowed from West Coast N. America despite higher cost | Quality requirements | Disallows Gulf to these Asian markets at lower cost | Maintained |
| Australia | Japan, Korea, Philippines, Singapore, Thailand | Wheat | Max shipment only allowed at recent values | Quality requirements | Force hard wheat form N. America. No direct impact on Canal | Maintained |
| Argentina, India | Japan, Korea, Philippines, Singapore, Thailand | Wheat | No shipments allowed | Quality requirements | Force hard wheat from N. America. No direct impact on Canal | Maintained |
| E. Europe | Japan | Wheat | No shipment allowed | Quality requirements | Forces hard wheat from N. America. No direct impact on Canal | Maintained |
| China | Korea | Corn | Imports of 3 mmt | Reflect recent trade | Reduce exports from US Gulf/Canal | Maintained |
| US West | Japan, Korea, China | Corn | PNW shipments restricted to 4.2, 1.9 and 1 mmt, base case actual values | Reflect trade and likely that ocean rate differentials are less than occur in practice | Reduce exports from US Gulf Canal | Maintained |
| US and Argentina | EU | Soy beans | Minimizes US/Arg to EU, thus, making Brazil dominant supplier to EU | Reduces exportable supplies for Canal shipment to Asia | GM-free soybeans are required in EU and produced only in Brazil. | Relaxed in 2005 forward |

Source: Prepared by Dr. William Wilson and D. Won Koo

many Asian markets. Similarly, Australia and Argentina are lower cost producers and shippers than North America to many regions. To capture these, we imposed restrictions of varying types to reflect historical trade flows.

There is an important restriction related to Genetically Modified oilseeds produced in Brazil. Currently, the European Union requires non-GM specifications, and the Government of Brazil provides a certificate indicating that soybeans exported from that country are GM free. None of the other major soybean producers are GM free. Thus, we restrict that a minimum volume must be exported from Brazil to the European Union. This is despite that Brazil would in fact be a lower cost supplier to some Asian markets relative to the European Union and relative to the alternative from the United States. This restriction is relaxed in 2005 in anticipation of GM adoption in Brazil, and, relaxation of import requirements in the European Union.

Finally, the base case restricted that current corn volumes from the U.S. west coast would continue to China, Korea and Japan. These values were 2.0 million, 1.9 million and 4.2 million metric tons respectively. Not imposing these restrictions had the impact of these markets being served from the U.S. Gulf through the Canal, thereby inflating Canal shipments. The reason this occurs in part is due to the ocean rate differentials in the base case model, between U.S. Gulf and the Pacific Northwest to these destinations, which were quite a bit less than observed during the base case year.

The *Grain Spatial Optimization Model* was run in 5-year intervals. In addition, a sequence of assumptions are imposed and relaxed to represent the most likely, pessimistic and optimistic scenarios. The sequence of changes imposed on the model is summarized in Table 3-6. In addition, incomes and population both change, impacting demand and yields change over time having the impact on costs and on supplies.

**Table 3-6. Sequence of Changes in Factors Impacting Canal Grain Shipments**

| Grain/Factor | Timing | Effect | Most Likely-Base Case | Pessimistic | Optimistic |
|---|---|---|---|---|---|
| Demand growth due to population and income growth | Continual | Greater expansion for Canal shipments due to China | Projections and scenarios based on WEFA projections for income and population | | |
| Soybeans/GM in Brazil | 2005 | Shift soybeans from Brazil to European Union to China, and replaced by U.S. Gulf going to European Union. | Maintained assumption in all cases | | |
| Rice to Cuba | 2005 | Liberalized trade will shift Cuba rice to U.S., thereby reducing Canal shipments from Asia | Maintained assumption in all cases | | |
| Corn/ethanol | Continual, but accelerating in 2010 | Reduced supplies for U.S. Pacific Northwest exports, shifting exports to Asia via the U.S. Gulf and Asia | Maintained assumption in all cases | | |
| Brazil transport projects adopted | 2010 | Reduced shipping costs for northerly shipments | Adopted | | |

## Existing Canal Case Results

Three models are run and compared which we refer as the base case (most likely), and pessimistic and optimistic cases. We define optimistic and pessimistic using DRI-WEFA's

definition/interpretation of changes in income. DRI-WEFA presents income projections defined as most likely (our base case), and, pessimistic and optimistic. In each case, these are regarding changes in income projections for all importing and exporting countries. These were applied to our econometric estimates of demand and used to generate alternative projections of consumption, and therefore import demand.

Thus, optimistic and pessimistic refer to the impact of income on country/regional demands in our analysis. Specifically, incomes and population growth affect demands for each grain. For those countries with positive income elasticities, increases in income, increases demand, and, vice versa.

The results are potentially compounded in several ways. For exporting countries increases (decease) in income, increase (decrease) domestic demand for those grains with positive income elasticities. Increase in domestic demand reduces exportable supplies, which reduces volumes exported, which prospectively reduced exports/shipments through the Canal. Likewise, decreases in domestic demand (relative to supplies) increases exportable surplus and exports, and therefore increased shipments shipped through the Canal. For most consuming countries/regions grains have positive income elasticities, but some are nears nil and potentially negative. These effects also vary geographically.

The forecasts of the Canal's potential market for the ***Existing Canal*** by direction of Canal transit and route and by commodity for the most probable case is presented in Table 3-7 and Table 3-8, respectively. Figure 3-6 shows the forecast of potential canal trade by grain. Highlights include:

- The range in world trade in 2025 for these grains is 270 million metric tons to 360 million metric tons (all grains, canal and non-Canal).
- Pessimistic: These indicate that Canal traffic, at zero tolls, will increase from 56 to 62 million metric tons, or by 6 million metric tons by 2025. In contrast to the most likely case shipments through the canal would be greater in the near term, but, increase by a lesser amount than in the most likely case.[20]
- Optimistic: These indicate that Canal traffic, at zero tolls, will increase by about 20 million metric tons by 2025, from 64 to 83 million metric tons. Compared to the most likely case, shipments would increase by about 3 million metric tons more by 2025.

---

[20] At first, this result seems counterintuitive but upon further review can be easily explained. The Worst Case is characterized by lower income levels in both importing and exporting countries. For exporting countries, the lower income levels generally decrease domestic demand for grains and therefore increases the surplus that is available for export. This has the effect of increasing the volume of grains that would be exported and forecast to be shipped through the Panama Canal.

It is true that one would normally expect import demand in the importing countries to be lower under the Worst Case scenario and thus trade volumes would be lower. However, under the Worst Case scenario, grain consumption in the US and other exporting countries is lower and the exportable surplus is larger. The exportable surplus is lower cost supply than domestic production or other supply sources in the major Far East importing countries and they would prefer to import US corn and soybean to meet demand. Thus, even though overall consumption may be lower in the importing country under the Worst case scenario, grain trade of corn and soybeans from the US is actually projected to increase.

There are a multitude of effects that impact these results. For the optimistic scenario, the most interesting and dramatic changes are increase in corn and soybeans to China, and wheat to China and Korea. For the pessimistic runs, there are a multitude of minor changes, but, that most dramatic is the reduction in corn to Japan. In addition to these generalizations, developments in China are critical. Looking into further details on China, under the most likely and best case, additional area is shifted into corn production resulting in and expansion by about 9-10 million metric tons. This is in contrast to the pessimistic case in which area is removed from corn production (because China is a high cost producer) resulting in reduced production and therefore increased imports.

**Table 3-7 All Grains: Forecast of Potential Canal Trade[a] by Route**
**Existing Canal**
**Actual 2000 and 2001 and Projected 2005 through 2025**
**(thousands of long tons)**

| | | Actual | | Projected | | | | | Annual Average Growth Rate (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Origin Region | Destination Region | 2000 | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2000-2005 | 2005-2010 | 2010-2015 | 2015-2020 | 2020-2025 |
| **Atlantic to Pacific routes** | | | | | | | | | | | | | |
| North America Gulf | Far East | | | | | | | | | | | | |
| North America Gulf | Japan | 15,166 | 15,724 | 16,413 | 16,184 | 16,206 | 16,252 | 16,778 | 1.6 | (0.3) | 0.0 | 0.1 | 0.6 |
| North America Gulf | S Korea | 2,737 | 2,868 | 3,233 | 3,240 | 3,299 | 3,359 | 3,419 | 3.4 | 0.0 | 0.4 | 0.4 | 0.4 |
| North America Gulf | Taiwan | 3,757 | 4,023 | 3,028 | 3,081 | 3,272 | 3,466 | 3,656 | (4.2) | 0.3 | 1.2 | 1.2 | 1.1 |
| North America Gulf | China | 4,217 | 3,554 | 2,998 | 8,922 | 12,182 | 14,558 | 15,947 | (6.6) | 24.4 | 6.4 | 3.6 | 1.8 |
| | Subtotal | 25,878 | 26,169 | 25,672 | 31,427 | 34,959 | 37,635 | 39,800 | (0.2) | 4.1 | 2.2 | 1.5 | 1.1 |
| South America East | Far East | | | | | | | | | | | | |
| Brazil | China | - | - | 5,330 | 7,583 | 8,195 | 10,648 | 13,909 | n.a. | 7.3 | 1.6 | 5.4 | 5.5 |
| Brazil | Japan | 179 | 268 | 2,070 | 2,026 | 2,035 | 2,043 | 2,052 | 63.1 | (0.4) | 0.1 | 0.1 | 0.1 |
| Brazil | S Korea | - | - | 1,559 | 1,618 | 1,614 | 1,634 | 1,654 | n.a. | 0.7 | (0.0) | 0.2 | 0.2 |
| | Subtotal | 179 | 268 | 8,959 | 11,227 | 11,844 | 14,325 | 17,615 | 118.6 | 4.6 | 1.1 | 3.9 | 4.2 |
| North America Gulf | South America West | 3,308 | 2,489 | 6,857 | 8,161 | 7,567 | 8,836 | 9,172 | 15.7 | 3.5 | (1.5) | 3.1 | 0.8 |
| North America Gulf | Central America West | 2,967 | 3,488 | 5,409 | 5,643 | 5,964 | 5,153 | 4,406 | 12.8 | 0.9 | 1.1 | (2.9) | (3.1) |
| North America Gulf | South East Asia | 1,884 | 1,206 | 1,260 | 3,319 | 3,614 | 3,508 | 4,366 | (7.7) | 21.4 | 1.7 | (0.6) | 4.5 |
| North America East | Far East | | | | | | | | | | | | |
| North America East | S Korea | 264 | 159 | 128 | 2,406 | 2,415 | 3,287 | 3,365 | (13.5) | 79.8 | 0.1 | 6.4 | 0.5 |
| North America East | China | 581 | 112 | - | - | - | 292 | 844 | n.a. | n.a. | n.a. | n.a. | 23.6 |
| | Subtotal | 845 | 271 | 128 | 2,406 | 2,415 | 3,579 | 4,209 | (31.4) | 79.8 | 0.1 | 8.2 | 3.3 |
| Europe | South America West | 106 | 51 | 380 | 433 | 685 | 695 | 700 | 29.1 | 2.6 | 9.6 | 0.3 | 0.1 |
| South America East | South America West | 29 | 79 | 16 | 20 | 21 | 23 | 24 | (10.8) | 4.2 | 1.1 | 1.8 | 0.8 |
| North America East | South America West | 102 | 191 | 3 | 4 | 4 | 4 | 4 | (51.0) | 4.2 | 1.2 | 1.8 | 0.9 |
| Other Atlanticto Pacific Routes | | 1,279 | 1,634 | - | - | - | - | - | n.a. | n.a. | n.a. | n.a. | n.a. |
| Total Atlantic to Pacific Routes | | 36,578 | 35,846 | 48,685 | 62,640 | 67,073 | 73,758 | 80,297 | 5.9 | 5.2 | 1.4 | 1.9 | 1.7 |
| **Pacific to Atlantic Routes** | | | | | | | | | | | | | |
| North America West | Middle East | 6 | 25 | 683 | 714 | 703 | 580 | 228 | 156.1 | 0.9 | (0.3) | (3.8) | (17.0) |
| North America West | South America East | 194 | 47 | 75 | 92 | 98 | 107 | 111 | (17.3) | 4.2 | 1.1 | 1.8 | 0.8 |
| North America West | Europe | 154 | 239 | 54 | 67 | 71 | 78 | 81 | (18.8) | 4.2 | 1.1 | 1.8 | 0.8 |
| Other Pacific to Atlantic Routes | | 2,512 | 2,330 | - | - | - | - | - | n.a. | n.a. | n.a. | n.a. | n.a. |
| Total Pacific to Atlantic Route | | 2,867 | 2,641 | 812 | 873 | 872 | 765 | 420 | (22.3) | 1.5 | (0.0) | (2.6) | (11.3) |
| **Total All Routes** | | 39,445 | 38,487 | 49,498 | 63,513 | 67,944 | 74,523 | 80,717 | 4.6 | 5.1 | 1.4 | 1.9 | 1.6 |

a. Potential canal trade assuming no canal tolls.

Source: Actual 2000 and 2001 from Autoridad de Canal de Panama; projected 2005 through 2025 prepared by Nathan Associates Inc.

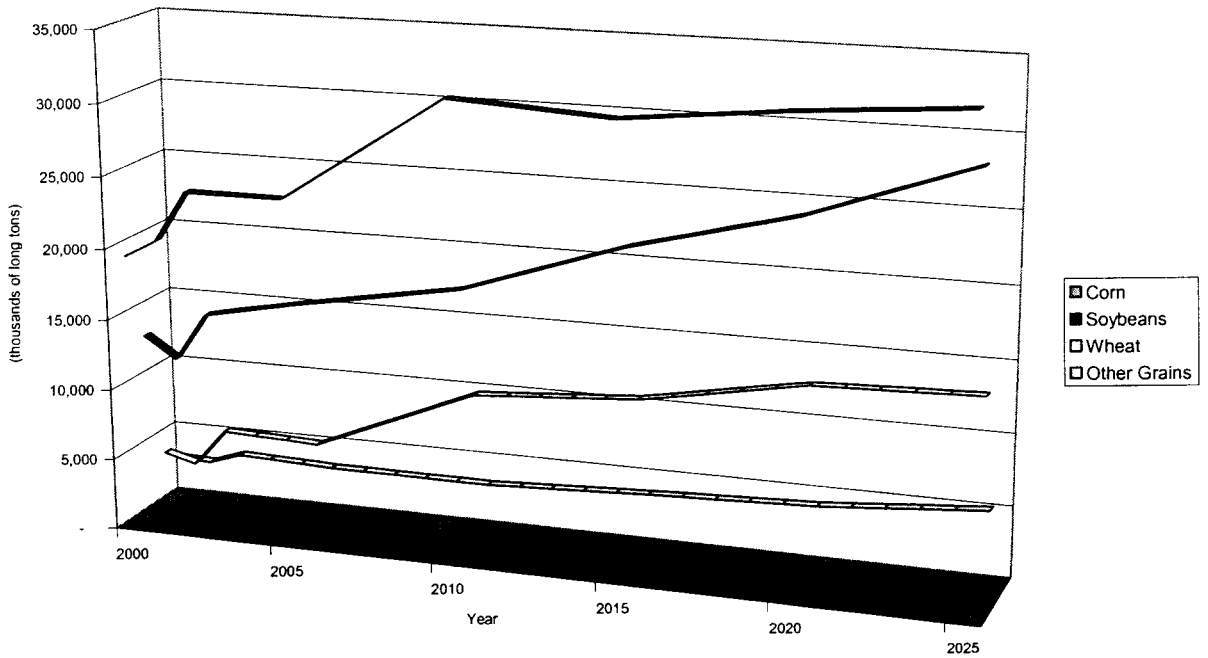
**Table 3-8. All Grains: Forecast of Potential Canal Trade[a] by Commodity**
**Existing Canal**
**Actual 2000 and 2001 and Projected 2005 through 2025**
**(thousands of long tons)**

| | Actual | | Projected | | | | | Annual Average Growth Rate (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Commodity | 2000 | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2000-2005 | 2005-2010 | 2010-2015 | 2015-2020 | 2020-2025 |
| Corn | 19,448 | 20,644 | 24,181 | 31,661 | 30,996 | 32,192 | 33,051 | 4.5 | 5.5 | (0.4) | 0.8 | 0.5 |
| Soybeans | 13,190 | 11,711 | 16,380 | 18,322 | 22,114 | 25,022 | 29,048 | 4.4 | 2.3 | 3.8 | 2.5 | 3.0 |
| Wheat | 3,973 | 3,378 | 5,694 | 10,336 | 11,132 | 13,185 | 13,546 | 7.5 | 12.7 | 1.5 | 3.4 | 0.5 |
| Sorghum | 871 | 680 | 1,063 | 700 | 683 | 669 | 1,163 | 4.1 | (8.0) | (0.5) | (0.4) | 11.7 |
| Rice | 781 | 1,050 | 1,032 | 1,098 | 1,136 | 1,063 | 761 | 5.7 | 1.2 | 0.7 | (1.3) | (6.5) |
| Grains, misc | 815 | 606 | 846 | 1,039 | 1,100 | 1,204 | 1,255 | 0.7 | 4.2 | 1.1 | 1.8 | 0.8 |
| Barley | 367 | 418 | 301 | 358 | 783 | 1,188 | 1,893 | (3.9) | 3.5 | 16.9 | 8.7 | 9.8 |
| Total | 39,445 | 38,487 | 49,498 | 63,513 | 67,944 | 74,523 | 80,717 | 4.6 | 5.1 | 1.4 | 1.9 | 1.6 |

a. Potential canal trade assuming no canal tolls.

Source: Actual 2000 and 2001 from Autoridad de Canal de Panama; projected 2005 through 2025 prepared by Nathan Associates Inc.

**Figure 3-6. All Grains: Forecast of Potential Canal Trade[a] by Commodity**
**Existing Canal**
**Actual 2000 and 2001 and Projected 2002 through 2025**




Source: Table 3-8.

## Expanded Canal

Concurrent with an Expanded Canal to be completed in 2010 would be the possibility of adoption of larger ships for grain shipments through the Canal. While larger vessel sizes have been gradually

being adopted over the years, it is expected these would be accelerated in the period following an Expanded Canal.

### *Simulation Procedures*

The model was used to evaluate these impacts using the change in ocean shipping costs under the Expanded Canal case prepared by the study team (see Section 4). These resulted in reduced shipping costs through the Canal, on average by $0.31per metric ton which varied by as much as $1.90 per metric ton to near nil Also, there were greater potential reductions from North American origins versus those in Brazil. In addition to the rate reductions for the Canal shipments, RLA derived likely concurrent reductions for non-Canal flows, which were on average $0.36 per metric ton, and for those from the Pacific Northwest.

The model was run for most likely, pessimistic and optimistic cases as above. And, the assumption of Panama Canal tolls equal to $0 per ton was retained.

### *Model Results*

The forecasts of the Canal's potential market for the ***Expanded Canal*** by direction of Canal transit and route and by commodity for the most probable case is presented in Table 3-9 and Table 3-10, respectively. Figure 3-7 shows the forecast of potential canal trade by grain.

Beginning in 2010, the most likely Canal flows would be 64.6 million metric tons and grow to 84.3 million metric ton in 2025. These results suggest an increase of about 2 million metric tons in 2010 from the Existing Canal Case, growing to an increase of about a 5 million metric tons increase in 2025.

These results do not suggest radical increases in Canal shipments relative to no-expansion. The reason for this is due to the assumption that rates on non-canal routes would decline similarly. Thus, in many cases the net advantage gained by the larger ships going through the Canal is negated by the reduction in rates for the competitive movements.

One of the results that are fairly interesting and deserving of explanation is soybeans to Japan. Brazil-North is the origin for soybean for Japan in all years through 2020. However, in 2025 there is a shift to Brazil-South which by-passes the Panama Canal. Concurrent with this change is for an increase in soybeans exported from Brazil-North to China. The effect of the latter, which provides a greater total cost advantage, is to shift Japan's purchases to Brazil-South. In total it does not impact Canal shipments because Brazil-North to China is still a Canal shipment. This again illustrates the very integral relationship amongst the U.S. Gulf, Brazil-North and Brazil-South and exports to China and Japan.

## Table 3-9. All Grains: Forecast of Potential Canal Trade[a] by Route
## Expanded Canal in 2010
## Actual 2000 and 2001 and Projected 2005 through 2025
## (thousands of long tons)

| Origin Region | Destination Region | Actual | | Projected | | | | | Annual Average Growth Rate (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2000 | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2000-2005 | 2005-2010 | 2010-2015 | 2015-2020 | 2020-2025 |
| **Atlantic to Pacific routes** | | | | | | | | | | | | | |
| North America Gulf | Far East | | | | | | | | | | | | |
| North America Gulf | Japan | 15,166 | 15,724 | 16,413 | 16,187 | 16,211 | 16,252 | 16,886 | 1.6 | (0.3) | 0.0 | 0.1 | 0.8 |
| North America Gulf | S Korea | 2,737 | 2,868 | 3,233 | 3,240 | 3,299 | 3,359 | 3,419 | 3.4 | 0.0 | 0.4 | 0.4 | 0.4 |
| North America Gulf | Taiwan | 3,757 | 4,023 | 3,028 | 3,081 | 3,272 | 3,466 | 3,656 | (4.2) | 0.3 | 1.2 | 1.2 | 1.1 |
| North America Gulf | China | 4,217 | 3,554 | 2,998 | 8,922 | 12,182 | 13,886 | 14,753 | (6.6) | 24.4 | 6.4 | 2.7 | 1.2 |
| | Subtotal | 25,878 | 26,169 | 25,672 | 31,430 | 34,964 | 36,963 | 38,714 | (0.2) | 4.1 | 2.2 | 1.1 | 0.9 |
| South America East | Far East | | | | | | | | | | | | |
| Brazil | China | - | - | 5,330 | 7,583 | 8,195 | 10,648 | 15,962 | n.a. | 7.3 | 1.6 | 5.4 | 8.4 |
| Brazil | Japan | 179 | 268 | 2,070 | 2,026 | 2,035 | 2,043 | - | 63.1 | (0.4) | 0.1 | 0.1 | n.a. |
| Brazil | S Korea | - | - | 1,559 | 1,618 | 1,614 | 1,634 | 1,654 | n.a. | 0.7 | (0.0) | 0.2 | 0.2 |
| | Subtotal | 179 | 268 | 8,959 | 11,227 | 11,844 | 14,325 | 17,616 | 118.6 | 4.6 | 1.1 | 3.9 | 4.2 |
| North America Gulf | South America West | 3,308 | 2,489 | 6,857 | 8,162 | 7,593 | 8,836 | 9,172 | 15.7 | 3.5 | (1.4) | 3.1 | 0.7 |
| North America Gulf | Central America West | 2,967 | 3,488 | 5,409 | 5,643 | 5,964 | 6,289 | 6,532 | 12.8 | 0.9 | 1.1 | 1.1 | 0.8 |
| North America Gulf | South East Asia | 1,884 | 1,206 | 1,260 | 4,687 | 5,649 | 5,748 | 5,831 | (7.7) | 30.0 | 3.8 | 0.4 | 0.3 |
| North America East | Far East | | | | | | | | | | | | |
| North America East | S Korea | 264 | 159 | 128 | 3,155 | 3,211 | 4,121 | 4,171 | (13.5) | 89.8 | 0.4 | 5.1 | 0.2 |
| North America East | China | 581 | 112 | - | - | 568 | 1,419 | 2,412 | n.a. | n.a. | n.a. | 20.1 | 11.2 |
| | Subtotal | 845 | 271 | 128 | 3,155 | 3,779 | 5,540 | 6,583 | (31.4) | 89.8 | 3.7 | 8.0 | 3.5 |
| Europe | South America West | 106 | 51 | 380 | 433 | 685 | 695 | 700 | 29.1 | 2.6 | 9.6 | 0.3 | 0.1 |
| South America East | South America West | 29 | 79 | 16 | 20 | 21 | 23 | 24 | (10.8) | 4.2 | 1.1 | 1.8 | 0.8 |
| North America East | South America West | 102 | 191 | 3 | 4 | 4 | 4 | 4 | (51.0) | 4.2 | 1.2 | 1.8 | 0.9 |
| Other Atlanticto Pacific Routes | | 1,279 | 1,634 | - | - | - | - | - | n.a. | n.a. | n.a. | n.a. | n.a. |
| Total Atlantic to Pacific Routes | | 36,578 | 35,846 | 48,685 | 64,760 | 70,502 | 78,424 | 85,176 | 5.9 | 5.9 | 1.7 | 2.2 | 1.7 |
| **Pacific to Atlantic Routes** | | | | | | | | | | | | | |
| North America West | Middle East | 6 | 25 | 683 | 714 | 703 | 580 | 228 | 156.1 | 0.9 | (0.3) | (3.8) | (17.0) |
| North America West | South America East | 194 | 47 | 75 | 92 | 98 | 107 | 111 | (17.3) | 4.2 | 1.1 | 1.8 | 0.8 |
| North America West | Europe | 154 | 239 | 54 | 67 | 71 | 78 | 81 | (18.8) | 4.2 | 1.1 | 1.8 | 0.8 |
| Other Pacific to Atlantic Routes | | 2,512 | 2,330 | - | - | - | - | - | n.a. | n.a. | n.a. | n.a. | n.a. |
| Total Pacific to Atlantic Route | | 2,867 | 2,641 | 812 | 873 | 872 | 765 | 420 | (22.3) | 1.5 | (0.0) | (2.6) | (11.3) |
| **Total All Routes** | | 39,445 | 38,487 | 49,498 | 65,634 | 71,374 | 79,188 | 85,597 | 4.6 | 5.8 | 1.7 | 2.1 | 1.6 |

a. Potential canal trade assuming no canal tolls.

Source: Actual 2000 and 2001 from Autoridad de Canal de Panama; projected 2005 through 2025 prepared by Nathan Associates Inc.

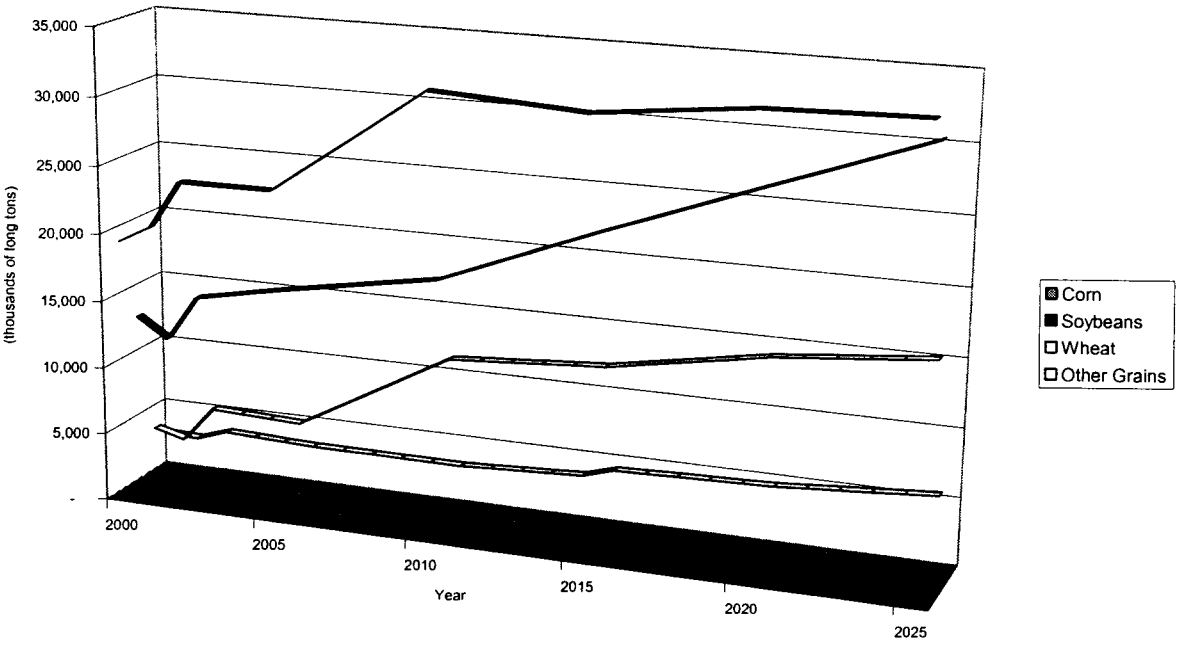
## Table 3-10. All Grains: Forecast of Potential Canal Trade[a] by Commodity
## Expanded Canal in 2010
## Actual 2000 and 2001 and Projected 2005 through 2025
## (thousands of long tons)

| Commodity | Actual | | Projected | | | | | Annual Average Growth Rate (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2000-2005 | 2005-2010 | 2010-2015 | 2015-2020 | 2020-2025 |
| Corn | 19,448 | 20,644 | 24,181 | 32,215 | 31,589 | 32,822 | 33,103 | 4.5 | 4.8 | 0.7 | 0.5 | 0.3 |
| Soybeans | 13,190 | 11,711 | 16,380 | 18,322 | 22,821 | 27,096 | 31,268 | 4.4 | 2.4 | 4.1 | 3.7 | 3.0 |
| Wheat | 3,973 | 3,378 | 5,694 | 11,899 | 12,651 | 14,653 | 15,780 | 7.5 | 13.0 | 3.2 | 2.7 | 1.8 |
| Sorghum | 871 | 680 | 1,063 | 703 | 688 | 669 | 1,163 | 4.1 | (7.6) | (2.3) | (0.5) | 9.6 |
| Rice | 781 | 1,050 | 1,032 | 1,098 | 1,136 | 1,063 | 761 | 5.7 | 1.2 | 0.8 | (0.9) | (5.3) |
| Grains, misc | 815 | 606 | 846 | 1,039 | 1,100 | 1,204 | 1,255 | 0.7 | 3.9 | 1.7 | 1.7 | 1.0 |
| Barley | 367 | 418 | 301 | 358 | 1,389 | 1,681 | 2,267 | (3.9) | 0.8 | 16.0 | 17.4 | 5.8 |
| Total | 39,445 | 38,487 | 49,498 | 65,634 | 71,374 | 79,188 | 85,597 | 4.6 | 5.8 | 1.7 | 2.1 | 1.6 |

a. Potential canal trade assuming no canal tolls.

Source: Actual 2000 and 2001 from Autoridad de Canal de Panama; projected 2005 through 2025 prepared by Nathan Associates Inc.

## Figure 3-7. All Grains: Forecast of Potential Canal Trade[a] by Commodity
## Expanded Canal in 2010
## Actual 2000 and 2001 and Projected 2002 through 2025




Source: Table 3-10.

# 4. Vessel Transit and Fleet Analysis

This section presents the world fleet and freight costs analyses and forecasts for the Existing Canal and an Expanded Canal. This part of the report covers the forecast variables required to prepare forecasts of potential transits for all cases for the required parameters and to run the *Transit Model*, described in Section 5 of this report.

The objectives of this part of the study center around three inter-related elements. These are:

- World Fleet Analyses and Forecasts
- Seaborne Freight Costs
- Seaborne Cost Differentials

The achievement of these objectives has been facilitated by the development of analytical tools for use in the forecast of freight costs. The world fleet analysis and forecast determines future developments in the size mix of the global dry bulk carrier fleet and creates the framework for analyses of future Panama Canal transit size ranges.

Seaborne freight costs and cost differentials are based on voyage calculations for all routes and size ranges and are the single most important element in the determination of vessel routing decisions and the tolls policy.

The presentation of this section is organized around the development of the global framework as represented by the development of the world fleet demand and supply forecasts; the capture of the maximum potential trade and traffic assuming no Panama Canal tolls through iterations between trade, traffic and seaborne freight costs and the development and forecast of these seaborne freight costs.

The section immediately below discuss the approach and methodology for the vessel fleet and voyage cost estimation., The next two subsections present analyses of existing actual and potential Canal trade and traffic. The first of these subsections particularly addresses ACP trade and traffic data as developed for use by study team members while the second addresses by pass traffic. The next two sections consider issues of global and Canal vessel size changes. Two sets of linked analytical tools have been developed, the *Transit Model* and the *Voyage Estimating Model* which have been used to forecast freight costs and transits. The *Voyage Estimating Model* is described in the final part of this section along with the analyses and results. Forecasts of transits are described in Section 5 of this report.

# APPROACH AND METHODOLOGY

## World Fleet Analysis and Forecast

The approach is expert driven, embracing both statistical analysis and industry insight. It provides forecasts of the world fleet for Existing and Expanded Canal conditions by size and size range.

There are four key elements to determination of the projections:

- The first is analyses of trends in the size and size distribution of the current world dry bulk fleet.
- The second is the use of projections of future global trade for key dry bulk commodity groups—both grains and other dry bulks—to determine the future demand supply for dry bulk carriers.
- Thirdly, in addition to historical trends and current newbuilding preferences, the future size break down takes into account potential expansion of the Canal, port developments, the replacement of older vessel by new vessels, changes in cargo quantities on individual routes, consolidation and other changes in trade practices affecting cargo sizes.
- Finally an assessment has been made of the potential impact of an Expanded Canal on the world fleet.

By consolidating grains and other dry bulk trade forecasts, we ensure that one internally consistent framework is created for forecasts of transits of vessels carrying grains and other dry bulk cargoes.

## Estimation of Total Seaborne Transport Cost on Canal Routes and Alternatives

In this section we provide estimates of seaborne freight costs by route, ship type and DWT size range for the Existing and Expanded Canals for a range of different circumstances. This includes vessels transiting the Canal, vessels on routes that represent alternatives to the Canal and where there are new routes and trades that could be attracted by the Expanded Canal. These are based on detailed assessments of dry bulk carrier size ranges and utilization on by pass trades plus freight cost assessments for Canal transits—including light loaded vessels. Weighted average freight costs have been forecast for all routes and for all cases for use in the Spatial Optimization Model. Because the size allocations by route change with trade volumes, weighted average freight costs are slightly different between the Most Probable, Best and Worst Cases as well as between the Existing and Expanded Canal

Decisions to utilize the Canal are based on marginal economics not long run costs so voyage calculations have been used to determine seaborne freight costs. These calculations use charter market rates rather than fully built up operating costs. Future estimates of charter rates have been linked to expected developments in total operating costs within the Voyage Estimating Model. The data and estimates used in these calculations include voyage mileages, vessel speeds, port times, Canal transit times, DWT utilization factors, fixed operating costs, bunker prices, port charges and

capital costs (vessel prices). The voyage calculations are based on representative ports within each region. The impact of structural change on future operating costs has also been assessed.

### Determination of Cost Differentials between Existing/Expanded Canals and Alternatives

For both the Existing Canal and the Expanded Canal and for each route pair and size range, freight cost differentials have been calculated for routes through the Canal versus least cost alternative routes for each year 2000–2025. These freight cost differentials are an important element in the development of the toll pricing strategy.

## HISTORICAL ANALYSIS OF ACP TRANSITS

In this section, we present the sources and analyses conducted of historical Panama Canal traffic and the methodology and factors used to forecast future vessel characteristics of Canal traffic. Laden transits are reviewed by vessel DWT size range, including direction of transit, route, cargo size distribution, average DWT and DWT utilization. This is followed by an analysis of ballast transits.

### Description of the Databases Used

The three databases described below contain the ACP data which were required for the study. To ensure that the study team had the latest data available, including any revisions to earlier versions, ACP were asked to provide the following three databases:

- **Carga.**mdb – This database contains data from 1973 and was used for the period not covered by the other databases (i.e. for 1973/4 to 1984/5). It consists of one table which contains data on vessel cargoes (vessel ID, transit date, cargo type, origin, destination, tonnage). Vessel characteristics were obtained from the other two databases.
- SDB85-97.mdb – This database contains data from 1985/6 to 1996/7 and was used for the period not covered by SDB94-02.mdb, that is, from 1985/6 to 1993/4. There are three main tables which contain data on vessel details, transits and cargoes. These are linked by vessel number and date. The transit table includes times, operational data, transit parameters and accounting data. The cargoes table, which also has extension tables for multiple cargoes, describes the cargoes and their origin, destination and tonnage.
- SDB94-02.mdb – This is a comprehensive management information system in which separate functions have their own tables which link appropriately with other functions. Thus separate tables exist for each accounting function, for operations, for transits and for cargoes. For each transit it is possible to extract all the necessary data on cargoes, accounting details (including revisions), ship details, transit parameters and the various operational requirements and timings during the transit.

### Vessel Definitions

Within this study transits were analyzed and forecast for those vessels carrying grains in bulk. In principle this includes dry bulk carriers, combined carriers operating in dry bulk trades and vehicle/dry bulk carriers. The latter is a vessel definition that is no longer in use by ACP although

some records still contain this description. These ships were aggregated together for transit purposes as all of these vessels are acting as dry bulk carriers. Further, combined carriers increasingly operate in the dry or wet markets but not both. There is no analytical advantage to developing transits separately and a number of disadvantages centering on unnecessary data delineation that hampers meaningful scrutiny and has no use when determining economic value of the Canal, marketing strategies or toll policy. We additionally incorporated transits for Ship Type 27 into dry bulk carrier transits in our analyses. Scrutiny of the actual vessels assigned to this code suggests that most of them are chip carriers which are a sub set of dry bulk carrier types.

It was agreed with ACP, trade volumes relating to products that are included in this study but which are not carried in dry bulk carriers have been excluded from the projections of future transits in this study. Nevertheless historical data on grain trade through the Canal on non bulk ship types by route have been identified and retained for future reference if needed.

Conversely, dry bulk carriers occasionally carry products which are not the subject of scrutiny in this study. In the most recent years - that is from FY1994/1995 onwards - these represent quantities varying between 2.8 percent and 3.8 percent annually of all commodities carried in bulk. Individually, these commodities are very small and they include autos and trucks; chemicals; container cargoes; food and agricultural products; fishmeal; clay, fire and china; and a range of manufactures and semi-manufactures. These are not included here in the future assessment of Canal transits in dry bulk carriers

## Data Preparation

### *Creation of New Databases*

In order to achieve perfect concordance between commodities and ship movements, it was decided to use the cargo data records and not the transit data for all information on commodities, origins and destinations including transit origins and destinations. This is because the transit data records are not designed to cater for multiple commodities or multiple routes for a transit. Indeed, the transit records in the ACP database are maintained using region codes that do not correspond to ACP's regional and country requirements in this study. Further, we know from detailed scrutiny of the data that approximately 25 percent of all bulk carrier transits involve the carriage of more than one cargo and a minimum of 11 percent of transits involve loading and/or discharging at two or more geographical areas. (By areas in this instance we mean geographical region. At a country level this percentage is obviously higher.) In our view this means that the link between commodities, routes and transits in the current database format is neither robust enough nor accurate enough for study purposes.

Therefore, tables were created which would allow for a complete analysis of all trade in bulk cargoes and all transits of bulk carriers. The first step was to transform the cargo data in SDB 85–97 into the same format as that for SDB 94–02, namely into one record for each cargo.

The cargo data (transit identification, commodity sequence number, commodity code, origin country, destination country and cargo tons) for each database was then expanded to include in each record:

- Fiscal year, obtained from the transit arrival date
- Ship type, obtained by linking to the Operational Table

- DWT obtained by linking to the ship characteristics
- DWT range (as specified by ACP)
- Total cargo for the transit, by summing all cargoes on a transit
- Transit fraction (cargo tons for the commodity sequence divided by total cargo for the transit).
- DWT equivalent (DWT multiplied by Transit fraction)

Each record was also checked to identify missing data so that it could be rectified if appropriate.

### *Trade and Transit Analyses*

An analysis of 2000/2001 multiple cargo transits showed that nearly all multiple transits that included a grain commodity also included:

- one or more other grain commodities or occasionally,
- one or more other grain commodities or in a very few instances:
- cargo that is not included within the scope of this study such as 'Other Agricultural Products' or containers.

Any transit with at least one grain cargo has been defined as a 'Grain' transit. All such transits were identified in each of the databases and all the cargoes and other data associated with these transits combined into a single table. Origin and destination countries were then combined into the study sub-regions and countries and analyses produced showing the DWT, cargo, and number of transits by year for each route and DWT size range. The following analyses were undertaken using the reconstructed ACP database:

- Tables of commodity trade by ship type and year;
- Analysis of grain trades by (sub) region to (sub) region, (sub) region to country and country/country combinations for individual products and groups of products as requested by ACP;
- Analysis of multiple cargoes on other grains transits;
- Analyses for grains bulk ship transits from 1985 through 2002 (part) adding study commodity groups and routes. Tables for transits, DWT and cargo by route and DWT size range;
- Annual trade of each ACP commodity in bulk ships by ship type. Each ACP commodity was aligned to its corresponding study commodity;
- Analysis of ballast transits by route, DWT range and bulk ship type;
- Transits by dry bulk carriers in ballast providing numbers of transits by size range, route and direction.

Detailed analyses were also undertaken of the distribution of cargoes by route and DWT size range, average DWT by route and DWT size range and DWT utilization by route and DWT size

range. An extraction of vessel characteristics data from the ACP database was used to aid the creation of conversion tables from DWT to PCUMS, Gross Tonnage, LOA, Beam and Draft ranges.

## Matching ACP Trade Data to Trade Data and Forecasts

Concordances were established between the study regions and ACP route structures, between commodity definitions in the ACP database and those specified in the study and between ACP trade and transit volumes and those of the Nathan team.

### *Concordance between Study Regions and ACP Route Structures*

The following details the concordance between the study regions—as described in the document Regiones para Estudios (1)—and the original routes used in the trade data. The original routes reflect 'normal' ACP route structures. The overall study regions conform to the ACP regions as set out in the database SDB94–02 except for the following:

- North America East is divided into North America Atlantic and North America Gulf
- North America Atlantic is combined with Canada East except for certain commodities
- North America West is combined with Canada West except for certain commodities
- Hawaii is included in North America West
- Cristobal RP is included in Central America East
- Balboa is included in Central America West
- Certain South America East countries are separated for some commodities
- Certain South America West countries are separated for some commodities
- Africa is separated (North and South) for some commodities
- Antarctica is included in Oceania
- Far East and South East Asia countries are separated out for some commodities

### *Concordance between ACP Trade/Transit Data and the Consultants' Data*

Work was undertaken to establish concordances between the Nathan team's trade data results and the ACP data. Reasons as to why data do not always match center on:

- definitional differences;
- when the Canal is not the shortest route but some cargo still goes through the Canal;
- differences in quantities even when there is no issue of complication over route or product definition. In the short term this is exacerbated by calendar versus fiscal year issues, when the Canal is not the shortest route but some cargo still goes through the Canal;
- by pass trades;

- technical issues of data from different sources, for example, ACP grains trade data and data from external sources;

All grain trades that can utilize the Canal on a mileage basis use up to Panamax vessels. The only grains trades of which we are aware that utilize post Panamax vessels are from the USA to Europe and South Brazil to Europe. This means that there are no all water grains bypass trades. The only bypass trade is a combination of overland plus water route i.e. US West Coast to Asia.

Therefore, except for potential switching between the US West Coast and US Gulf Coast routes to Asia, the existing trade routes through the Canal represent close to the maximum even on the basis of excluding tolls and concentrating only on mileages. This was verified through subsequent examination of mileages on Canal and alternative routes. It includes soybeans from North Brazil to various Asian destinations. On a mileage basis soybeans from the rest of Brazil to Asia would not go through the Canal.

### *Historical Trade*

As background to the commodity trade forecasts, historical grain trade by commodity, region to region route – or country to country route, as required - and ship type were extracted from the restructured database for the period 1985/1986 to 2000/2001.

A detailed specification of trade by individual routes was undertaken. This specification, in combination with the revised ACP database tables was used to produce an analysis of each region to region and country to country route by commodity as agreed.

All trade from the ACP database is available in principle on a country by country basis. Each country is given a code in the ACP system which places it within a specific geographic region - or regions - if the country has more than one coastline, which is important for Canal trade. Therefore the trade data could generally be provided at a level of aggregation best suited to the TOR for forecast trade although in practice of course not all countries are specified in the ACP database and there are various 'non specified' catch all categories within each area.

## Analysis of Laden Transits by Ship Type, Route and DWT Size Range

Details of grains trade by commodity, route and ship type were extracted from the restructured ACP database to determine the usage of different ship types in the transport of grains. The results were used to derive allocations to ship type for the forecast future trade. In general there were no clear trends in the apportionment of trade by vessel type at a route and commodity level and five year averages were used to calculate the split of future trade by size unless it was clear from the data that trends had been changing in more recent years. In these cases, either three year averages were used or the most recent year.

These allocations were applied at the commodity and route level. A summary covering all routes and all commodities for recent years is shown below as an example.

| Grain Cargoes - % by Ship Type | | | | | | | |
|---|---|---|---|---|---|---|---|
| All routes | 1994/95 | 19959/6 | 1996/97 | 1997/98 | 1998/99 | 1999/00 | 2000/01 |
| Container/Break-Bulk | 0.6% | 1.0% | 1.4% | 1.4% | 1.1% | 2.1% | 1.6% |
| Chip Carrier | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% |
| Dry Bulk Carrier | 95.0% | 95.2% | 95.5% | 94.4% | 94.5% | 95.4% | 95.9% |
| Dry/Liquid Bulk Carrie | 0.5% | 0.2% | 0.4% | 0.1% | 0.1% | 0.1% | 0.2% |
| Full Container | 0.0% | 0.0% | 0.0% | 0.3% | 0.0% | 0.1% | 0.0% |
| General Cargo | 1.3% | 1.3% | 1.2% | 1.8% | 1.7% | 1.6% | 1.6% |
| Liquid Gas | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Other | 0.4% | 0.2% | 0.0% | 0.1% | 0.8% | 0.4% | 0.7% |
| Refrigerated Cargo | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Roll-on/Roll-off | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Tanker | 0.2% | 0.1% | 0.4% | 1.3% | 0.8% | 0.2% | 0.2% |
| Vehicle/Dry Bulk | 1.9% | 1.9% | 1.2% | 0.8% | 1.0% | 0.4% | 0.5% |
| Vehicle Carrier | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% |

Source: ACP/ Richardson Lawrie Associates.

As can be seen from the above table that over the seven year period from FY 1994/1995 to FY 2000/2001 the overall proportion of grains that were shipped through the Canal in dry bulk carriers remained around 95 percent.

The allocation of commodity forecasts to ship type is the first step in the determination of future transits of these commodities in dry bulk carriers.

## Cargo Distribution by Route and DWT Size Range

As a starting point for projecting future cargo size distributions on Canal routes, a series of regressions have been developed. It is stressed that these trends—based as they are on historical ACP data—are not necessarily applicable for by pass or new trades which may be attracted to an Expanded Canal. Treatment of cargo allocation by size range for the Expanded Canal is discussed in a later section.

The purpose of the regressions is to assist in the estimation of the rates of annual change in DWT range percentages for the Existing Canal in the future and so provide a sound statistical framework for the transit forecasts. The dependent variables are time – that is, the natural logarithm of time - and total cargo which encapsulate all the relevant variables that could be used in an unbiased regression. Time represents the general trend of vessel usage over the historical period whilst total cargo represents the manner in which different sized vessels might be used when trade volumes increase or decline.

Regressions undertaken on a route basis did not provide statistically acceptable results. To gain a better understanding of the manner in which different DWT size ranges were used, the major trades were identified for separate and combined analyses. However, it was concluded that in order to obtain statistically significant results it was necessary to determine overall trends in cargo distribution by size at the north and south levels. Table 4-1 shows the development of cargo by DWT size range, North and South, for the period from FY1985/1986 to 2000/2001.

A methodology was subsequently developed to enable these overall trends to be applied at the individual route and commodity levels (see below).

Table 4-1 highlights the steady decline in the employment of 60,000-70,000 DWT vessels from around the mid 1990s and the corresponding rise in 70,000-80,000 DWT size range. Employment of vessels in the 40,000-50,000 DWT size range has also shown strong growth over the same period and although recently there have been very small gains in the share represented by the 50,000-60,000 DWT range its share remains well below the maximum of 10 percent recorded in the late 1980s.

Northbound, the trends are less clear, although in recent years the 60,000-80,000 DWT size ranges have gained in importance and the 40,000-50,000 DWT range has declined. In contrast to the southbound routes there is a significant proportion (43 percent) of cargo transported in 25,000-40,000 DWT carriers.

**Table 4-1. Historical Allocation of Cargo to Dwt Size Range 1986-2001 (percent)**

| DWT Range and Direction | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **South** | | | | | | | | | | | | | | | | |
| Less or equal to 10,000 | 1.2 | 0.7 | 0.7 | 0.4 | 0.4 | 0.3 | 0.3 | 0.4 | 0.3 | 0.2 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 0.1 |
| Greater than 10,000–Less than 15,000 | 0.3 | 0.2 | 0.1 | 0.1 | 0.3 | 0.3 | 0.5 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.6 | 0.4 | 0.3 |
| Greater or equal to 15,000–Less than 20,000 | 1.4 | 0.8 | 0.7 | 0.7 | 0.8 | 0.7 | 0.9 | 1.7 | 1.2 | 0.6 | 0.5 | 1.0 | 0.6 | 1.1 | 0.3 | 0.5 |
| Greater or equal to 20,000–Less than 25,000 | 1.9 | 2.4 | 2.9 | 3.0 | 2.6 | 2.3 | 2.5 | 1.8 | 2.8 | 3.8 | 2.2 | 2.7 | 2.6 | 2.3 | 2.5 | 2.1 |
| Greater or equal to 25,000–Less than 30,000 | 5.5 | 6.6 | 6.4 | 6.5 | 5.8 | 5.0 | 5.0 | 4.8 | 6.1 | 6.7 | 7.1 | 7.8 | 9.2 | 7.8 | 7.0 | 6.8 |
| Greater or equal to 30,000–Less than 40,000 | 18.2 | 16.2 | 14.0 | 12.4 | 11.7 | 10.6 | 11.8 | 9.2 | 8.9 | 8.5 | 8.5 | 6.5 | 8.9 | 7.9 | 6.9 | 8.8 |
| Greater or equal to 40,000–Less than 50,000 | 8.4 | 5.9 | 6.5 | 8.7 | 7.2 | 7.8 | 9.5 | 5.0 | 5.4 | 9.0 | 6.7 | 8.2 | 19.0 | 18.8 | 18.1 | 19.1 |
| Greater or equal to 50,000–Less than 60,000 | 9.7 | 9.2 | 9.8 | 9.8 | 8.4 | 7.4 | 7.1 | 5.7 | 5.3 | 5.2 | 4.0 | 1.4 | 1.7 | 2.0 | 2.0 | 2.7 |
| Greater or equal to 60,000–Less than 70,000 | 49.0 | 53.1 | 54.9 | 54.1 | 58.4 | 62.5 | 59.3 | 69.2 | 64.4 | 59.5 | 60.8 | 57.5 | 42.1 | 37.3 | 38.2 | 35.5 |
| Greater or equal to 70,000–Less than 80,000 | 4.5 | 4.8 | 3.9 | 4.2 | 4.3 | 2.7 | 3.2 | 1.8 | 4.9 | 5.6 | 9.7 | 14.4 | 15.3 | 22.3 | 24.5 | 24.3 |
| Greater or equal to 80,000–Less than 90,000 | - | 0.2 | 0.2 | - | - | 0.2 | - | 0.1 | 0.2 | 0.5 | 0.1 | 0.2 | - | - | - | - |
| Greater or equal to 90,000–Less than 100,000 | - | - | - | - | - | - | - | - | 0.2 | 0.1 | - | - | - | - | - | - |
| Total South | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| **North** | | | | | | | | | | | | | | | | |
| Less or equal to 10,000 | 0.6 | - | 0.7 | - | - | - | - | - | - | 0.2 | 0.2 | 0.4 | - | 0.3 | - | - |
| Greater than 10,000–Less than 15,000 | 1.4 | 0.5 | 1.1 | 0.7 | 1.0 | 0.6 | - | 0.3 | 0.5 | 1.2 | 1.4 | 0.4 | 2.1 | 1.2 | 1.9 | 3.2 |
| Greater or equal to 15,000–Less than 20,000 | 2.2 | 1.3 | 2.0 | 1.6 | 5.4 | 3.2 | 1.5 | 1.4 | 2.3 | 3.8 | 1.8 | 4.0 | 4.0 | 1.9 | 2.2 | 3.6 |
| Greater or equal to 20,000–Less than 25,000 | 3.2 | 2.4 | 9.4 | 6.7 | 6.5 | 3.6 | 6.1 | 7.5 | 4.8 | 7.8 | 1.8 | 4.6 | 7.3 | 7.1 | 5.6 | 5.6 |
| Greater or equal to 25,000–Less than 30,000 | 20.8 | 21.7 | 23.5 | 28.9 | 18.4 | 24.3 | 17.6 | 21.6 | 14.6 | 24.1 | 17.4 | 18.0 | 19.1 | 16.8 | 22.3 | 18.2 |
| Greater or equal to 30,000–Less than 40,000 | 23.5 | 30.2 | 42.8 | 31.5 | 24.3 | 26.7 | 23.8 | 24.8 | 26.5 | 27.7 | 31.2 | 35.5 | 36.6 | 21.5 | 26.7 | 24.5 |
| Greater or equal to 40,000–Less than 50,000 | 12.7 | 9.7 | 15.0 | 13.4 | 9.7 | 11.1 | 10.0 | 8.9 | 3.1 | 7.0 | 14.8 | 25.2 | 16.4 | 19.3 | 10.3 | 12.0 |
| Greater or equal to 50,000–Less than 60,000 | 8.0 | 7.2 | - | - | - | 3.2 | 1.8 | 3.7 | 3.5 | 3.0 | 6.9 | 4.2 | 1.4 | 0.9 | 0.9 | 1.4 |
| Greater or equal to 60,000–Less than 70,000 | 27.6 | 24.3 | 5.6 | 17.2 | 32.0 | 25.4 | 39.1 | 30.0 | 44.7 | 25.1 | 24.8 | 5.8 | 7.6 | 18.2 | 16.0 | 16.9 |
| Greater or equal to 70,000–Less than 80,000 | - | - | - | - | 2.6 | - | - | 1.8 | - | - | - | 1.9 | 5.5 | 12.9 | 14.1 | 14.6 |
| Greater or equal to 80,000–Less than 90,000 | - | 2.7 | - | - | - | 2.0 | - | - | - | - | - | - | - | - | - | - |
| Greater or equal to 90,000–Less than 100,000 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Total North | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: Richardson Lawrie Associates

## Average DWT by Size Range and Route

For similar reasons to those described above, analyses and regressions of historical data on average DWT sizes within DWT size range on Canal routes were undertaken at a North/South level. The broad conclusions were that for most DWT size ranges, the average DWT of transits through the Panama Canal remained fairly flat over the 17 year period analyzed. Moreover, when upward or downward trends appear in the Panama Canal transits, these tend to be mirrored in the world fleet.

The final conclusions were that for the Existing Canal, the same average DWT should be used for North and South transits in both the Grains and Other Dry Bulk studies and that these should remain unchanged in the future.

The adopted approach was to use a combination of Panama Canal transit data and world fleet data to obtain a single constant average DWT for each size range. For the 0–10,000 DWT range, the average Canal Transit figure for 2000 was used. For the ranges 10,000–15,000 DWT to 50,000–60,000 DWT the world fleet data and Panama Transit data are very similar and the world fleet data were used. For the larger DWT size ranges up to 100,000 DWT, significant differences exist between the world fleet and Panama Transit data and so the Panama data for 2000 was again used. This resulted in the use of average DWT as shown in the following table.

| Size Range | Adopted Average Dwt |
|---|---|
| 0 to 10k | 4135 |
| 10 to 15k | 12540 |
| 15 to 20k | 17862 |
| 20 to 25k | 23009 |
| 25 to 30k | 27441 |
| 30 to 40k | 35495 |
| 40 to 50k | 44408 |
| 50 to 60k | 53444 |
| 60 to 70k | 66644 |
| 70 to 80k | 72040 |
| 80 to 90k | 82224 |
| 90 to 100k | 91388 |

Source: Richardson Lawrie Associates.

Since it has been concluded, that within each of these two cases the DWT size within a range should be the same for all routes these are not repeated for each route in these tables. However in the transit model (see Section 7) the input tables of average DWT by vessel size range are shown at a route level. Although in this instance the average DWT for a given size range is the same for all routes, this will permit ACP to change the assumptions at a route level if this were deemed to be desirable at some time in the future.

Under existing Canal conditions, the vessel size ranges in the world fleet contain vessels that are unable to transit the Canal. Therefore it is not appropriate in this instance to calculate representative vessel DWT based on the world fleet. This has to be done with reference to the actual vessels utilizing the Canal. For the expanded Canal most vessels in the world fleet would be able to transit the Canal in terms of their LOA and beam although, as discussed below, vessels of more than 110,000-120,000DWT would need to transit the Canal partly loaded. Therefore in this case it is appropriate to base vessel characteristics on those of the world fleet.

For the Expanded Canal, it is assumed that average DWT within size ranges for vessels above 60,000 DWT will reflect those in the world fleet.

## DWT Utilization by DWT Size Range and Route

As with the treatment of cargo allocations by size range and average DWT the analysis of DWT utilization – the ratio of cargo to DWT – for grains was carried out on a 17 year time series of data extracted from the ACP database at the North/South level. For most DWT size ranges and trades, the average utilization of transits through the Panama Canal remained fairly flat over the 17 year period analyzed, to the extent that there is no statistical evidence for varying utilizations over time.

The development of constant utilization factors for each trade (North/South; Grain/Other Dry Bulk) for each DWT size range was adopted as the best approach. There is strong evidence that Northbound trades have different utilization levels to Southbound trades and that grain and other dry bulk also differ. In order to establish a consistent set of utilization figures – for example, for use in freight cost calculations by size – utilization levels by size range, North and South were determined by dividing the average cargo sizes from 1985/1986 onwards for the different DWT size ranges by the average DWT established in the previous sections. The results – which have been used in the forecasts of freight coast and transits for the Existing Canal – are shown below:

| | Mean Utilization | | | |
|---|---|---|---|---|
| | Grain | | Other Dry Bulk | |
| | South | North | South | North |
| 0 to 10k | 77.9% | 76.3% | 80.8% | 81.4% |
| 10 to 15k | 80.3% | 78.1% | 77.6% | 79.9% |
| 15 to 20k | 86.0% | 75.5% | 82.5% | 80.2% |
| 20 to 25k | 84.6% | 75.3% | 81.2% | 76.5% |
| 25 to 30k | 85.5% | 81.1% | 84.3% | 75.9% |
| 30 to 40k | 86.4% | 77.7% | 82.5% | 77.0% |
| 40 to 50k | 87.5% | 73.6% | 83.1% | 77.5% |
| 50 to 60k | 89.8% | 75.3% | 85.6% | 82.3% |
| 60 to 70k | 81.1% | 77.0% | 80.7% | 74.8% |
| 70 to 80k | 77.3% | 74.5% | 76.4% | 72.5% |
| 80 to 90k | 70.1% | 75.2% | 71.8% | 73.0% |
| 90 to 100k | 64.4% | | | 41.2% |

Source: Richardson Lawrie Associates

For the Expanded Canal, utilization levels for larger vessels between 60,000 and 100,000 DWT have been increased as ships in these size ranges will no longer be constrained by draft and larger cargoes will be permitted. For the Expanded Canal, utilization levels for vessels between 60,000 DWT and 100,000 DWT are assumed to increase to 81 percent for Northbound transits and to 87 percent Southbound.

Even though the maximum vessel size that would be able to transit an Expanded Canal fully laden would be in the region of 110,000 to 120,000 DWT, vessel utilization factors have not been calculated for vessels above 100,000 DWT. Even under Expanded Canal conditions it is felt that grains cargoes will continue to be constrained by factors other than the Panama Canal (see below).

## Vessel Utilization and Stowage Factors for Different Grain Types

### *Vessel Utilization*

While cargo sizes are a function of shippers/receivers requirements, clearly different grains have different stowage factors. One of the issues that has been considered is whether freight rates are 'unduly influenced' by the different stowage factors of the different grains. In summary, a very high proportion of grains sailings through the Canal include more than one grain commodity and therefore, in our view, the average cargo size on a route, by vessel size range, is more than adequate as an input to the determination of $ per cargo ton freight rates that are then applicable to all grains types. Approximately 40 percent of Canal transits in 2000/2001 were multi-cargo transits. While the TOR specifies analysis of a wide range of cargo types, very few have any real significance for Canal transits.

**Total Grains Transiting the Canal 1999/2000**

| | Tons | | |
|---|---|---|---|
| | Total | Dry Bulk Carrier Ship types | |
| Barley | 366920 | 286551 | 1% |
| Corn | 19447629 | 18720600 | 50% |
| Oats | 43788 | 22991 | 0% |
| Rice | 780757 | 458072 | 1% |
| Sorghum | 870921 | 824441 | 2% |
| Soybeans | 13214664 | 12785614 | 34% |
| Wheat | 3946184 | 3761453 | 10% |
| Other Miscellaneous Grains | 773657 | 720388 | 2% |
| **Total** | 39444520 | 37580110 | 100% |

Source: Richardson Lawrie Associates.

To illustrate the issue of freight sensitivity to cargo size within size range, various cargo size analyses have been undertaken for the US Gulf to Far East as this route is the most populous with easily the most data observations. For all cargoes, whether single cargoes or multiple cargoes, the important vessel size ranges are 40,000–50,000 DWT, 60,000–70,000 DWT and 70,000–80,000 DWT. Examples of cargo size variations versus the mean in these 3 size ranges reveal the following:

- Corn only: -0.7 percent, 0.3 percent, -0.3 percent;
- Soybeans only: 1.5 percent, 1.1 percent, 0.4 percent;
- Corn/soybeans combinations: -1 percent, -1 percent, 0 percent;
- Corn/sorghum combinations: -1 percent, -2.2 percent, -0.4 percent.

All other cargo combinations of any significance show variations of the same order of magnitude. These variations are well within any normal variations used in assessments of freight rates within a

vessel size range. From the following table, it can be seen that in the size ranges that matter, the overall utilization factors for single cargoes are very similar to those for multi cargo transits.

**US Gulf to Far East Grains Cargoes, 1999/2000**

**Single Cargo Transits**

| DWT Range | Total Cargo | Total Dwt | No Transits | Average Cargo Tons | Average Dwt | % Util. |
|---|---|---|---|---|---|---|
| 15-20k | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 to 25k | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 to 30k | 433311 | 470139 | 17 | 25489 | 27655 | 92.2 |
| 30k-40k | 128665 | 136834 | 4 | 32166 | 34209 | 94.0 |
| 40 to 50k | 2946636 | 3166065 | 71 | 41502 | 44592 | 93.1 |
| 50 to 60k | 505780 | 606838 | 11 | 45980 | 55167 | 83.3 |
| 60 to 70k | 7989393 | 9690158 | 145 | 55099 | 66829 | 82.4 |
| 70 to 80k | 4341918 | 5537594 | 77 | 56389 | 71917 | 78.4 |
| **Total multi-cargo transits** | | | | | | |
| 15-20k | 11678 | 12497 | 0.7 | 16845 | 18026 | 93.4 |
| 20 to 25k | 15254 | 23642 | 1.0 | 15254 | 23642 | 64.5 |
| 25 to 30k | 72867 | 88318 | 3.2 | 22496 | 27266 | 82.5 |
| 30k-40k | 119961 | 145367 | 4.0 | 29990 | 36342 | 82.5 |
| 40 to 50k | 1417591 | 1534158 | 34.0 | 41694 | 45122 | 92.4 |
| 50 to 60k | 178646 | 209301 | 4.0 | 44662 | 52325 | 85.4 |
| 60 to 70k | 4509460 | 5466566 | 80.4 | 56104 | 68011 | 82.5 |
| 70 to 80k | 3046000 | 3886313 | 54.0 | 56407 | 71969 | 78.4 |
| **Single + Multi-Cargo Transits** | | | | | | |
| 15-20k | 11678 | 12497 | 0.7 | 16845 | 18026 | 93.4 |
| 20 to 25k | 15254 | 23642 | 1.0 | 15254 | 23642 | 64.5 |
| 25 to 30k | 506178 | 558457 | 20.2 | 25010 | 27593 | 90.6 |
| 30k-40k | 248626 | 282201 | 8.0 | 31078 | 35275 | 88.1 |
| 40 to 50k | 4364227 | 4700223 | 105.0 | 41564 | 44764 | 92.9 |
| 50 to 60k | 684426 | 816139 | 15.0 | 45628 | 54409 | 83.9 |
| 60 to 70k | 12498853 | 15156724 | 225.4 | 55457 | 67250 | 82.5 |
| 70 to 80k | 7387918 | 9423907 | 131.0 | 56396 | 71938 | 78.4 |

Incls. 5.3 partial transits with cargo for another route

### *Stowage Factors*

Stowage factors for corn, sorghum and soybeans are not significantly different in shipping terms at 1.38768 cubic meters per ton. Wheat is heaver at 1.24608 cubic meters per ton while a cargo such as barley stows at around 1.47264.

#### *Cubic Capacity*

The following is an example of data from the global dry bulk carrier fleet by TOR DWT size ranges:

| *Average DWT* | *Average Cubic* |
|---|---|
| 44,470 | 58,478 |
| 65,718 | 78,023 |
| 73,498 | 85,827 |

In other words, on average, vessel cubics do not constrain the stowage of grains cargoes such that, within any given vessel size range, the amount that can be lifted for one cargo type is not markedly different from what can be lifted for another cargo type.

The conclusion that we have come to is that cargo size/vessel utilization by individual product is not an issue in this study. We recognize that commodities such as oats are considerably less dense than say, wheat. However, certainly for Canal trades, they are moved in sufficiently small quantities such that their carriage does not result in cargo shut out for other grains carried on the same vessel. Hence, within route, little variation is seen overall in cargo sizes by vessel size.

## Conclusions

Average cargo sizes (from 1985/6 onwards) for the different DWT ranges are shown in the table below.

| | **Mean Cargo** | | | |
|---|---|---|---|---|
| | Grain | | Other Dry Bulk | |
| | South | North | South | North |
| 0 to 10k | 5384 | 4416 | 4303 | 4293 |
| 10 to 15k | 10074 | 9788 | 9727 | 10014 |
| 15 to 20k | 15354 | 13490 | 14728 | 14333 |
| 20 to 25k | 19471 | 17328 | 18683 | 17610 |
| 25 to 30k | 23462 | 22264 | 23142 | 20839 |
| 30 to 40k | 30666 | 27565 | 29279 | 27317 |
| 40 to 50k | 38839 | 32691 | 36895 | 34394 |
| 50 to 60k | 47995 | 40266 | 45753 | 43984 |
| 60 to 70k | 54080 | 51314 | 53794 | 49862 |
| 70 to 80k | 55686 | 53674 | 55036 | 52211 |
| 80 to 90k | 57605 | 61802 | 59042 | 60006 |
| 90 to 100k | 58871 | | | 37640 |

Source: ACP/Richardson Lawrie Associates

The mean cargoes for the smallest DWT size range were greater than the proposed average DWT for this size range. This is due to the extremely low usage of this size range coupled with smaller vessels being used in the later years. Data obtained from the mean utilization factors was therefore substituted. The utilizations for the remaining size ranges are derived by dividing mean cargo by proposed average DWT. These are presented in the table below and are the latest recommendations.

| | Mean Utilization | | | |
|---|---|---|---|---|
| | Grain | | Other Dry Bulk | |
| | South | North | South | North |
| 0 to 10k | 77.9% | 76.3% | 80.8% | 81.4% |
| 10 to 15k | 80.3% | 78.1% | 77.6% | 79.9% |
| 15 to 20k | 86.0% | 75.5% | 82.5% | 80.2% |
| 20 to 25k | 84.6% | 75.3% | 81.2% | 76.5% |
| 25 to 30k | 85.5% | 81.1% | 84.3% | 75.9% |
| 30 to 40k | 86.4% | 77.7% | 82.5% | 77.0% |
| 40 to 50k | 87.5% | 73.6% | 83.1% | 77.5% |
| 50 to 60k | 89.8% | 75.3% | 85.6% | 82.3% |
| 60 to 70k | 81.1% | 77.0% | 80.7% | 74.8% |
| 70 to 80k | 77.3% | 74.5% | 76.4% | 72.5% |
| 80 to 90k | 70.1% | 75.2% | 71.8% | 73.0% |
| 90 to 100k | 64.4% | | | 41.2% |

Source: Richardson Lawrie Associates

For the expanded Canal, utilization levels for larger vessels will likely be relaxed as ships in the above size ranges will no longer be constrained by draft and larger cargoes will be permitted. The extent to which utilization levels could change will be determined by likely port and terminal developments and market research with shippers and ship owners/operators.

From 2010, utilization levels for vessels between 60,000 DWT and 100,000 DWT are assumed to increase to 87 percent for Southbound transits and about 81 percent for Northbound transits. For the Expanded Canal there is the potential to increase utilization levels as well as vessel sizes for ships transiting the Canal. Table 4-1(a) summarizes the calculation of maximum grains cargoes for the Expanded Canal. Generally, the data shown are based on average vessel dimensions by size range for modern ships in the existing dry bulk carrier fleet. This is so as to capture more recent vessel design parameters, although for some size ranges – in particular between 100,000 and 120,000 DWT - there are few, if any, modern ships.

**Table 4-1a Calculation of Maximum Grains Cargoes for the Expanded Canal**

| Size Range (000 DWT) | | 40-50 | 50-60 | 60-70 | 70-80 | 80-90 | 90-100 | 100-110 | 110-120 |
|---|---|---|---|---|---|---|---|---|---|
| Average DWT[1)] | | 46,727 | 51,285 | 69,335 | 74,434 | 86,828 | 91,544 | 107,017 | 116,089 |
| Average draft[1)] | (m) | 11.62 | 11.77 | 13.12 | 13.64 | 13.31 | 12.86 | 15.72 | 15.97 |
| | (feet) | 38.13 | 38.63 | 43.06 | 44.75 | 43.67 | 42.18 | 51.57 | 52.39 |
| Immersion factor | (tpc) | 50.53 | 54.50 | 65.23 | 67.02 | 76.11 | 87.22 | 90.90 | 92.55 |
| | (tpi) | 128.35 | 138.43 | 165.69 | 170.23 | 193.31 | 221.55 | 230.89 | 235.08 |
| Grain capacity | (cbm) | 59,537 | 65,685 | 82,385 | 88,494 | 103,337 | 109,751 | 122,043 | 125,427 |
| Grains cargo @ max draft | | 43,381 | 47,861 | 60,029 | 64,480 | 75,296 | 79,969 | 88,926 | 91,391 |
| **% Utilization** | | **92.8** | **93.3** | **86.6** | **86.6** | **86.7** | **87.4** | **83.1** | **78.7** |
| Grains cargo @ 46 ft/14.02m | | 43,381 | 47,861 | 60,029 | 64,480 | 75,296 | 79,969 | 74,685 | 73,364 |
| **% Utilization** | | **92.8** | **93.3** | **86.6** | **86.6** | **86.7** | **87.4** | **69.8** | **63.2** |
| Grains cargo @ 50 ft/15.24m | | 43,381 | 47,861 | 60,029 | 64,480 | 75,296 | 79,969 | 85,562 | 84,655 |
| **% Utilization** | | **92.8** | **93.3** | **86.6** | **86.6** | **86.7** | **87.4** | **80.0** | **72.9** |

Source: Richardson Lawrie Associates

The table covers the size ranges from 40,000 DWT up to 120,000 DWT. At the bottom end of this range, vessel utilization is not constrained by the existing Canal dimensions. At the top end of the range we have concluded that for grains there will not be a requirement for vessels above 120,000 DWT and probably not above 100,000 DWT. The table shows average DWT in each size range, average drafts, grains capacities and immersion factors. Immersion factors are a measure of the number of tons by which a cargo needs to be reduced in order to decrease the vessel draft by 1 cm (tpc)or 1 inch (tpi).

In order to calculate the maximum grain cargo – in tons – for each vessel size we have assumed a typical mix of grains cargoes to estimated average density. This has been applied to the cubic capacities for each ship size to determine the maximum cargo size.

It can be seen that on maximum draft, only those vessels in the 40,000 to 60,000 DWT ranges would be able to transit the Existing Canal fully laden. The Existing Canal draft is 39.5' (12.04 m). The first phase of the proposed expansion would increase the draft to 46' (14.02m) at which point vessels up to 100,000 DWT could transit the Canal fully laden. With the Canal draft at 50' (15.24m) from 2020 some vessels between 100,000 DWT and 120,000 DWT could transit the Canal fully laden but for both size ranges the average maximum drafts on full loads would still be in excess of the Canal draft.

As a footnote, there are a few ships in excess of 120,000 DWT that could transit a 50' draft Canal fully laden. Currently in the 120,000 to 149,999 DWT size range there are 161 vessels. All of these vessels would be able to use the fully expanded Canal in terms of beam and LOA – that is, they would be able to transits the Canal light loaded - but just eight would be able to transit on full draft. These eight ships range from 122,760 up to 141,475 DWT.

From Table 4-1(a), it can be seen that on maximum vessel drafts, utilization levels for grains fall from around 93% for ships between 40,000 DWT and 60,000 DWT to around 87 percent for ships

between 60,000 DWT and 100,000 DWT and to about 79 percent for vessels between 110,000 DWT and 120,000 DWT. In other words, these larger ships are not optimized for the carriage of grains. It is notable that even though the two smallest vessels sizes could transit the Canal fully laden actual utilization levels observed are between 85 percent and 88 percent southbound and only 70 percent to 78 percent northbound.

For the proposed phase 1 expansion of the Canal it is assumed that the utilization levels on ships between 60,000 DWT and 100,000 DWT increase to 87 percent. The second phase of the Canal expansion up to a draft of 50' would have no further effect on utilization levels in these size ranges since these are already at maximum levels for grains.

## Conversion Factors for PCUMS, Gross Tonnage, LOA, Beam and Draft from DWT

In order to determine transits and cargo through the Canal by vessel characteristic a series of distribution factors were developed which map the percentage of DWT transiting the Canal to each subject characteristic range. These distribution factors were developed for each DWT range and vessel characteristic range as defined in the Terms of Reference.

The series of conversion factors developed for the Existing Canal and the Expanded Canal are provided in *Volume 3: Vessel Transit and Fleet Analysis*, Tables 2-7 to 2-12, of this study.

### *Approach*

The development of the conversion factors for all characteristics except PCUMS was based in the first instance on the world fleet which was analyzed by vessel characteristics as follows:

- Length Overall (LOA)
- Beam
- Design Draft
- Gross Registered Tons

These analyses were undertaken within each vessel DWT size range and in a number of pre-defined ranges for the vessel characteristics as defined in the Terms of Reference. For the world fleet therefore, total DWT within each size range was subdivided by vessel characteristic such that within each DWT size range, the distribution pattern conforming to each characteristic could be calculated. An example of the analysis is provided below:

**Dry Bulk Carriers 50,000 - 59,999 dwt: Characteristics Analysis**

| Beam Range (m) | % total dwt | LOA (m) Range (m) | % total dwt | Draft Range (m) | % total dwt | GRT Range | % total dwt |
|---|---|---|---|---|---|---|---|
| 27.75-28.96 | 4.73 | <200 | 23.64 | 10.00 | 0.73 | < 9,999 | 0.00 |
| 28.97-30.49 | 3.80 | 200-230.90 | 75.53 | 10.00-10.50 | | 10,000 - <19,999 | 0.00 |
| 30.50-32.31 | 88.97 | 230.90-289.56 | 0.83 | 10.50-11.00 | 3.08 | 19,999 - <29,999 | 14.90 |
| 32.32-33.53 | 0.00 | | | 11.00-11.50 | 3.26 | 29,999 - < 39,999 | 75.47 |
| 33.54-36.58 | 1.70 | | | 11.50-12.04 | 8.33 | 9,999 - < 49,999 | 8.60 |
| 36.59-39.63 | 0.79 | | | 12.04-12.50 | 49.93 | 49,999 - < 59,999 | 1.03 |
| | | | | 12.50-13.00 | 28.14 | | |
| | | | | 13.00-13.50 | 4.87 | | |
| | | | | 13.50-14.00 | 1.66 | | |
| Total | 100.00 | Total | 100.00 | Total | 100.00 | | 100.00 |

Source: Richardson Lawrie Associates.

These data, rather than data from the ACP transit data were chosen as the basis of inputs to the forecasts of transits and cargo by vessel characteristic range. This was to ensure conformity and internal consistency between for example:

- Data to be used for the Existing and Expanded Canals;
- Data to be used for grains and other dry bulk transits and cargo.

Further, utilization of global fleet data screened out any serendipitous distribution patterns that could be present in any one year's transit data.

### *Modifications*

There were however instances where it was necessary to modify the global data in order to ensure its relevance and accuracy for both the Existing and Expanded Canal analyses.
In the first instances this centered on vessels which cannot transit the Existing Canal due to either beam or LOA restrictions.

These vessels were concentrated in the following DWT ranges:

- 60,000–70,000
- 70,000–80,000
- 80,000–90,000
- 90,000–100,000

A number of vessels were therefore removed from the analyses and the distribution patterns for vessels in these size ranges adjusted accordingly. For the first two vessel size ranges, while the removals improved the accuracy of the data, the statistical impact was small. For vessels in the 80,000–90,000 DWT range, the extent of the removals as a proportion of the total fleet (60 percent) highlighted the fact that such vessels are not necessarily built in order to transit the Existing Canal.

Dry bulk carriers in the 90,000–100,000 DWT range are the largest recorded transiting the Canal but this is an infrequent occurrence as demonstrated by the fact that all but one vessel in this size range has either a beam or LOA constraint.

For the Expanded Canal, the distribution pattern for each DWT size range reverted to the global data except where vessels which had been removed were Lakers, that is, vessels carrying grains within the Great Lakes.

### *PCUMS*

For vessels which transit the Existing Canal, conversion factors from DWT to PCUMS were derived from analyses of the FY 1994/1995 to FY 2000/2001 ACP database. All vessels which had transited the Canal in this period were sorted by DWT range and PCUMS. The data series developed counted individual vessels once only.

In order to develop relationships between vessel DWT and PCUMS for larger vessels transiting the Expanded Canal only, a series of regressions was undertaken between DWT and PCUMS data in the ACP database. These relationships reflected a high degree of statistical correlation with R squared at 0.97.

## Analysis of Ballast Transits

Individual vessels undertaking ballast transits in recent years were identified together with the dates of these transit(s) and route. Itineraries of a sample of these vessels were obtained as input to the determination of establishing the drivers of ballast transits.

### *Historical Trends*

Ballast transits for the fiscal years 1994/1995 to 2000/2001 were identified from the ACP database. The majority of transits in ballast were Northbound, comprising over 80 percent of the total in each of the years. Of these Northbound transits, 70 percent or more related to just four routes with a common destination of the U.S. East Coast (including U.S. Gulf). The origins for these routes were:

- U.S. West Coast
- Central America West
- South America West
- Asia

The last named route, Asia to U.S. East Coast, had the largest number of transits in ballast, about 35 percent of total Northbound.

The number of ballasts in transit by dry bulk carriers declined steeply and steadily over the seven year period analyzed, the total in 2000–2001 being just 30 percent of the total in 1994–1995. This decline affected all routes which had a reasonable number (3 per year) of ballast transits.

| Number of Ballast Transits by Dry Bulk Carriers | | | | | | | |
|---|---|---|---|---|---|---|---|
| DWT Range | 1994-1995 | 1995-1996 | 1996-1997 | 1997-1998 | 1998-1999 | 1999-2000 | 2000-2001 |
| 0 to 10k | 45 | 35 | 40 | 37 | 21 | 18 | 22 |
| 10 to 15k | 20 | 20 | 19 | 16 | 22 | 6 | 6 |
| 15 to 20k | 29 | 22 | 30 | 20 | 13 | 9 | 5 |
| 20 to 25k | 77 | 49 | 40 | 22 | 18 | 15 | 13 |
| 25 to 30k | 99 | 117 | 91 | 84 | 78 | 46 | 34 |
| 30 to 40k | 71 | 86 | 61 | 37 | 23 | 33 | 30 |
| 40 to 50k | 134 | 151 | 144 | 133 | 103 | 98 | 73 |
| 50 to 60k | 23 | 15 | 12 | 7 | 11 | 7 | 6 |
| 60 to 70k | 151 | 171 | 68 | 25 | 31 | 18 | 12 |
| 70 to 80k | 17 | 53 | 16 | 9 | 7 | 5 | 3 |
| 80 to 90k | 2 | 8 | 4 | 0 | 1 | 0 | 0 |
| Total | 668 | 727 | 525 | 390 | 328 | 255 | 204 |

The decline in the number of transits in ballast also affected all size ranges as well as all routes. In particular, the 60,000–70,000 DWT size range had only 8 percent of the 1994–1995 ballast transits in 2000–2001. This was partly to be expected as the use of this size range, particularly on the US Gulf to Far East grain trade, had decreased significantly in the mid to late 1990s, being replaced by newer bulk carriers in the 40,000–50,000 DWT and 70,000–80,000 DWT size ranges.

To evaluate all the reasons behind the rapid decline in ballast transits over the seven year period would require a major study. However, the consultants identified two major causes, namely:

- Ballast transits from Central America West, South America West and Asia northbound through the canal were and still are the major components of ballast transits. During the seven year period, the net balance of laden canal trade by dry bulk carriers from these regions has increased steadily, i.e. the canal trade from these regions minus the trade to these regions has increased. This means that vessels previously returning northbound in ballast through the canal, now have cargo to carry.

- During the mid to late 1990s, the old 60-70k range vessels taking grain from North America to the Far East were rapidly phased out and replaced by much newer vessels in the 40-50k range and then the 70-80k range. The older, inflexible 60-70k range vessels often returned in ballast, whereas the newer vessels did not. With the rising intra-regional coal trade in the Asia-Pacific area, after carrying grain to Asia, Panamax vessels carry coal and iron ore from Australia to Europe or they remain in Pacific markets. The more coal cargoes there are from Australia to Europe the less ballasting.

As a measure of the depth and extent of the work undertaken here, the analysis included scrutiny of individual vessel itineraries. At one extreme, many ballast transits could be directly linked to laden transits on a one to one basis. At the other extreme, a few ballast transits could not be linked to any laden transit by the vessel concerned. In the middle were a number of vessels transiting in ballast once for every two, three or higher number of laden transits. Considerable effort was expended identifying the most likely link to a laden transit. Of the 459 ballast transits by dry bulk carriers studied in the two year period (2000 and 2001), we are confident that the correct links have been

identified. Moreover, for the expanded Canal, the individual itineraries were scrutinized for larger (for example, Capesize) vessels that might transit the Canal in ballast either as part of an itinerary involving laden transit of the Canal or as the result of the Canal offering an optimum route for re-positioning a ballast vessel which previously had carried a cargo on a non canal route. We considered a study into trade routes followed by various bulk carriers and types of commodities hauled on various legs of the trade route but concluded that it would not have provided any additional insight into factors that give rise to ballast shipments. The resources required to undertake this analysis would be enormous. There is no certainty that the results would be conclusive and the level of effort suggested is simply not commensurate with the importance of ballast transits as compared with laden transits.

As a means of developing forecasts of future ballast transits, statistical techniques were ruled out and a discrete method developed linking ballast transits with specific laden transits passing through the canal in the opposite direction. The fiscal years 1999–2000 and 2000–2001 were used as the basis for the analysis. The steps involved:

- identifying all transits in ballast by dry bulk carriers from the ACP database, noting the region to region route, DWT and ship number;
- identifying all laden transits for the above ships, using the ship number, and, for each laden transit, noting the transit sequence number;
- extracting details of the laden transits of these ships, using the transit sequence number, noting the commodities, origins and destinations.

The ballast transits for each vessel were examined against their laden transits in order to identify those for which a direct link between laden and ballast transits could be established. In other cases, ballast transits could only be considered as positioning voyages relating to a much larger number of laden transits. In these cases, judgment had to be used to establish the trade link which was most likely to be associated with the ballast transit. Such trade links were not always associated with a single commodity, or the same end points as the ballast transits.

The number of ballast transits per ship was then grossed up to take account of a relatively small number of transits for which insufficient details were available and an annual figure derived. For grain ballast transits this led to 56 separately defined ballast transits.

## DETERMINATION AND ANALYSIS OF VESSEL SAILINGS ON BYPASS TRADES

### Determination of ByPass Trades

Bypass routes are defined in one of two ways:

- Routes involving both overland and sea transportation which offer a potentially competitive alternative to the Canal;
- Those all water alternative routes for which the mileages are greater than those via the Canal but which account for all or a portion of the trade between the points of origin and

destination because it is possible to utilize larger vessels than can transit the Canal, thereby achieving economies of scale.

All grain trades that can utilize the Canal on a mileage basis use up to Panamax vessels. The only grains trades of which we are aware that utilize post Panamax vessels are from the USA to Europe and South Brazil to Europe. This means that there are no all water grains bypass trades. The only bypass trade is a combination of overland plus water route i.e. US West Coast to Asia. Therefore, except for potential switching between the US West Coast and US Gulf Coast routes to Asia, the existing trade routes through the Canal represent close to the maximum even on the basis of excluding tolls and concentrating only on mileages.

However, because of its potential importance as a growing source of exports to Asia in the future, we have also examined sailings out of Brazil more closely. This is particularly important because, on a simple mileage basis, only exports from the north of Brazil represent potential Canal trade. However, the differences in mileages between Canal and alternative routes for all except Japan are relatively small and therefore the routing of grains trade from this region is particularly sensitive to Canal tolls. Grains exports from more southerly ports in Brazil – for example, Santos and Rio Grande - are logically routed to Japan, China, South Korea and Taiwan via either Cape Horn or the Cape of Good Hope.

In the transportation study on the Grain Market Segment and the Panama Canal, the allocation of trade between Canal and by-pass routes is undertaken in the spatial optimization model using estimated freight costs generated in this part of the study. As part of the work done in the spatial optimization model there were numerous alternative trades and routes contained in the analysis and shipping costs. These included not only the PNW, but also Gulf direct to the import market, bypassing the canal, as well as from Brazil North and Brazil South by-passing the Canal, and, going through the Canal. In addition, shipments from Eastern Canada and elsewhere were allowed to go through the Canal, or, by-pass. For example, we took into account the possibility that additional wheat shipments would move to Asia from Australia if Canal tolls were substantially increased. The forecast that was prepared of wheat from Australia to Asia is included in the table of world grain trade on non-Canal routes in this report. In our base case Australia already exports to 12 Asian countries and Africa east. At that point, it exhausts its supply. The purpose of this section is to focus not on the freight cost comparisons of the Canal versus non Canal trades. Here we discuss the factors and the freight costs that will determine for potential Canal trades, the competitive position of the Canal versus by pass routes.

Bypass trades are assigned to the Expanded Canal on the basis of:

- The current and future allocation of cargo to ship sizes. Current data are based on our market research with shippers, owners and port agents. The future allocation is based on rates of change in the global fleet and port developments. Specific assumptions made on the future size distribution of grains cargoes by route for the Expanded Canal are discussed in later.
- Comparisons of freight costs for the Panama Canal route and the least cost alternative routes. In some instances this will modify the original cargo allocation patterns. For example, previous experience suggests that there could be some instances where a

smaller vessel transiting the Canal could be cheaper than a larger vessel on the least cost alternative route. However, for the larger ship sizes which can only transit the Expanded Canal part loaded then the voyage economics can swing back in favor of the longer route based on comparisons not only within a size range but sometimes across size ranges as well.

The following section describes the data obtained on grains sailings from the Pacific Northwest and Brazil and the analyses undertaken.

## Analysis of Vessel Sailings on Bypass Trades

### *Pacific Northwest*

Freight rates by vessel size and weighted average freight costs for the period 2000 through 2025 have been calculated as part of the work on freight costs for the grains trades from the Pacific Northwest to the Far East and South East Asia which is discussed later. Here we describe the estimated vessel size distributions (Table 4-2) and load factors that have been established for these trades using data and information from the following sources:

- British Columbia Grain Shippers Clearance Association. This organization has provided a complete list of vessels with destinations and cargoes loading out of Vancouver in the period from Sept 2001 through August 2002.
- Columbia Grain have provided a list of all vessels loading at their terminal on the Columbia River, West Coast USA for the period CY 1998 through 2001. Data comprises vessel name, cargo tons, destination and commodity. We have a written request from Columbia Grain to handle the data in confidence.
- Lower Columbia River Forecasts, August 2002. This report was prepared for the US Army Corps Peer Review.
- Exhibit L from the Revised Economic Analysis, 43 Foot Columbia River Channel Improvement Project, 2002. This was prepared for the Supplemental Final Environmental Impact Statement. The purpose of this analysis was to revise the benefits for the 43 foot channel identified in an earlier 1999 study. Figures on sailings are presented by vessel draft range and had to be converted into equivalent DWT size ranges for the purpose of this analysis.
- International Chartering Services, a British Columbia based broking company.

**Table 4-2. Cargo Size Distribution by Route and DWT Size Range on Pacific Northwest America - Asia Trades (percent)**

| Origin | Destination | Vessel Size Range (000 DWT) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 20 to 25k | 25 to 30k | 30 to 40k | 40 to 50k | 50 to 60k | 60 to 70k | 70 to 80k | 80 to 90k | 90 to 100k |
| West Coast Canada | Japan | 41.4 | 27.4 | 9.7 | 13.8 | 3.9 | 1.9 | 1.9 | - | - |
| West Coast Canada | China Mainland | 41.4 | 27.4 | 9.7 | 13.8 | 3.9 | 1.9 | 1.9 | - | - |
| West Coast Canada | Rep. Of Korea | 41.4 | 27.4 | 9.7 | 13.8 | 3.9 | 1.9 | 1.9 | - | - |
| West Coast Canada | Taiwan | 41.4 | 27.4 | 9.7 | 13.8 | 3.9 | 1.9 | 1.9 | - | - |
| West Coast Canada | Other Far East | 41.4 | 27.4 | 9.7 | 13.8 | 3.9 | 1.9 | 1.9 | - | - |
| West Coast USA | Japan | 5.0 | 3.0 | 1.0 | 63.4 | 13.9 | 3.0 | 4.0 | 6.9 | - |
| West Coast USA | China Mainland | 1.3 | 5.4 | 18.5 | 21.8 | 3.6 | 5.7 | 33.8 | 4.3 | 5.5 |
| West Coast USA | Rep. Of Korea | 1.3 | 5.4 | 18.5 | 21.8 | 3.6 | 5.7 | 33.8 | 4.3 | 5.5 |
| West Coast USA | Taiwan | 1.3 | 5.4 | 18.5 | 21.8 | 3.6 | 5.7 | 33.8 | 4.3 | 5.5 |
| West Coast USA | Other Far East | 1.3 | 5.4 | 18.5 | 21.8 | 3.6 | 5.7 | 33.8 | 4.3 | 5.5 |
| West Coast Canada | Indonesia | 41.4 | 27.4 | 9.7 | 13.8 | 3.9 | 1.9 | 1.9 | - | - |
| West Coast Canada | Malaysia | 41.4 | 27.4 | 9.7 | 13.8 | 3.9 | 1.9 | 1.9 | - | - |
| West Coast Canada | Philippines | 41.4 | 27.4 | 9.7 | 13.8 | 3.9 | 1.9 | 1.9 | - | - |
| West Coast Canada | Singapore | 41.4 | 27.4 | 9.7 | 13.8 | 3.9 | 1.9 | 1.9 | - | - |
| West Coast Canada | Thailand | 41.4 | 27.4 | 9.7 | 13.8 | 3.9 | 1.9 | 1.9 | - | - |
| West Coast USA | Indonesia | 1.3 | 5.4 | 18.5 | 21.8 | 3.6 | 5.7 | 33.8 | 4.3 | 5.5 |
| West Coast USA | Malaysia | 1.3 | 5.4 | 18.5 | 21.8 | 3.6 | 5.7 | 33.8 | 4.3 | 5.5 |
| West Coast USA | Philippines | 1.3 | 5.4 | 18.5 | 21.8 | 3.6 | 5.7 | 33.8 | 4.3 | 5.5 |
| West Coast USA | Singapore | 1.3 | 5.4 | 18.5 | 21.8 | 3.6 | 5.7 | 33.8 | 4.3 | 5.5 |
| West Coast USA | Thailand | 1.3 | 5.4 | 18.5 | 21.8 | 3.6 | 5.7 | 33.8 | 4.3 | 5.5 |

Source: Richardson Lawrie Associates

The broad conclusions are as follows:

- Based on 2001/2002 grains shipments data from Vancouver into Asia, over 90 percent were destined for Japan, with a further 7 percent going to South Korea and small quantities moving to China and Taiwan.
- There were a high proportion of grains shipped in vessels of between 20,000– 30,000 DWT, nearly 69 percent in the case of Japan.
- For South Korea, vessel sizes used were spread more evenly between 20,000–30,000 DWT and Panamax sizes but there were relatively few sailings. The limited shipments to China and Taiwan were all in vessels of less than 50,000 DWT;
- There were no shipments from Vancouver to South East Asian destinations.
- From the Columbia River, the size distribution for grains cargoes to Japan appears to be markedly different from that to the other Asian destinations. For Japan, over 63 percent of grains are shipped in vessels between 40,000 and 50,000 DWT, with a further 14 percent in the 50,000 to 60,000 DWT size ranges. The remainder of cargoes bound for Japan is distributed thinly over the remaining size ranges from 20,000 DWT up to 90,000 DWT.

- For the other Asian destinations, the main size ranges are 30,000–40,000 DWT (18.5 percent), 40,000–50,000 DWT (21.8 percent) and 70,000 to 80,000 DWT (33.8 percent) with cargoes in the other size ranges spread from 20,000 DWT up to 100,000 DWT.
- From the Columbia River, approximately 7 percent to 10 percent of cargoes shipped to the Far East are in vessels of between 80,000 and 100,000 DWT. Data from the 43 Foot Columbia River Channel Improvement Project, 2002 are supported by the information from Columbia Grain showing an average of just over 9 percent of grains moving in larger than Panamax tonnage, although figures for the last two years suggest this may have risen closer to 13 percent. This contrasts with shipments out of the US Gulf where vessels are limited to a maximum of 80,000 DWT. The data from Columbia Grain also confirm a high proportion of cargoes are moved in Handy Size and Handymax vessels

Average cargo sizes for Vancouver have been calculated from the sailings data. Average cargo sizes from North America West Coast have been assumed to be the same as those on the competing routes from the US Gulf to North Pacific and South East Asia respectively. For the largest DWT size ranges from the US West Coast—where there are no equivalent cargo size data from the US Gulf—it is assumed that average cargoes are the same as those for the 70,000 to 80,000 DWT size range.

### *Brazil*

Sailings data for grain shipments were obtained for Itacoatiara, Ponta da Madeira, and Santos. Data are summarized in Table 4-3. The sources for these data were Grupo Maggi and the local port agents at Ponta da Madeira and Santos respectively.
The main conclusions are:

- Over the eight months from March to October 2001, grains exports from Itacoatiara totaled almost 1.4 million tons, of which about 71 percent went to Europe and the remaining 29 percent was exported to Japan, China and Taiwan. Of the total of about 400,000 tons (equivalent to 600,000 tons in a full year) moving to the Far East, 200,000 tons went to Japan, about 120,000 tons were exported to China and just over 70,000 tons went to Taiwan.
- There were a total of 7 ships loaded for the Far East in this eight month period and compared with other trades, vessel sizes were more closely concentrated in the size ranges between 40,000 DWT and 80,000 DWT. Twenty two percent was in the 40,000–50,000 DWT size range, 26 percent in the 50,000–60,000 DWT range, 34 percent between 60,000 DWT and 70,000 DWT with 18 percent in the largest size range. Despite this, the largest cargo from Itacoatiara was 57,400 tons (to Europe) and the largest cargo shipped to the Far East was about 54,000 tons, that is, about the same cargo sizes as observed from the US Gulf to the Far East. There are however draft restrictions in the Amazon which limit the size of cargo loaded at Itacoatiara. Utilization levels for the larger vessel sizes are just slightly below those for Panama Canal grains trades in general.

## Table 4-3. Cargo Size Distribution by Route and DWT Size Range on Potential and Competing Trades: Brazil to Far East

| Origin and Vessel Size (DWT) | Destination | | | | |
|---|---|---|---|---|---|
| | China | Japan | Korea | Taiwan | All Far East |
| | | **Cargo in long tons** | | | |
| **North Brazil** | | | | | |
| Greater or equal to 20,000–Less than 25,000 | - | - | - | - | - |
| Greater or equal to 40,000–Less than 50,000 | - | 89,116 | - | - | 89,116 |
| Greater or equal to 50,000–Less than 60,000 | 52,580 | 52,544 | - | - | 105,124 |
| Greater or equal to 60,000–Less than 70,000 | 69,174 | 126,956 | - | - | 196,130 |
| Greater or equal to 70,000–Less than 80,000 | - | - | - | 72,651 | 72,651 |
| Grand Total | 121,754 | 268,616 | - | 72,651 | 463,021 |
| **Santos** | | | | | |
| Greater or equal to 20,000–Less than 25,000 | - | 19,325 | - | - | 19,325 |
| Greater or equal to 40,000–Less than 50,000 | - | 166,677 | - | - | 166,677 |
| Greater or equal to 50,000–Less than 60,000 | - | - | - | - | - |
| Greater or equal to 60,000–Less than 70,000 | 174,940 | 112,750 | - | 58,747 | 346,437 |
| Greater or equal to 70,000–Less than 80,000 | 540,303 | 290,098 | 120,225 | - | 950,626 |
| Grand Total | 715,243 | 588,851 | 120,225 | 58,747 | 1,483,066 |
| | | **Cargo Distribution (per cent)** | | | |
| **North Brazil** | | | | | |
| Greater or equal to 20,000–Less than 25,000 | - | - | - | - | - |
| Greater or equal to 40,000–Less than 50,000 | - | 33.2 | - | - | 19.2 |
| Greater or equal to 50,000–Less than 60,000 | 43.2 | 19.6 | - | - | 22.7 |
| Greater or equal to 60,000–Less than 70,000 | 56.8 | 47.3 | - | - | 42.4 |
| Greater or equal to 70,000–Less than 80,000 | - | - | - | 100.0 | 15.7 |
| Grand Total | 100.0 | 100.0 | - | 100.0 | 100.0 |
| **Santos** | | | | | |
| Greater or equal to 20,000–Less than 25,000 | - | 3.3 | - | - | 1.3 |
| Greater or equal to 40,000–Less than 50,000 | - | 28.3 | - | - | 11.2 |
| Greater or equal to 50,000–Less than 60,000 | - | - | - | - | - |
| Greater or equal to 60,000–Less than 70,000 | 24.5 | 19.1 | - | 100.0 | 23.4 |
| Greater or equal to 70,000–Less than 80,000 | 75.5 | 49.3 | 100.0 | - | 64.1 |
| Grand Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

Source: Richardson Lawrie Associates

- According to ACP data, 268,000 tons of grains were shipped from Brazil to Japan through the Panama Canal in FY00-01. No cargoes were recorded for China and Taiwan. An analysis of vessel itineraries leaving Itacoatiara for Japan was undertaken to see whether these ships transited the Canal on leaving Brazil. Based on information from Lloyds Seasearcher, only one vessel was confirmed as transiting the Canal between Itacoatiara and Japan. While there may be gaps in the Seasearcher information it may be the case that not all Japanese bound cargoes went through Canal. From Itacoatiara to the

Far East, Japan is the destination most likely to create demand for Canal transits. The distance via the Canal is just over 3,000 miles shorter that the next shortest route around the Cape of Good Hope. For South Korea, China and Taiwan the mileage savings are approximately 2,270 miles, 1,500 miles and 500 miles respectively.

- Relatively few ships load grains out of Ponta Da Madeira and, of those that do, most are loaded for Europe. In the second half of 2002 there was just one vessel which loaded for the Far East and that was for Japan, via the Canal. The utilization, at 84 percent for the size range 60,000–70,000 DWT, was just slightly higher than that assumed generally for vessels transiting the Canal
- Overall from North Brazil, 19 percent of trade to the Far East was in 40,000-50,000 DWT vessels, 23 percent in 50,000-60,000 DWT, 42 percent in 60,000-70,000 DWT and 16 percent in 70,000-80,000 DWT. In contrast nearly 87 percent of the cargoes loading out of Santos were in vessels above 60,000 DWT. Although in both cases, there was no difference between the maximum DWT ranges employed into Japan and China, the size distributions for China were weighted more towards the larger size ranges than for Japan.
- There were some 9.5 million tons of grains shipped out of Santos in 2002. Most of this was destined for Europe (7.5 million tons) with just less than 1.5 million tons exported to Japan, China, South Korea and Taiwan. China and Japan accounted for the lion's share of this trade with 0.7 million tons and 0.6 million tons respectively, although none of this volume would have gone through the Canal
- Cargoes to the Far East were concentrated particularly in the 70,000 DWT to 80,000 DWT size range and to a lesser extent the 60,000–70,000 DWT size range although there were several cargos to Japan in Handymax vessels. There were no vessels utilized above 80,000 DWT.
- Within the 60,000 DWT to 80,000 DWT sizes ranges on Far East trades, utilization levels for Japan were similar to those on Canal routes but cargo sizes to China and South Korea were a little higher in both cases.
- Vessels up to 150,000 DWT (smaller Capesizes) were employed in the trades to Europe. However, the grains cargoes loaded on these ships were generally between 45,000 tons and 80,000 tons. A sample check on itineraries showed that a majority of these vessels called at Tubarao prior to loading grain at Santos. The call at Tubarao would almost certainly have been to discharge thermal coal from, for example, Australia.

It is apparent that ACP data on the cargo allocation by size range for grains trades originating in Brazil differs from that obtained from the three Brazilian ports that also provide data. Based on the analysis of ACP data, cargo allocations for grain trades originating in Brazil are concentrated in 40-50 and 50-60 KDWT ranges, but information from the ports of Santos, Ponta da Madeira, Itacoatiara indicate ships sailing with grains are concentrated in the 60-70 and 70-80 KDWT size ranges.
Above we noted that for loadings out of Itacoatiara to the Far East '22 percent was in the 40,000-50,000 DWT size range, 26 percent in the 50,000-60,000 DWT range, 34 percent between 60,000 DWT and 70,000 DWT with 18 percent in the largest (70,000-80,000 DWT) size range.
Taking potential cargoes from Ponta da Madeira into account, the cargo allocation from North Brazil to the Far East between the above four size ranges becomes 19 percent, 23 percent, 42 percent and 16percent respectively.

However data from these two ports was only partial and scrutiny of vessel itineraries on shipments to the Far East were not totally clear as to whether they were routed via the Canal or an alternative route. We acknowledge that ACP data for grains transits from Brazil to the Far East is relatively sparse. However, the number of sailings recorded in total from North Brazil to the Far East, based on data from local agents are also relatively few. The ACP data used showed 11 vessels transiting the Canal in this trade over a three year period: 5 in the 40-50k range; 2 in the 50-60k range; 3 in the 60-70k range and 1 in the 70-80k size group. Given the sparseness of both data sets, the uncertainty over the routing of some ships appearing in the ports data and the fact that the ACP data does at least record actual cargo allocations on the Canal route, we believe that for consistency the ACP figures should serve as the start point for vessel size distribution on this trade. Based on the average of values for the three years to FY2000-2001, the initial cargo allocation was therefore 40 percent 40,000-50,000 DWT, 17percent 50,000-60,000 DWT, 32 percent 60,000-70,000 DWT and 11 percent 70,000-80,000 DWT.

Data on sailings from Santos were included for the purpose of comparison. Shipments from Santos to the Far East do not represent potential Canal trade.

The conclusion from this analysis is that the size of grains cargoes to the Far East is not particularly restricted by the current size of the Panama Canal, in particular in the case of Japan.

Freight costs are discussed in detail in a later part of this section. However to provide context here, Table 4-4 shows weighted average freight costs from North America Gulf to Japan versus North Brazil to Japan and West Coast USA to Japan. Freight costs from North Brazil to Japan are between $1.14 per ton and $1.45 per ton higher than those from the US Gulf and this widens to a differential of up to $2.22 per ton under the Expanded Canal. Comparing freight costs from the US Gulf to Japan to those from the US West Coast to Japan, indicates a saving of $2.66 per ton to $3.34 per ton from the Pacific Northwest under Existing Canal conditions and a saving of almost $2.00 per ton under Expanded Canal assumptions.

**Table 4-4. Comparison of Weighted Average Freight Costs into Japan for Selected Years, 2001-2025, Most Probable Case (2002$/ton)**

| Origin Region | Origin Port | Destination Region | Destination Port | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|---|
| **Existing** | | | | | | | | | |
| North America Gulf | New Orleans | Japan | Yokohama | 13.86 | 13.87 | 13.94 | 14.12 | 14.31 | 14.52 |
| Brazil | Salvador | Japan | Yokohama | 15.03 | 15.00 | 15.19 | 15.42 | 15.68 | 15.98 |
| Difference | | | | 1.16 | 1.14 | 1.25 | 1.31 | 1.37 | 1.45 |
| North America Gulf | New Orleans | Japan | Yokohama | 13.86 | 13.87 | 13.94 | 14.12 | 14.31 | 14.52 |
| US West | Portland | Japan | Yokohama | 11.21 | 10.75 | 10.85 | 10.96 | 11.07 | 11.19 |
| Difference | | | | -2.66 | -3.11 | -3.09 | -3.16 | -3.24 | -3.34 |
| **Expanded** | | | | | | | | | |
| North America Gulf | New Orleans | Japan | Yokohama | 13.86 | 13.87 | 12.72 | 12.85 | 12.99 | 13.16 |
| Brazil | Salvador | Japan | Yokohama | 15.03 | 15.00 | 14.59 | 14.83 | 15.09 | 15.38 |
| Difference | | | | 1.16 | 1.14 | 1.87 | 1.98 | 2.10 | 2.22 |
| North America Gulf | New Orleans | Japan | Yokohama | 13.86 | 13.87 | 12.72 | 12.85 | 12.99 | 13.16 |
| US West | Portland | Japan | Yokohama | 11.21 | 10.75 | 10.85 | 10.96 | 11.07 | 11.19 |
| Difference | | | | -2.66 | -3.11 | -1.87 | -1.89 | -1.93 | -1.97 |

Source: Richardson Lawrie Associates

## WORLD FLEET DEVELOPMENT BY SIZE

The potential growth in the world fleet and the potential impact of an Expanded Canal on its development are important background to the projection of changes in the allocation of cargo to different size ranges of vessel in the Canal transit forecasts. This section examines historical trends in the growth of the world fleet by size range and, for vessels below 80,000 DWT, makes comparisons with the trends observed in transits through the Canal. Forecasts of the world fleet by size range for the Existing and Expanded Canals have been developed based on future expectations of world trade growth in dry bulk commodities, changing preferences for ordering particular vessel sizes, the age distribution of the existing fleet and projected scrapping by size range.

### Analysis of Trends in the World Dry Bulk Carrier Fleet by Size Range

The potential growth in the world fleet and the potential impact of an Expanded Canal on its development are important background to the projection of changes in the allocation of cargo to different size ranges of vessel in the Canal transit forecasts. This section examines historical trends in the growth of the world fleet by size range and, for vessels below 80,000 DWT, makes comparisons with the trends observed in transits through the Canal. Forecasts of the world fleet by size range for the Existing and Expanded Canals have been developed based on future expectations of world trade

growth in dry bulk commodities, changing preferences for ordering particular vessel sizes, the age distribution of the existing fleet and projected scrapping by size range.

The world dry bulk carrier fleet increased from 290 million DWT at the beginning of 2002 to 298 million DWT by the start of 2003. Analysis of the current world fleet shows the spread of vessels over a wide number of size ranges. However, it also shows the concentration of tonnage around the Handy Size/Handymax (30,000–50,000 DWT), Panamax (60,000–80,000 DWT) and the Capesize (120,000–200,000 DWT) size ranges. It also highlights the dearth of tonnage that exists in the size ranges between 80,000 and 120,000 DWT. This may be significant since this is precisely the size ranges which—on a fully laden basis—could be accommodated by an Expanded Canal.

The proportions of the world fleet – in DWT terms – in DWT ranges below 40,000 DWT are declining slowly and steadily, as is the case for Panama Canal transits. Also evident is a decline in the 60,000–70,000 DWT range and an increase in the 70,000–80,000 DWT range although these are not as steep as exhibited by transits through the Canal since the impact of the Japanese '15 year rule' on vessels carrying grains in relative terms is less significant in the context of the world fleet.

The increase in the employment of 70,000 to 80,000 DWT dry bulk carriers through the Canal is a function of the age structure of the world Panamax fleet and the Japanese preference for modern vessels. They prefer vessels to be less than 10 years of age and will not accept vessels over 15 years. There is a concentration of 60,000 to 70,000 DWT Panamaxes built around the mid 1980s which have been phased out from this trade under the 15 year old rule. In contrast, China will take vessels up to 20 years.

Recently, the steady increase in the 40,000–50,000 DWT range in the world fleet has stopped and its share has remained constant, while the slow decline in the 50,000–60,000 DWT range has also stopped and a small increase appeared. This is unlike transits through the Panama Canal for which the increase in the 40,000–50,000 DWT range and decrease in the 50,000–60,000 DWT range have continued.

### World Dry Bulk Carrier New Building Order Book

The new building order book as at January 2003 comprised 33.8 million DWT, equivalent to about 11 percent of the existing fleet. This is a relatively moderate figure in comparison with the size of the current fleet. For tankers, for example, the comparable figure is around 20 percent. Orders are scheduled at 11.2 million DWT in 2003, 14.1 million DWT in 2004, 8.0 million DWT in 2005 and 0.5 million DWT in 2006. Yard space for additional orders for delivery over the next two years is limited although, undoubtedly, further orders will eventually be placed for deliveries in 2005 and 2006

Orders are concentrated in three size ranges in particular; 50,000–60,000 DWT (19 percent of the order book), 70,000–80,000 DWT (almost 24 percent) and 170,000-200,000 DWT (25 percent). Some orders are beginning to be placed in the size range from 80,000 to 90,000 DWT and there are two ships in the 90,000–100,000 DWT size range but there are no orders for vessels between 100,000 DWT and 150,000 DWT.

Currently, the largest Panamax dry bulk carriers are 76,000 DWT. New dry bulk carrier designs are being offered for vessels in the 80,000–90,000 DWT size range. Japanese yard, Tsuneishi reported signing its first contract in March 2003 for its new super Panamax vessel of 82,300 DWT.

With an LOA of 229 meters—slightly longer than a conventional Panamax vessel—it has a beam of 32.26 meters and therefore would be capable of transiting the existing Canal part laden. These ships appear to have been designed primarily for non Canal trades but have the flexibility to transit the Canal.

### Dry Bulk Carrier Scrapping Model

Future scrapping has been calculated by looking at historical data which shows the progressive removal of vessels for a given year and size. The approach taken is the same as taken in all medium and long term forecasts of vessel removals in the international bulk shipping sectors and was originally developed by RLA in the early 1980s. The approach is based on historical data analysis which combines:

- historical fleet data by size range and age
- vessel scrapping by size range, year scrapped and age of vessel when scrapped.

From these data it is possible to develop functions which express the average likelihood of vessels of certain ages being scrapped (or conversely remaining in the fleet) for any given year or sequence of years. In other words this approach recognizes that older vessels are phased out over a range of ages and do not simply 'drop dead' at, say, age 25 years. Obviously the amount of scrapping will vary from year to year according to both the age structure of the fleet and market conditions. The model is designed to capture typical scrapping profiles, which are representative of a complete market cycle, covering both peaks and troughs, and therefore estimated scrapping levels relate specifically to the age profile of the fleet by size range in each year.

In summary vessels below 40,000 DWT are assumed to be largely phased out once they reach ages of between 24 and 34 years. For larger ships, the age range is assumed to be between 23 and 29 years. In view of increasing concerns over aging vessels in the shipping industry generally it is possible that a combination of tougher legislation and charterers' requirements could cause vessels to be scrapped in future at earlier ages than has been observed in the past. However, providing any new rule is introduced gradually there should be sufficient elapsed time for the industry to adjust without substantial disruptions to the overall tonnage balance.

It should be recognized that the resulting figures indicate the potential long term trend in scrapping and that market developments in the short term will determine actual deletions from the fleet. In high markets, scrapping would be expected to fall below the long term trend while at times of low rates the reverse would be true.

The projections show annual scrapping rising from 5.8 million DWT in 2002 to just over 12 million DWT in 2010 before easing back to just over 7 million DWT in 2016/2017. After that, scrapping is estimated to commence a rising trend again with annual deletions at the end of the period reaching almost 14 million DWT. Between now and 2010, scrapping is expected to increase most significantly in the 30,000–50,000 DWT, 60,000–70,000 DWT and 120,000–200,000 DWT size ranges. The rise again in scrapping beyond 2017 is estimated to be concentrated in the 40,000–50,000 DWT, 70,000–80,000 DWT and 150,000–200,000 DWT size ranges.

## Forecast of World Dry Bulk Carrier Fleet by Size Range

### *Existing Canal Conditions*

As a first step, world dry bulk carrier supply by size range has been projected from the position at the beginning of 2002 through to 2005 on the basis of actual deliveries and deletions in 2002 plus scheduled deliveries from the new order book in 2003 and 2004 and less expected scrapping from the fleet.

Longer term, future dry bulk carrier supply by size range has been determined with reference to estimated demand in the main world bulk trades. Based on data from CRU - prepared as part of the work undertaken in the Transportation Study on the Dry Bulk Market Segment and the Panama Canal - and the study team's grain trade specialists - as part of the work undertaken and described in Volume 2 of this study - RLA has constructed world trade matrices for minor bulks, grains, coal and iron ore trades every five years over the period from 2000 to 2025. Tables of representative mileages have been developed for each of the four groups of trades and assuming vessel operating characteristics representative of ships operating in each of these sectors, estimates of total vessel demand have been calculated for each of these commodity groups on a matrix basis. Annual estimates of dry bulk carrier demand for intervening years were derived by interpolation.

In calculating vessel demand from a series of trade matrices we have used a widely accepted methodology which calculates demand by estimating the amount of tonnage required to move a certain amount of commodity in a given trade for a given year. The results are aggregated for all trades to determine overall demand. Tonnage required is calculated by determining the vessels' annual carrying capacities on a route based on its speed, port and Canal times and DWT utilization. In other words a series of tables has been constructed for each of the four commodity groups which determines the amount of DWT that would be required to move each forecast cargo on the route indicated. The formula which is applied for each route is as follows:

> Trade*(mileage*2/speed(knots)*24 + port time + canal time)/(vessel annual days in service*cargo size)

The resulting DWT were summed across all routes for each of the commodity groups to determine total demand by commodity group and hence determine overall demand In order to derive estimates of historical dry bulk carrier demand for comparison with supply trends, estimates of dry bulk carrier seaborne trade back to 1996 were estimated, for consistency, from the WEFA data on world grain trade and from the CRU world trade data on other dry bulks. Estimates for the same four commodity groups were made for the period 1996–1999 based on regressions of seaborne trade versus world trade for the forecast period from 2000 to 2005. Dry bulk carrier demand for each of the four commodity groups for the years 1996–1999 was estimated from a series of regressions of vessel demand for commodity group versus seaborne trade for that group over the period from 2000 to 2025.

For the Existing Canal, these size ranges were broken down further into the vessel size ranges specified in the TOR using the results of regression analyses on trends in the proportions of the world fleet within the three broad size ranges over the period from 1996 to 2005. The results of these

regressions were used to project future trends in the vessel size distribution of the world fleet from 2005 through 2025 (Table 4-5).

**Table 4-5. Dry Bulk Carrier Supply, 1996-2025, Existing Canal (million DWT)**

| | Vessel Size Range (000 DWT) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 10-15 | 15-20 | 20-25 | 25-30 | 30-40 | 40-50 | 50-60 | 60-70 | 70-80 | 80-90 | 90-100 | 100-110 | 110-120 | 120-150 | 150-200 | 200-250 | 250+ | Total |
| 1995 | 3.0 | 8.5 | 12.6 | 23.7 | 35.1 | 25.5 | 9.5 | 34.2 | 12.8 | 2.9 | 0.8 | 1.2 | 4.1 | 23.5 | 22.3 | 6.6 | 2.5 | 229.0 |
| 1996 | 3.0 | 8.6 | 13.1 | 24.4 | 35.2 | 28.9 | 9.4 | 35.4 | 15.5 | 3.2 | 1.1 | 1.2 | 3.7 | 24.5 | 26.5 | 6.6 | 2.5 | 242.9 |
| 1997 | 3.1 | 8.5 | 13.3 | 24.7 | 34.8 | 32.4 | 8.3 | 35.3 | 17.9 | 3.1 | 1.1 | 1.1 | 3.1 | 24.4 | 32.5 | 7.0 | 2.5 | 253.2 |
| 1998 | 3.0 | 8.2 | 13.4 | 24.7 | 34.6 | 35.0 | 8.1 | 35.5 | 22.0 | 2.9 | 1.3 | 0.8 | 3.0 | 24.4 | 37.8 | 7.2 | 3.2 | 265.2 |
| 1999 | 3.0 | 7.7 | 13.0 | 24.3 | 32.9 | 37.5 | 7.4 | 34.1 | 25.5 | 2.6 | 1.3 | 0.8 | 2.3 | 23.7 | 39.3 | 7.0 | 3.2 | 265.7 |
| 2000 | 3.0 | 7.4 | 12.8 | 23.6 | 32.6 | 38.5 | 6.5 | 33.3 | 29.5 | 2.3 | 1.1 | 0.8 | 1.5 | 22.9 | 43.1 | 7.3 | 3.2 | 269.4 |
| 2001 | 3.0 | 7.1 | 12.7 | 23.2 | 32.4 | 39.5 | 6.5 | 33.1 | 33.5 | 2.8 | 1.4 | 0.7 | 1.2 | 22.8 | 48.2 | 7.3 | 2.9 | 278.2 |
| 2002 | 3.0 | 7.0 | 12.3 | 22.9 | 31.4 | 40.8 | 9.2 | 31.7 | 41.0 | 2.7 | 1.5 | 0.9 | 0.9 | 22.3 | 52.1 | 7.5 | 2.9 | 290.0 |
| 2003 | 3.0 | 6.8 | 11.9 | 22.5 | 31.3 | 41.6 | 12.3 | 30.6 | 44.7 | 3.0 | 1.6 | 0.7 | 0.7 | 21.6 | 55.5 | 7.7 | 2.9 | 298.3 |
| 2004 | 3.0 | 6.6 | 11.4 | 21.9 | 31.1 | 42.2 | 14.5 | 29.5 | 45.8 | 3.2 | 1.5 | 0.7 | 0.6 | 21.3 | 59.3 | 8.1 | 2.9 | 303.8 |
| 2005 | 3.0 | 6.3 | 10.8 | 21.3 | 30.6 | 42.5 | 16.4 | 28.2 | 49.7 | 3.4 | 1.7 | 0.7 | 0.6 | 21.2 | 63.4 | 9.2 | 2.9 | 311.8 |
| 2006 | 3.0 | 6.4 | 11.4 | 21.8 | 30.5 | 43.6 | 16.9 | 27.6 | 54.5 | 3.3 | 1.7 | 0.7 | 0.1 | 19.4 | 67.8 | 9.1 | 2.9 | 320.6 |
| 2007 | 3.0 | 6.5 | 11.8 | 22.4 | 30.8 | 44.1 | 18.5 | 26.6 | 58.4 | 3.4 | 1.8 | 0.6 | | 19.0 | 70.2 | 9.2 | 2.8 | 329.3 |
| 2008 | 3.0 | 6.7 | 12.3 | 23.0 | 31.1 | 44.7 | 20.2 | 25.6 | 62.3 | 3.6 | 1.9 | 0.6 | | 18.6 | 72.5 | 9.4 | 2.8 | 338.3 |
| 2009 | 3.0 | 6.9 | 12.8 | 23.6 | 31.5 | 45.2 | 22.1 | 24.5 | 66.4 | 3.7 | 1.9 | 0.6 | | 18.1 | 74.9 | 9.6 | 2.8 | 347.6 |
| 2010 | 3.0 | 7.1 | 13.3 | 24.3 | 31.9 | 45.6 | 23.9 | 23.4 | 70.5 | 3.8 | 2.0 | 0.6 | | 17.7 | 77.4 | 9.8 | 2.8 | 357.1 |
| 2011 | 3.0 | 7.3 | 13.9 | 25.0 | 32.3 | 46.1 | 24.8 | 22.8 | 72.7 | 3.9 | 2.0 | 0.6 | | 17.5 | 78.8 | 9.9 | 2.8 | 363.3 |
| 2012 | 3.0 | 7.6 | 14.5 | 25.8 | 32.8 | 46.5 | 25.6 | 22.3 | 74.9 | 3.9 | 2.1 | 0.5 | | 17.2 | 80.3 | 10.0 | 2.8 | 369.7 |
| 2013 | 3.1 | 7.8 | 15.1 | 26.5 | 33.2 | 46.8 | 26.5 | 21.7 | 77.2 | 4.0 | 2.1 | 0.5 | | 17.0 | 81.7 | 10.1 | 2.8 | 376.2 |
| 2014 | 3.1 | 8.1 | 15.7 | 27.3 | 33.7 | 47.2 | 27.4 | 21.1 | 79.4 | 4.0 | 2.1 | 0.5 | | 16.7 | 83.2 | 10.2 | 2.8 | 382.8 |
| 2015 | 3.1 | 8.4 | 16.4 | 28.2 | 34.3 | 47.5 | 28.3 | 20.5 | 81.7 | 4.1 | 2.2 | 0.5 | | 16.4 | 84.8 | 10.3 | 2.8 | 389.5 |
| 2016 | 3.1 | 8.8 | 17.2 | 29.3 | 35.0 | 47.8 | 29.3 | 19.9 | 84.1 | 4.2 | 2.2 | 0.5 | | 16.2 | 86.4 | 10.4 | 2.8 | 397.1 |
| 2017 | 3.1 | 9.2 | 18.1 | 30.4 | 35.7 | 48.1 | 30.4 | 19.3 | 86.4 | 4.2 | 2.3 | 0.5 | | 15.9 | 88.0 | 10.5 | 2.7 | 404.9 |
| 2018 | 3.1 | 9.6 | 19.0 | 31.6 | 36.5 | 48.4 | 31.4 | 18.7 | 88.8 | 4.3 | 2.3 | 0.5 | | 15.5 | 89.7 | 10.7 | 2.7 | 412.8 |
| 2019 | 3.1 | 10.0 | 20.0 | 32.8 | 37.3 | 48.7 | 32.5 | 18.0 | 91.2 | 4.4 | 2.3 | 0.4 | | 15.2 | 91.4 | 10.8 | 2.7 | 421.0 |
| 2020 | 3.2 | 10.5 | 21.0 | 34.1 | 38.1 | 48.9 | 33.6 | 17.3 | 93.7 | 4.5 | 2.4 | 0.4 | | 14.9 | 93.1 | 11.0 | 2.7 | 429.3 |
| 2021 | 3.2 | 10.5 | 21.1 | 34.3 | 38.2 | 49.2 | 35.0 | 16.5 | 96.6 | 4.6 | 2.4 | 0.4 | | 14.8 | 93.8 | 11.0 | 2.7 | 434.4 |
| 2022 | 3.2 | 10.6 | 21.3 | 34.5 | 38.3 | 49.4 | 36.4 | 15.7 | 99.5 | 4.7 | 2.5 | 0.4 | | 14.7 | 94.6 | 11.0 | 2.7 | 439.6 |
| 2023 | 3.2 | 10.6 | 21.5 | 34.7 | 38.4 | 49.7 | 37.9 | 14.9 | 102.5 | 4.8 | 2.5 | 0.4 | | 14.6 | 95.3 | 11.1 | 2.7 | 444.8 |
| 2024 | 3.2 | 10.7 | 21.7 | 35.0 | 38.6 | 49.9 | 39.4 | 14.0 | 105.5 | 4.9 | 2.6 | 0.4 | | 14.5 | 96.0 | 11.1 | 2.7 | 450.2 |
| 2025 | 3.2 | 10.8 | 21.9 | 35.3 | 38.7 | 50.2 | 40.9 | 13.1 | 108.6 | 5.0 | 2.6 | 0.4 | | 14.4 | 96.7 | 11.2 | 2.7 | 455.6 |

Source: Clarkson Research Studies/Richardson Lawrie Associates.

### *Expanded Canal Conditions*

The approach to estimating size trends in the world fleet under Expanded Canal conditions was the same as for the Existing Canal with adjustments made to take into account the following:

- the impact of trade switching from bypass routes to Canal routes;
- the potential for utilizing larger vessel sizes on existing trades through the Canal.

The first of these adjustments was made by calculating the effect on dry bulk carrier demand by size range as the result of switching trade to the shorter Canal routes and, in some cases, switching vessel sizes.

The second part of the analysis started with the assumption that the impact of an Enlarged Canal on the dimensions currently planned will be focused almost entirely on the size mix of vessels between 60,000 DWT and 100,000 DWT. The maximum size of vessel that could transit the Canal fully laden would be around 110,000 DWT. This comment is based on the average dimensions for vessels in the 100,000-110,000 DWT of LOA 249.9m, beam 40.6m and draft 15.3m. For the 110,000-120,000 DWT size range the average dimensions are LOA 258.1m, beam 40.1 and draft 16.1m. Calculations have been based on the average dimensions of vessels within each size range although it is recognized that 8 vessels of over 120,000 DWT could transit the expanded Canal with a draft of 15.24m fully laden. However these vessels are not representative of ships in the 120,000-140,000 DWT size range

By way of further clarification, the important consideration for the Expanded Canal is vessel draft. In the expanded case – unlike for the Existing Canal - beam would not be a restriction. For the existing Canal there is a restriction of just over 32m. We have also considered whether one should take average or 'optimum' dimensions as representative of a size range. We think our approach – based on average dimensions - is correct since there is no surety that vessels over 100,000 DWT would be optimized for Panama Canal trading.

Up until 2009, it is assumed that the world fleet under the Expanded Canal would be the same as that for the Existing Canal. From 2009, vessels scrapped between 60,000 and 100,000 DWT would be replaced by a larger size mix of new ships. Starting with supply by size range in 2009, and using the results of the scrapping model, the amount of new tonnage required in each year from 2009 through 2025 to replace older tonnage and to meet rising demand has been calculated for the 60,000–100,000 DWT size range in total.

The way in which this new tonnage has been apportioned between the individual size ranges is as follows:

- For the 60,000–70,000 DWT range size range it is assumed that the relative lack of interest in newbuildings will continue and that further annual additions to this size range will remain at around the 1.4 percent of the total deliveries between 60,000 DWT and 100,000 DWT, that is, a similar proportion to that in the current order book.
- Looking at the current new building order book, ships in the 90,000 to 100,000 DWT range account for just 2 percent of the contracts for vessels between 60,000 DWT and 100,000 DWT. Over the period from 1988 to 2004, deliveries in the 80,000 DWT to 100,000 DWT range in total are estimated to account for an average of only 7.2 percent of the vessels in the

60,000–100,000 DWT segment of the fleet and the pattern has been somewhat sporadic. It has therefore been assumed that future new deliveries in the 90,000–100,000 DWT size range from 2009 will be equivalent to 7.2 percent of the deliveries in the 60,000 DWT to 100,000 DWT size range.

- Between 70,000 DWT and 90,000 DWT it is envisaged that there would be a marked shift in the distribution of vessels above and below 80,000 DWT, in favor of the larger size range. This trend has been patterned on observations from the changes in vessel size distribution that have taken place between the 60,000–70,000 DWT and 70,000–80,000 DWT size ranges from 1988 to date. In 1988/9 the 60,000–70,000 DWT size range accounted for about 86 percent of the newbuilding deliveries in the 60,000–100,000 DWT size range. Although there are a few vessels scheduled for delivery this year, this proportion had fallen to zero by 1999. Conversely the share represented by the 70,000–80,000 DWT size range increased from 13/14 percent in 1988/9 and is now around 80 to 90 percent, having briefly reached almost 100 percent in 2001. It seems reasonable to assume that removal of the Existing Canal constraints would result in a similar switch taking place between vessels of 70,000–80,000 DWT and 80,000–90,000 DWT in the period from 2010.

## Results

### *Existing Fleet*

Table 4-5 shows the fleet at the beginning of 2002 was equivalent to 290 million DWT. During the year, new deliveries totaled 14.0 million DWT—more than offsetting scrapping which amounted to 5.8 million DWT. Based on the newbuilding order book at January 2003, deliveries in 2003 and 2004 are projected at 11.3 million DWT and 14.1 million DWT respectively. With scrapping assumed at 5.7 million DWT in 2003 and 6.0 million DWT in 2004, the total world fleet is estimated to have increased to 298 million DWT by the beginning of 2003 and is projected to reach 312 million DWT by January 2005. It is recognized that the scale of scrapping to date in 2003—about 1.3 million DWT has been reported so far as at mid May—has been less than would be implied based on our assumptions. This is due to the sharp spike currently being experienced in the charter market.

In the period from 2005 through 2025, the results show the world fleet growing steadily to reach 458 million DWT by 2025. Overall, this represents an average annual growth rate from 2003 to 2025 of about 2 percent.

Vessel sizes in which growth is expected to be concentrated are between 40,000 and 60,000 DWT, between 70,000 and 90,000 DWT and above 150,000 DWT. The size ranges between 40,000DWT and 60,000 DWT would increase as a proportion of the world fleet from just over 17 percent in 2002 to 20 percent in 2025. Ships between 70,000 DWT and 90,000 DWT which accounted for 15 percent of the world fleet in 2002 would make up 25 percent by 2025. The share represented by vessels above 150,000 DWT would rise from almost 22 percent to over 24 percent. Vessels between 90,000 DWT and 120,000 DWT would continue to represent a small proportion of the fleet.

Projections of the world dry bulk carrier fleet for both the Existing and Expanded Canals indicate a phase out of vessels in the size range between 110,000 DWT and 120,000 DWT and a decline in interest in vessels of around 120,000 DWT generally. Currently there are just 7 ships in the 110,000 to 120,000 DWT size range. Of these, 5 were built in the 1970s. The remaining two were built in 1986 and 1990 respectively and therefore if a 25 year life is assumed both of these ships would still exist in 2010 but they would be removed from the fleet by 2020. This study assumes all ships in this size range would be removed by 2010. Although vessels may be scrapped before they reach the age of 25 years it is possible we have phased out this size range slightly earlier than might be the case. However we are talking about very few vessels here.

Between 120,000 and 130,000 DWT there are 29 vessels, of which 1 was built in 1986 and 12 built between 1990 and 1996. Therefore applying the simple 25 year rule, all of these vessels would be in the fleet in 2010 but just 4 would survive until 2020. In Tables 4-25(a) and 4-26(a) of the Grains Study, Volume III, we show a continuing, although declining, supply of dry bulk carriers in the 120,000 to 150,000 DWT size range. This is consistent with the view of a declining interest in vessels of around 120,000 DWT.

Within the time frame envisaged, this view was confirmed in discussions with three prominent ship owners, one of whom currently owns a number of the very few ships around 120,000 DWT. Even though this company currently operates five of the 1990s built vessels of around 123,000 DWT and have employed these in the grains trades from the US Gulf into Europe, they do not see these as the vessel size for the future and this view is not changed when considering the potential expansion of the Canal.

This view is supported by the current dry bulk carrier order book which contains no dry bulk carriers between 100,000 and 140,000 DWT There are just 2 combined carriers of 121,000 DWT but these can be considered exceptional due to their dry bulk and oil carrying capability. Vessels of around 120,000 DWT are considered just too big for general grains trading. While they might find employment in limited trades they would be extremely inflexible. This would mean almost inevitably that these vessels would be confined to trading on a round voyage basis, which would incur a substantial proportion of ballast trading. In the true coal and iron ore Cape Size trades which increasingly employ vessels of 150,000 DWT and upwards, vessels of around 120,000 DWT would not be competitive.

### *Expanded Canal*

Table 4-6 shows the development of the world fleet for the Expanded Canal. Changes from 2010 take into account the impact on the global fleet between 60,000 DWT and 100,000 DWT as the result of a move to larger vessel sizes up to 100,000 DWT. They also reflect those changes which would result from the switching of other dry bulk trades which are currently being shipped in vessels of between 120,000 DWT and 200,000 DWT from bypass routes to Canal routes.

The main difference between the Existing and Expanded Canal conditions is that under the latter conditions, the 70,000–80,000 DWT size range would be expected to peak at around 79 million DWT in 2018 before declining to just under 65 million DWT in 2025. This compares with a steady rise to nearly 109 million DWT under Existing Canal conditions. In contrast, with an Expanded Canal, the 80,000–90,000 DWT size range would increase to 54 million DWT instead of about 5

million DWT in the former case. There would also be an approximately 4 million DWT increase in the size of the 90,000–100,000 DWT size range by the end of the forecast period.

**Table 4-6 Dry Bulk Carrier Supply, 1996-2025, Expanded Canal (million DWT)**

| | Vessel Size Range (000 DWT) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 10-15 | 15-20 | 20-25 | 25-30 | 30-40 | 40-50 | 50-60 | 60-70 | 70-80 | 80-90 | 90-100 | 100-110 | 110-120 | 120-150 | 150-200 | 200-250 | 250+ | Total |
| 1995 | 3.0 | 8.5 | 12.6 | 23.7 | 35.1 | 25.5 | 9.5 | 34.2 | 12.8 | 2.9 | 0.8 | 1.2 | 4.1 | 23.5 | 22.3 | 6.6 | 2.5 | 229.0 |
| 1996 | 3.0 | 8.6 | 13.1 | 24.4 | 35.2 | 28.9 | 9.4 | 35.4 | 15.5 | 3.2 | 1.1 | 1.2 | 3.7 | 24.5 | 26.5 | 6.6 | 2.5 | 242.9 |
| 1997 | 3.1 | 8.5 | 13.3 | 24.7 | 34.8 | 32.4 | 8.3 | 35.3 | 17.9 | 3.1 | 1.1 | 1.1 | 3.1 | 24.4 | 32.5 | 7.0 | 2.5 | 253.2 |
| 1998 | 3.0 | 8.2 | 13.4 | 24.7 | 34.6 | 35.0 | 8.1 | 35.5 | 22.0 | 2.9 | 1.3 | 0.8 | 3.0 | 24.4 | 37.8 | 7.2 | 3.2 | 265.2 |
| 1999 | 3.0 | 7.7 | 13.0 | 24.3 | 32.9 | 37.5 | 7.4 | 34.1 | 25.5 | 2.6 | 1.3 | 0.8 | 2.3 | 23.7 | 39.3 | 7.0 | 3.2 | 265.7 |
| 2000 | 3.0 | 7.4 | 12.8 | 23.6 | 32.6 | 38.5 | 6.5 | 33.3 | 29.5 | 2.3 | 1.1 | 0.8 | 1.5 | 22.9 | 43.1 | 7.3 | 3.2 | 269.4 |
| 2001 | 3.0 | 7.1 | 12.7 | 23.2 | 32.4 | 39.5 | 6.5 | 33.1 | 33.5 | 2.8 | 1.4 | 0.7 | 1.2 | 22.8 | 48.2 | 7.3 | 2.9 | 278.2 |
| 2002 | 3.0 | 7.0 | 12.3 | 22.9 | 31.4 | 40.8 | 9.2 | 31.7 | 41.0 | 2.7 | 1.5 | 0.9 | 0.9 | 22.3 | 52.1 | 7.5 | 2.9 | 290.0 |
| 2003 | 3.0 | 6.8 | 11.9 | 22.5 | 31.3 | 41.6 | 12.3 | 30.6 | 44.7 | 3.0 | 1.6 | 0.7 | 0.7 | 21.6 | 55.5 | 7.7 | 2.9 | 298.3 |
| 2004 | 3.0 | 6.6 | 11.4 | 21.9 | 31.1 | 42.2 | 14.5 | 29.5 | 45.8 | 3.2 | 1.5 | 0.7 | 0.6 | 21.3 | 59.3 | 8.1 | 2.9 | 303.8 |
| 2005 | 3.0 | 6.3 | 10.8 | 21.3 | 30.6 | 42.5 | 16.4 | 28.2 | 49.7 | 3.4 | 1.7 | 0.7 | 0.6 | 21.2 | 63.4 | 9.2 | 2.9 | 311.8 |
| 2006 | 3.0 | 6.4 | 11.4 | 21.8 | 30.5 | 43.6 | 16.9 | 27.6 | 54.5 | 3.3 | 1.7 | 0.7 | 0.1 | 19.4 | 67.8 | 9.1 | 2.9 | 320.6 |
| 2007 | 3.0 | 6.5 | 11.8 | 22.4 | 30.8 | 44.1 | 18.5 | 26.6 | 58.4 | 3.4 | 1.8 | 0.6 | - | 19.0 | 70.2 | 9.2 | 2.8 | 329.3 |
| 2008 | 3.0 | 6.7 | 12.3 | 23.0 | 31.1 | 44.7 | 20.2 | 25.6 | 62.3 | 3.6 | 1.9 | 0.6 | - | 18.6 | 72.5 | 9.4 | 2.8 | 338.3 |
| 2009 | 3.0 | 6.9 | 12.8 | 23.6 | 31.5 | 45.2 | 22.1 | 24.5 | 66.4 | 3.7 | 1.9 | 0.6 | - | 18.1 | 74.9 | 9.6 | 2.8 | 347.6 |
| 2010 | 3.0 | 7.1 | 13.3 | 24.3 | 31.9 | 45.6 | 23.9 | 22.5 | 70.6 | 4.5 | 2.1 | 0.6 | - | 17.6 | 77.1 | 9.6 | 2.8 | 356.6 |
| 2011 | 3.0 | 7.3 | 13.9 | 25.0 | 32.3 | 46.1 | 24.8 | 20.4 | 73.1 | 5.6 | 2.3 | 0.6 | - | 17.3 | 78.6 | 9.7 | 2.8 | 362.9 |
| 2012 | 3.0 | 7.6 | 14.5 | 25.8 | 32.8 | 46.5 | 25.6 | 18.6 | 74.9 | 7.1 | 2.6 | 0.5 | - | 17.1 | 80.1 | 9.8 | 2.8 | 369.3 |
| 2013 | 3.1 | 7.8 | 15.1 | 26.5 | 33.2 | 46.8 | 26.5 | 17.0 | 76.2 | 8.9 | 2.9 | 0.5 | - | 16.9 | 81.6 | 9.9 | 2.8 | 375.7 |
| 2014 | 3.1 | 8.1 | 15.7 | 27.3 | 33.7 | 47.2 | 27.4 | 15.5 | 77.2 | 11.0 | 3.1 | 0.5 | - | 16.6 | 83.1 | 10.0 | 2.8 | 382.3 |
| 2015 | 3.1 | 8.4 | 16.4 | 28.2 | 34.3 | 47.5 | 28.3 | 14.2 | 77.9 | 13.2 | 3.4 | 0.5 | - | 16.3 | 84.6 | 10.1 | 2.8 | 389.1 |
| 2016 | 3.1 | 8.8 | 17.2 | 29.3 | 35.0 | 47.8 | 29.3 | 12.9 | 78.3 | 15.6 | 3.6 | 0.5 | - | 16.1 | 86.2 | 10.2 | 2.8 | 396.7 |
| 2017 | 3.1 | 9.2 | 18.1 | 30.4 | 35.7 | 48.1 | 30.4 | 11.8 | 78.5 | 18.1 | 3.8 | 0.5 | - | 15.7 | 87.9 | 10.4 | 2.7 | 404.5 |
| 2018 | 3.1 | 9.6 | 19.0 | 31.6 | 36.5 | 48.4 | 31.4 | 10.8 | 78.5 | 20.8 | 4.0 | 0.5 | - | 15.5 | 89.5 | 10.5 | 2.7 | 412.4 |
| 2019 | 3.1 | 10.0 | 20.0 | 32.8 | 37.3 | 48.7 | 32.5 | 9.6 | 78.0 | 24.1 | 4.3 | 0.4 | - | 15.1 | 91.2 | 10.7 | 2.7 | 420.6 |
| 2020 | 3.2 | 10.5 | 21.0 | 34.1 | 38.1 | 48.9 | 33.6 | 8.5 | 77.1 | 27.8 | 4.5 | 0.4 | - | 14.8 | 93.0 | 10.8 | 2.7 | 428.9 |
| 2021 | 3.2 | 10.5 | 21.1 | 34.3 | 38.2 | 49.2 | 35.0 | 7.4 | 75.7 | 32.2 | 4.8 | 0.4 | - | 14.7 | 93.7 | 10.8 | 2.7 | 434.0 |
| 2022 | 3.2 | 10.6 | 21.3 | 34.5 | 38.3 | 49.4 | 36.4 | 6.5 | 73.7 | 37.1 | 5.1 | 0.4 | - | 14.6 | 94.4 | 10.9 | 2.7 | 439.2 |
| 2023 | 3.2 | 10.6 | 21.5 | 34.7 | 38.4 | 49.7 | 37.9 | 5.7 | 71.1 | 42.4 | 5.5 | 0.4 | - | 14.5 | 95.1 | 10.9 | 2.7 | 444.4 |
| 2024 | 3.2 | 10.7 | 21.7 | 35.0 | 38.6 | 49.9 | 39.4 | 5.0 | 68.0 | 48.1 | 5.9 | 0.4 | - | 14.4 | 95.9 | 11.0 | 2.7 | 449.8 |
| 2025 | 3.2 | 10.8 | 21.9 | 35.3 | 38.7 | 50.2 | 40.9 | 4.6 | 64.5 | 53.9 | 6.2 | 0.4 | - | 14.3 | 96.6 | 11.0 | 2.7 | 455.2 |

## DEVELOPMENT OF TRADE BY VESSEL SIZE ON CANAL ROUTES

This section summarizes some of the main comments and observations obtained as the result of market research and through responses from Delphi Panel members. The final part of this section describes the approaches adopted to determine future vessel size distributions on Canal routes for the Existing and Expanded Canals and discusses the results.

## Ports and Port Developments

### *Japan*

Information was provided by ACP for a total of 32 Japanese ports encompassing 54 grains terminals. A survey of grains port developments worldwide was also undertaken. Of the Japanese grains ports:

- All but two terminals have draft restrictions up to and including 12 meters. One terminal has a draft restriction of 12.35 meters and only one is significantly larger at 16.8 meters.
- LOA restrictions are variable. However, all restrictions fall within a range of 165 - 260 meters with the exception of two terminals which have restrictions of 300 meters. This includes the terminal at Yokohama which has a draft of 16.8 meters.
- Maximum DWT data was provided for 49 out of the 54 terminals included in the survey. Of these 14 or 29 percent are restricted to vessel sizes below 60,000 DWT, 31 or 63 percent are Panamax, that is, up to 80,000 DWT and four or 6 percent are in a range equal or above 80,000 DWT. Of these, three are at or close to 80,000 DWT. It was noted during one of our interviews with shipowners that it is not unknown for DWT restrictions in Japan to be unconnected to physical size restraints. This company had first hand experience of the difficulties that can be encountered trying to get a terminal to accept an 'over DWT' vessel even though it conformed in every other respect to beam, draft and LOA restrictions. The argument appeared to be that there had always been a DWT restriction and that this should continue to be the case.

It can be concluded therefore that currently it is the dimensions at Japanese ports as much as the Panama Canal itself which are the prime constraints to the introduction of larger vessels. The consensus view is that, even if the Panama Canal is expanded, the development of Japanese ports will either be extremely slow or, more probably, will not take place even over the longer term.

As two examples of the comments received from operators, Blue Water Shipping think that Japanese port facilities will not expand. The view, based on experience of working in the Japan in the grains sector, is that shippers and importers have already upgraded their facilities in what is a low draft environment. While the approach channels to ports may indeed be dredged, these will not be extended up to the grains handling berths. Cargill at Portland say that while not all of Japan's ports are draft restricted, customers demand smaller parcel shipments there because of the added harbor fee charge applied to larger vessels. Until this "institutional" problem is resolved, Japan will never demand larger parcel shipments/vessels.

The above message was reinforced by a major grains trader and shipper with interests in Brazil where is felt there may be constraints to exports in Cape Size (>80,000 DWT ships). The opinion there is that Japan would not buy in Cape Size parcels but China would.

An owner of dry bulk carriers of all sizes in Copenhagen is more skeptical about the potential employment of Cape Size vessels in grains to the Far East. In the Continent - where some Cape Sizes are employed in the grains trades out of the US Gulf and also on trades from Santos in Brazil - Rotterdam has the infrastructure and acts as a focal point for inland distribution. Therefore big grain traders can take small Cape Size cargoes loading grain from the US Gulf. There are no such economics in Japan and China. There are no central distribution points and it is cheaper to bring the

grain directly to the end consumer. Moreover in Japan the future development of such distribution points is though to be extremely unlikely. From the discussions held on China the possibility of creating the inland infrastructure to develop central distribution points is simply an unknown, although the focus currently appears to be on developing coastal sites.

There has been considerable discussion on the likelihood or otherwise of current Canal trades switching to by pass routes in Cape Size vessels. Historically, the term 'Capesize' has been used generically to cover all vessels over 80,000 DWT. However, as the Cape Size fleet has developed the term perhaps is now more widely associated with vessels in the 120,000 to 180,000 DWT range. To avoid confusion it is probably clearer to deal with the question in terms of DWT size ranges. On the by pass trades from the Pacific Northwest to the Far East vessels up to 100,000 DWT are currently employed and we see this continuing over the study period. Trade out of North Brazil is expected to be sourced predominantly from Itacoatiara and Santarem.

Following are some comments received from a major grains trader and shipper with interests in Brazil regarding future shipments from the new Santarem terminal (detailed comments are included in the private and confidential Appendix B): "There are size limitations in the Amazon River which restrict cargos to Panamax size. While it may appear that this new facility may be able to handle very large vessels, as a practical matter that's not really the case. Presently, there is an LOA restriction of 250 meters. This will keep the max deadweight alongside to roughly 110,000 MT - a very small Cape indeed. The draft at Barra Norte – at the mouth of the Amazon River - is restricted to 37 ft 7 in fresh water. On a Cape of that size, her max DWCC on that draft would be something on the order of 66000 MT. At a stow factor of 49 cft per MT, she 'cubes out' lifting 87000 MT cargo on a sailing draft of 44 ft 6 in SW - or she would need a topoff portion of some 21000 MT. A topoff premium would probably range between USD 2.50/3.00 per MT for this size ship. In today's marketplace, Cape Size vessels are receiving distinct premia to Panamaxes and the economies of scale tend to evaporate in such an environment. As a general rule, soybeans do not travel to the Far East on Capes. There is some effort being made to transport them to the PRC (Peoples Republic of China) that way but not into Japan or South Korea - where the berthing is restricted."

For these reasons we have assumed the maximum size range for cargoes from North Brazil to the Far East is 70,000-80,000 DWT.The other issue here is 'could we see US Gulf – Far East trade being switched away from the existing Canal through use of larger vessels?' Our view is that restrictions in both the US Gulf and the Far East are likely to limit the maximum vessel size to around 100,000 DWT. The freight cost of utilizing this size on the least cost alternative route is more than that for a Panamax vessel through the existing Canal. In other words on the least cost alternative route the slight economies of scale achieved through utilization of a 100,000 DWT vessel would be more than offset by the greater mileage as compared with the Panama Canal route. As a result we do not envisage US Gulf to Far East grains trade switching to a by pass route.

### *South Korea*

There are no known plans for grains terminal or port expansions. According to Cenex Harvest States, draft restrictions in South Korea are around 41 feet or 12.4 meters. On the other hand Blue Water Shipping suggests Cape size vessels could be a more important consideration for South Korea given there is sufficient draft there.

### *Taiwan*

The grain terminal at Kaohsiung has a draft of 14.0 meters and an LOA restriction of 330 meters. According to Cenex Harvest States, generally, draft restrictions in Taiwan are 41 feet or 12.4 meters. Again, Blue Water Shipping consider Cape Size vessels would be a more important consideration to Taiwan - as compared with Japan - given sufficient draft there.

### *China*

The grain terminal at Shanghai has a draft restriction of 9.5 meters and LOA of 210 meters. At Dalian there is currently an 11.6 meters draft restriction at the terminal and a maximum LOA of 246 meters. There are plans for a possible expansion of the channel from 13 meters to 15 meters. There are draft restrictions generally in China of 11.8 to 12.5 meters. However it is felt that China will be more flexible than Japan in expanding port capacity although there is little or no solid information to support this.

While it remains very much a matter of opinion, the consensus appears to be that Cape Size vessels are more likely to appear in trades to China rather than elsewhere in the Far East. One large trader points out that much of the new crushing capacity in China is located on the water in port areas and these would be capable of taking Cape Size vessels. However, there are questions over the size limits for such vessels if they are to be suitable for major grains exporting terminals in the US Gulf and North Brazil and retain flexibility to operate and compete efficiently in the international dry bulk trades.

### *United States*

#### *Portland*

The typical dimensions of vessels loading at the Columbia Grain terminal in Portland range from about 20,000-52,000 DWT. The facility also loads Panamax vessels, ranging from 62,000-75,000 DWT. The channel depth and berth is maintained to 40 ft (12.1 meters) at low water, although Columbia River ports are sponsoring a project to deepen the channel to 43 feet (13 meters) with completion for 2006/7. The deepening is being done primarily with the container trades as the target.

Cargill's Terminal 4 is idle because the company is not handling enough volume to be using it. They are using two smaller private facilities/silos called Irving and O Dock. Channel draft to these facilities is 40 feet. Primarily food agency shipments are handled there which rely on Handy Size and Handymax vessels. However, it is apparent that many of their 20,000 DWT vessels are not filled. The port handles shipments primarily to Japan, Korea, Taiwan and the Philippines. They cannot handle Cape Size vessels because of draft, although if the channel was deeper the Terminal 4 facility could because of its handling capacity. In contrast, Cape Size vessels can be handled in Puget Sound near Seattle because of deeper draft there.

*Vancouver*

All grains cargoes loading in Vancouver for the Far East are in vessels up to Panamax but are mainly in significantly smaller sizes.

*US Gulf Coast*

The Army Corps of Engineers completed a maintenance dredging program to the channel's authorized depth of 45 feet (13.6 meters) about a year or so ago. The draft, however, is actually 47-48 feet (14.2 meters to 14.6 meters). So some of the terminals on the Lower River - generally between New Orleans and LaPlace/Convent - can accommodate small Cape Size vessels.

***Brazil***

The principal physical vessel size restriction for the Amazon ports of Santarém and Itacoatiara is the depth at the mouth of the river limiting vessel drafts to 37 feet, 11.2 meters. Consideration has been given to building an export terminal at the mouth of the Amazon but this would be very costly and would require almost continuous dredging.

- Santarém is near Manaus and is between Itacoataria and the mouth of the Amazon. It is a new facility being developed by Cargill. (See below).
- Itacoatiara is some 1,000 km up the Amazon River. Grupo Maggi, who operates the terminal, confirms that the limitation on vessel size is determined by the draft of 37 feet at the entrance to the River. The LOA at the berth is 220 meters.

As discussed above, grain loadings are in the range of 58,000-60,000 tons, typically in Panamax vessels of between 60,000 DWT and 80,000 DWT. They could partly load Cape Size vessels and top them off in Sao Luis after clearing the mouth of the Amazon. However other industry contacts have questioned the economics of such an operation (see below).

Operators at Santarem have indicated that although it may appear that the new facility at Santarém may be able to handle very large vessels as a practical matter that is not really the case. The LOA restriction of 250 meters keeps the maximum to 110,000 DWT, which is a very small Cape Size vessel. The fresh water draft at Barra Norte (mouth of the Amazon) is restricted to 37 feet 7 inches. That means for a vessel of that size, the maximum DWT carrying capacity is 66,000 MT. A stowage factor of 49 cu. feet per metric ton gives 87,000 tons of cargo on a ship of this size with a sailing draft of 44 feet 6 inches. In order to obtain this the vessel would need to top off some 21,000 tons at Sao Luis. This would cost $2.50-3.00 per ton which probably is not economic. The top off costs would be equivalent to $0.60-0.72 per ton spread over the total cargo of 87,000 tons, which could not be justified, based on the freight costs for North Brazil to the Far East.

Most exports from Brazil are in Panamax vessels, although a few medium size Capes do part load out of Santos for Europe. However none of the data we have gathered on sailings from Brazilian grains ports suggest that vessels larger than Panamax are being used to the Far East.

### *Global*

According to a large North European owner, if the Canal were expanded and vessels increased to 85,000 DWT, an Owner may prefer to keep to a 12 m draft and optimize on beam and possibly LOA. However the use of larger vessels in grains could present a problem with Silo capacity at load ports where often only 80 percent of a Panamax cargo is in place when a vessel arrives because the facilities were built for smaller vessels.

There are also some operators like this owner who see advantages in moving to smaller DWT sizes for grains. Handymax vessels of less than 50,000 DWT cannot load preferred grain cargo sizes but the new super Handies of 56,000 have excellent cubic capacity - better than older vessels. This means they can load grains cargoes of 54,000 tons. Use of smaller vessels into Japan, for example, may also reduce the number of port/terminal calls at the discharge end.

In the view of another Danish ownwer employing a Panamax through the Canal is dependent on grain shipments but the 52,000 DWT vessel is an excellent vessel for Far East receivers from the perspective of grains storage and port facilities. If a Panamax is lifting grain this is a two port discharge whereas a Handymax can get into one port. Also the Handymax can position back to the US in minor bulks which are not a Panamax trades. They find it difficult to see grains moving in a vessel of say 120,000 DWT. This is not a standard ship. Standard ships are 75,000 DWT and 170,000 DWT. Re-building the Canal to the size of an approximately 120,000 DWT vessel does not matter in their opinion. It is unlikely that ships would be built specifically for the Panama Canal. This would all center around the grains trades and in order to accommodate large vessels one would need to upgrade storage facilities, cargo handling and berths.

Agents for one of the world's largest private ship owners with Handy Size, Panamax and Cape Size vessels under commercial management - whose major trades for their Panamaxes are predominantly from the US Gulf to Far East in grains - confirm there are restrictions at the receiving ports of 230 m LOA. They do not see grain cargo sizes increasing even if the Panama Canal is expanded. (They do not believe that there has been an increase in 'super Handymaxes' going through the Canal to the Far East in grains.) Handymaxes are also deployed to West Coast S. America.

They are involved in the lifting of grains (soybeans) from the US Gulf to Europe using their small Cape Sizes. The beans are destined for animal feedstuffs. However, from the receivers' perspective, handling around 100,000 tons of soybean cargoes can create commercial and operational problems. Also, receivers are restricted on storage space. They do not see the use of small Cape Sizes as a growing trend. They do not believe that a shift to large grains cargoes of around 100,000 tons would take place even if the Canal could take larger vessels. Wheat, for example, moves in smaller vessels.

There are very few dry bulk carriers in the 120,000- 125,000 DWT size range left - probably only about ten and this company owns six of them. There are some OBOs but these have poor cubic for grain. Nobody is building in this size range any more.

While topping off may be an option for utilizing Cape Sizes, grains cargoes are not trans-shipped. The double handling, additional discharge berths or ports and the transshipment vessel or barge costs make this a completely uneconomic option.

From the perspective of a major Far East owner, the problem for shipowners is that if they carried more grain because Panama Canal restrictions were lifted they would not earn more revenue.

Vessels are being used inefficiently currently. Once restrictions are lifted there would be less demand for ships and freight rates for Owners will decrease. In other words, cargo sizes would increase to the new Panamax size but Owners would not earn more money. Nevertheless, Owners have to pay the Panama Canal toll in any circumstances because there is no alternative.
In the view of this company, if there were an expanded Canal, shipyards would market a new Panamax at 14.0 meters draft and grains cargo sizes would increase. A lot of facilities have beam restrictions at their ports; one needs to look at other cargoes, for example, from Australia to Europe; there are beam restrictions in some Italian ports. Coe Clerici has developed a special cargo handling system to get round this problem. The view was expressed that a new Panamax would be 14 meter draft with a 38 meter beam and a deadweight of around 85,000 DWT. This is an apparently different view from the previous company described above but closer to the view held by one of the Danish companies.

Finally, the Far East company confirms there has not been a lot of investment in dry bulk ports. Generally, ports are afraid to make investments for their long term benefit given the difficulty of making a financial return.

Views to date from the Delphi Panel have been mixed on the likelihood of a potential shift of grains cargoes from 40,000-60,000 DWT up to 60,000-80,000 DWT for the Existing Canal and to over 80,000 DWT for the Expanded Canal have been mixed. As for the proportions of transits in different size ranges, under the Existing Canal expectations were either for little change in current composition of rising employment of 40,00-60,000 DWT carriers at the expense of vessels below 40,000 DWT. For the Expanded Canal it could be expected that the 80,000-100,000 DWT size range would take a rising proportion of trade. One respondent felt some cargo would move in 100,000-120,000 DWT ships.

### Allocation of Future Grains Cargoes to DWT Size Ranges for the Existing and Expanded Canal

For the Existing Canal, the development of the algorithms used to determine forecasts of changes in the mix of vessel sizes have been described in an earlier section. Appendix B, Table B-1 shows the allocation of cargoes by route and DWT size range on Canal routes for the Existing Canal, Most Probable Case for selected years through to 2025. For US Gulf to Far East trades this shows in particular a continuing shift from the 60,000-70,000 DWT size range to the 70,000-80,000 DWT size range and a slight build in the 50,000-60,000 DWT range. From Brazil, growth is seen both in the 70,000-80,000 DWT and 50,000-60,000 DWT size ranges.

For the Expanded Canal these algorithms clearly required amendment. The first step was to undertake research into ships utilized for grain cargoes, in particular those into the Far East which did not transit the Panama Canal. These were used as a guide to the determination of size ranges used when the Canal is not a constraint.

These data revealed that cargoes from the US West Coast to the Far East and South East Asia were sometimes carried in ships in the 80,000-100,000 DWT ranges. For Japanese destinations, about 10 percent of cargo was carried in vessels in the 80,000-90,000 DWT range and for Other Far East and South East Asia destinations; about 5 percent was carried in each of the 80,000-90,000 and 90,000-100,000 DWT ranges. Accordingly, it was surmised that with an Expanded Canal, similar

percentages would be carried in these size ranges from North America Gulf and East regions. The grain routes were therefore categorized as follows:

- Type 1 - No change from the trends forecast for the Existing Canal;
- Type 2 - A starting point where 10 percent of cargo was allocated to vessels in the 80,000-90,000 DWT range;
- Type 3 - A starting point where 5 percent of cargo was allocated to vessels in each of 80-90,000 and 90-100,000 DWT ranges.

Type 2 routes comprised North America Gulf to Japan only. Type 3 routes comprised North America Gulf to China, South Korea, Taiwan and South East Asia plus North America East to South Korea. For Type 2 and 3 routes the following amendments were made to the method of allocating cargo to DWT size ranges:

- In 2010 all original allocations to the DWT ranges were reduced by 10 percent. For example, an allocation of 40 percent to the 70,000-80,000 DWT range would be reduced to 36 percent.
- In subsequent years this reduction was accelerated at a rate directly related to the increase in the original allocation. For example, if the 70,000-80,000 DWT range originally increased from 50 to 55 percent from 2010 to 2011, then the reduction factor would be 11 percent in 2011.

The shortfall in the percentage allocation to ship sizes was then added to the 80-100,000 DWT ranges as follows:

- 100 percent to the 80,000-90,000 DWT range for Type 2 routes
- 50 percent to the 80,000-90,000 DWT range and 50 percent to the 90,000-100,000 range for Type 3 routes.

This was repeated step wise for each subsequent year. The results are included in Appendix B, Table B-2 which shows the allocation of cargoes by route and DWT size range on Canal routes for the Expanded Canal, most probable case for selected years to 2025. For US Gulf to Far East routes, this shows the proportion of cargoes in vessel sizes of 80,000 DWT and above reaching 12 percent by 2025. The change in cargo size will be much greater than this due to the improvements in DWT utilization accompanying an Expanded Canal. For trades from North Brazil, vessel sizes are seen to remain below 80,000 DWT. If larger vessels are to be used it seems more likely that they will be from more southerly ports which do not generate Canal traffic.

## ANALYSIS OF FUTURE SHIP COSTS AND FREIGHT COSTS

This section describes the approach, methodology and the calculations used to determine freight costs for Canal, least cost alternative and by pass routes. These are essential inputs to the identification, for subsequent tasks, of the cost points at which commodity–route pairs will divert from the Canal under alternative marketing and pricing policies. The accuracy and reliability of the

freight cost analyses and forecasts are central to the credibility of the Canal forecast for grains and other dry bulk traffic and the Canal marketing and pricing analysis.

For the purpose of this study we define freight costs as the freight paid by the shipper to the ship owner or operator. While these represent the cost to the shipper these are not the same as operating costs (capital, fixed and variable) borne by the owner (see below). Capital costs comprise capital repayments plus interest charges. Fixed operating costs include manning, repairs and maintenance, insurance, stores and supplies and overheads. Variable costs cover bunkers, port charges and Canal dues, where applicable.

Estimates of freight costs—expressed in terms of US$ per cargo ton—have been developed through voyage estimates by route and deadweight (DWT) size range for:

- All vessels transiting the Canal,
- By pass routes
- Routes that represent alternatives to the Existing Canal, and
- Routes where cargo moves in vessels that could transit the Existing Canal but are precluded from so doing by current toll policies.

Estimates of freight costs are used in later sections of this study as one of the inputs to the determination of future Canal traffic demand. With an Expanded Canal, some trades which move in larger vessels will be attracted to the Canal but it is necessary to determine the relative freight costs between these, by pass, trades and Canal routes. The basis selected for calculating freight costs reflects the way in which owners and operators view their economics when deciding whether or not to use the Canal. In reviewing future seaborne freight costs, the following two elements must be considered:

- In the shipping sector it can be demonstrated that long-run costs — defined as the equivalent of fully built-up costs (capital plus fixed operating costs) for a vessel delivered in the year in question—do not equal long-run revenue. We therefore have not used this approach in forecasting transportation costs.
- Owners' decisions on whether to route ships via the Canal, when there are other options, are based generally on market freight rate levels. Utilizing the Canal saves vessel time and fuel costs but results in incurring tolls. The higher the market – and bunker prices – the greater the savings on vessel time and fuel costs from using the Canal. Also from a shippers' perspective, use of the Canal, or otherwise, affects vessel requirements that are covered, at the margin, in the spot market. Marginal economics, therefore, determine operators' routing policies. In other words, the approach is based on opportunity costs rather than actual costs when putting a value on the vessel's time.

It is also important to recognize that the relationship between vessel costs and earnings on the one hand and vessel size on the other is not linear. In the first instance the relationship reflects economies of scale as one moves up through the individual size ranges. These economies of scale are a feature of all of the main cost elements, that is, capital costs, fixed direct operating costs and

variable operating costs. This statement applies to all cargo carrying vessels including obviously the dry bulk carrier fleet. This is broadly a log relationship.

Additionally, there can be other elements that impact on the cost/earnings to size relationship. These generally center on the fact that vessel designs are not the same across all size ranges. To put this simply, a 35,000 DWT bulk carrier is not the same as say, a 70,000 DWT dry bulk carrier only half the size. For dry bulk carriers, one of the essential differences is the provision or otherwise of cargo handling gear on board the vessel. Generally, smaller vessels are geared while larger vessels are not. This type of difference in vessel design again impacts on the cost/earnings to size relationship. From a statistical perspective it could be said to distort the relationship.

The incidence of high or low port charges and also geographical variations in port times can also distort freight cost comparisons between different routes, particularly on shorter hauls.

## APPROACH TO THE DETERMINATION OF LONG TERM FREIGHT COSTS

In order to calculate the numerous freight costs by route and vessel size required in this study, Richardson Lawrie Associates have developed a Voyage Estimating Model from its own in-house system. The following sections explain the approach to the determination of long term freight costs, the relationships between operating costs and market rates and the construction of voyage estimates. The section concludes with a description of the voyage estimating model and the results.

### The Basis for the Calculation of Freight Costs

Freight rates are determined by a series of voyage calculations in which there are three essential components:

- The cost or value of the ship's time (normally expressed as the net daily return or time) charter equivalent rate;
- Bunker fuel costs;
- Port charges;

Panama Canal tolls would also be an element in determining the freight cost. However in this section of the study freight costs have been calculated without consideration of tolls so as to determine the maximum potential for Canal transits. In consideration of least cost alternative routes, which could entail transit of the Suez Canal, tolls for Suez transits have been included.

Of the three variables above, the last two are specific to each individual voyage. Bunker fuel costs are determined by bunker fuel prices, voyage length and the speed and fuel consumption characteristics of the vessel. Port charges are a function of vessel size and the ports considered. The value which is placed on the ship's time is broadly independent of the voyage performed with the possible exception of 'back-haul' voyages where owners may be prepared to accept less than general market levels in order to make a contribution to costs on what otherwise might have been a ballast voyage.

The issue then is on what basis the time value—the time charter equivalent rate—of a vessel should be determined. In the dry bulk shipping market, ship operators' decisions on whether to transit

the Canal are based on marginal economics in which the value placed on the vessel's time is determined by its potential earnings in the short term or single voyage (spot) charter market.

The answer is that is should be valued at its daily earnings potential in the market at that time. The higher the market, the greater will be the incentive for an owner to take the shorter route. This is the concept underlying the toll pricing strategy of the Suez Canal Authority. When charter market rates (freight rates) decline and therefore the value of the time saved by transiting the Canal falls, tolls are also adjusted downward to encourage operators to continue to use the Canal.

The key to our approach is therefore establishing the relationship between trends in short term charter rates and vessel operating cost levels—or more precisely the net daily return or time charter equivalent rate of vessels in relation to total fixed and capital operating costs. Owners' net daily returns are what are left as a contribution to fixed and capital costs after variable costs have been deducted from the total voyage revenue.

Reviewing historical trends, a number of issues become apparent:

- Short term charter rates are extremely volatile, being determined principally by changes in demand and supply balances in the market;
- Trends in charter rates are cyclical in nature;
- Except at times of market peaks, short term charter rates are not sufficient to cover fully built up operating costs—that is capital costs fixed operating costs (manning, repairs and maintenance, insurance, stores, spares and overheads) plus variable costs (bunkers and port charges)—and for prolonged periods may fall significantly below these levels. For this reason fully built up costs are not appropriate for the determination of long term freight costs on relevant routes.
- While not a major determinant of short term charter rates, operating costs broadly define the limits within which rates fluctuate according to supply and demand developments. At one extreme operators will not fix their ships at levels below total variable costs which—leaving Canal dues aside—equate to bunker fuel costs and port charges. The maximum charter rate is broadly determined by fully built up costs since at this point operators have an incentive to order new tonnage and as a result the tight demand and supply balance which causes high charter rates is eased as additional tonnage is delivered.

For studies of near term developments it is reasonable to attempt to determine short term charter rates on the basis of global vessel demand and supply analyses and in so doing capture potential rate fluctuations. In a long term study of this nature it is not appropriate to try and predict future cyclical trends in the market but to determine a basis for projecting the future underlying trend in short term charter rates.

To attempt to determine net daily returns (market earnings) for individual voyages based on spot market rates is not a practical proposition given the wide array of routes and ship sizes to be analyzed and the fact that rates for particular voyages may be subject to localized supply and demand balances which are short lived and not representative of underlying market levels. The alternative therefore is to select a market indicator that reflects underlying trends in the short term charter market but which

is not subject to the extreme volatility observed in individual voyage charter rates. For this purpose we have used estimates of one year time charter rates.

The dry bulk shipping market has the characteristics of a virtually perfect market with free competition. The impact of structural changes on either vessel demand or supply generally are offset within relatively short time frames by adjustments to the fleet, either through increased scrapping or the ordering of new tonnage. This means that it is totally reasonable to pattern future market trends on observations from past market behavior. In this case we have related trends in one year time charter rates to developments in operating costs—that is, the sum of fixed direct and capital costs. We have determined the underlying relationship between these two variables and also the range within which rates are likely to fluctuate.

The historical relationships of one year time charter rates to fixed operating and capital costs have been applied to forecasts of these future costs for all relevant ship sizes specified in the TOR. Factors taken into account in forecasting future fixed operating and capital costs include developments in vessel construction costs, manning, repairs and maintenance and insurance costs.

## Determination of Future Trends in Ship Operating Costs and Prices

RLA maintains a certain amount of time series data on newbuilding prices and fixed direct operating costs by main items of expense for various sizes of dry bulk carrier. These data have been supplemented by other sources. For historical data, we have obtained further information from operating companies and also used resources such as the U.S. Army Corps of Engineers' database on deep sea vessel operating costs.

Past trends in these various cost elements in relation to general levels of cost inflation are one input in the projection of future costs. However future trends in costs will be determined also by technological and structural changes which may not necessarily bear a close relationship to past developments. For example, improvements in the design and structure of dry bulk carriers for safety and environmental reasons may exert upward pressure on prices. Fixed direct operating costs may be adversely impacted by the increasingly rigorous operating standards placed on the industry or may benefit further from new technology requiring, for example, fewer crew numbers to operate vessels. Meanwhile future manning costs will be determined also by the worldwide availability of qualified seaman and the sources of supply. These considerations dictate that the assessment of future costs should largely be based on an expert driven approach, using the consultants own knowledge plus input from the market.

A discussion paper was prepared and was sent to major ship owners and operators to obtain their views on the future direction of ship newbuilding prices and costs. It described the trends apparent in prices and costs back to 1988 and requested respondents to comment on the likelihood that these trends would continue into the future. In order to project future costs, trends and analyses were developed for all vessel sizes. However since the results for each item of cost were similar and in order to keep the market survey as simple as possible a 60,000 DWT vessel was selected as being

representative[21]. The discussion paper, together with responses is included as part of this study as *Volume 3: Vessel Transit and Fleet Analysis*, Appendix C.

Historical trends in vessel prices and operating costs, by major item of expense where presented to respondents together with a lists of the factors that could affect future developments. Respondents were then invited to comment on the likelihood of various trends extending into the future and the reasons for their views. These inputs supplemented, and served as a test of, the numbers produced from our own research.

Forecasts of one year charter rates have been developed in the Vessel Earnings Estimating Module, which is part of the *Voyage Estimating Model*. Newbuilding prices are converted to annual capital costs. These are added to annual fixed operating costs and, using average historical relationships between total costs and one year time charter rates, projections of future one year time charter rates were made.

The resulting forecasts of one year time charter rates have then been combined with the forecasts of variable operating costs (bunkers and port charges) to determine future long term annual freight costs in terms of $/cargo ton, in the first instance, excluding Canal tolls.

### Methodology for Voyage Estimates

The use of voyage estimates to determine freight rates is an internationally accepted methodology used by owners and charterers. The voyage estimating model has been designed to provide the maximum flexibility in the calculation of freight rates in that some options built into the system may in fact not be required.

The voyage estimate comprises four main elements:

- The vessel hire cost is determined by multiplying the total voyage time by the daily time charter rate or net daily return. The total voyage time is calculated by dividing the voyage mileage by the vessel speed and adding the appropriate allowances for port and Canal transit times.
- Bunker costs are calculated by multiplying the daily bunker fuel consumption rates for the vessel's main and auxiliary engines at sea and in port by the respective times spent at sea and in port and by representative bunker fuel prices for the trade in question.
- Port charges are the costs incurred by the vessel at the load and discharge ports and include, for example, the costs of pilots, tugs and harbor dues (see below).
- Canal dues are the costs incurred by the vessel in transiting, for example, the Panama or Suez Canals. Initially Panama Canal dues have been excluded from our calculations with only those for Suez transits on alternative routes included where applicable.

These four elements are summed to derive the total voyage cost. The freight cost is determined by dividing this total cost by the cargo carried.

---

[21] The discussion paper, together with responses is included as part of this study as *Volume 3: Vessel Transit and Fleet Analysis*, Appendix C.

The freight rates calculated for grains in this study exclude any ballast voyage. They relate to the laden passage—including load and discharge port times—only. The results therefore will be seen to differ from spot freight rates quoted in the market. The spot freight rates reported by, for example, brokers' reports include a provision for a ballast or positioning voyage. However for the purposes of this study, as discussed previously, the important consideration is the *difference* between freight costs via the Canal and those on least cost alternative routes. The ballast voyage will be common to both options. Moreover, the precise nature of the ballast voyage will vary dependent on trade and market conditions. To include the ballast voyage in this instance is to introduce a level of spurious accuracy. The exclusion of the ballast passage is, as we understand it, also consistent with the approach adopted in the study being undertaken for ACP on the Tanker Segment

Even with the inclusion of a ballast leg, there would probably be some difference between the freight costs calculated on the basis of one year time charter rates and spot market rates. As discussed above, spot rates are more volatile than period charter rates. In high markets, spot rates could be expected to rise above one year time charter rates. In a weak market the reverse is true. Over an extended period of time, rates should average out more closely and it is for this reason that one year time charter rates are chosen to represent market levels over the long term. Again, the approach used in the tanker study, as we understand it, would appear to be consistent with this.

## VOYAGE ESTIMATING MODEL

### Description of the Model Inputs

The *Voyage Estimating Model* has been developed in Microsoft Access in order to calculate freight rates as required in:

- the determination of the economic value of the Canal;
- the comparison of freight costs on Canal, by pass and alternative routes;

Below is a list the individual components that comprise the determination of one year time charter rates and voyage estimates. RLA maintains its own databases on, for example, charter rates, bunker prices, port charges and port times. This information has been supplemented by further market research. As part of the model, input tables have been developed for each of these cost elements and data input for base year 2000—and in some cases 2001 and 2002—as follows:
All cost inputs to the model are in terms of nominal US dollars and various escalation factors have been built into the model to project future costs in nominal dollars. The model outputs provide for freight costs expressed in both nominal dollars and real 2002 dollars. Freight costs are produced for individual routes for Canal, by pass and least cost alternative routes (which are selected automatically by the model from series of calculations run for Cape Horn, Cape of Good Hope and Suez Canal alternatives).

- Fixed Operating Costs. Data on fixed direct costs covers manning, repairs and maintenance, insurance, stores and spares, management fee and overheads. These data are compiled directly from owners' and operators' actual cost data.

- One Year Time Charter Rates (Table 4-7).
- Dry Bulk Cargoes. Average dry bulk cargo sizes are determined in the Transit Model (see Section 5) through the application of utilization factors to average DWT by size range. The size distributions by route are also input from the Transit Model and vary, dependent upon the level of trade on individual routes.
- Bunker Prices.
- Mileages.
- Port Charges. Port charges by size range have been determined for a range of representative grains ports within the specified regions. Data have been assembled from information received directly from ship agents worldwide as published tariffs, even if available, generally do not include all the elements of the port charges. Significant variation in calculation and terminology of these elements was observed across different ports around the world.
- Port Times. Details of typical port times by port and vessel size were obtained from port agents as part of the exercise above.
- Vessel Characteristics. This includes PCUMS, Suez Canal Net Tonnage (SCNT), laden and ballast speeds, bunker consumption at sea (laden and ballast) and bunker consumption in port for modern vessels by DWT size range.
- Canal Transit Times
- Canal Tolls. Two separate tables have been developed for the calculation of Panama and Suez Canal tolls. Information on the formulae for calculating Suez Canal tolls has been obtained from vessel owners transiting the Canal. In the voyage estimating model provision has been made for either including or excluding Panama Canal tolls.
- Port Description Table. A table has been developed which links port name with a Sequence Code in the voyage estimating model, the UN port code, the ACP country code, country abbreviation and country name, the ACP region code and name.

**Table 4-7 Projections of One Year Time Charter Rates (Nominal $/day)**

| Vessel Size Range (000 DWT) | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|
| 0 to 10k | 3,848 | 4,932 | 5,618 | 6,320 | 7,035 | 7,761 |
| 10 to 15k | 4,260 | 5,764 | 6,567 | 7,388 | 8,224 | 9,073 |
| 15 to 20k | 6,042 | 6,304 | 7,177 | 8,071 | 8,982 | 9,908 |
| 20 to 25k | 6,262 | 6,781 | 7,717 | 8,674 | 9,652 | 10,645 |
| 25 to 30k | 6,459 | 7,258 | 8,256 | 9,278 | 10,321 | 11,382 |
| 30 to 40k | 6,759 | 7,867 | 8,947 | 10,053 | 11,182 | 12,329 |
| 40 to 50k | 7,177 | 8,222 | 9,343 | 10,492 | 11,665 | 12,858 |
| 50 to 60k | 7,432 | 8,526 | 9,689 | 10,881 | 12,097 | 13,334 |
| 60 to 70k | 8,135 | 8,915 | 10,132 | 11,378 | 12,650 | 13,942 |
| 70 to 80k | 8,309 | 9,342 | 10,618 | 11,925 | 13,258 | 14,613 |
| 80 to 90k | 8,852 | 10,204 | 11,594 | 13,018 | 14,471 | 15,948 |
| 90 to 100k | 9,097 | 11,232 | 12,758 | 14,321 | 15,916 | 17,538 |
| 100 to 110k | 9,606 | 12,050 | 13,685 | 15,360 | 17,070 | 18,809 |
| 110 to 120k | 10,014 | 12,647 | 14,365 | 16,124 | 17,920 | 19,745 |
| 120 to 150k | 11,232 | 13,343 | 15,155 | 17,011 | 18,906 | 20,831 |
| 150 to 170k | 11,813 | 13,676 | 15,536 | 17,440 | 19,384 | 21,359 |
| 170 to 200k | 12,393 | 14,380 | 16,338 | 18,343 | 20,389 | 22,467 |
| 200 to 230k | 13,989 | 14,877 | 16,906 | 18,982 | 21,100 | 23,252 |
| 230 to 250k | 15,116 | 15,357 | 17,453 | 19,598 | 21,786 | 24,009 |
| 250 to 300k | 15,932 | 15,837 | 18,000 | 20,213 | 22,471 | 24,765 |
| 300+k | 18,381 | 16,316 | 18,547 | 20,829 | 23,157 | 25,522 |

Source: Richardson Lawrie Associates

## Results of Freight Costs Calculations

Freight costs by vessel size and trade have been calculated for all grains movements involving transit of the Panama Canal (excluding tolls) together with the costs for alternative routes and by pass routes via the Suez Canal, Cape of Good Hope and Cape Horn for all years from 2000 through 2025. The main differences in the rates between the Existing and Expanded Canals are, of course, the use of larger vessels on certain routes and improved utilization in the latter case.

The results of the freight cost calculations are shown Table 4-8 through Table 4-13. The main conclusions—expressed in terms of $2002—when Panama Canal tolls are excluded are presented below for the Existing Canal and Expanded Canal scenarios.

### *Existing Canal*

The main conclusions – expressed in terms of $2002 - when Panama Canal tolls are excluded are as follows:

- In comparing the Canal with least cost alternative routes under Existing Canal conditions, weighted average freight costs from the US Gulf to the Far East through the Canal have an approximately $2.65 per ton to $5.00 per ton advantage.

- The greatest saving is for Japan, then South Korea, China and Taiwan. By contrast, a similar comparison for exports from North Brazil indicates differentials in favor of the Canal ranging from just $0.16 per ton to $2.50 per ton.
- For exports to S E Asia from the US Gulf the Canal enjoys an advantage of between $0.10 per ton and about $2.40 per ton although only into the Philippines is the differential significant and for Malaysia the Canal would not be the favored route even at zero tolls.
- For North Brazil the Canal is not competitive at all for exports to South East Asia. Not surprisingly, the Canal is most competitive for relatively short hauls on intra W Hemisphere trades.

### *Expanded Canal*

For the Expanded Canal the conclusions tend to be broadly the same, except that the differentials are, if anything, slightly smaller.

- Expansion of the Panama Canal would reduce weighted average freight costs from the US Gulf to the Far East by between $1.00 per ton and $1.60 per ton. Similar reductions would be seen from the US Gulf to South East Asia. These generally represent the greatest savings offered by an Expanded Canal. Freight costs from Brazil to the Far East would be reduced by around $0.50 per ton.
- The Expanded Canal permits two things to happen. Firstly it creates the opportunity to employ larger vessels. By virtue of the economies of scale this acts to reduce the freight cost, provided that DWT utilization levels (cargo to DWT ratios) are maintained. For vessels above 60,000 DWT, which already transit the Canal laden, there is the opportunity to increase utilization levels due to the deeper draft on the Canal. This would also reduce freight costs. Therefore because it is assumed that an Expanded Canal would result in the employment of larger vessels and improved utilization of existing vessels transiting the Canal, freight costs would fall.
- Freight costs for larger vessels expected to be deployed on Canal routes under the Expanded Canal scenario need to be compared with the freight costs for these same vessels using the non-Canal alternative routing. Hence, the estimates of freight costs for the non-Canal least cost alternative routes also fall under the Expanded Canal scenario due to the economies of scale element mentioned above. The exception to this is in the case of by pass routes where both vessel sizes and utilization levels are already higher than those for Canal routes. In these cases, the shipping economics for by pass routes are unchanged between the Existing and Expanded Canal cases.
- Looking at differentials between some of the key trades, freight costs from North Brazil to Japan are between $1.14 per ton and $1.45 per ton higher than those from the US Gulf and this widens to a differential of up to $2.22 per ton under the Expanded Canal. Comparing freight costs from the US Gulf to Japan to those from the US West Coast to Japan, indicates a saving of $2.66 per ton to $3.34 per ton from the Pacific North West under Existing Canal conditions and a saving of almost $2.00 per ton under Expanded Canal assumptions.

As discussed earlier in this section, the freight costs calculated here are designed to capture the expected long term underlying trend. It is recognized that over the course of the study period, the

market will fluctuate above and below this trend and as a result the difference in freight costs between Canal and least cost alternative routes will vary. To provide an indication of the sensitivity of the Canal's competitive position versus least cost alternative routes we have assessed the impact of different freight market conditions with reference to market conditions over the period from 1995 to 2002. The real implications over these variations might not impact the trade, but depending on the level of Canal tolls, transits could be diverted or tolls adjusted to take advantage of short term changes in the economic value of the Canal.

For the trade from the North America Gulf (USG) to Japan we have calculated the differentials over the period from 1995 to 2002 based on both average spot earnings and one year time charter rates. The results are as follows:

| Basis of Calculation | Spot Market Earnings | | | One Year Time Charter Rates | | |
|---|---|---|---|---|---|---|
| | Via Panama[1)] | Via CGH | Diff | Via Panama[1)] | Via CGH | Diff |
| | | | | | | $/ton |
| 1995 | 32.71 | 40.32 | 7.61 | 22.47 | 26.82 | 4.34 |
| 1996 | 23.81 | 28.60 | 4.79 | 18.50 | 21.60 | 3.10 |
| 1997 | 23.25 | 27.67 | 4.42 | 19.00 | 22.07 | 3.06 |
| 1998 | 15.47 | 17.27 | 1.80 | 14.88 | 16.50 | 1.62 |
| 1999 | 18.18 | 20.77 | 2.58 | 16.51 | 18.56 | 2.04 |
| 2000 | 23.00 | 27.25 | 4.25 | 21.27 | 24.97 | 3.70 |
| 2001 | 20.22 | 23.49 | 3.27 | 18.00 | 20.55 | 2.55 |
| 2002 | 21.04 | 24.49 | 3.45 | 18.04 | 20.41 | 2.37 |

[1)] Including Panama Canal Tolls

Source: Richardson Lawrie Associates

From the above table it can be seen that, on the basis of spot market earnings, the differential between the Canal and the Cape route varied from $7.61/ton in a high market down to $1.80/ton in a low market. This includes Canal tolls, without which the figures would be $9.17/ton and $3.50/ton respectively. These latter differentials are equivalent to $13.29/PCUMS and $3.15/PCUMS.
Due to the less volatile nature of one year time charter rates the annual differentials do not vary over such a wide range. If tolls are included in the comparison, the range is from $4.34/ton down to 1.62/ton. With the exclusion of tolls, the figures are $5.91/ton and $3.31/ton respectively.
The magnitude of the differential has a potential impact on the levels of tolls that could be sustained by the Canal and also volume of trade that might be attracted towards or away from the Canal. These issues are examined further in the Final Report, Volume 5. However the impact on the Canal's competitive position will vary dependent on the toll pricing policy from which one is starting.

**Table 4-8. Weighted Average Ocean Freight Rates for Existing Canal, North West America - Pacific Routes, Selected Years 2001-2025, Most Probable Case (2002$ per ton)**

| Origin Region | Origin Port | Destination Region | Destination Port | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|---|
| Canada West | Vancouver | Japan | Yokohama | 12.73 | 12.61 | 12.76 | 12.93 | 13.11 | 13.31 |
| Canada West | Vancouver | China | Shanghai | 11.85 | 11.70 | 11.86 | 12.05 | 12.26 | 12.48 |
| Canada West | Vancouver | S Korea | Ulsan | 10.70 | 10.57 | 10.72 | 10.89 | 11.08 | 11.29 |
| Canada West | Vancouver | Taiwan | Kaohsiung | 12.45 | 12.29 | 12.48 | 12.69 | 12.92 | 13.17 |
| US West | Portland | Japan | Yokohama | 11.21 | 10.75 | 10.85 | 10.96 | 11.07 | 11.19 |
| US West | Portland | China | Shanghai | 10.07 | 9.95 | 10.05 | 10.17 | 10.29 | 10.43 |
| US West | Portland | S Korea | Ulsan | 9.24 | 9.13 | 9.23 | 9.33 | 9.45 | 9.57 |
| US West | Portland | Taiwan | Kaohsiung | 10.44 | 10.33 | 10.45 | 10.58 | 10.72 | 10.87 |
| Canada West | Vancouver | Indonesia | Jakarta | 20.70 | 20.50 | 20.78 | 21.10 | 21.43 | 21.80 |
| Canada West | Vancouver | Malaysia | Port Kelang | 16.48 | 16.27 | 16.51 | 16.79 | 17.08 | 17.41 |
| Canada West | Vancouver | Philipines | Manila | 14.30 | 14.13 | 14.33 | 14.56 | 14.80 | 15.08 |
| Canada West | Vancouver | Singapore | Singapore | 16.32 | 16.11 | 16.35 | 16.61 | 16.90 | 17.22 |
| Canada West | Vancouver | Thailand | Ko Sichang | 15.69 | 15.48 | 15.71 | 15.97 | 16.26 | 16.58 |
| US West | Portland | Indonesia | Jakarta | 17.43 | 16.73 | 16.92 | 17.11 | 17.32 | 17.54 |
| US West | Portland | Malaysia | Port Kelang | 13.98 | 13.39 | 13.54 | 13.71 | 13.90 | 14.10 |
| US West | Portland | Philipines | Manila | 12.49 | 11.97 | 12.10 | 12.24 | 12.39 | 12.56 |
| US West | Portland | Singapore | Singapore | 14.16 | 13.57 | 13.72 | 13.89 | 14.07 | 14.26 |
| US West | Portland | Thailand | Ko Sichang | 12.99 | 12.41 | 12.55 | 12.71 | 12.89 | 13.08 |

Source: Richardson Lawrie Associates

**Table 4-9. Weighted Average Ocean Freight Rates Canal Tolls for Existing Canal, Via Panama Canal, Selected Years 2001-2025, Most Probable Case (2002$ per ton)**

| Origin Region | Origin Port | Destination Region | Destination Port | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|---|
| North America Gulf | New Orleans | Japan | Yokohama | 13.86 | 13.87 | 13.94 | 14.12 | 14.31 | 14.52 |
| North America Gulf | New Orleans | China | Shanghai | 11.73 | 11.70 | 11.79 | 11.96 | 12.15 | 12.35 |
| North America Gulf | New Orleans | S Korea | Ulsan | 11.18 | 11.16 | 11.24 | 11.40 | 11.58 | 11.78 |
| North America Gulf | New Orleans | Taiwan | Kaohsiung | 11.93 | 11.96 | 12.12 | 12.31 | 12.51 | 12.73 |
| North America East | Port Cartier | Japan | Yokohama | 15.74 | 15.16 | 14.18 | 14.27 | 14.33 | 14.41 |
| North America East | Port Cartier | China | Shanghai | 11.26 | 11.18 | 11.35 | 11.55 | 11.77 | 12.02 |
| North America East | Port Cartier | S Korea | Ulsan | 10.51 | 10.45 | 10.59 | 10.77 | 10.98 | 11.21 |
| North America East | Port Cartier | Taiwan | Kaohsiung | 11.50 | 11.42 | 11.54 | 11.75 | 11.99 | 12.25 |
| Brazil | Salvador | Japan | Yokohama | 15.03 | 15.00 | 15.19 | 15.42 | 15.68 | 15.98 |
| Brazil | Rio Grande | Japan | Yokohama | 16.22 | 16.19 | 16.39 | 16.65 | 16.94 | 17.26 |
| North America East | Port Cartier | Central America West | Acajutla | 9.04 | 8.87 | 8.87 | 8.86 | 9.14 | 9.56 |
| North America East | Port Cartier | South America West | Guayaquil | 8.26 | 8.13 | 8.62 | 8.82 | 9.36 | 10.11 |
| North America East | Port Cartier | South East Asia | Jakarta | 21.49 | 21.59 | 21.96 | 22.26 | 22.63 | 23.06 |
| North America East | Port Cartier | South East Asia | Port Kelang | 17.78 | 17.76 | 18.12 | 18.38 | 18.74 | 19.15 |
| North America East | Port Cartier | South East Asia | Manila | 15.84 | 15.82 | 16.13 | 16.36 | 16.67 | 17.03 |
| North America East | Port Cartier | South East Asia | Singapore | 17.44 | 17.42 | 17.76 | 18.02 | 18.36 | 18.76 |
| North America East | Port Cartier | South East Asia | Ko Sichang | 16.54 | 16.50 | 16.81 | 17.04 | 17.36 | 17.74 |
| North America Gulf | New Orleans | North America West | Portland | 10.75 | 10.82 | 10.92 | 11.02 | 11.14 | 11.26 |
| North America Gulf | New Orleans | Central America West | Acajutla | 9.27 | 9.16 | 9.03 | 8.98 | 9.16 | 9.50 |
| North America Gulf | New Orleans | South America West | Guayaquil | 8.24 | 8.10 | 7.95 | 7.91 | 8.05 | 8.29 |
| North America Gulf | New Orleans | Oceania | Melbourne | 14.79 | 14.65 | 14.69 | 14.84 | 15.10 | 15.40 |
| North America Gulf | New Orleans | South East Asia | Jakarta | 19.34 | 19.45 | 19.40 | 19.57 | 19.74 | 19.93 |
| North America Gulf | New Orleans | South East Asia | Port Kelang | 16.40 | 16.47 | 16.48 | 16.67 | 16.86 | 17.09 |
| North America Gulf | New Orleans | South East Asia | Manila | 14.68 | 14.74 | 14.74 | 14.90 | 15.07 | 15.26 |
| North America Gulf | New Orleans | South East Asia | Singapore | 16.25 | 16.33 | 16.36 | 16.54 | 16.74 | 16.95 |
| North America Gulf | New Orleans | South East Asia | Ko Sichang | 15.07 | 15.11 | 15.06 | 15.22 | 15.38 | 15.57 |
| South America East | San Lorenzo | South America West | Guayaquil | 20.74 | 9.97 | 9.64 | 9.70 | 9.80 | 9.92 |
| South America East | Salvador | South America West | Guayaquil | 14.49 | 7.41 | 7.21 | 7.27 | 7.35 | 7.44 |
| South America East | Rio Grande | South America West | Guayaquil | 17.48 | 8.71 | 8.46 | 8.53 | 8.63 | 8.75 |
| Europe | Dunkirk | North America West | Portland | 13.39 | 13.58 | 13.75 | 13.94 | 14.15 | 14.39 |
| Europe | Dunkirk | Central America West | Acajutla | 10.06 | 10.33 | 10.41 | 10.52 | 10.59 | 10.57 |
| Europe | Dunkirk | South America West | Guayaquil | 10.95 | 10.10 | 9.96 | 9.98 | 10.19 | 10.51 |
| North America West | Vancouver | North America East | Port Cartier | 11.79 | 11.94 | 12.13 | 12.34 | 12.56 | 12.82 |
| North America West | Vancouver | North America Gulf | New Orleans | 12.37 | 12.39 | 12.52 | 12.68 | 12.86 | 13.05 |
| North America West | Vancouver | Central America East | Veracruz | 12.61 | 12.63 | 12.81 | 13.02 | 13.24 | 13.49 |
| North America West | Vancouver | South America East | Rio Grande | 17.64 | 18.09 | 18.40 | 18.77 | 19.18 | 19.69 |
| North America West | Vancouver | South America East | Puerto Cabello | 13.91 | 14.31 | 14.52 | 14.76 | 15.03 | 15.35 |
| North America West | Vancouver | Caribbean Basin | Rio Haina | 17.06 | 17.02 | 17.26 | 17.52 | 17.78 | 18.07 |
| North America West | Vancouver | Europe | Rotterdam | 15.70 | 15.51 | 15.71 | 15.95 | 16.20 | 16.48 |
| North America West | Vancouver | Africa | Algiers | 12.49 | 12.54 | 12.67 | 12.83 | 13.01 | 13.19 |
| North America West | Vancouver | Middle East | Tartous | 20.15 | 19.96 | 20.29 | 20.66 | 21.07 | 21.53 |
| Central America West | Manzanillo | Central America East | Veracruz | 9.69 | 9.83 | 9.97 | 10.13 | 10.30 | 10.49 |
| Central America West | Manzanillo | South America East | Rio Grande | 21.87 | 24.32 | 24.75 | 25.23 | 25.75 | 26.34 |
| Central America West | Manzanillo | South America East | Puerto Cabello | 15.07 | 16.77 | 17.01 | 17.27 | 17.54 | 17.84 |
| Central America West | Manzanillo | Africa | Algiers | 14.55 | 14.62 | 14.86 | 15.14 | 15.45 | 15.79 |
| South America West | Matarani | North America East | Port Cartier | 12.97 | 12.88 | 13.08 | 13.31 | 13.54 | 13.80 |
| South America West | Matarani | Central America East | Veracruz | 13.40 | 13.10 | 13.28 | 13.48 | 13.70 | 13.93 |
| South America West | Matarani | South America East | Rio Grande | 19.77 | 20.42 | 20.80 | 21.21 | 21.67 | 22.19 |
| South America West | Matarani | South America East | Puerto Cabello | 14.53 | 15.00 | 15.22 | 15.45 | 15.69 | 15.97 |
| South America West | Matarani | Caribbean Basin | Rio Haina | 16.53 | 16.16 | 16.37 | 16.59 | 16.82 | 17.06 |

## Table 4-9 (continued)

| Origin Region | Origin Port | Destination Region | Destination Port | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|---|
| Far East | Dalian | Caribbean Basin | Rio Haina | 27.22 | 26.54 | 27.01 | 27.54 | 28.12 | 28.78 |
| South East Asia | Haiphong | South America East | Puerto Cabello | 37.06 | 35.60 | 36.15 | 36.75 | 37.39 | 38.11 |
| South East Asia | Haiphong | Caribbean Basin | Rio Haina | 29.58 | 29.93 | 30.35 | 30.80 | 31.28 | 31.82 |
| Brazil | Itacoatiara | Japan | Yokohama | 14.24 | 14.22 | 14.39 | 14.61 | 14.85 | 15.13 |
| Brazil | Rio Grande | Japan | Yokohama | 16.22 | 16.19 | 16.39 | 16.65 | 16.94 | 17.26 |
| Brazil | Itacoatiara | China | Shanghai | 12.77 | 12.71 | 12.87 | 13.09 | 13.33 | 13.61 |
| Brazil | Rio Grande | China | Shanghai | 14.75 | 14.68 | 14.87 | 15.13 | 15.41 | 15.75 |
| Brazil | Itacoatiara | S Korea | Ulsan | 11.94 | 11.90 | 12.05 | 12.26 | 12.49 | 12.76 |
| Brazil | Rio Grande | S Korea | Ulsan | 13.93 | 13.86 | 14.05 | 14.29 | 14.57 | 14.89 |
| Brazil | Itacoatiara | Taiwan | Kaohsiung | 13.07 | 13.02 | 13.20 | 13.43 | 13.68 | 13.97 |
| Brazil | Rio Grande | Taiwan | Kaohsiung | 15.05 | 14.99 | 15.20 | 15.46 | 15.77 | 16.11 |
| Brazil | Itacoatiara | South America West | Guayaquil | 12.20 | 6.36 | 6.20 | 6.21 | 6.26 | 6.33 |

Source: Richardson Lawrie Associates

**Table 4-10 Weighted Average Ocean Freight Rates Excluding Panama Canal Tolls for Existing Canal, Least Cost Alternative and By Pass Routes, by Vessel Size, Selected Years 2001-2025, Most Probable Case (2002$ per ton)**

| Origin Region | Origin Port | Destination Region | Destination Port | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|---|
| North America Gulf | New Orleans | Japan | Yokohama | 18.68 | 18.65 | 18.73 | 19.00 | 19.29 | 19.61 |
| North America Gulf | New Orleans | China | Shanghai | 15.16 | 15.11 | 15.23 | 15.48 | 15.74 | 16.03 |
| North America Gulf | New Orleans | S Korea | Ulsan | 15.30 | 15.26 | 15.37 | 15.61 | 15.88 | 16.19 |
| North America Gulf | New Orleans | Taiwan | Kaohsiung | 14.58 | 14.60 | 14.80 | 15.04 | 15.30 | 15.59 |
| North America East | Port Cartier | Japan | Yokohama | 20.11 | 19.26 | 17.83 | 17.94 | 18.00 | 18.09 |
| North America East | Port Cartier | China | Shanghai | 13.32 | 13.22 | 13.42 | 13.66 | 13.93 | 14.24 |
| North America East | Port Cartier | S Korea | Ulsan | 13.17 | 13.08 | 13.26 | 13.50 | 13.76 | 14.06 |
| North America East | Port Cartier | Taiwan | Kaohsiung | 12.77 | 12.67 | 12.81 | 13.05 | 13.31 | 13.61 |
| Brazil | Salvador | Japan | Yokohama | 15.06 | 15.04 | 15.22 | 15.46 | 15.72 | 16.01 |
| Brazil | Rio Grande | Japan | Yokohama | 14.41 | 14.39 | 14.57 | 14.79 | 15.04 | 15.31 |
| North America East | Port Cartier | Central America West | Acajutla | 19.57 | 19.11 | 19.22 | 19.28 | 20.04 | 21.13 |
| North America East | Port Cartier | South America West | Guayaquil | 16.93 | 16.60 | 17.73 | 18.18 | 19.43 | 21.16 |
| North America East | Port Cartier | South East Asia | Jakarta | 19.70 | 19.81 | 20.14 | 20.41 | 20.74 | 21.12 |
| North America East | Port Cartier | South East Asia | Port Kelang | 15.70 | 15.69 | 16.00 | 16.23 | 16.54 | 16.91 |
| North America East | Port Cartier | South East Asia | Manila | 16.73 | 16.70 | 17.03 | 17.27 | 17.60 | 17.99 |
| North America East | Port Cartier | South East Asia | Singapore | 16.14 | 16.13 | 16.45 | 16.68 | 17.00 | 17.36 |
| North America East | Port Cartier | South East Asia | Ko Sichang | 15.95 | 15.91 | 16.21 | 16.43 | 16.74 | 17.10 |
| North America Gulf | New Orleans | North America West | Portland | 16.82 | 16.93 | 17.13 | 17.37 | 17.62 | 17.91 |
| North America Gulf | New Orleans | Central America West | Acajutla | 20.49 | 20.16 | 20.06 | 20.06 | 20.74 | 21.87 |
| North America Gulf | New Orleans | South America West | Guayaquil | 18.02 | 17.62 | 17.38 | 17.34 | 17.81 | 18.56 |
| North America Gulf | New Orleans | Oceania | Melbourne | 18.31 | 18.11 | 18.17 | 18.37 | 18.71 | 19.11 |
| North America Gulf | New Orleans | South East Asia | Jakarta | 19.44 | 19.54 | 19.50 | 19.67 | 19.84 | 20.03 |
| North America Gulf | New Orleans | South East Asia | Port Kelang | 16.26 | 16.33 | 16.34 | 16.53 | 16.72 | 16.94 |
| North America Gulf | New Orleans | South East Asia | Manila | 17.02 | 17.08 | 17.06 | 17.26 | 17.45 | 17.68 |
| North America Gulf | New Orleans | South East Asia | Singapore | 16.77 | 16.85 | 16.87 | 17.06 | 17.26 | 17.49 |
| North America Gulf | New Orleans | South East Asia | Ko Sichang | 16.18 | 16.21 | 16.16 | 16.34 | 16.51 | 16.72 |
| South America East | San Lorenzo | South America West | Guayaquil | 16.84 | 8.25 | 7.98 | 8.03 | 8.10 | 8.18 |
| South America East | Salvador | South America West | Guayaquil | 17.68 | 8.77 | 8.52 | 8.59 | 8.69 | 8.81 |
| South America East | Rio Grande | South America West | Guayaquil | 14.71 | 7.48 | 7.28 | 7.34 | 7.41 | 7.51 |
| Europe | Dunkirk | North America West | Portland | 18.12 | 18.38 | 18.64 | 18.93 | 19.26 | 19.63 |
| Europe | Dunkirk | Central America West | Acajutla | 16.07 | 16.48 | 16.62 | 16.83 | 16.96 | 16.97 |
| Europe | Dunkirk | South America West | Guayaquil | 17.07 | 15.60 | 15.41 | 15.46 | 15.84 | 16.42 |
| North America West | Vancouver | North America East | Port Cartier | 20.31 | 20.55 | 20.89 | 21.28 | 21.72 | 22.21 |
| North America West | Vancouver | North America Gulf | New Orleans | 22.55 | 22.53 | 22.83 | 23.20 | 23.61 | 24.07 |
| North America West | Vancouver | Central America East | Veracruz | 24.43 | 24.37 | 24.77 | 25.24 | 25.75 | 26.33 |
| North America West | Vancouver | South America East | Rio Grande | 16.48 | 16.90 | 17.19 | 17.53 | 17.91 | 18.37 |
| North America West | Vancouver | South America East | Puerto Cabello | 24.90 | 25.58 | 26.03 | 26.54 | 27.12 | 27.82 |
| North America West | Vancouver | Caribbean Basin | Rio Haina | 28.76 | 28.57 | 29.04 | 29.57 | 30.13 | 30.75 |
| North America West | Vancouver | Europe | Rotterdam | 22.43 | 22.11 | 22.41 | 22.77 | 23.17 | 23.59 |
| North America West | Vancouver | Africa | Algiers | 16.83 | 16.79 | 16.98 | 17.21 | 17.46 | 17.72 |
| North America West | Vancouver | Middle East | Tartous | 27.02 | 26.75 | 27.20 | 27.72 | 28.30 | 28.94 |
| Central America West | Manzanillo | Central America East | Veracruz | 21.81 | 22.06 | 22.44 | 22.90 | 23.41 | 23.97 |
| Central America West | Manzanillo | South America East | Rio Grande | 20.12 | 22.37 | 22.75 | 23.18 | 23.66 | 24.19 |
| Central America West | Manzanillo | South America East | Puerto Cabello | 33.74 | 37.69 | 38.35 | 39.09 | 39.90 | 40.79 |
| Central America West | Manzanillo | Africa | Algiers | 21.53 | 21.61 | 21.98 | 22.43 | 22.92 | 23.49 |
| South America West | Matarani | North America East | Port Cartier | 20.32 | 20.15 | 20.50 | 20.90 | 21.33 | 21.80 |
| South America West | Matarani | Central America East | Veracruz | 15.76 | 15.39 | 15.62 | 15.87 | 16.15 | 16.46 |
| South America West | Matarani | South America East | Rio Grande | 13.40 | 13.81 | 14.03 | 14.27 | 14.54 | 14.84 |
| South America West | Matarani | South America East | Puerto Cabello | 24.80 | 25.67 | 26.13 | 26.64 | 27.19 | 27.82 |

**Table 4-10 (continued)**

| Origin Region | Origin Port | Destination Region | Destination Port | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|---|
| South America West | Matarani | Caribbean Basin | Rio Haina | 26.80 | 26.14 | 26.54 | 27.00 | 27.49 | 28.03 |
| Far East | Dalian | Caribbean Basin | Rio Haina | 35.44 | 34.48 | 35.13 | 35.86 | 36.67 | 37.60 |
| South East Asia | Haiphong | South America East | Puerto Cabello | 40.19 | 38.58 | 39.19 | 39.86 | 40.57 | 41.38 |
| South East Asia | Haiphong | Caribbean Basin | Rio Haina | 32.12 | 32.47 | 32.93 | 33.44 | 33.98 | 34.59 |
| Brazil | Itacoatiara | Japan | Yokohama | 16.56 | 16.53 | 16.73 | 17.00 | 17.29 | 17.63 |
| Brazil | Rio Grande | Japan | Yokohama | 14.41 | 14.39 | 14.57 | 14.79 | 15.04 | 15.31 |
| Brazil | Itacoatiara | China | Shanghai | 13.78 | 13.71 | 13.89 | 14.12 | 14.39 | 14.69 |
| Brazil | Rio Grande | China | Shanghai | 12.39 | 12.34 | 12.49 | 12.70 | 12.93 | 13.20 |
| Brazil | Itacoatiara | S Korea | Ulsan | 13.61 | 13.55 | 13.72 | 13.97 | 14.24 | 14.55 |
| Brazil | Rio Grande | S Korea | Ulsan | 12.14 | 12.09 | 12.24 | 12.45 | 12.69 | 12.96 |
| Brazil | Itacoatiara | Taiwan | Kaohsiung | 13.22 | 13.18 | 13.36 | 13.59 | 13.85 | 14.15 |
| Brazil | Rio Grande | Taiwan | Kaohsiung | 11.84 | 11.81 | 11.96 | 12.17 | 12.39 | 12.65 |
| Brazil | Itacoatiara | South America West | Guayaquil | 20.52 | 9.89 | 9.57 | 9.61 | 9.70 | 9.83 |

Source: Richardson Lawrie Associates

## Table 4-11. Least Cost Alternative Routes Existing Canal - 2002

| | | | | Vessel Size Range (000 DWT) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 to | 10 to | 15 to | 20 to | 25 to | 30 to | 40 to | 50 to | 60 to | 70 to | 80 to | 90 to |
| Origin Region | Origin Port | Destination Region | Destination Port | 10k | 15k | 20k | 25k | 30k | 40k | 50k | 60k | 70k | 80k | 90k | 100k |
| North America Gulf | New Orleans | Japan | Yokohama | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | China | Shanghai | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | S Korea | Ulsan | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | Taiwan | Kaohsiung | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | Japan | Yokohama | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | China | Shanghai | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | S Korea | Ulsan | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | Taiwan | Kaohsiung | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Salvador | Japan | Yokohama | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Rio Grande | Japan | Yokohama | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America East | Port Cartier | Central America West | Acajutla | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America East | Port Cartier | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America East | Port Cartier | South East Asia | Jakarta | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | South East Asia | Port Kelang | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | South East Asia | Manila | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | South East Asia | Singapore | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | South East Asia | Ko Sichang | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | North America West | Portland | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America Gulf | New Orleans | Central America West | Acajutla | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America Gulf | New Orleans | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America Gulf | New Orleans | Oceania | Melbourne | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America Gulf | New Orleans | South East Asia | Jakarta | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | South East Asia | Port Kelang | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | South East Asia | Manila | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | South East Asia | Singapore | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | South East Asia | Ko Sichang | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| South America East | San Lorenzo | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America East | Salvador | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America East | Rio Grande | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Europe | Dunkirk | North America West | Portland | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Europe | Dunkirk | Central America West | Acajutla | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Europe | Dunkirk | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | North America East | Port Cartier | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | North America Gulf | New Orleans | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | Central America East | Veracruz | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | South America East | Rio Grande | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | South America East | Puerto Cabello | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | Caribbean Basin | Rio Haina | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | Europe | Rotterdam | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | Africa | Algiers | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | Middle East | Tartous | S | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Central America West | Manzanillo | Central America East | Veracruz | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Central America West | Manzanillo | South America East | Rio Grande | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Central America West | Manzanillo | South America East | Puerto Cabello | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Central America West | Manzanillo | Africa | Algiers | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America West | Matarani | North America East | Port Cartier | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America West | Matarani | Central America East | Veracruz | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America West | Matarani | South America East | Rio Grande | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America West | Matarani | South America East | Puerto Cabello | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America West | Matarani | Caribbean Basin | Rio Haina | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Far East | Dalian | Caribbean Basin | Rio Haina | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |

## Table 4-11 (continued)

| Origin Region | Origin Port | Destination Region | Destination Port | Vessel Size Range (000 DWT) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 to 10k | 10 to 15k | 15 to 20k | 20 to 25k | 25 to 30k | 30 to 40k | 40 to 50k | 50 to 60k | 60 to 70k | 70 to 80k | 80 to 90k | 90 to 100k |
| South East Asia | Haiphong | South America East | Puerto Cabello | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| South East Asia | Haiphong | Caribbean Basin | Rio Haina | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Itacoatiara | Japan | Yokohama | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Rio Grande | Japan | Yokohama | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Brazil | Itacoatiara | China | Shanghai | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Rio Grande | China | Shanghai | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Itacoatiara | S Korea | Ulsan | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Rio Grande | S Korea | Ulsan | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Brazil | Itacoatiara | Taiwan | Kaohsiung | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Rio Grande | Taiwan | Kaohsiung | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Itacoatiara | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |

Source: Richardson Lawrie Associates

**Table 4-12. Weighted Average Ocean Freight Rates Canal Tolls for Expanded Canal, Via Panama Canal, Selected Years 2001-2025, Most Probable Case (2002$ per ton)**

| Origin Region | Origin Port | Destination Region | Destination Port | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|---|
| North America Gulf | New Orleans | Japan | Yokohama | 13.86 | 13.87 | 12.72 | 12.85 | 12.99 | 13.16 |
| North America Gulf | New Orleans | China | Shanghai | 11.73 | 11.70 | 10.58 | 10.72 | 10.87 | 11.04 |
| North America Gulf | New Orleans | S Korea | Ulsan | 11.18 | 11.16 | 10.23 | 10.35 | 10.49 | 10.65 |
| North America Gulf | New Orleans | Taiwan | Kaohsiung | 11.93 | 11.96 | 10.68 | 10.82 | 10.97 | 11.15 |
| North America East | Port Cartier | Japan | Yokohama | 15.74 | 15.16 | 13.18 | 13.14 | 13.05 | 13.00 |
| North America East | Port Cartier | China | Shanghai | 11.26 | 11.18 | 10.27 | 10.44 | 10.62 | 10.83 |
| North America East | Port Cartier | S Korea | Ulsan | 10.51 | 10.45 | 9.43 | 9.56 | 9.72 | 9.90 |
| North America East | Port Cartier | Taiwan | Kaohsiung | 11.50 | 11.42 | 10.09 | 10.27 | 10.47 | 10.70 |
| Brazil | Salvador | Japan | Yokohama | 15.03 | 15.00 | 14.59 | 14.83 | 15.09 | 15.38 |
| Brazil | Rio Grande | Japan | Yokohama | 16.22 | 16.19 | 15.74 | 16.01 | 16.30 | 16.62 |
| North America East | Port Cartier | Central America West | Acajutla | 9.04 | 8.87 | 8.95 | 9.02 | 9.44 | 9.89 |
| North America East | Port Cartier | South America West | Guayaquil | 8.26 | 8.13 | 8.77 | 9.11 | 9.85 | 10.71 |
| North America East | Port Cartier | South East Asia | Jakarta | 21.49 | 21.59 | 22.00 | 22.32 | 22.72 | 23.15 |
| North America East | Port Cartier | South East Asia | Port Kelang | 17.78 | 17.76 | 18.16 | 18.45 | 18.83 | 19.26 |
| North America East | Port Cartier | South East Asia | Manila | 15.84 | 15.82 | 16.16 | 16.42 | 16.75 | 17.13 |
| North America East | Port Cartier | South East Asia | Singapore | 17.44 | 17.42 | 17.80 | 18.08 | 18.45 | 18.87 |
| North America East | Port Cartier | South East Asia | Ko Sichang | 16.54 | 16.50 | 16.84 | 17.10 | 17.45 | 17.83 |
| North America Gulf | New Orleans | North America West | Portland | 10.75 | 10.82 | 9.51 | 9.61 | 9.70 | 9.81 |
| North America Gulf | New Orleans | Central America West | Acajutla | 9.27 | 9.16 | 9.08 | 9.08 | 9.42 | 9.85 |
| North America Gulf | New Orleans | South America West | Guayaquil | 8.24 | 8.10 | 7.99 | 7.99 | 8.23 | 8.50 |
| North America Gulf | New Orleans | Oceania | Melbourne | 14.79 | 14.65 | 14.74 | 14.93 | 15.22 | 15.54 |
| North America Gulf | New Orleans | South East Asia | Jakarta | 19.34 | 19.45 | 17.94 | 18.00 | 18.06 | 18.16 |
| North America Gulf | New Orleans | South East Asia | Port Kelang | 16.40 | 16.47 | 15.22 | 15.32 | 15.42 | 15.57 |
| North America Gulf | New Orleans | South East Asia | Manila | 14.68 | 14.74 | 13.61 | 13.69 | 13.78 | 13.90 |
| North America Gulf | New Orleans | South East Asia | Singapore | 16.25 | 16.33 | 15.12 | 15.23 | 15.33 | 15.47 |
| North America Gulf | New Orleans | South East Asia | Ko Sichang | 15.07 | 15.11 | 13.91 | 13.98 | 14.06 | 14.17 |
| South America East | San Lorenzo | South America West | Guayaquil | 20.74 | 9.97 | 9.12 | 9.15 | 9.23 | 9.33 |
| South America East | Salvador | South America West | Guayaquil | 14.49 | 7.41 | 6.82 | 6.85 | 6.92 | 7.00 |
| South America East | Rio Grande | South America West | Guayaquil | 17.48 | 8.71 | 8.00 | 8.04 | 8.13 | 8.23 |
| Europe | Dunkirk | North America West | Portland | 13.39 | 13.58 | 13.75 | 13.94 | 14.15 | 14.39 |
| Europe | Dunkirk | Central America West | Acajutla | 10.06 | 10.33 | 10.39 | 10.48 | 10.49 | 10.29 |
| Europe | Dunkirk | South America West | Guayaquil | 10.95 | 10.10 | 10.01 | 10.08 | 10.40 | 10.80 |
| North America West | Vancouver | North America East | Port Cartier | 11.79 | 11.94 | 11.62 | 11.82 | 12.04 | 12.28 |
| North America West | Vancouver | North America Gulf | New Orleans | 12.37 | 12.39 | 11.71 | 11.85 | 12.01 | 12.18 |
| North America West | Vancouver | Central America East | Veracruz | 12.61 | 12.63 | 12.48 | 12.68 | 12.90 | 13.14 |
| North America West | Vancouver | South America East | Rio Grande | 17.64 | 18.09 | 17.95 | 18.31 | 18.71 | 19.21 |
| North America West | Vancouver | South America East | Puerto Cabello | 13.91 | 14.31 | 14.16 | 14.39 | 14.65 | 14.97 |
| North America West | Vancouver | Caribbean Basin | Rio Haina | 17.06 | 17.02 | 17.08 | 17.33 | 17.60 | 17.89 |
| North America West | Vancouver | Europe | Rotterdam | 15.70 | 15.51 | 14.98 | 15.20 | 15.43 | 15.68 |
| North America West | Vancouver | Africa | Algiers | 12.49 | 12.54 | 11.65 | 11.79 | 11.94 | 12.09 |
| North America West | Vancouver | Middle East | Tartous | 20.15 | 19.96 | 20.29 | 20.66 | 21.07 | 21.53 |
| Central America West | Manzanillo | Central America East | Veracruz | 9.69 | 9.83 | 9.56 | 9.72 | 9.88 | 10.06 |
| Central America West | Manzanillo | South America East | Rio Grande | 21.87 | 24.32 | 24.75 | 25.23 | 25.75 | 26.34 |
| Central America West | Manzanillo | South America East | Puerto Cabello | 15.07 | 16.77 | 17.01 | 17.27 | 17.54 | 17.84 |
| Central America West | Manzanillo | Africa | Algiers | 14.55 | 14.62 | 14.46 | 14.73 | 15.03 | 15.36 |
| South America West | Matarani | North America East | Port Cartier | 12.97 | 12.88 | 13.08 | 13.31 | 13.54 | 13.80 |
| South America West | Matarani | Central America East | Veracruz | 13.40 | 13.10 | 13.28 | 13.48 | 13.70 | 13.93 |
| South America West | Matarani | South America East | Rio Grande | 19.77 | 20.42 | 20.80 | 21.21 | 21.67 | 22.19 |
| South America West | Matarani | South America East | Puerto Cabello | 14.53 | 15.00 | 15.22 | 15.45 | 15.69 | 15.97 |
| South America West | Matarani | Caribbean Basin | Rio Haina | 16.53 | 16.16 | 16.37 | 16.59 | 16.82 | 17.06 |

## Table 4-12 (continued)

| Origin Region | Origin Port | Destination Region | Destination Port | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|---|
| Far East | Dalian | Caribbean Basin | Rio Haina | 27.22 | 26.54 | 26.88 | 27.41 | 27.99 | 28.65 |
| South East Asia | Haiphong | South America East | Puerto Cabello | 37.06 | 35.60 | 36.15 | 36.75 | 37.39 | 38.11 |
| South East Asia | Haiphong | Caribbean Basin | Rio Haina | 29.58 | 29.93 | 29.97 | 30.42 | 30.90 | 31.43 |
| Brazil | Itacoatiara | Japan | Yokohama | 14.24 | 14.22 | 13.82 | 14.05 | 14.29 | 14.56 |
| Brazil | Rio Grande | Japan | Yokohama | 16.22 | 16.19 | 15.74 | 16.01 | 16.30 | 16.62 |
| Brazil | Itacoatiara | China | Shanghai | 12.77 | 12.71 | 12.38 | 12.60 | 12.84 | 13.11 |
| Brazil | Rio Grande | China | Shanghai | 14.75 | 14.68 | 14.30 | 14.56 | 14.85 | 15.18 |
| Brazil | Itacoatiara | S Korea | Ulsan | 11.94 | 11.90 | 11.59 | 11.80 | 12.03 | 12.30 |
| Brazil | Rio Grande | S Korea | Ulsan | 13.93 | 13.86 | 13.51 | 13.76 | 14.04 | 14.36 |
| Brazil | Itacoatiara | Taiwan | Kaohsiung | 13.07 | 13.02 | 12.69 | 12.92 | 13.17 | 13.46 |
| Brazil | Rio Grande | Taiwan | Kaohsiung | 15.05 | 14.99 | 14.61 | 14.88 | 15.18 | 15.52 |
| Brazil | Itacoatiara | South America West | Guayaquil | 12.20 | 6.36 | 6.19 | 6.20 | 6.25 | 6.32 |

Source: Richardson Lawrie Associates

**Table 4-13. Weighted Average Ocean Freight Rates Excluding Panama Canal Tolls for Expanded Canal, Least Cost Alternative and By Pass Routes, by Vessel Size, Selected Years 2001-2025, Most Probable Case (2002$ per ton)**

| Origin Region | Origin Port | Destination Region | Destination Port | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|---|
| North America Gulf | New Orleans | Japan | Yokohama | 18.68 | 18.65 | 17.08 | 17.28 | 17.50 | 17.76 |
| North America Gulf | New Orleans | China | Shanghai | 15.16 | 15.11 | 13.67 | 13.86 | 14.08 | 14.32 |
| North America Gulf | New Orleans | S Korea | Ulsan | 15.30 | 15.26 | 14.00 | 14.18 | 14.39 | 14.64 |
| North America Gulf | New Orleans | Taiwan | Kaohsiung | 14.58 | 14.60 | 13.04 | 13.22 | 13.42 | 13.65 |
| North America East | Port Cartier | Japan | Yokohama | 20.11 | 19.26 | 16.59 | 16.53 | 16.39 | 16.30 |
| North America East | Port Cartier | China | Shanghai | 13.32 | 13.22 | 12.15 | 12.35 | 12.57 | 12.82 |
| North America East | Port Cartier | S Korea | Ulsan | 13.17 | 13.08 | 11.80 | 11.98 | 12.18 | 12.42 |
| North America East | Port Cartier | Taiwan | Kaohsiung | 12.77 | 12.67 | 11.20 | 11.40 | 11.63 | 11.88 |
| Brazil | Salvador | Japan | Yokohama | 15.06 | 15.04 | 14.62 | 14.86 | 15.12 | 15.42 |
| Brazil | Rio Grande | Japan | Yokohama | 14.41 | 14.39 | 13.99 | 14.22 | 14.47 | 14.74 |
| North America East | Port Cartier | Central America West | Acajutla | 19.57 | 19.11 | 19.44 | 19.69 | 20.79 | 21.97 |
| North America East | Port Cartier | South America West | Guayaquil | 16.93 | 16.60 | 18.05 | 18.83 | 20.55 | 22.54 |
| North America East | Port Cartier | South East Asia | Jakarta | 19.70 | 19.81 | 20.17 | 20.46 | 20.82 | 21.20 |
| North America East | Port Cartier | South East Asia | Port Kelang | 15.70 | 15.69 | 16.04 | 16.29 | 16.63 | 17.00 |
| North America East | Port Cartier | South East Asia | Manila | 16.73 | 16.70 | 17.06 | 17.33 | 17.69 | 18.09 |
| North America East | Port Cartier | South East Asia | Singapore | 16.14 | 16.13 | 16.48 | 16.74 | 17.08 | 17.46 |
| North America East | Port Cartier | South East Asia | Ko Sichang | 15.95 | 15.91 | 16.24 | 16.49 | 16.82 | 17.19 |
| North America Gulf | New Orleans | North America West | Portland | 16.82 | 16.93 | 14.93 | 15.13 | 15.36 | 15.60 |
| North America Gulf | New Orleans | Central America West | Acajutla | 20.49 | 20.16 | 20.23 | 20.41 | 21.53 | 22.97 |
| North America Gulf | New Orleans | South America West | Guayaquil | 18.02 | 17.62 | 17.51 | 17.59 | 18.34 | 19.19 |
| North America Gulf | New Orleans | Oceania | Melbourne | 18.31 | 18.11 | 18.23 | 18.49 | 18.88 | 19.30 |
| North America Gulf | New Orleans | South East Asia | Jakarta | 19.44 | 19.54 | 18.03 | 18.09 | 18.15 | 18.25 |
| North America Gulf | New Orleans | South East Asia | Port Kelang | 16.26 | 16.33 | 15.09 | 15.19 | 15.29 | 15.43 |
| North America Gulf | New Orleans | South East Asia | Manila | 17.02 | 17.08 | 15.76 | 15.86 | 15.96 | 16.10 |
| North America Gulf | New Orleans | South East Asia | Singapore | 16.77 | 16.85 | 15.60 | 15.70 | 15.81 | 15.95 |
| North America Gulf | New Orleans | South East Asia | Ko Sichang | 16.18 | 16.21 | 14.92 | 15.00 | 15.09 | 15.22 |
| South America East | San Lorenzo | South America West | Guayaquil | 16.84 | 8.25 | 7.55 | 7.57 | 7.62 | 7.70 |
| South America East | Salvador | South America West | Guayaquil | 17.68 | 8.77 | 8.06 | 8.10 | 8.18 | 8.29 |
| South America East | Rio Grande | South America West | Guayaquil | 14.71 | 7.48 | 6.88 | 6.92 | 6.98 | 7.07 |
| Europe | Dunkirk | North America West | Portland | 18.12 | 18.38 | 18.64 | 18.93 | 19.26 | 19.63 |
| Europe | Dunkirk | Central America West | Acajutla | 16.07 | 16.48 | 16.59 | 16.76 | 16.79 | 16.49 |
| Europe | Dunkirk | South America West | Guayaquil | 17.07 | 15.60 | 15.51 | 15.64 | 16.22 | 16.92 |
| North America West | Vancouver | North America East | Port Cartier | 20.31 | 20.55 | 20.01 | 20.39 | 20.81 | 21.28 |
| North America West | Vancouver | North America Gulf | New Orleans | 22.55 | 22.53 | 21.35 | 21.69 | 22.06 | 22.47 |
| North America West | Vancouver | Central America East | Veracruz | 24.43 | 24.37 | 24.14 | 24.59 | 25.09 | 25.66 |
| North America West | Vancouver | South America East | Rio Grande | 16.48 | 16.90 | 16.76 | 17.09 | 17.47 | 17.92 |
| North America West | Vancouver | South America East | Puerto Cabello | 24.90 | 25.58 | 25.39 | 25.89 | 26.46 | 27.15 |
| North America West | Vancouver | Caribbean Basin | Rio Haina | 28.76 | 28.57 | 28.75 | 29.27 | 29.83 | 30.45 |
| North America West | Vancouver | Europe | Rotterdam | 22.43 | 22.11 | 21.38 | 21.71 | 22.08 | 22.47 |
| North America West | Vancouver | Africa | Algiers | 16.83 | 16.79 | 15.62 | 15.82 | 16.04 | 16.26 |
| North America West | Vancouver | Middle East | Tartous | 27.02 | 26.75 | 27.20 | 27.72 | 28.30 | 28.94 |
| Central America West | Manzanillo | Central America East | Veracruz | 21.81 | 22.06 | 21.54 | 21.97 | 22.45 | 22.99 |
| Central America West | Manzanillo | South America East | Rio Grande | 20.12 | 22.37 | 22.75 | 23.18 | 23.66 | 24.19 |
| Central America West | Manzanillo | South America East | Puerto Cabello | 33.74 | 37.69 | 38.35 | 39.09 | 39.90 | 40.79 |
| Central America West | Manzanillo | Africa | Algiers | 21.53 | 21.61 | 21.41 | 21.83 | 22.31 | 22.85 |
| South America West | Matarani | North America East | Port Cartier | 20.32 | 20.15 | 20.50 | 20.90 | 21.33 | 21.80 |
| South America West | Matarani | Central America East | Veracruz | 15.76 | 15.39 | 15.62 | 15.87 | 16.15 | 16.46 |
| South America West | Matarani | South America East | Rio Grande | 13.40 | 13.81 | 14.03 | 14.27 | 14.54 | 14.84 |
| South America West | Matarani | South America East | Puerto Cabello | 24.80 | 25.67 | 26.13 | 26.64 | 27.19 | 27.82 |

**Table 4-13 (continued)**

| Origin Region | Origin Port | Destination Region | Destination Port | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|---|
| South America West | Matarani | Caribbean Basin | Rio Haina | 26.80 | 26.14 | 26.54 | 27.00 | 27.49 | 28.03 |
| Far East | Dalian | Caribbean Basin | Rio Haina | 35.44 | 34.48 | 34.96 | 35.70 | 36.51 | 37.43 |
| South East Asia | Haiphong | South America East | Puerto Cabello | 40.19 | 38.58 | 39.19 | 39.86 | 40.57 | 41.38 |
| South East Asia | Haiphong | Caribbean Basin | Rio Haina | 32.12 | 32.47 | 32.53 | 33.03 | 33.56 | 34.18 |
| Brazil | Itacoatiara | Japan | Yokohama | 16.56 | 16.53 | 16.07 | 16.35 | 16.64 | 16.97 |
| Brazil | Rio Grande | Japan | Yokohama | 14.41 | 14.39 | 13.99 | 14.22 | 14.47 | 14.74 |
| Brazil | Itacoatiara | China | Shanghai | 13.78 | 13.71 | 13.35 | 13.60 | 13.86 | 14.16 |
| Brazil | Rio Grande | China | Shanghai | 12.39 | 12.34 | 12.01 | 12.22 | 12.46 | 12.72 |
| Brazil | Itacoatiara | S Korea | Ulsan | 13.61 | 13.55 | 13.20 | 13.45 | 13.71 | 14.02 |
| Brazil | Rio Grande | S Korea | Ulsan | 12.14 | 12.09 | 11.77 | 11.99 | 12.23 | 12.49 |
| Brazil | Itacoatiara | Taiwan | Kaohsiung | 13.22 | 13.18 | 12.84 | 13.08 | 13.34 | 13.63 |
| Brazil | Rio Grande | Taiwan | Kaohsiung | 11.84 | 11.81 | 11.50 | 11.71 | 11.93 | 12.19 |
| Brazil | Itacoatiara | South America West | Guayaquil | 20.52 | 9.89 | 9.56 | 9.58 | 9.68 | 9.81 |

Source: Richardson Lawrie Associates

## Table 4-14. Least Cost Alternative Routes Expanded Canal - 2002

| | | | | Vessel Size Range (000 DWT) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 to | 10 to | 15 to | 20 to | 25 to | 30 to | 40 to | 50 to | 60 to | 70 to | 80 to | 90 to |
| Origin Region | Origin Port | Destination Region | Destination Port | 10k | 15k | 20k | 25k | 30k | 40k | 50k | 60k | 70k | 80k | 90k | 100k |
| North America Gulf | New Orleans | Japan | Yokohama | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | China | Shanghai | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | S Korea | Ulsan | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | Taiwan | Kaohsiung | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | Japan | Yokohama | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | China | Shanghai | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | S Korea | Ulsan | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | Taiwan | Kaohsiung | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Salvador | Japan | Yokohama | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Rio Grande | Japan | Yokohama | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America East | Port Cartier | Central America West | Acajutla | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America East | Port Cartier | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America East | Port Cartier | South East Asia | Jakarta | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | South East Asia | Port Kelang | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | South East Asia | Manila | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | South East Asia | Singapore | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America East | Port Cartier | South East Asia | Ko Sichang | S | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | North America West | Portland | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America Gulf | New Orleans | Central America West | Acajutla | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America Gulf | New Orleans | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America Gulf | New Orleans | Oceania | Melbourne | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America Gulf | New Orleans | South East Asia | Jakarta | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | South East Asia | Port Kelang | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | South East Asia | Manila | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | South East Asia | Singapore | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| North America Gulf | New Orleans | South East Asia | Ko Sichang | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| South America East | San Lorenzo | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America East | Salvador | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America East | Rio Grande | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Europe | Dunkirk | North America West | Portland | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Europe | Dunkirk | Central America West | Acajutla | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Europe | Dunkirk | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | North America East | Port Cartier | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | North America Gulf | New Orleans | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | Central America East | Veracruz | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | South America East | Rio Grande | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | South America East | Puerto Cabello | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | Caribbean Basin | Rio Haina | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | Europe | Rotterdam | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | Africa | Algiers | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| North America West | Vancouver | Middle East | Tartous | S | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Central America West | Manzanillo | Central America East | Veracruz | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Central America West | Manzanillo | South America East | Rio Grande | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Central America West | Manzanillo | South America East | Puerto Cabello | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Central America West | Manzanillo | Africa | Algiers | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America West | Matarani | North America East | Port Cartier | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America West | Matarani | Central America East | Veracruz | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America West | Matarani | South America East | Rio Grande | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America West | Matarani | South America East | Puerto Cabello | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| South America West | Matarani | Caribbean Basin | Rio Haina | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Far East | Dalian | Caribbean Basin | Rio Haina | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |

## Table 4-14 (continued)

| Origin Region | Origin Port | Destination Region | Destination Port | Vessel Size Range (000 DWT) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 to 10k | 10 to 15k | 15 to 20k | 20 to 25k | 25 to 30k | 30 to 40k | 40 to 50k | 50 to 60k | 60 to 70k | 70 to 80k | 80 to 90k | 90 to 100k |
| South East Asia | Haiphong | South America East | Puerto Cabello | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| South East Asia | Haiphong | Caribbean Basin | Rio Haina | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Itacoatiara | Japan | Yokohama | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Rio Grande | Japan | Yokohama | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Brazil | Itacoatiara | China | Shanghai | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Rio Grande | China | Shanghai | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Itacoatiara | S Korea | Ulsan | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Rio Grande | S Korea | Ulsan | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |
| Brazil | Itacoatiara | Taiwan | Kaohsiung | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Rio Grande | Taiwan | Kaohsiung | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH | CGH |
| Brazil | Itacoatiara | South America West | Guayaquil | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH | CH |

Source: Richardson Lawrie Associates

# 5. Potential Panama Canal Transits and Economic Value of the Canal

In this section commences with a description of the *Transit Model* that was used to determine number and size of vessels that would be required to carry the cargo forecasted on Panama Canal routes. This is followed by the presentation and discussion of the forecast of potential Panama Canal transits and the determination of the economic value of the Panama Canal under the Existing and Expanded Canal scenarios.

## TRANSIT MODEL

The first part of this section starts by describing the Transit Model that has been developed as an analytical tool to calculate future transits of laden and ballast dry bulk carriers for the Existing and Expanded Canals and for all scenarios, in terms of cargo tons, numbers of transits, DWT and PCUMS by route and DWT size range. The outputs include also projections of these parameters by other vessel size range characteristics such as PCUMS, GRT, beam, LOA and draft. In this section, the Transit Model is used to produce forecasts of potential transits that is, assuming zero tolls and before the pricing strategy is considered.
Separate transit models have been designed for grains and other dry bulks (ODB). This reflects:

- variations in route definitions required for each study;
- differences evident in vessel sizes and utilization;
- the necessity to maintain separate outputs for the development of freight costs and economic value.

In addition, the Transit Model has been developed to generate final laden and ballast transit forecasts with tolls based on the preferred pricing strategy. These include projections of toll revenue as specified in the TOR. This is discussed further in *Volume 6: Forecast of Panama Canal Cargo, Transits and Toll Revenue.*

These analytical tools have been developed and coded in Microsoft Access with input data and output data in Microsoft Excel. The system has been set up so as to enable the Client to update the model easily. The input and output tables are designed to allow maximum flexibility for the user and are set up to run each of the following cases.

- Existing Canal - Most Probable Case
- Existing Canal - Best Case
- Existing Canal - Worst Case
- Expanded Canal - Most Probable Case

- Expanded Canal - Best Case
- Expanded Canal - Worst Case

The second part of this section discusses the results from the Transit Model. Results on potential Canal transits contained in this report are based on the determination of the Canal's potential market presented in Section 3. The Canal's potential market represents our estimate of the maximum market share that the Canal could capture of world trade assuming a value of zero for Panama Canal tolls.

## Transit Model Design and Assumptions

The model design is described below. For clarity each input and output is provided with a sequential numbering system. The description follows the logical flow of model inputs and outputs together with descriptions of supporting analyses and assumptions. A number of the input tables differ to take account of different trade forecasts, new routes where applicable, larger vessel sizes and improved DWT utilizations for some ship sizes transiting the Expanded Canal. Summarized below is a listing of inputs/outputs for laden and ballast transits. The various input tables are all derived from the work described in Section 4 of this report.

### *Inputs*

- ODB potential trade forecasts by route and commodity for each year from 2000 through 2025. For the Expanded Canal this includes potential by pass trades that would be shifted to the Canal at zero tolls.
- Percentage split by ship type for each individual commodity within each route and every year 2000 through 2025 inclusive. These assumptions are derived from an Access routine developed to calculate the proportion of each product carried in each subject ACP ship type by route from the historical data. Within the same routine 3 year and 5 year averages were also calculated. Based on these data, assumptions were made concerning the future split of ship types to be assumed. Generally the five year average was assumed unless it was clear that the shorter term data were more representative.
- Percentage split of cargo allocation to ship sizes for each route and each year within route. The Percentage for each route totals 100. This table is based on an analysis of historical data by routes and represents the start point from which future percentage splits are determined by the Cargo Allocation Module in the transit model.
- Average DWT for dry bulk carriers for each size range and year within route. It was not strictly necessary to create input Excel tables which specified these data by route. However the model is 'over specified' to allow for any use or requirement for sensitivities that ACP may have in the future.
- Percentage utilization level—that is, cargo to DWT ratios—for dry bulk carriers for each size range and year within route. As with above input, it is not strictly necessary to format tables and input on a route basis. However, this has been undertaken in order to allow for any future uses that ACP may have.

- A conversion factor from DWT to PCUMS for each DWT size range and year within route. These are a series of factors which, when multiplied with the average DWT in each size range, give average PCUMS per size range. The data were derived from a series of analyses of data taken from the ACP database utilizing PCUMS and summer DWT data for individual vessels within each subject size range. Data for larger vessel sizes was determined by regression analysis.
- Conversion factors for DWT range to GRT/LOA/Beam/PCUMS/Draft ranges. Within each subject DWT size range a series of factors which convert DWT to each of these other measurements are input to the model. These are not simple average factors for each size range. Instead, for each size range RLA have calculated the proportion of DWT which falls within all relevant measurement ranges. Data within each DWT range is therefore split into an array of measurement ranges.
- A table of trades and factors by size range linking ballast transits to laden transits.

***Outputs***

With the exception of outputs concerned with cargoes, all of the following apply to both laden and ballast transits:

- ODB cargoes allocated to dry bulk carriers in thousands of tons for each route and for each commodity within route and for each year 2000 through 2025.
- ODB cargoes allocated to all other ship types in thousands of tons for each route and for each commodity within route and for each year 2000 through 2025. Also included at this stage of the model is a 'check output'. This lists any commodities by route in the original input data which do not appear in either of the outputs which allocate trade to ship type. This is designed to be particularly useful if trade assumptions are changed and is an additional check to ensure, for example, that syntax remains consistent and that ship type assumptions are input for all commodity/route combinations.
- ODB trades forecasts in thousands of tons for trade in dry bulk carriers only. These are within each route, for commodities in aggregate for that route—highlighting commodities/routes for specific focus—and for each year, that is, 2000 through 2025 inclusive. This is derived from the output streams above.
- ODB trades forecasts in thousands of tons for trade in all other ship types within each route, for commodities in aggregate for that route and for each year from 2000 through 2025 inclusive. This is derived from the output streams above.
- Percentage split of cargo allocation to ship size for each route and each year to 2025 within route. This is the output from the cargo allocation module with percentages changed from 2002 to reflect trends in size distributions, the volumes of trade and changes in the world fleet mix. (This table also provides an input to the Voyage Estimating Model for use in the calculation of weighted average freight costs as required for the Spatial Optimization Model in the study on the Grains Segment.)
- Total cargo in thousands of tons by route, DWT size range and year.
- Total DWT in thousands by DWT size range, route and year. There is a further check output at this stage which lists any routes and size ranges which may be missing. This is

designed to ensure that percentage utilization factors are available for all necessary routes, vessel sizes and years.

- Number of transits by DWT size range, route and year with the option also to produce output by commodity.
- Total PCUMS in thousands by DWT size range, route and year.
- Average cargo size by DWT size range, route and year together with overall weighted average cargo size to enable the trends resulting from the cargo allocation model to be monitored.
- Summaries of total cargo, DWT, Number of transits and PCUMS by route and year.
- Total cargo in thousands of long tons by DWT/GRT/LOA/Beam/PCUMS/Draft range by year and direction.
- Total number of transits by DWT/GRT/LOA/Beam/PCUMS/Draft range by year and direction.
- Total PCUMS in thousands of long tons by DWT/GRT/LOA/Beam/PCUMS/Draft range by year and direction

## POTENTIAL PANAMA CANAL TRANSITS

Table 5-1 summarizes potential laden transits in terms of cargo tons, DWT, numbers of transits and PCUMS for both the Existing and Expanded Canals and for all cases. For the Most Probable Cases, grains cargo transits for the Existing Canal are estimated to increase by 67 percent from 47 million tons in 2001 to over 79 million tons in 2025 and for the Expanded Canal by 77 percent to almost 84 million tons. For the Existing Canal similar percentage increases are projected for transits in terms of DWT and PCUMS. However because of the expected continuing trend towards the utilization of larger vessels, the total number of transits is forecast to increase by about 54 percent for the Existing Canal, from 1,205 in 2001 to 1,852 in 2025.

**Table 5-1 Potential Laden Transits in Cargo Tons, DWT, Number of Transits and PCUMS, Existing and Expanded Canal, No Tolls, All Cases**

| | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Case | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **Cargo (000 long tons)** | | | | | | | | | | |
| Most Probable | 47,400 | 48,305 | 62,195 | 66,576 | 73,130 | 79,231 | 64,210 | 69,859 | 77,547 | 83,941 |
| Best | 47,400 | 49,439 | 63,820 | 70,929 | 75,947 | 83,133 | 65,425 | 72,781 | 81,737 | 87,768 |
| Worst | 47,400 | 53,691 | 56,099 | 59,580 | 58,627 | 60,824 | 57,560 | 60,259 | 62,574 | 62,233 |
| **Vessel Size (000 WT)** | | | | | | | | | | |
| Most Probable | 57,204 | 58,205 | 75,218 | 80,637 | 88,651 | 96,105 | 73,778 | 80,208 | 89,006 | 96,285 |
| Best | 57,204 | 59,582 | 77,215 | 85,933 | 92,259 | 100,949 | 75,177 | 83,576 | 93,838 | 100,688 |
| Worst | 57,204 | 65,070 | 68,021 | 72,152 | 71,090 | 74,001 | 66,048 | 69,081 | 71,712 | 71,322 |
| **Transits** | | | | | | | | | | |
| Most Probable | 1,205 | 1,216 | 1,506 | 1,577 | 1,722 | 1,852 | 1,468 | 1,559 | 1,752 | 1,910 |
| Best | 1,205 | 1,245 | 1,549 | 1,706 | 1,776 | 1,963 | 1,500 | 1,651 | 1,860 | 2,028 |
| Worst | 1,205 | 1,278 | 1,293 | 1,358 | 1,306 | 1,333 | 1,239 | 1,282 | 1,301 | 1,263 |
| **PCUMS (000)** | | | | | | | | | | |
| Most Probable | 28,828 | 29,436 | 37,871 | 40,483 | 44,471 | 48,195 | 37,162 | 40,250 | 44,692 | 48,382 |
| Best | 28,828 | 30,127 | 38,860 | 43,142 | 46,159 | 50,583 | 37,858 | 41,979 | 47,046 | 50,579 |
| Worst | 28,828 | 32,562 | 34,051 | 36,168 | 35,563 | 36,891 | 33,088 | 34,651 | 35,859 | 35,547 |

Source: Richardson Lawrie Associates

For the Expanded Canal the projected growth in transits in terms of DWT and PCUMS remains at around 68 percent. This is less than the rate of growth in cargoes of 77 percent because of the improved utilization that would result from an enlarged Canal. The number of transits would grow by 59 percent overall as the result of both greater utilization levels and the trend towards larger vessel sizes.

For both the Existing and Expanded Canals, the figures for the Most Probable Case are much closer to the Best Case than the Worst Case, the difference between the Most Probable and Worst Cases being around 82/83 percent of the difference between Best and Worst Cases for the Existing Canal and around 85 percent for the Expanded Canal. Figures 5-1 to 5-4 illustrate the values shown in Table 5-1.

**Figure 5-1 Potential Laden Transits in Cargo Tons, Existing and Expanded Canal, No Tolls, All Cases**

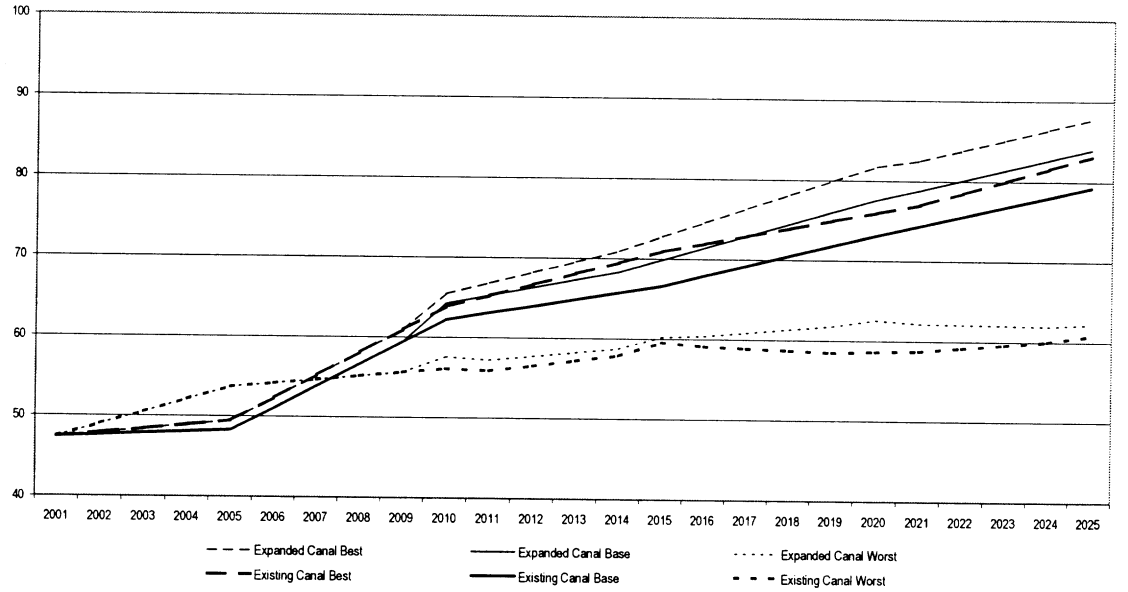



**Figure 5-2 Potential Number of Laden Transits, Existing and Expanded Canal, No Tolls, All Cases**

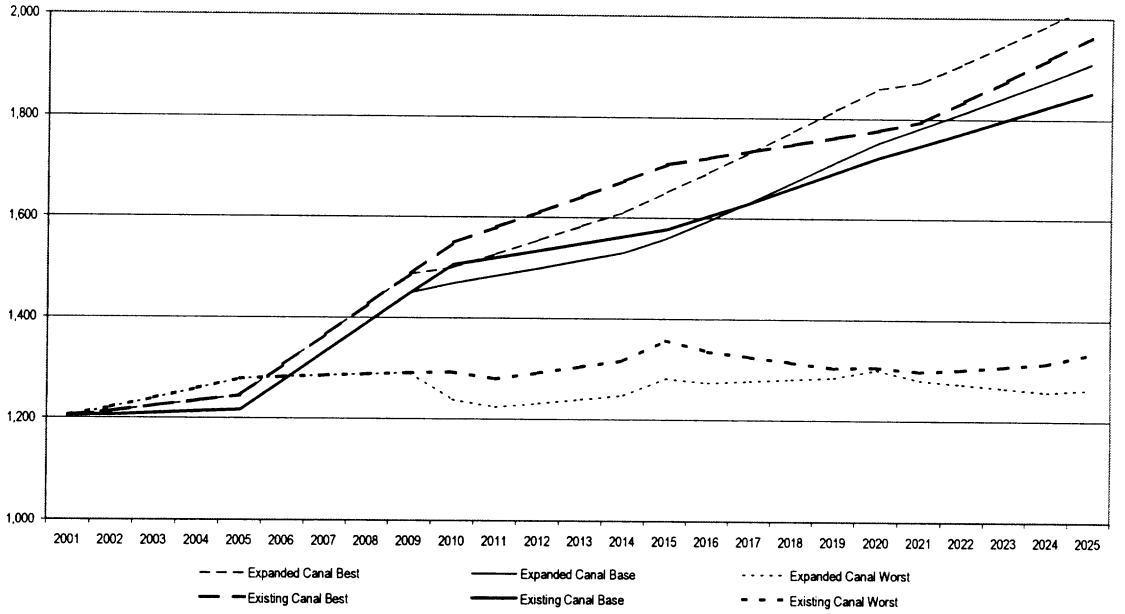


**Figure 5-3 Potential Laden Transits in DWT, Existing and Expanded Canal, No Tolls, All Cases**

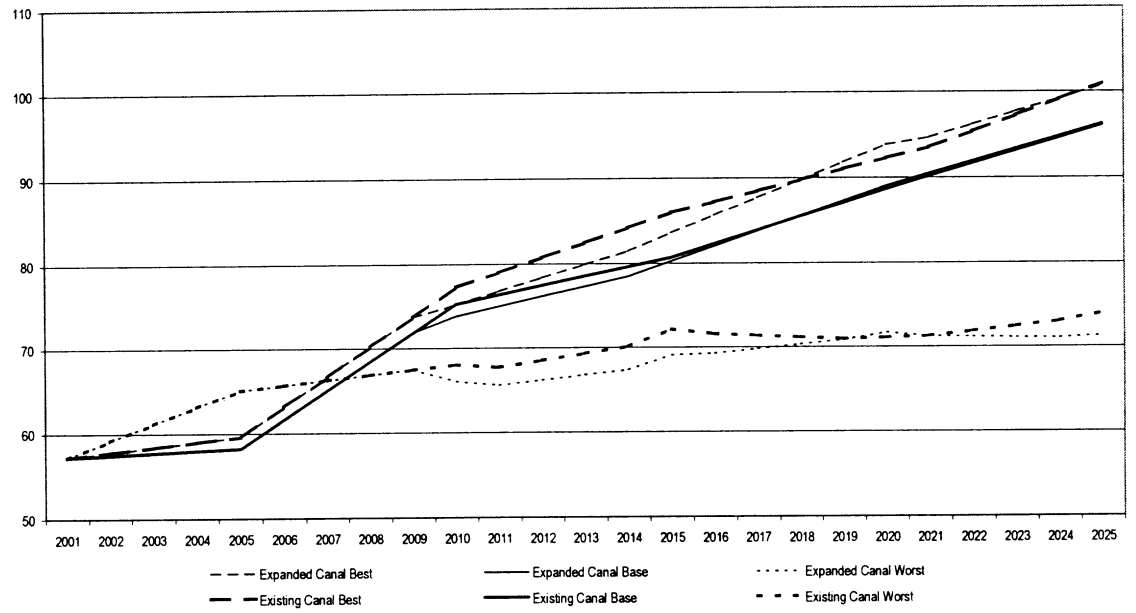



**Figure 5-4 Potential Laden Transits in PCUMS, Existing and Expanded Canal, No Tolls, All Cases**

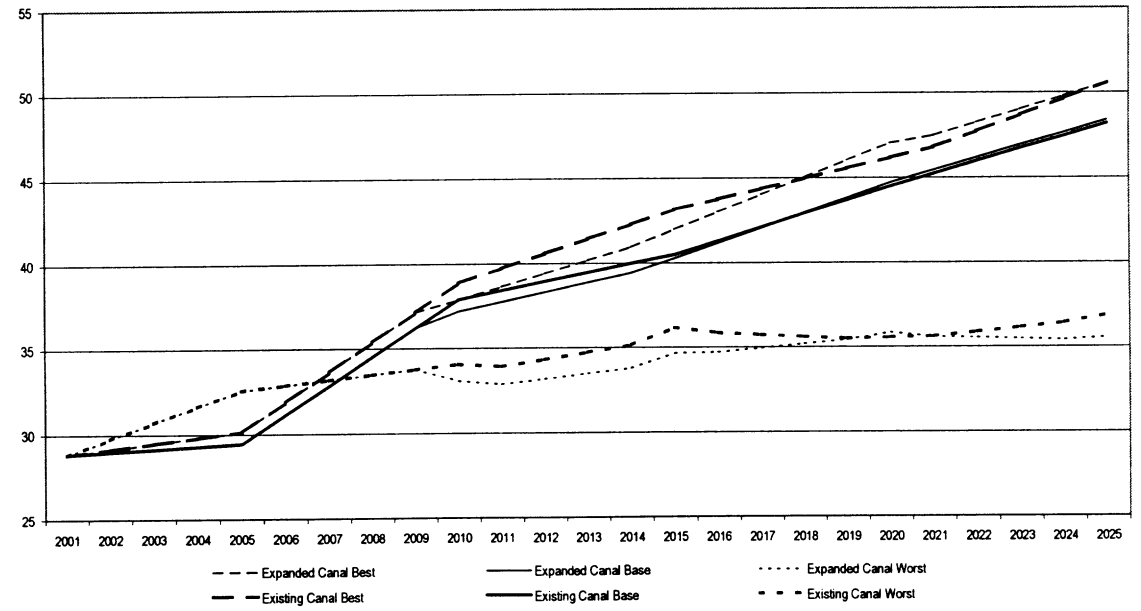
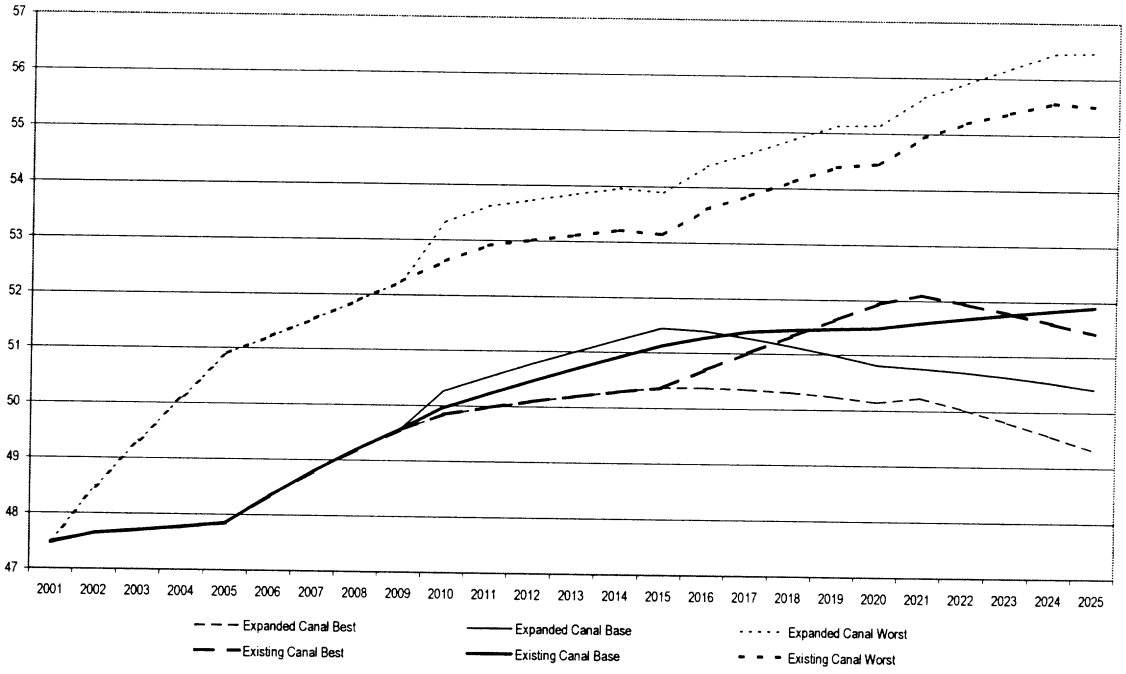


**Figure 5-5 Potential Average DWT, Existing and Expanded Canal, No Tolls, All Cases**




The summaries of total laden transits encompass a number of different trends. The combination of variations in trade forecasts and shifts in the cargo allocation to size ranges on individual routes result in individual size ranges being substituted by others and variations around the mean growth rates both between vessel sizes and individual time periods. For the Existing Canal,

The most salient features of the southbound laden transits are the stronger than average increases in the 50,000-60,000 DWT size range encompassing the modern Handymax sizes and in the 70,000-80,000 DWT size range encompassing the modern Panamax and representing the limit of most grain port capabilities. Specifically:

- The substitution of vessels in the 20,000-30,000 DWT size ranges by, in the first instance vessels of 30,000-50,000 DWT.
- After 2010 vessels of 30,000-40,000 DWT decline year on year at an accelerating rate while transits of vessels between 40,000 and 50,000 DWT continue to increase at numbers which are similar to the overall average.
- Meanwhile, the DWT of vessels of 50,000-60,000 DWT incorporating the newer Handymax sizes are forecast to increase substantially. This trend is at its most acute in the short term as transits through the Canal reflect more closely changes in the world fleet and thereafter growth rates which vary between nearly twice and 3.5 times the average DWT growth.
- As would be expected the share of the traditional Panamax size range of 60,000 - 70,000 DWT declines - from 33 percent to 23 percent - as the share of the 70,000 - 80,000 DWT range consequently increases from 21 percent to 36 percent.
- These trends are respectively accelerated and dampened in the Best and Worst cases.

In the case of the Expanded Canal, despite the likelihood that larger vessels will transit the Canal in this case, total DWT for laden transits actually declines in the earlier years of the forecast compared to the Existing Canal case as the utilization levels of size ranges up to 80,000 DWT improve and inefficiencies are removed from the global shipping system. In the second half of the forecast period, the total DWT through the Canal southbound increases compared to the Existing Canal with increased use of vessels up to 100,000 DWT. Specifically:

- While there are fluctuations in individual time periods, the overall usage of the 60,000-70,000 DWT size range is fairly flat;
- While the share of the 70,000-80,000 DWT range continues to increase, this is to a lesser degree than in the Existing Canal as this is the size range which benefits most from improvements in vessel utilization.
- Vessels in excess of 80,000 DWT would be expected to land cargo in the Far East, particularly in China, South Korea and Taiwan.

Tables 5-2 to 5-5 summarize potential laden transits in cargo tons, DWT, numbers of transits and PCUMS by DWT size range for the Existing and Expanded Canal. Figure 5-5 shows the potential weighted average DWT which result from these forecasts. In the period to around 2015, the average DWT is estimated to increase in all cases from under 48,000DWT in 2001 to between 50,000 DWT and 54,000 DWT in 2015. Thereafter the trends for the Most Probable and Best Cases tend to flatten out or even decline slightly while the rising trend for the Worst Case is maintained. These variations come about because of the variations in trade forecasts between cases and the fact that different trades have markedly different vessel size distributions.

## Table 5-2. Potential Laden Transits in Cargo Tons, Existing and Expanded Canal, No Tolls, Most Probable Case, Selected Years, 2001-2025 (000 tons)

| Vessel Size Range (DWT) | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **South** | | | | | | | | | | |
| Less or equal to 10,000 | 11 | - | - | - | - | - | - | - | - | - |
| Greater than 10,000–Less than 15,000 | 272 | 297 | 845 | 958 | 1,271 | 1,552 | 944 | 1,154 | 1,697 | 2,233 |
| Greater or equal to 15,000–Less than 20,000 | 355 | 321 | 911 | 994 | 1,265 | 1,534 | 1,042 | 1,260 | 1,826 | 2,410 |
| Greater or equal to 20,000–Less than 25,000 | 1,272 | 1,399 | 1,044 | 282 | - | - | 951 | 72 | - | - |
| Greater or equal to 25,000–Less than 30,000 | 3,920 | 2,913 | - | - | - | - | - | - | - | - |
| Greater or equal to 30,000–Less than 40,000 | 3,860 | 4,770 | 5,624 | 5,382 | 4,151 | 2,468 | 5,383 | 4,910 | 3,529 | 1,561 |
| Greater or equal to 40,000–Less than 50,000 | 10,429 | 10,721 | 14,498 | 15,118 | 16,848 | 18,499 | 14,874 | 15,784 | 17,809 | 19,680 |
| Greater or equal to 50,000–Less than 60,000 | 2,015 | 3,209 | 5,206 | 6,588 | 8,431 | 10,518 | 5,026 | 6,341 | 8,108 | 10,162 |
| Greater or equal to 60,000–Less than 70,000 | 15,267 | 13,636 | 17,042 | 17,188 | 17,646 | 17,899 | 15,946 | 16,265 | 16,585 | 16,661 |
| Greater or equal to 70,000–Less than 80,000 | 9,224 | 10,247 | 16,175 | 19,220 | 22,781 | 26,369 | 15,359 | 18,541 | 21,869 | 24,894 |
| Greater or equal to 80,000–Less than 90,000 | - | - | - | - | - | - | 2,702 | 3,197 | 3,611 | 3,981 |
| Greater or equal to 90,000–Less than 100,000 | - | - | - | - | - | - | 1,135 | 1,489 | 1,777 | 1,968 |
| Total Southbound | 46,626 | 47,512 | 61,346 | 65,730 | 72,393 | 78,839 | 63,361 | 69,013 | 76,810 | 83,550 |
| **North** | | | | | | | | | | |
| Less or equal to 10,000 | - | - | - | - | - | - | - | - | - | - |
| Greater than 10,000–Less than 15,000 | - | - | - | - | - | - | - | - | - | - |
| Greater or equal to 15,000–Less than 20,000 | 8 | 9 | 11 | 12 | 14 | 15 | 11 | 12 | 14 | 15 |
| Greater or equal to 20,000–Less than 25,000 | 4 | 5 | 6 | 6 | 7 | 7 | 6 | 6 | 7 | 7 |
| Greater or equal to 25,000–Less than 30,000 | 7 | 8 | 10 | 11 | 12 | 12 | 10 | 11 | 12 | 12 |
| Greater or equal to 30,000–Less than 40,000 | 694 | 705 | 740 | 730 | 609 | 258 | 740 | 730 | 609 | 258 |
| Greater or equal to 40,000–Less than 50,000 | 27 | 30 | 36 | 38 | 40 | 41 | 36 | 38 | 40 | 41 |
| Greater or equal to 50,000–Less than 60,000 | 23 | 26 | 32 | 33 | 37 | 39 | 32 | 33 | 37 | 39 |
| Greater or equal to 60,000–Less than 70,000 | 2 | - | - | - | - | - | - | - | - | - |
| Greater or equal to 70,000–Less than 80,000 | 4 | - | - | - | - | - | - | - | - | - |
| Greater or equal to 80,000–Less than 90,000 | 4 | 11 | 15 | 16 | 18 | 20 | 15 | 16 | 18 | 20 |
| Greater or equal to 90,000–Less than 100,000 | - | - | - | - | - | - | - | - | - | - |
| Total Northbound | 774 | 793 | 849 | 846 | 737 | 391 | 849 | 846 | 737 | 391 |
| Grand Total | 47,400 | 48,305 | 62,195 | 66,576 | 73,130 | 79,231 | 64,210 | 69,859 | 77,547 | 83,941 |

Source: Richardson Lawrie Associates

## Table 5-3. Potential Laden Transits in DWT, Existing and Expanded Canal, No Tolls, Most Probable Case, Selected Years, 2001-2025 (000 DWT)

| | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vessel Size Range (DWT) | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **South** | | | | | | | | | | |
| Less or equal to 10,000 | 14 | - | - | - | - | - | - | - | - | - |
| Greater than 10,000–Less than 15,000 | 339 | 369 | 1,052 | 1,192 | 1,583 | 1,932 | 1,175 | 1,437 | 2,113 | 2,781 |
| Greater or equal to 15,000–Less than 20,000 | 413 | 373 | 1,059 | 1,156 | 1,471 | 1,784 | 1,212 | 1,465 | 2,123 | 2,803 |
| Greater or equal to 20,000–Less than 25,000 | 1,503 | 1,653 | 1,234 | 333 | - | - | 1,124 | 85 | - | - |
| Greater or equal to 25,000–Less than 30,000 | 4,584 | 3,407 | - | - | - | - | - | - | - | - |
| Greater or equal to 30,000–Less than 40,000 | 4,468 | 5,521 | 6,509 | 6,230 | 4,805 | 2,856 | 6,231 | 5,683 | 4,084 | 1,806 |
| Greater or equal to 40,000–Less than 50,000 | 11,919 | 12,253 | 16,569 | 17,278 | 19,255 | 21,142 | 16,998 | 18,039 | 20,353 | 22,492 |
| Greater or equal to 50,000–Less than 60,000 | 2,244 | 3,573 | 5,798 | 7,337 | 9,388 | 11,713 | 5,596 | 7,061 | 9,029 | 11,317 |
| Greater or equal to 60,000–Less than 70,000 | 18,825 | 16,814 | 21,014 | 21,193 | 21,759 | 22,070 | 18,328 | 18,695 | 19,063 | 19,150 |
| Greater or equal to 70,000–Less than 80,000 | 11,933 | 13,256 | 20,925 | 24,864 | 29,471 | 34,112 | 17,654 | 21,312 | 25,137 | 28,613 |
| Greater or equal to 80,000–Less than 90,000 | - | - | - | - | - | - | 3,106 | 3,675 | 4,151 | 4,576 |
| Greater or equal to 90,000–Less than 100,000 | - | - | - | - | - | - | 1,305 | 1,712 | 2,043 | 2,262 |
| Total Southbound | 56,244 | 57,220 | 74,161 | 79,583 | 87,731 | 95,610 | 72,729 | 79,163 | 88,095 | 95,800 |
| **North** | | | | | | | | | | |
| Less or equal to 10,000 | - | - | - | - | - | - | - | - | - | - |
| Greater than 10,000–Less than 15,000 | - | - | - | - | - | - | 15 | 16 | 18 | 20 |
| Greater or equal to 15,000–Less than 20,000 | 10 | 12 | 15 | 16 | 18 | 20 | 8 | 8 | 9 | 9 |
| Greater or equal to 20,000–Less than 25,000 | 6 | 6 | 8 | 8 | 9 | 9 | 13 | 14 | 15 | 16 |
| Greater or equal to 25,000–Less than 30,000 | 10 | 11 | 13 | 14 | 15 | 16 | 912 | 900 | 751 | 318 |
| Greater or equal to 30,000–Less than 40,000 | 856 | 869 | 912 | 900 | 751 | 318 | 44 | 46 | 50 | 50 |
| Greater or equal to 40,000–Less than 50,000 | 35 | 38 | 46 | 48 | 52 | 52 | 39 | 41 | 45 | 48 |
| Greater or equal to 50,000–Less than 60,000 | 32 | 35 | 43 | 45 | 50 | 52 | - | - | - | - |
| Greater or equal to 60,000–Less than 70,000 | 3 | - | - | - | - | - | - | - | - | - |
| Greater or equal to 70,000–Less than 80,000 | 5 | - | - | - | - | - | 18 | 20 | 23 | 25 |
| Greater or equal to 80,000–Less than 90,000 | 5 | 15 | 20 | 22 | 25 | 27 | - | - | - | - |
| Greater or equal to 90,000–Less than 100,000 | - | - | - | - | - | - | - | - | - | - |
| Total Northbound | 961 | 985 | 1,057 | 1,054 | 920 | 494 | 1,049 | 1,046 | 911 | 485 |
| Grand Total | 57,204 | 58,205 | 75,218 | 80,637 | 88,651 | 96,105 | 73,778 | 80,208 | 89,006 | 96,285 |

Source: Richardson Lawrie Associates

## Table 5-4. Potential Laden Transits in Number of Transits, Existing and Expanded Canal, No Tolls, Most Probable Case, Selected Years, 2001-2025 (transits)

| Vessel Size Range (DWT) | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **South** | | | | | | | | | | |
| Less or equal to 10,000 | 3.5 | - | - | - | - | - | - | - | - | - |
| Greater than 10,000–Less than 15,000 | 27.0 | 29.5 | 83.9 | 95.1 | 126.2 | 154.1 | 93.7 | 114.6 | 168.5 | 221.7 |
| Greater or equal to 15,000–Less than 20,000 | 23.1 | 20.9 | 59.3 | 64.7 | 82.4 | 99.9 | 67.8 | 82.0 | 118.9 | 156.9 |
| Greater or equal to 20,000–Less than 25,000 | 65.3 | 71.9 | 53.6 | 14.5 | - | - | 48.8 | 3.7 | - | - |
| Greater or equal to 25,000–Less than 30,000 | 167.1 | 124.2 | - | - | - | - | - | - | - | - |
| Greater or equal to 30,000–Less than 40,000 | 125.9 | 155.5 | 183.4 | 175.5 | 135.4 | 80.5 | 175.5 | 160.1 | 115.1 | 50.9 |
| Greater or equal to 40,000–Less than 50,000 | 268.4 | 275.9 | 373.1 | 389.1 | 433.6 | 476.1 | 382.8 | 406.2 | 458.3 | 506.5 |
| Greater or equal to 50,000–Less than 60,000 | 42.0 | 66.9 | 108.5 | 137.3 | 175.7 | 219.2 | 104.7 | 132.1 | 169.0 | 211.7 |
| Greater or equal to 60,000–Less than 70,000 | 282.5 | 252.3 | 315.3 | 318.0 | 326.5 | 331.2 | 266.2 | 271.5 | 276.9 | 278.2 |
| Greater or equal to 70,000–Less than 80,000 | 165.6 | 184.0 | 290.5 | 345.1 | 409.1 | 473.5 | 240.4 | 290.2 | 342.2 | 389.6 |
| Greater or equal to 80,000–Less than 90,000 | - | - | - | - | - | - | 35.9 | 42.5 | 48.0 | 52.9 |
| Greater or equal to 90,000–Less than 100,000 | - | - | - | - | - | - | 14.1 | 18.5 | 22.1 | 24.5 |
| Total Southbound | 1,170.4 | 1,181.0 | 1,467.6 | 1,539.3 | 1,688.8 | 1,834.4 | 1,430.0 | 1,521.4 | 1,718.9 | 1,892.8 |
| **North** | | | | | | | | | | |
| Less or equal to 10,000 | | | | | | | | | | |
| Greater than 10,000–Less than 15,000 | - | - | - | - | - | - | - | - | - | - |
| Greater or equal to 15,000–Less than 20,000 | 0.8 | 0.9 | 1.2 | 1.3 | 1.4 | 1.6 | 1.2 | 1.3 | 1.4 | 1.6 |
| Greater or equal to 20,000–Less than 25,000 | 0.3 | 0.3 | 0.4 | 0.5 | 0.5 | 0.5 | 0.4 | 0.5 | 0.5 | 0.5 |
| Greater or equal to 25,000–Less than 30,000 | 0.4 | 0.5 | 0.6 | 0.6 | 0.7 | 0.7 | 0.6 | 0.6 | 0.7 | 0.7 |
| Greater or equal to 30,000–Less than 40,000 | 31.2 | 31.7 | 33.2 | 32.8 | 27.4 | 11.6 | 33.2 | 32.8 | 27.4 | 11.6 |
| Greater or equal to 40,000–Less than 50,000 | 1.0 | 1.1 | 1.3 | 1.4 | 1.5 | 1.5 | 1.3 | 1.3 | 1.4 | 1.4 |
| Greater or equal to 50,000–Less than 60,000 | 0.7 | 0.8 | 1.0 | 1.0 | 1.1 | 1.2 | 0.9 | 0.9 | 1.0 | 1.1 |
| Greater or equal to 60,000–Less than 70,000 | 0.0 | - | - | - | - | - | - | - | - | - |
| Greater or equal to 70,000–Less than 80,000 | 0.1 | - | - | - | - | - | - | - | - | - |
| Greater or equal to 80,000–Less than 90,000 | 0.1 | 0.2 | 0.3 | 0.3 | 0.3 | 0.4 | 0.2 | 0.3 | 0.3 | 0.3 |
| Greater or equal to 90,000–Less than 100,000 | - | - | - | - | - | - | - | - | - | - |
| Total Northbound | 34.6 | 35.5 | 38.0 | 37.8 | 32.9 | 17.4 | 37.8 | 37.6 | 32.7 | 17.2 |
| Grand Total | 1,205.1 | 1,216.4 | 1,505.5 | 1,577.1 | 1,721.7 | 1,851.8 | 1,467.8 | 1,559.0 | 1,751.5 | 1,910.0 |

Source: Richardson Lawrie Associates

## Table 5-5. Potential Laden Transits in PCUMS, Existing and Expanded Canal, No Tolls, Most Probable Case, Selected Years, 2001-2025 (000 PCUMS)

| | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vessel Size Range (DWT) | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **South** | | | | | | | | | | |
| Less or equal to 10,000 | 9 | - | - | - | - | - | - | - | - | - |
| Greater than 10,000–Less than 15,000 | 197 | 215 | 611 | 693 | 920 | 1,123 | 683 | 835 | 1,228 | 1,616 |
| Greater or equal to 15,000–Less than 20,000 | 225 | 203 | 576 | 629 | 800 | 971 | 659 | 797 | 1,155 | 1,525 |
| Greater or equal to 20,000–Less than 25,000 | 897 | 987 | 737 | 199 | - | - | 671 | 51 | - | - |
| Greater or equal to 25,000–Less than 30,000 | 2,415 | 1,795 | - | - | - | - | - | - | - | - |
| Greater or equal to 30,000–Less than 40,000 | 2,397 | 2,962 | 3,492 | 3,342 | 2,578 | 1,532 | 3,343 | 3,049 | 2,191 | 969 |
| Greater or equal to 40,000–Less than 50,000 | 6,367 | 6,545 | 8,851 | 9,230 | 10,286 | 11,294 | 9,081 | 9,637 | 10,873 | 12,015 |
| Greater or equal to 50,000–Less than 60,000 | 1,228 | 1,955 | 3,172 | 4,014 | 5,137 | 6,409 | 3,062 | 3,864 | 4,941 | 6,192 |
| Greater or equal to 60,000–Less than 70,000 | 8,949 | 7,993 | 9,990 | 10,075 | 10,344 | 10,492 | 8,713 | 8,887 | 9,062 | 9,104 |
| Greater or equal to 70,000–Less than 80,000 | 5,636 | 6,261 | 9,883 | 11,744 | 13,919 | 16,112 | 8,338 | 10,066 | 11,872 | 13,514 |
| Greater or equal to 80,000–Less than 90,000 | - | - | - | - | - | - | 1,452 | 1,719 | 1,941 | 2,140 |
| Greater or equal to 90,000–Less than 100,000 | - | - | - | - | - | - | 605 | 794 | 948 | 1,049 |
| Total Southbound | 28,321 | 28,916 | 37,313 | 39,926 | 43,984 | 47,933 | 36,608 | 39,697 | 44,211 | 48,125 |
| **North** | | | | | | | | | | |
| Less or equal to 10,000 | - | - | - | - | - | - | - | - | - | - |
| Greater than 10,000–Less than 15,000 | - | - | - | - | - | - | 9 | 9 | 10 | 11 |
| Greater or equal to 15,000–Less than 20,000 | 6 | 7 | 9 | 9 | 10 | 11 | 4 | 4 | 5 | 5 |
| Greater or equal to 20,000–Less than 25,000 | 3 | 3 | 4 | 4 | 5 | 5 | 8 | 8 | 9 | 9 |
| Greater or equal to 25,000–Less than 30,000 | 6 | 6 | 8 | 8 | 9 | 9 | 481 | 474 | 396 | 168 |
| Greater or equal to 30,000–Less than 40,000 | 451 | 458 | 481 | 474 | 396 | 168 | 24 | 25 | 27 | 27 |
| Greater or equal to 40,000–Less than 50,000 | 19 | 20 | 25 | 26 | 28 | 28 | 21 | 22 | 24 | 25 |
| Greater or equal to 50,000–Less than 60,000 | 17 | 19 | 23 | 24 | 27 | 28 | - | - | - | - |
| Greater or equal to 60,000–Less than 70,000 | 1 | - | - | - | - | - | - | - | - | - |
| Greater or equal to 70,000–Less than 80,000 | 2 | - | - | - | - | - | 9 | 9 | 11 | 12 |
| Greater or equal to 80,000–Less than 90,000 | 3 | 7 | 9 | 10 | 12 | 13 | - | - | - | - |
| Greater or equal to 90,000–Less than 100,000 | - | - | - | - | - | - | - | - | - | - |
| Total Northbound | 507 | 520 | 558 | 557 | 486 | 262 | 554 | 552 | 482 | 257 |
| | | | | | | | - | - | - | - |
| Grand Total | 28,828 | 29,436 | 37,871 | 40,483 | 44,471 | 48,195 | 37,162 | 40,250 | 44,692 | 48,382 |

Source: Richardson Lawrie Associates

Table 5-6 presents summary forecasts of ballast transits in terms of numbers of transits, DWT, and PCUMS. They cover the Most Probable, Best and Worst Cases for the Existing and Expanded Canal.

For the Existing Canal, in the Most Probable Case, the number of transits is estimated to increase from 72 transits in 2001 to 92 transits by 2025. In the Best Case they would reach 93 transits in 2025 and in the Worst Case this figure would fall to 89 transits. What minor changes there are in the growth of future transits would be reflected largely in Northbound transits which account for most of

the total in all cases. The main conclusions from the results of the ballast transit forecasts are as follows:

- ballast transits of dry bulk carriers are almost entirely northbound;
- for the Most Probable Case, the total number of transits - north and south - is projected to rise from 72 in 2001 to 87 in 2025. The estimated range of forecasts in 2025, as represented by the Best and Worst Cases - is 93 down to 68;
- in the Most Probable Case, transits in DWT terms are projected to rise from 2.2 million DWT to 2.9 million DWT with a potential range in 2025 of 2.5 to 3.1 million DWT.
- in terms of PCUMS this translates into an increase in the Most Probable Case from 1.2 to 1.5 million PCUMS and a range in 2025 of 1.3 to 1.6 million.

Under the Expanded Case, ballast transits in 2025 would increase to 106 transits in the Most Probable Case, 109 transits in the Best Case and 90 transits in the Worst Case. The results of the forecasts of ballast transits are summarized as follows:

- in the Most Probable Case, the number of transits in 2005 would rise to 106, 19 more than for the Existing Canal. In the Best case the figure would rise further to 115 transits but the Worst Case would be little changed from that under Existing Canal conditions;
- in terms of DWT, ballast transits in the Most Probable Case would rise to 3.5 million DWT with a maximum of 3.8 million DWT projected in the Best Case;
- forecasts of PCUMS show an increase to 1.8 million DWT in 2025 in the Most Case with a range of 1.3 to 2.0 million DWT. In other words, the overall total in the Worst Case is the same as that for the Existing Canal.

**Table 5-6. Potential Ballast Transits in DWT, Number of Transits and PCUMS, Existing and Expanded Canal, No Tolls, All Cases**

| | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Case | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **Vessel Size (000 DWT)** | | | | | | | | | | |
| Most Probable | 2,245 | 2,459 | 2,699 | 2,920 | 3,022 | 2,976 | 2,755 | 3,006 | 3,333 | 3,455 |
| Best | 2,245 | 2,469 | 2,712 | 2,949 | 2,863 | 3,029 | 2,759 | 2,998 | 3,381 | 3,559 |
| Worst | 2,245 | 2,270 | 2,409 | 2,543 | 2,708 | 3,054 | 2,481 | 2,587 | 2,848 | 3,117 |
| **Transits (no.)** | | | | | | | | | | |
| Most Probable | 72 | 81 | 89 | 93 | 95 | 92 | 90 | 94 | 103 | 106 |
| Best | 72 | 81 | 90 | 96 | 89 | 93 | 90 | 96 | 104 | 109 |
| Worst | 72 | 72 | 75 | 79 | 83 | 89 | 75 | 80 | 85 | 89 |
| **PCUMS (000)** | | | | | | | | | | |
| Most Probable | 1,181 | 1,301 | 1,429 | 1,534 | 1,583 | 1,552 | 1,455 | 1,575 | 1,744 | 1,806 |
| Best | 1,181 | 1,307 | 1,436 | 1,556 | 1,496 | 1,579 | 1,459 | 1,580 | 1,768 | 1,859 |
| Worst | 1,181 | 1,190 | 1,257 | 1,329 | 1,410 | 1,577 | 1,292 | 1,350 | 1,477 | 1,607 |

Source: Richardson Lawrie Associates

## ECONOMIC VALUE OF THE PANAMA CANAL

This section of the Draft Final Report presents the determination of the economic value of the Existing and Expanded Canal. For purposes of this study, the economic value of the Canal refers to the transportation cost differential for specific commodity route pairs through the Panama Canal as compared to the least cost alternative routing[22].

The economic value determination builds on determination of the Canal's potential market and vessel transit and fleet analysis that are presented in *Volume 2: Panama Canal's Potential Market* and *Volume 3: Vessel Transit and Fleet* Analysis. It is important to note that for purposes of this study the term "Canal's potential market" represents our estimate of the maximum market share that the Canal could capture of world trade assuming a value of zero for Panama Canal tolls. *Volume 5: Marketing Strategy* identifies and analyzes the impact of alternative Canal toll structures and rates on forecast traffic volume.

The objectives of this part of the study center on the following elements:

- Identification of Canal commodity–route pairs and least-cost alternative routes
- Identification of transport system constraints and development
- Transportation cost of Canal routes and alternatives routes including land transportation costs elements where relevant;

[22] Economic value as used by the ACP for this study refers to cost-savings as compared to the use of alternative transport routes and modes. It does not include the Canal's broader economic impact on income and employment generation that will be estimated in another study.

- For the Expanded Canal, consideration of grain carrier dimensions and characteristics greater cargo utilization rates, and cost savings due to larger drafts and shorter routes compared to other alternatives; and,
- For the present Canal, and for the Expanded Canal commencing in 2010, the provision of an estimate of the economic value of the Canal's main and potential trades, as compared with alternative routes and other transportation means;
- Determination of the relative margin between the economic value of the Existing Canal and the Expanded Canal from 2010 and 2025.

In developing the approach and methodology for this component of the study, we have drawn on our team's in-depth understanding of global trends in shipping and maritime trade, detailed knowledge of specific product and transportation markets, and ability to organize and conduct meticulous, rigorous transport cost analyses for specific commodity–route pairs. In this section, we present our methodology for estimating the economic value of canal routes for the Existing and Expanded Canal.

## Approach

The determination of the economic value of the Canal involves comparing the total cost of transporting grain commodities over routes transiting the Panama Canal and over alternative routes. For each potential Canal route involving grain commodities, we first identified all current and projected viable alternative routes and then identified the least cost alternative route. Depending on the commodity and particular Canal route under consideration, the least-cost alternative may be one of the following:

- An all-water route such as those around Cape Horn, the Cape of Good Hope or through the Suez Canal,
- A different source of origin of the commodity that does not involve a Canal transit. An effective substitute for the product under consideration.

The definition of the least-cost alternatives takes into account the following factors:

- Mileage, if necessary, at a port level where more than one port might be considered representative of a particular origin or destination.
- Size and characteristics of vessels forecast to be operating on specific commodity–route pairs for all-water alternative routes
- Current and projected draft of ports that serve the Canal and alternative routes. These include the ports of origin and destination, as well as intermediate ports.
- Current and projected capacity constraints in the transportation system, including bottlenecks and congestion at ports, limits of the land transport system, and the capacity of the Panama Canal under Existing and Expanded Canal scenarios.

- Commodity market forecasts that look at production and consumption trends and developments that will help identify current and future geographic and product competition.
- Timing. Route structures may change during the projection period, as improvements in the transportation system and other developments are implemented. Typically, if one expects trade on a specific route to grow over the forecast period, then, all other things being equal, cargo sizes will increase and there is also the possibility that the incidence of "parceling" of cargoes will increase to the utilization of larger vessels as has been seen in the coal and iron ore trades.
- Typical cargo sizes that may be determined not by transportation considerations but by industrial requirements and trade volumes.
- Inventory costs for the additional time required for shipping over the longer distances associated with least cost alternative routes.

For each commodity–route pair, we compared the total freight cost of the commodity via routes through the Existing Canal and the least-cost alternative route. The cost differential was then determined on an annual basis from 2000 through 2025. Hence, the timing of developments that affect the cost or capacity of the system was integrated directly in the transport cost analysis.

## Results

Table 5-7 summarizes the total economic values calculated for both the Existing and Expanded Canal, through to 2025. Under Existing Canal conditions, the economic value of the Canal is estimated to remain within the range of the equivalent of $4.93 per ton to $5.67 per ton in $2002 terms. Translated into total economic value, this results in a steady increase from $259 million in 2001 to $390 million in 2025.

**Table 5-7. Summary of Economic Value of Existing and Expanded Panama Canal, Most Probable Case, Selected Years 2001-2025**

| | Existing Canal | | | | Expanded Canal | | | | Margin Expanded vs. Existing Canal | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Potential Panama Canal Transits | Potential Panama Canal cargo (tons 000s) | Economic Value of Canal ($/ton | Economic Value of Canal ($000s) | Potential Panama Canal Transits | Potential Panama Canal cargo (tons 000s) | Economic Value of Canal ($/ton) | Economic Value of Canal ($000s) | Economic Value of Canal ($/ton) | Economic Value of Canal ($000s) |
| 2001 | 1,202 | 47,339 | 5.48 | 259,522 | | | | | | |
| 2005 | 1,213 | 48,238 | 5.67 | 273,674 | | | | | | |
| 2010 | 1,502 | 62,114 | 5.21 | 323,405 | 1,464 | 63,186 | 6.01 | 379,903 | 0.81 | 56,498 |
| 2015 | 1,573 | 66,490 | 5.13 | 340,865 | 1,555 | 68,731 | 5.96 | 409,510 | 0.83 | 68,645 |
| 2020 | 1,717 | 73,036 | 5.06 | 369,893 | 1,748 | 77,449 | 6.05 | 468,557 | 0.99 | 98,664 |
| 2025 | 1,847 | 79,133 | 4.93 | 389,775 | 1,906 | 83,841 | 6.13 | 513,845 | 1.20 | 124,071 |

Source: Nathan Associates Inc.

For the Expanded Canal, the economic value is projected to increase from the equivalent of $6.01 per ton in 2010 to $6.13 per ton in 2025. Total economic value would rise from $380 million to $514 million. The margins between the Expanded Canal and the Existing Canal from 2010 to 2025 are estimated to increase from $0.81 per ton to $1.20 per ton, or from $56 million to $124 million.

Table 5-8 presents the detailed results of the economic value calculations at the route, commodity level for 2001 and 2005. Table 5-9 presents the results of the Existing and Expanded Canal cases and the margin in economic value of the Expanded Canal; versus the Existing Canal for 2010. Table 5-10 presents the same items for 2025.

**Table 5-8. Economic Value of Existing Panama Canal, Most Probable Case by Route and Commodity, 2001 and 2005**

| | | | 2001 | | | | 2005 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Origin | Destination | Commodity | Potential Panama Canal Transits | Potential Panama Canal cargo (tons 000s) | Economic Value of Canal ($/ton) | Economic Value of Canal ($000s) | Potential Panama Canal Transits | Potential Panama Canal cargo (tons 000s) | Economic Value of Canal ($/ton) | Economic Value of Canal ($000s) |
| North America East | South Korea | Wheat | - | - | - | - | 2.5 | 128.0 | 3.11 | 398.1 |
| North America Gulf | Central America West | Corn | 118.0 | 2,931.4 | 12.41 | 36,374.3 | 113.4 | 2,931.4 | 12.18 | 35,702.6 |
| North America Gulf | Central America West | Grains, misc | 2.4 | 60.4 | 12.41 | 749.4 | 2.7 | 68.6 | 12.18 | 836.0 |
| North America Gulf | Central America West | Rice | 10.0 | 248.1 | 12.41 | 3,078.1 | 10.7 | 275.7 | 12.18 | 3,358.0 |
| North America Gulf | Central America West | Sorghum | 1.0 | 25.3 | 12.44 | 314.3 | 1.4 | 36.1 | 12.18 | 439.4 |
| North America Gulf | Central America West | Soybeans | 9.7 | 241.0 | 12.41 | 2,991.0 | 10.5 | 270.5 | 12.18 | 3,294.3 |
| North America Gulf | Central America West | Wheat | 7.9 | 196.2 | 12.41 | 2,434.3 | 53.1 | 1,372.6 | 12.18 | 16,718.1 |
| North America Gulf | South America West | Corn | 101.7 | 2,590.7 | 10.84 | 28,092.2 | 94.1 | 2,510.9 | 10.59 | 26,593.2 |
| North America Gulf | South America West | Grains, misc | 1.4 | 34.9 | 10.84 | 378.5 | 1.5 | 38.7 | 10.59 | 410.1 |
| North America Gulf | South America West | Sorghum | 3.2 | 81.9 | 10.84 | 888.1 | 3.2 | 86.4 | 10.59 | 915.1 |
| North America Gulf | South America West | Wheat | 136.2 | 3,467.5 | 10.84 | 37,600.0 | 138.9 | 3,707.6 | 10.59 | 39,268.5 |
| North America Gulf | South East Asia | Corn | - | - | - | - | 0.9 | 39.7 | 0.16 | 6.2 |
| North America Gulf | South East Asia | Grains, misc | 0.8 | 33.8 | 0.16 | 5.3 | 0.8 | 37.2 | 0.16 | 5.8 |
| North America Gulf | South East Asia | Soybeans | 36.8 | 1,610.0 | 0.16 | 250.3 | 26.4 | 1,174.0 | 0.16 | 182.2 |
| North America Gulf | South East Asia | Wheat | 46.7 | 2,046.9 | 0.16 | 318.2 | - | - | - | - |
| North America Gulf | China | Soybeans | 57.6 | 2,983.0 | 4.06 | 12,103.9 | 57.6 | 2,998.0 | 4.04 | 12,107.0 |
| North America Gulf | Taiwan | Corn | 54.6 | 2,925.0 | 3.15 | 9,214.4 | 55.2 | 2,966.0 | 3.15 | 9,329.1 |
| North America Gulf | Taiwan | Grains, misc | 0.9 | 48.6 | 3.15 | 153.1 | 1.0 | 53.8 | 3.15 | 169.1 |
| North America Gulf | Taiwan | Sorghum | 0.1 | 7.7 | 3.12 | 23.9 | 0.1 | 7.7 | 3.11 | 23.9 |
| North America Gulf | Japan | Corn | 252.2 | 12,029.5 | 5.64 | 67,869.3 | 247.9 | 12,030.5 | 5.60 | 67,424.2 |
| North America Gulf | Japan | Grains, misc | 7.5 | 357.7 | 5.64 | 2,018.3 | 8.1 | 394.0 | 5.60 | 2,208.2 |
| North America Gulf | Japan | Sorghum | 26.9 | 1,285.0 | 5.64 | 7,249.9 | 18.8 | 912.0 | 5.60 | 5,111.3 |
| North America Gulf | Japan | Soybeans | 60.3 | 2,877.9 | 5.64 | 16,237.0 | 60.3 | 2,925.5 | 5.60 | 16,395.5 |
| North America Gulf | South Korea | Corn | 65.1 | 3,215.0 | 4.84 | 15,568.4 | 64.9 | 3,219.0 | 4.82 | 15,530.9 |
| North America Gulf | South Korea | Grains, misc | 0.2 | 9.7 | 4.76 | 46.4 | 0.2 | 11.1 | 4.76 | 52.6 |
| North America Gulf | South Korea | Sorghum | 0.1 | 2.8 | 4.76 | 13.6 | 0.1 | 2.8 | 4.76 | 13.5 |
| Brazil | China | Soybeans | 70.3 | 3,233.0 | 1.20 | 3,877.6 | 115.7 | 5,330.0 | 1.19 | 6,346.1 |
| Brazil | Japan | Soybeans | 45.7 | 2,102.0 | 0.08 | 167.1 | 44.9 | 2,070.0 | 0.08 | 163.9 |
| Brazil | South Korea | Soybeans | 33.1 | 1,522.0 | 1.95 | 2,972.8 | 33.8 | 1,559.0 | 1.94 | 3,022.6 |
| Europe | South America West | Barley | 16.1 | 376.6 | 6.94 | 2,612.4 | 9.4 | 264.9 | 6.38 | 1,689.6 |
| Europe | South America West | Grains, misc | 3.1 | 71.9 | 6.76 | 486.2 | 2.8 | 79.2 | 6.15 | 487.1 |
| North America West | Europe | Grains, misc | 1.9 | 49.4 | 7.44 | 367.5 | 2.0 | 54.4 | 7.31 | 398.0 |
| North America West | Middle East | Rice | 30.3 | 674.0 | 7.52 | 5,066.5 | 30.7 | 683.0 | 7.43 | 5,073.4 |
| Total | | | 1,201.7 | 47,338.9 | 5.48 | 259,522.2 | 1,213.4 | 48,238.2 | 5.67 | 273,673.6 |

Source: Nathan Associates Inc.

## Table 5-9. Economic Value of Existing and Expanded Panama Canal, Most Probable Case by Commodity and Route, 2010

| | | | Existing Canal | | | | Expanded Canal | | | | Margin Expanded vs. Existing Canal | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Origin | Destination | Commodity | Potential Panama Canal Transits | Panama Canal cargo (tons 000s) | Economic Value of Canal ($/ton) | Economic Value of Canal ($000s) | Potential Panama Canal Transits | Potential Panama Canal cargo (tons 000s) | Economic Value of Canal ($/ton) | Economic Value of Canal ($000s) | Economic Value of Canal ($/ton) | Economic Value of Canal ($000s) |
| Brazil | South Korea | Barley | 0.50 | 23 | 1.96 | 45.1 | 0.48 | 23 | 2.31 | 52.6 | 0.35 | 7.5 |
| Europe | South America West | Barley | 10.16 | 295 | 6.45 | 1,901.8 | 10.29 | 295 | 6.50 | 1,916.8 | 0.05 | 14.9 |
| North America Gulf | Central America West | Corn | 113.85 | 2,931 | 12.22 | 35,811.5 | 115.90 | 2,930 | 12.36 | 36,207.1 | 0.14 | 395.6 |
| North America Gulf | South America West | Corn | 129.13 | 3,492 | 10.50 | 36,653.8 | 131.15 | 3,490 | 10.60 | 37,012.6 | 0.11 | 358.9 |
| North America Gulf | South East Asia | Corn | 2.05 | 95 | 0.15 | 14.6 | 10.78 | 535 | 1.66 | 891.5 | 1.51 | 876.8 |
| North America Gulf | China | Corn | 120.12 | 6,333 | 4.07 | 25,796.6 | 106.53 | 6,183 | 5.41 | 33,436.1 | 1.33 | 7,639.5 |
| North America Gulf | Taiwan | Corn | 55.56 | 3,006 | 3.19 | 9,574.1 | 48.36 | 2,932 | 4.75 | 13,927.9 | 1.56 | 4,353.8 |
| North America Gulf | Japan | Corn | 241.97 | 12,032 | 5.61 | 67,544.4 | 219.12 | 11,783 | 6.98 | 82,194.1 | 1.36 | 14,649.8 |
| North America Gulf | South Korea | Corn | 64.09 | 3,223 | 4.86 | 15,664.6 | 57.78 | 3,149 | 5.97 | 18,798.8 | 1.11 | 3,134.2 |
| North America Gulf | Central America West | Grains, misc | 3.16 | 81 | 12.22 | 993.3 | 3.21 | 81 | 12.36 | 1,004.2 | 0.14 | 11.0 |
| North America Gulf | South America West | Grains, misc | 1.75 | 47 | 10.50 | 496.2 | 1.78 | 47 | 10.60 | 501.0 | 0.11 | 4.9 |
| North America Gulf | South East Asia | Grains, misc | 0.99 | 46 | 0.15 | 7.1 | 0.91 | 45 | 1.66 | 75.2 | 1.51 | 68.1 |
| North America Gulf | Taiwan | Grains, misc | 1.24 | 67 | 3.19 | 213.4 | 1.08 | 65 | 4.75 | 310.4 | 1.56 | 97.0 |
| North America Gulf | Japan | Grains, misc | 9.76 | 485 | 5.61 | 2,724.7 | 8.84 | 475 | 6.98 | 3,315.6 | 1.36 | 591.0 |
| North America Gulf | South Korea | Grains, misc | 0.28 | 14 | 4.86 | 67.7 | 0.25 | 14 | 5.97 | 81.2 | 1.11 | 13.5 |
| Europe | South America West | Grains, misc | 3.36 | 98 | 6.09 | 594.4 | 3.40 | 98 | 6.14 | 598.6 | 0.04 | 4.2 |
| North America West | South America East | Grains, misc | - | - | - | | 0.24 | 10 | 0.37 | 3.6 | n.a. | n.a. |
| North America West | Europe | Grains, misc | 2.51 | 67 | 7.41 | 496.6 | 2.41 | 67 | 8.15 | 544.4 | 0.74 | 47.8 |
| North America Gulf | Central America West | Rice | 11.78 | 303 | 12.22 | 3,706.1 | 11.99 | 303 | 12.36 | 3,747.0 | 0.14 | 40.9 |
| North America West | Middle East | Rice | 32.08 | 714 | 7.55 | 5,394.1 | 32.08 | 714 | 7.55 | 5,394.1 | - | - |
| North America Gulf | Central America West | Sorghum | 1.82 | 47 | 12.22 | 571.0 | 1.85 | 47 | 12.36 | 577.3 | 0.14 | 6.3 |
| North America Gulf | South America West | Sorghum | 3.39 | 92 | 10.50 | 963.5 | 3.45 | 92 | 10.60 | 973.0 | 0.11 | 9.4 |
| North America Gulf | Taiwan | Sorghum | 0.15 | 8 | 3.19 | 25.5 | 0.13 | 8 | 4.75 | 37.1 | 1.56 | 11.6 |
| North America Gulf | Japan | Sorghum | 10.66 | 530 | 5.61 | 2,975.2 | 9.71 | 522 | 6.98 | 3,640.9 | 1.36 | 665.8 |
| North America Gulf | South Korea | Sorghum | 0.06 | 3 | 4.86 | 14.6 | 0.05 | 3 | 5.97 | 17.5 | 1.11 | 2.9 |
| North America Gulf | Central America West | Soybeans | 11.68 | 301 | 12.22 | 3,675.3 | 11.89 | 301 | 12.36 | 3,715.9 | 0.14 | 40.6 |
| North America Gulf | South East Asia | Soybeans | 25.73 | 1,187 | 0.15 | 183.4 | 23.54 | 1,169 | 1.66 | 1,947.0 | 1.51 | 1,763.6 |
| North America Gulf | China | Soybeans | 49.11 | 2,589 | 4.07 | 10,545.9 | 43.55 | 2,528 | 5.41 | 13,669.0 | 1.33 | 3,123.1 |
| North America Gulf | Japan | Soybeans | 60.03 | 2,985 | 5.61 | 16,755.5 | 54.36 | 2,923 | 6.98 | 20,389.6 | 1.36 | 3,634.1 |
| Brazil | China | Soybeans | 163.78 | 7,583 | 1.21 | 9,138.2 | 157.96 | 7,504 | 1.58 | 11,850.8 | 0.37 | 2,712.6 |
| Brazil | Japan | Soybeans | 43.76 | 2,026 | 0.08 | 161.4 | 42.20 | 2,005 | 0.54 | 1,073.0 | 0.46 | 911.6 |
| Brazil | South Korea | Soybeans | 34.45 | 1,595 | 1.96 | 3,130.4 | 33.22 | 1,578 | 2.31 | 3,648.9 | 0.35 | 518.5 |
| North America East | South Korea | Wheat | 46.28 | 2,406 | 3.15 | 7,577.5 | 53.47 | 3,088 | 4.37 | 13,489.4 | 1.22 | 5,911.9 |
| North America Gulf | Central America West | Wheat | 58.28 | 1,501 | 12.22 | 18,331.4 | 59.33 | 1,500 | 12.36 | 18,533.9 | 0.14 | 202.5 |
| North America Gulf | South America West | Wheat | 145.68 | 3,940 | 10.50 | 41,352.2 | 147.98 | 3,938 | 10.60 | 41,761.9 | 0.11 | 409.7 |
| North America Gulf | South East Asia | Wheat | 42.67 | 1,969 | 0.15 | 304.2 | 55.19 | 2,742 | 1.66 | 4,564.8 | 1.51 | 4,260.6 |
| Total | | | 1,502 | 62,114 | 5.21 | 323,405 | 1,464 | 63,186 | 6.01 | 379,903 | 0.81 | 56,498 |

Source: Nathan Associates Inc.

**Table 5-10. Economic Value of Existing and Expanded Panama Canal, Most Probable Case by Commodity and Route, 202**

| | | | Existing Canal | | | | Expanded Canal | | | | Margin Expanded vs. Existing Canal | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Origin | Destination | Commodity | Potential Panama Canal Transits | Potential Panama Canal cargo | Economic Value of Canal ($/ton) | Economic Value of Canal ($000s) | Potential Panama Canal Transits | Potential Panama Canal cargo | Economic Value of Canal ($/ton) | Economic Value of Canal ($000s) | Economic Value of Canal ($/ton) | Economic Value of Canal ($000s) |
| North America East | China | Barley | 16.14 | 844 | 2.60 | 2,193.5 | 19.91 | 1,153 | 3.79 | 4,366.7 | 1.19 | 2,173.3 |
| North America Gulf | China | Barley | 0.57 | 30 | 4.31 | 129.3 | 1.58 | 95 | 5.78 | 549.2 | 1.47 | 419.9 |
| Brazil | China | Barley | 9.38 | 437 | 1.28 | 557.5 | 9.06 | 437 | 1.66 | 725.6 | 0.38 | 168.0 |
| Europe | South America West | Barley | 18.11 | 512 | 7.09 | 3,631.2 | 19.12 | 512 | 7.35 | 3,764.5 | 0.26 | 133.3 |
| North America Gulf | Central America West | Corn | 124.76 | 2,931 | 13.57 | 39,771.2 | 135.87 | 2,931 | 14.34 | 42,023.9 | 0.77 | 2,252.7 |
| North America Gulf | South America West | Corn | 135.30 | 3,492 | 11.34 | 39,599.5 | 143.54 | 3,492 | 11.77 | 41,119.8 | 0.44 | 1,520.3 |
| North America Gulf | South East Asia | Corn | 12.00 | 575 | 0.16 | 91.3 | 11.56 | 617 | 2.00 | 1,233.1 | 1.84 | 1,141.9 |
| North America Gulf | China | Corn | 119.56 | 6,333 | 4.31 | 27,285.9 | 105.17 | 6,333 | 5.78 | 36,611.1 | 1.47 | 9,325.2 |
| North America Gulf | Taiwan | Corn | 65.31 | 3,567 | 3.36 | 11,997.3 | 56.30 | 3,567 | 5.11 | 18,214.1 | 1.74 | 6,216.8 |
| North America Gulf | Japan | Corn | 240.32 | 12,092 | 5.92 | 71,535.1 | 215.21 | 12,092 | 7.46 | 90,151.5 | 1.54 | 18,616.4 |
| North America Gulf | South Korea | Corn | 67.19 | 3,399 | 5.14 | 17,464.5 | 59.82 | 3,399 | 6.40 | 21,743.5 | 1.26 | 4,279.0 |
| North America Gulf | Central America West | Grains, misc | 4.18 | 98 | 13.57 | 1,332.2 | 4.55 | 98 | 14.34 | 1,407.7 | 0.77 | 75.5 |
| North America Gulf | South America West | Grains, misc | 2.21 | 57 | 11.34 | 647.3 | 2.35 | 57 | 11.77 | 672.2 | 0.44 | 24.9 |
| North America Gulf | South East Asia | Grains, misc | 1.16 | 55 | 0.16 | 8.8 | 1.04 | 55 | 2.00 | 110.6 | 1.84 | 101.8 |
| North America Gulf | Taiwan | Grains, misc | 1.48 | 81 | 3.36 | 272.4 | 1.28 | 81 | 5.11 | 413.6 | 1.74 | 141.2 |
| North America Gulf | Japan | Grains, misc | 11.65 | 586 | 5.92 | 3,467.9 | 10.43 | 586 | 7.46 | 4,370.4 | 1.54 | 902.5 |
| North America Gulf | South Korea | Grains, misc | 0.33 | 17 | 5.14 | 86.5 | 0.30 | 17 | 6.40 | 107.7 | 1.26 | 21.2 |
| Europe | South America West | Grains, misc | 4.16 | 118 | 6.55 | 771.1 | 4.40 | 118 | 6.77 | 797.4 | 0.22 | 26.3 |
| North America West | South America East | Grains, misc | - | - | - | - | 0.30 | 13 | 0.39 | 4.9 | n.a. | n.a. |
| North America West | Europe | Grains, misc | 2.99 | 81 | 7.82 | 632.9 | 2.86 | 81 | 8.62 | 697.2 | 0.79 | 64.3 |
| North America Gulf | Central America West | Rice | 17.92 | 421 | 13.57 | 5,712.9 | 19.52 | 421 | 14.34 | 6,036.5 | 0.77 | 323.6 |
| North America West | Middle East | Rice | 10.25 | 228 | 8.06 | 1,837.5 | 10.25 | 228 | 8.06 | 1,837.5 | - | - |
| North America Gulf | Central America West | Sorghum | 3.77 | 89 | 13.57 | 1,201.5 | - | - | - | - | n.a. | n.a. |
| North America Gulf | South America West | Sorghum | 3.84 | 99 | 11.34 | 1,122.6 | 4.07 | 99 | 11.77 | 1,165.7 | 0.44 | 43.1 |
| North America Gulf | Taiwan | Sorghum | 0.15 | 8 | 3.36 | 26.9 | 0.13 | 8 | 5.11 | 40.9 | 1.74 | 13.9 |
| North America Gulf | Japan | Sorghum | 18.56 | 934 | 5.92 | 5,525.5 | 18.55 | 1,042 | 7.46 | 7,768.7 | 1.54 | 2,243.2 |
| North America Gulf | South Korea | Sorghum | 0.06 | 3 | 5.14 | 15.4 | 0.05 | 3 | 6.40 | 19.2 | 1.26 | 3.8 |
| North America Gulf | Central America West | Soybeans | 19.62 | 461 | 13.57 | 6,253.5 | 21.36 | 461 | 14.34 | 6,607.7 | 0.77 | 354.2 |
| North America Gulf | South East Asia | Soybeans | - | - | - | - | 41.55 | 2,219 | 2.00 | 4,433.3 | n.a. | n.a. |
| North America Gulf | China | Soybeans | 157.17 | 8,325 | 4.31 | 35,868.5 | 138.25 | 8,325 | 5.78 | 48,126.9 | 1.47 | 12,258.4 |
| North America Gulf | Japan | Soybeans | 59.89 | 3,014 | 5.92 | 17,828.1 | 53.63 | 3,014 | 7.46 | 22,467.7 | 1.54 | 4,639.6 |
| Brazil | China | Soybeans | 289.14 | 13,472 | 1.28 | 17,187.9 | 321.98 | 15,525 | 1.66 | 25,776.2 | 0.38 | 8,588.3 |
| Brazil | Japan | Soybeans | 44.04 | 2,052 | 0.08 | 168.3 | - | - | - | - | n.a. | n.a. |
| Brazil | South Korea | Soybeans | 35.50 | 1,654 | 2.08 | 3,439.3 | 34.30 | 1,639 | 2.43 | 3,989.5 | 0.35 | 550.2 |
| North America East | China | Wheat | - | - | - | - | 21.74 | 1,259 | 3.79 | 4,768.2 | n.a. | n.a. |
| North America East | South Korea | Wheat | 64.09 | 3,365 | 3.33 | 11,205.3 | 69.28 | 4,171 | 4.71 | 19,659.2 | 1.38 | 8,453.9 |
| North America Gulf | Central America West | Wheat | - | - | - | - | 95.26 | 2,055 | 14.34 | 29,464.5 | n.a. | n.a. |
| North America Gulf | South America West | Wheat | 187.61 | 4,842 | 11.34 | 54,909.8 | 199.03 | 4,842 | 11.77 | 57,014.7 | 0.44 | 2,104.8 |
| North America Gulf | South East Asia | Wheat | 75.13 | 3,601 | 0.16 | 571.6 | 52.34 | 2,795 | 2.00 | 5,584.1 | 1.84 | 5,012.5 |
| North America Gulf | China | Wheat | 23.77 | 1,259 | 4.31 | 5,424.4 | - | - | - | - | n.a. | n.a. |
| Total | | | 1,847 | 79,133 | 4.93 | 389,775 | 1,906 | 83,841 | 6.13 | 513,845 | 1.20 | 124,071 |

Source: Nathan Associates Inc.

# 6. Canal Toll Pricing Strategy and Forecast of Canal Transits and Toll Revenue

This section presents the analysis and recommendations for a marketing strategy for the Existing and Expanded Canal. The recommended marketing strategy identifies an optimum pricing strategy for the dry bulk market segment including the structure and rates for Canal tolls and its implementation.

## APPROACH

Our approach consists of the following steps:

- Review toll policy theory and concepts.
- Evaluate the theoretical dimensions and performance of the current Canal toll policy, structure, and rates.
- Conduct a comparative analysis of toll policies and rate schedules at facilities similar to the Panama Canal.
- Specify and analyze alternative Canal toll structures and rates and develop optimal structure and rates.
- Prepare a strategic implementation plan for introducing the revised toll policy.

## TOLL POLICY THEORY AND CONCEPTS

A toll policy represents a set of principles underlying the objectives to be achieved by a given toll rate structure. Basic objectives include

- Revenues expected to be generated by the toll rates and traffic volumes;
- Equity or fairness, which can be measured by whether the toll rates reflect the
  - Cost of providing service through the waterway,
  - Value of service to the user, and
  - User's ability to pay, which can be measured by cubic cargo capacity, quantity of cargo, and value of cargo;
- Promotion of traffic growth;
- Efficiency or capacity utilization of the waterway; and
- Administrative simplicity.

Determining the optimal toll structure depends on the priority of these objectives. Some objectives conflict, so it is important to define limits or acceptable ranges for some of them. For instance, maximizing revenue could conflict with equity or fairness, if carried to an extreme. Other objectives could also conflict, such as the promotion of traffic growth and generation of revenues. The treatment of these issues for this study is described in Section 3.

## PANAMA CANAL TOLL POLICY

From it opening in 1914 through 1999, the Panama Canal was operated under the control of the United States and with toll policies and rates established by the United States. With the transfer of control of the Panama Canal to Panama in December 1999, toll policy and rates were established by the newly created Panama Canal Authority in accordance with Panamanian law and existing treaties. In the sections below, we discuss the key elements of the Panama Canal toll policy and rates for these two periods.

### Prior to 2000

#### *Policy*

Until 2000, Panama Canal tolls were set at rates calculated to produce revenues to cover as nearly as practicable all costs of maintaining and operating the Canal and related facilities and appurtenances and to provide capital for plant replacement, expansion, and improvement. Tolls were assessed on the earning capacity of the ship, defined as the gross tonnage minus spaces used for operating the ship, such as the engine room, fuel tanks, and crew quarters. On July 1, 1997, the rules of measurement were modified to apply to on-deck container carrying capacity.

Tolls were required to be set at rates calculated to produce revenues to cover, as nearly as practicable, all costs of maintaining and operating the canal and related facilities and appurtenances and to provide capital for plant replacement, expansion, and improvements.

#### *Rate Structure*

Tolls were assessed on the earning capacity of the ship. Earning capacity is the cubic cargo-carrying capacity of the ship. It equals the total enclosed space (gross tonnage) of the ship minus the spaces used for operating the ship – the spaces required for the engine room, fuel tanks, and crew quarters. At the Panama Canal, a ship's earning capacity is referred to as the Panama Canal net tons.

On October 1, 1994, the Panama Canal Commission adopted the Panama Canal Universal Measurement System (PC/UMS) to determine the volume of vessel to be used to assess Panama Canal tolls. The system is compatible with the standard tonnage measurement promulgated in the 1969 International Convention on Tonnage Measurement of Ships.

The Panama Canal system of tolls applies rates per PC/UMS ton. There are differentiated rates only for laden and ballast vessel. The structure of the toll structure at the Panama Canal does not vary by merchant ship type or by ship size. It does, however, differentiate between laden and ballast merchant vessels.

Panama Canal tolls remain unchanged from its opening in 1914 to 1974. From 1974 to 2000, Panama Canal tolls were increased 8 times as shown in Table 6-1.

**Table 6-1 Panama Canal Tolls for Laden and Ballast Transits 1974-2002 ($ per PCUMS)**

| Date | Landen | Ballast |
|---|---|---|
| Before July 8, 1974 | 0.9 | 0.72 |
| July 8, 1974 | 1.08 | 0.86 |
| November 18, 1976 | 1.29 | 1.03 |
| October 1, 1979 | 1.67 | 1.33 |
| March 12, 1983 | 1.83 | 1.46 |
| October 1, 1989 | 2.01 | 1.6 |
| October 1, 1992 | 2.21 | 1.76 |
| January 1, 1997 | 2.39 | 1.9 |
| January 1, 1998 | 2.57 | 2.04 |

Source: Autoridad de Canal de Panama.

## Post 2000

### *Policy*

In 2000, the ACP announced that new guidelines that would permit the Canal to earn a profit rather than simply cover costs would be established. Under the new guidelines, tolls will be based on the following principles:

- Canal operating and maintenance costs
- The protection of water resources
- Working capital and required reserves
- Payments to the national treasury stipulated by the constitution and the law governing the ACP
- Funds needed to expand, upgrade, and modernize the canal
- Interest on the Canal's value based upon the interest rate approved by the ACP
- Losses from previous years.

### *Rate Structure*

In October 2002, Panama implemented a new rate structure for Canal tolls. The new structure is based on ship size and type with a separate provision for use of locomotives. Along with the new rate structure, two toll increases were adopted; the first to take effect on October 1, 2002 and the second to take effect on July 1, 2003. The new rate structure and toll levels are presented in Table 6-2. While the new rate structure allows for tolls to vary by type of vessel, actual toll levied remain uniform across vessel types.

**Table 6-2. Panama Canal Tolls, 2002-2003 ($ per PCUMS)**

| Type of vessel | First 10,000 tons | | Next 10,000 tons | | Remaining tons | |
|---|---|---|---|---|---|---|
| | Laden | Ballast | Laden | Ballast | Laden | Ballast |
| **Panama Canal Tolls - October 1, 2002** | | | | | | |
| General cargo | $2.80 | $2.22 | $2.78 | $2.21 | $2.75 | $2.18 |
| Refrigerated cargo | $2.80 | $2.22 | $2.78 | $2.21 | $2.75 | $2.18 |
| Dry bulk | $2.80 | $2.22 | $2.78 | $2.21 | $2.75 | $2.18 |
| Tankers | $2.80 | $2.22 | $2.78 | $2.21 | $2.75 | $2.18 |
| Container ships | $2.80 | $2.22 | $2.78 | $2.21 | $2.75 | $2.18 |
| Vehicle carriers | $2.80 | $2.22 | $2.78 | $2.21 | $2.75 | $2.18 |
| Passenger ships | $2.80 | $2.22 | $2.78 | $2.21 | $2.75 | $2.18 |
| Others | $2.80 | $2.22 | $2.78 | $2.21 | $2.75 | $2.18 |
| **Panama Canal Tolls Structure- July 1, 2003** | | | | | | |
| General cargo | $2.96 | $2.35 | $2.90 | $2.30 | $2.85 | $2.26 |
| Refrigerated cargo | $2.96 | $2.35 | $2.90 | $2.30 | $2.85 | $2.26 |
| Dry bulk | $2.96 | $2.35 | $2.90 | $2.30 | $2.85 | $2.26 |
| Tankers | $2.96 | $2.35 | $2.90 | $2.30 | $2.85 | $2.26 |
| Container ships | $2.96 | $2.35 | $2.90 | $2.30 | $2.85 | $2.26 |
| Vehicle carriers | $2.96 | $2.35 | $2.90 | $2.30 | $2.85 | $2.26 |
| Passenger ships | $2.96 | $2.35 | $2.90 | $2.30 | $2.85 | $2.26 |
| Others | $2.96 | $2.35 | $2.90 | $2.30 | $2.85 | $2.26 |

## Achievement of Underlying Objectives

Prior studies of the Panama Canal tolls examined how well the Panama Canal toll structure in the pre-2000 period met stated toll policies. However, as current Panama Canal tolls are uniform by vessel type and vary only slightly by vessel size, findings regarding Canal tolls in the pre-2000 remain relevant today.

Based on cost of service, small vessels pay less than the marginal cost of providing Canal service and a disproportionately small share of fixed costs; large vessels pay more than the marginal cost of service and a disproportionately large share of fixed costs. The marginal cost of providing service is the cost that varies with the number of transits or the size of the vessel. In contrast, the fixed cost of providing service does not vary with traffic. It is a sunk cost incurred to make the Canal available to shippers.

Tolls are not necessarily proportional to the value of the service provided by the Canal. Value of service is directly related to the degree that shippers need to use the Canal. For shippers who have no economically attractive alternative to the Canal to move cargo from supply sources to demand destinations, the value of the Canal is high. The toll should be relatively high to reflect this value. However, when commodities can be purchased from numerous alternative sources of supply or when they can be transported by several different modes of transportation or in large vessels, shippers have more transportation alternatives available to them, some of which are likely to be an economically attractive alternative to the Canal. In these cases, the value of service provided by the Canal is relatively low and shippers should be charged in a lower toll to encourage their continued use of the Canal. The Existing Canal toll structure, however, does not vary by value of service. All shippers

pay the same rate. As a result, larger vessels, which, because of economies of scale, have more routing alternatives than do smaller vessels, pay a toll not necessarily proportional to the value of service they receive from the Canal. And, for some commodities, tolls are not proportional to the value of Canal service

The structure reflects ability to pay on the basis of earning capacity. Only indirectly, through a toll differential on laden versus ballast movements, does the structure reflect ability to pay on the basis of the quantity of cargo carried. Only coincidentally – when dense cargoes are of low value – does the current structure reflect ability to pay on the basis of cargo value. Iron and steel, however, are dense, high-value Canal cargoes for which the toll structure does not reflect to pay on the basis of cargo value.

Efficiency was not promoted by the pre-200- Canal toll structure. It encouraged use by small ships and discourages use by large ships. As a result, it discouraged use by those who contribute most to recovery of fixed cost.

## PANAMA CANAL TREATIES OF 1977 AND TOLL POLICY IMPLICATIONS

Beginning in 1903, the U.S.-Panama Treaty of 1903 and subsequent amendments have governed Canal operations since the construction of the waterway. Under the treaty, the United States had total control of the Canal operations and the Canal Zone.

The Panama Canal Treaty and the Treaty Concerning the Permanent Neutrality and Operation of the Panama Canal, signed September 7, 1977, changed the relationship between the United States and Panama. These treaties provide for the transfer of all rights to and operation of the Canal to Panama by December 31, 1999. In addition, the goals of the treaties were to ensure that the Canal would be efficiently operated and would remain secure, neutral, and open to all nations.

Article I of the Panama Canal Treaty of 1977 provided that "The Republic of Panama declares that the Canal, as an international transit waterway, shall be permanently neutral in accordance with the regime established in this Treaty. The same regime of neutrality shall apply to any other international waterway that may be built either partially or wholly in the territory of the Republic of Panama."

Article II, Paragraph 1(c), of the 1977 Treaty Concerning the Permanent Neutrality and Operation of the Panama Canal provides that for purposes of the security, efficiency, and proper maintenance of the Canal, "tolls and other charges for transit and ancillary services shall be just, reasonable, equitable and consistent with the principles of international law."

During ratification of the treaties, the U.S. Senate introduced an "Understanding" to the neutrality treaty, which reads as follow:

> "(1) Paragraph 1 (c) of Article III of the Treaty shall be construed as requiring, before any adjustment in tolls for use of the Canal, that the effects of any such toll adjustment on the trade patterns of the two Parties shall be given full consideration, including consideration of the following factors in a manner consistent with the regime of neutrality:
>
> (A) the costs of the operating and maintaining the Panama Canal;
> (B) the competitive position of the use of the Canal in relation to other means of transportation;

(C) the interests of both Parties in maintaining their domestic fleets;
(D) the impact of such an adjustment on the various geographic areas of each of the two Parties; and
(E) the interests of both Parties in maximizing their international commerce."

On September 30, 1979, the Panama Canal Company was terminated and the Panama Canal Commission (PCC) was established according to the Panama Canal Treaty of 1977 by P.L. 96-70. Chapter 6 of the law is concerned with tolls for use of the Panama Canal.

Section 1602(b) of Chapter 6 stipulates that "tolls shall be prescribed at rates calculated to produce revenues to cover as nearly as practicable all costs of maintaining and operating the Panama Canal, together with the facilities and appurtenances related thereto, including unrecovered costs incurred on or after the effective date of this Act, interest, depreciation, payments to the Republic of Panama pursuant to paragraph 5 of Article III and paragraph 4(a) and (b) of Article XIII of the Panama Canal Treaty of 1977[23], and capital for plant replacement, expansion, and improvement. Tolls shall not be prescribed at rates calculated to produce revenue sufficient cover payments to the Republic of Panama pursuant to paragraph 4 (c) of Article XIII of the Panama Canal Treaty of 1977."

Undertaking the Canal Expansion Program requires an increase in toll rates in order to aid the financing of the expansion It is clear from a reading of the treaty that the Panama Canal must remain neutral and nondiscriminatory, but it is less clear how much the treaty actually inhibits the ability to raise tolls. The treaty does offer the opportunity to raise tolls and to cover costs, including those associated with financing capital improvement. This opportunity is reiterated in P.L. 96-70, which states that "tolls shall be prescribed at rates calculated to produce revenues to cover as nearly as practicable all costs of ... capital for plant replacement, expansion, and improvement." However, treaty also states that "the effects of any such toll adjustment on the trade patterns of the two Parties shall be given full consideration..."

Despite the language on the regional impact of tolls, there appears to be sufficient justification to raise tolls because it will help finance one of the alternatives to the Canal, which will help maximize world trade. In addition, our analysis of the transportation costs shows that the effect of the toll increase on most trade routes will be relatively small compared with total transportation costs.

Toll policies, schedules, and rates at other facilities are relevant to the Panama Canal in several ways. First, these toll systems are part of the current accepted global practice concerning differentiated toll rates. Second, for some commodity–route pairs, these facilities may be an alternative to Panama Canal routes. In this task we will identify and evaluate toll systems used for other international waterways, such as the Suez Canal and the Saint Lawrence Seaway.

---

[23] Articles III and XIII are concerned with payments to Panama. According to the Treaty, Panama shall receive "the sum of ten million United States dollars ($10,000,000) per annum for the foregoing services...and in the event Canal operating revenues in any year do not produce a surplus sufficient to cover this payment, the unpaid balance shall be paid from operating surpluses in future years..."

# SUEZ CANAL

## Policy

The Suez Canal Authority, a government entity of the United Arab Republic of Egypt, runs, manages, maintains, and improves the Suez Canal. The Authority sets tolls and turns revenue over to the Central government, excluding a portion set aside for improvements. The Suez Canal toll rate structure is based on vessel earning capacity. It differs from the Panama Canal toll structure by differentiating among ship types, cargo carried by the ship, and within ship-type and cargo combination size intervals of the ship's earning capacity. Recognizing the economies of scale, the toll rate per Suez Canal net ton declines with ship size. But tolls levied are also market related and for a given ship size will rise with vessel earning capacity, bunker fuels prices, and, as a result, the potential savings offered by Canal transits.

The primary policy objective is to maximize cargo tonnage moving through the Canal.

## Structure and Rates

The Suez Canal toll rate structure is based on vessel earning capacity. It differs from the Panama Canal toll structure by differentiating among ship type, cargo carried by the ship, and with a ship-type and cargo combination, size intervals of the ship's earning capacity.

The toll rate per Suez Canal net ton declines as the ships earning capacity increases.[24] Suez Canal tolls are expressed in Standard Drawing Rights (SDR), the unit of currency of the International Monetary Fund. Because the SDR represents a basket of currencies, Suez Canal rates fluctuates when converted to U.S. dollars.

Table 6-3 presents current Suez Canal transit dues in SDRs and their US dollar equivalent as of January 1, 2003.

---

[24] The system of measurement of the Suez Canal net ton differs from that of the Panama Canal net ton. Although both have the objective of measuring the earning capacity of a vessel, the system of net ton measurement is unique to each canal. The Suez Canal system of measurement was specified by the International Commission held at Constantinople in 1873. The system of measurement for the Panama Canal Commission net ton is specified in Title 35, Parts 133 and 135 of the U.S. Code of Federal Regulations. Both systems of measurement are extremely detailed and complex and differ in their treatment of vessel space to be included in the net ton calculation.

**Table 6-3. Suez Canal Transit Dues by Type and Size of Vessel, January 1, 2003**

| Type of Vessel | First 5,000 | | Next 5,000 | | Next 10,000 | | Next 20,000 | | Next 30,000 | | Rest | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Laden | Ballast | Laden | Ballast | Laden | Ballast | Laden | Ballast | Laden | Ballast | Laden | Ballast |
| **Dues in SDRs** | | | | | | | | | | | | |
| Crude oil tankers | 6.49 | 5.52 | 3.62 | 3.08 | 3.25 | 2.77 | 1.40 | 1.19 | 1.40 | 1.19 | 1.21 | 1.03 |
| Tanker of petroleum products | 6.75 | 5.52 | 3.77 | 3.08 | 3.43 | 2.77 | 1.93 | 1.19 | 1.93 | 1.19 | 1.93 | 1.03 |
| Dry bulk carriers | 7.21 | 6.13 | 4.14 | 3.52 | 2.97 | 2.53 | 1.05 | 0.90 | 1.00 | 0.85 | 1.00 | 0.85 |
| Other bulk liquid & LNG carriers | 7.50 | 6.38 | 4.18 | 3.56 | 3.81 | 3.24 | 2.68 | 2.28 | 2.68 | 2.28 | 2.68 | 2.28 |
| LPG carrier | 6.75 | 5.75 | 3.77 | 3.21 | 3.43 | 2.92 | 2.42 | 2.06 | 2.42 | 2.06 | 2.42 | 2.06 |
| Car/container vessels | 7.21 | 6.13 | 4.10 | 3.49 | 3.37 | 2.87 | 2.42 | 2.06 | 2.42 | 2.06 | 1.83 | 1.56 |
| Special floating units | 7.21 | - | 4.14 | - | 3.77 | - | 2.63 | - | 2.63 | - | 2.63 | - |
| Other vessels | 7.21 | 6.13 | 4.14 | 3.52 | 3.77 | 3.21 | 2.63 | 2.24 | 2.63 | 2.24 | 2.63 | 2.24 |
| **Dues in US dollars a/** | | | | | | | | | | | | |
| Crude oil tankers | 8.81 | 7.49 | 4.91 | 4.18 | 4.41 | 3.76 | 1.90 | 1.62 | 1.90 | 1.62 | 1.64 | 1.40 |
| Tanker of petroleum products | 9.16 | 7.49 | 5.12 | 4.18 | 4.66 | 3.76 | 2.62 | 1.62 | 2.62 | 1.62 | 2.62 | 1.40 |
| Dry bulk carriers | 9.79 | 8.32 | 5.62 | 4.78 | 4.03 | 3.43 | 1.43 | 1.22 | 1.36 | 1.15 | 1.36 | 1.15 |
| Other bulk liquid & LNG carriers | 10.18 | 8.66 | 5.68 | 4.83 | 5.17 | 4.40 | 3.64 | 3.10 | 3.64 | 3.10 | 3.64 | 3.10 |
| LPG carrier | 9.16 | 7.81 | 5.12 | 4.36 | 4.66 | 3.96 | 3.29 | 2.80 | 3.29 | 2.80 | 3.29 | 2.80 |
| Car/container vessels | 9.79 | 8.32 | 5.57 | 4.74 | 4.58 | 3.90 | 3.29 | 2.80 | 3.29 | 2.80 | 2.48 | 2.12 |
| Special floating units | 9.79 | - | 5.62 | - | 5.12 | - | 3.57 | - | 3.57 | - | 3.57 | - |
| Other vessels | 9.79 | 8.32 | 5.62 | 4.78 | 5.12 | 4.36 | 3.57 | 3.04 | 3.57 | 3.04 | 3.57 | 3.04 |

a. Suez Canal dues are paid in Special Drawing Rights (SDRs), an international reserve asset created by the International Monetary Fund whose value is calculated of a basket of five currencies. As of January 1, 2003 a SDR was equal to 1.35766 US dollars.

The Suez Canal also offers long-haul users the opportunity to request rebates on Suez Canal dues if the vessel operators can demonstrate that the vessel's alternative routing through the Cape of Good Hope or the Panama Canal is less expensive than the route through the Suez Canal. The application for rebates must be submitted well before the vessel reaches the deviation point and is valid for up to 60 days prior to Suez Canal arrival date. The rebate provided is released after all required documentation is submitted, usually within 3-4 months from the date of transit.

## ST. LAWRENCE SEAWAY

### Policy

The toll policy and rate schedule for the St. Lawrence Seaway are determined jointly by the U.S. and Canadian governments.

The St. Lawrence Seaway Development Corporation, a wholly owned U.S. government corporation created in 1954 within the Department of Transportation, is responsible for the development, seasonal operation, and the maintenance of the seaway between Montreal and Lake Erie and within the territorial limits of the United States.

The St. Lawrence Seaway Authority, which is a parent Crown corporation, was established in 1954 to construct and operate a deep waterway between the Port of Montreal and Lake Erie, together with works and other property deemed necessary. Tolls are determined by the amount needed to

cover operating and maintenance costs and maximize traffic. Specifically the provisions of the St Lawrence Seaway Act concerning tolls state that charges should be guided by the following principles[25]:

1. That the rates shall be fair and equitable and shall give due consideration to encouragement of increased utilization of the navigation facilities, and to the special character of bulk agricultural, mineral, and other raw materials.
2. That rates shall vary according to the character of cargo with the view that each classification of cargo shall so far as practicable derive relative benefits from the use of these facilities.
3. That the rates on vessels in ballast with passengers or cargo may be less than the rates for vessels with passengers or cargo.
4. That the rates prescribed shall be calculated to cover as nearly as practicable, all costs operating and maintaining the works under the administration of the Corporation, including depreciation, and payments in lieu of taxes.

## Rate Structure

The St. Lawrence Seaway toll rate structure comprises a primary component based on cargo carried and a secondary component based on vessel earning capacity.

The primary component differentiates among cargo types but not among cargo tonnage intervals. The rate charged per metric ton remains constant regardless of the total tons carried on any transit.

The St. Lawrence Seaway's secondary toll component, which is based on ship earning capacity, does not differentiate among vessel types or sizes. It is charged on the basis of the ship's gross registered tons.

Table 6-4 presents the current St. Lawrence Seaway toll schedule. Tolls were raised by 2 percent on March 26, 2002 and raised by 1.2 percent February 7, 2003.

---

[25] Saint Lawrence Seaway Act, Public Law 35 (as amended through September 30, 1994), Sec.12. (b) (§988).

**Table 6-4. St. Lawrence Seaway Tolls, 2003 (US$)**

| Charge Type | Between Montreal and Lake Ontario | Between Lake Ontario and Lake Erie |
|---|---|---|
| Vessel Charge per Gross Registered Ton | 0.0894 | 0.1453 |
| Cargo charge per metric ton | | |
| Bulk Cargo | 0.9275 | 0.6145 |
| General Cargo | 2.2348 | 0.9834 |
| Steel Slab | 2.0225 | 0.7040 |
| Containerized Cargo | 0.9275 | 0.6145 |
| Grain | 0.5698 | 0.6145 |
| Coal | 0.5475 | 0.6145 |
| Lock charge | | |
| Per Passenger per Lock | 1.3185 | 1.3185 |
| Per Cargo Vessel per Welland Canal Transit | | |
| Laden per Lock | n.a. | 490.79 |
| In Ballast per Lock | n.a. | 362.62 |

Source: 2003 St. Lawrence Seaway Schedule of Tolls (2003/02/07).

In this section we identify a set of alternative Panama Canal marketing strategies to be analyzed followed by a description of the Panama *Canal Dry Bulk Toll Pricing Model* used in the analysis. We then present the interpretation of the results and the recommended Panama Canal marketing implementation strategy.

## ALTERNATIVE PANAMA CANAL MARKETING STRATEGIES

The terms of reference for the study state that the marketing strategy shall pursue the following objectives:

- Maximize Canal's earnings
- Maximize the canal market share for the dry bulk segment, and
- Be non-discriminatory within the dry bulk segment

Based on our review of the Panama Canal Neutrality Treaty and of toll policies at comparable facilities, we believe there is ample scope to differentiate Panama Canal tolls by size of vessel and commodity. Accordingly, we identified alternative toll pricing options for analysis that had tolls varying by size of vessel, and by commodity[26]. Toll options were also analyzed with tolls assessed by PCUMS and by ton of cargo carried. From the initial set of toll pricing options reviewed, it was determined that no pricing benefit was obtained from the assessment of tolls by ton of cargo carried that was not already captured by one of the PCUMS-based pricing options. Hence, all pricing options for further analysis were conducted on PCUMS-based options or commodity-based options (using discounts applied to PCUMS-based rates) as shown in Table 6-5.

[26] As this market segment only deals with dry bulk carriers, Panama Canal toll pricing options by type of vessel were not analyzed.

**Table 6-5. Grain Market Segment: Panama Canal Toll Pricing Options Analyzed**

| PCUMS-Based Canal Toll Pricing Options | | | | Commodity-BasedCanal Toll Pricing Options | | | | |
|---|---|---|---|---|---|---|---|---|
| | Canal toll per portion of PCUMS (laden transits) | | | | Percent of full toll applied by commodity to PCUMS Option 4 (100% increase) | | | |
| Canal tolll policy | 1st 10,000 | 2nd 10,000 | Remainder | Commodity Group | 1 | 2 | 3 | 4 |
| A. ACP prior Oct 2002 | 2.57 | 2.57 | 2.57 | Barley | 1.00 | 1.00 | 1.00 | 1.00 |
| B. ACP Oct 2002-June 2003 | 2.80 | 2.78 | 2.75 | Corn | 1.00 | 0.90 | 0.95 | 1.00 |
| C. ACP July 2003 | 2.96 | 2.90 | 2.85 | Rice | 1.00 | 1.00 | 1.00 | 1.00 |
| D. PCUMS Option 1 (25% increase) | 3.70 | 3.63 | 3.56 | Sorghum | 1.00 | 1.00 | 1.00 | 1.00 |
| E. PCUMS Option 2 (50% increase) | 4.44 | 4.35 | 4.28 | Soybeans | 1.00 | 1.00 | 1.00 | 1.00 |
| F. PCUMS Option 3 (75% increase) | 5.18 | 5.08 | 4.99 | Wheat | 0.90 | 0.90 | 0.90 | 0.95 |
| G. PCUMS Option 4 (100% increase) | 5.92 | 5.80 | 5.70 | Grains, misc | 1.00 | 1.00 | 1.00 | 1.00 |
| H. PCUMS Option 5 (125% increase) | 6.66 | 6.53 | 6.41 | | | | | |
| I. PCUMS Option 6 (140% increase) | 7.10 | 6.96 | 6.84 | | | | | |
| J. PCUMS Option 7 (150% increase) | 7.40 | 7.25 | 7.13 | | | | | |

Source: Nathan Associates Inc.

Toll pricing options included ACP tolls in effect prior to October 2002, from October 2002 through June 2003 and ACP tolls to take effect in July 1, 2003. The ACP tolls as of July 1, 2003 were used as the basis for examining a series of toll increases at 25 percent intervals from 25 percent increase through a 150 percent increase.

For pricing reasons discussed in more detail later in this section, a toll pricing option at 140 percent increase was also analyzed. Four additional pricing options were analyzed in which discounts of 5 or 10 percent off of the increased tolls were assigned to specific commodities.

## REVIEW OF ALTERNATIVE PANAMA CANAL MARKETING STRATEGIES

The Panama *Canal Grains Toll Pricing Model* was used to assess each of the 14 Canal toll pricing options shown in Table 6-5. Canal traffic was assumed to be diverted to the alternative route whenever the total of freight costs for the Canal route and Canal tolls exceeded the total of freight cost and incremental inventory interest cost of the alternative route. In general, the review process for each toll pricing option involves:

- determination of the total number of transits, cargo and toll revenue associated with the pricing option resulted
- identification of the traffic by route commodity and vessel size range that was diverted from the canal under the toll pricing option
- close examination of the route, commodity and vessel size ranges where the cost disadvantage of the Panama Canal was less than 35 cents per cargo ton.

The detailed review of the Canal toll pricing options revealed the following findings.

- Approximately 15 percent of the potential transits (with no tolls) would be diverted to alternative routes once any non-insignificant Canal tolls were imposed. These involved

routes North America Gulf to South East Asia, from Brazil North to Japan, and from South America East to South America West.

- A sizable number of transits and cargo would be diverted at certain pricing points for particular commodity-route pairs.
- After certain levels of toll increases, Canal revenues decline as the loss of toll revenue due to diverted transits is not offset by toll increases for the remaining Panama Canal transits.

Table 6-6 through 6-8 present summarized results of the 14 Canal toll pricing options for the Existing Canal and Expanded Canal, Most Probable Case for 2001, 2010 and 2025. Annual results from 2001 through 2025 of the canal toll pricing options for the Most Probable case are presented in Appendix C. The tables show the potential Canal transits and cargo (with no tolls) and the forecast of Canal transits and cargo for each Canal toll pricing option. The tables also present the forecast of Canal revenues.

These tables clearly show the potential for the Panama Canal to increase toll revenues. In 2001, estimated Canal toll revenues for dry bulk vessels in the grain market segment under 2001 toll rates total $58.9 million (Table 6-6). The Canal captured 83 percent of potential transits in this market segment and 81 percent of potential grain dry bulk cargo. However, the Canal toll revenues of $58.9 million only accounted for 23 percent of the estimated economic value of the Canal of $259 million. Using Canal toll rates in effect as of July 1, 2003 estimated revenue for 2001would have been 66.7 million or 14 percent higher. If tolls rate from July 1, 2003 were doubled, toll revenues for 2001 traffic would be $118.7 million, an increase of 78 percent. Even with tolls doubled, the Canal would still only capture 46 percent of the total economic value of the Canal[27].

The demand for Canal services is inelastic relative to tolls. That is, a given percentage increase in tolls would result in a smaller percentage decrease in Canal transits and would generate higher Canal toll revenues. A review of Table 6-7 provides an indication of the price inelasticity of demand. A 75 percent increase in tolls from July 1, 2003 levels reduces the forecast of Canal grain bulk transits in 2010 from 1,223 vessels to 1,188 vessels, or only 2.9 percent. A 100 percent increase in tolls reduces the forecast of Canal grain bulk transits to 1,096 vessels or 10.4 percent.

Appendix C presents results of the Canal toll pricing options for both the Existing Canal from 2001-2025 and the Expanded Canal from 2010-2025. For all years and pricing options, the Existing Canal scenario is shown to generate more toll revenues than the Existing Canal for the grains market segment. While these results initially seem counter-intuitive, there are three factors that together fully explain these findings.

---

[27] For the Canal to capture 100 percent of the economic value of the Canal, it would have to have a toll pricing policy that charged each vessel transiting the full benefit of using the Canal over alternative routings. Such a policy is not administratively practical, nor consistent with the Panama Canal Neutrality Treaty.

First, the total potential Panama Canal grain cargo under the Expanded Canal scenario of 63.3 million tons in 2010 (Table 6-7) is only slightly higher than the Existing Canal scenario of 62.2 million tons. Thus, the introduction of the Expanded Canal does not significantly impact the volume of grain trade that could potentially use the Canal.

**Table 6-6. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing Canal, Most Probable Case, 2001**

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 |
| Potential Panama Canal Cargo (ton 000s) | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 |
| Forecast Panama Canal Transits (no.) | 1,001 | 1,001 | 1,001 | 968 | 968 | 968 | 916 | 914 | 863 | 862 | 916 | 967 | 916 | 916 |
| Percent of Potential Transits | 83.1% | 83.1% | 83.1% | 80.4% | 80.4% | 80.4% | 76.0% | 75.9% | 71.6% | 71.5% | 76.0% | 80.3% | 76.0% | 76.0% |
| Forecast Panama Canal Cargo (ton 000s) | 38,314 | 38,314 | 38,314 | 36,792 | 36,792 | 36,792 | 33,921 | 33,862 | 31,100 | 31,049 | 33,921 | 36,738 | 33,921 | 33,921 |
| Percent of Potential Cargo | 80.8% | 80.8% | 80.8% | 77.6% | 77.6% | 77.6% | 71.6% | 71.4% | 65.6% | 65.5% | 71.6% | 77.5% | 71.6% | 71.6% |
| Economic Value of Canal for Potential Transits ($000s) | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 4,618 | 4,618 | 4,618 | 7,591 | 7,591 | 7,591 | 16,539 | 16,763 | 27,703 | 27,924 | 16,539 | 7,762 | 16,539 | 16,539 |
| Forecast Panama Canal Toll Revenues ($000s) | 58,855 | 63,707 | 66,749 | 80,145 | 96,174 | 112,202 | 118,654 | 133,243 | 131,076 | 135,050 | 117,305 | 118,493 | 113,671 | 117,979 |
| Average Toll Revenue per Forecasted Transit ($000) | 59 | 64 | 67 | 83 | 99 | 116 | 130 | 146 | 152 | 157 | 128 | 122 | 124 | 129 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.54 | 1.66 | 1.74 | 2.18 | 2.61 | 3.05 | 3.50 | 3.93 | 4.21 | 4.35 | 3.46 | 3.23 | 3.35 | 3.48 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Potential Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Percent of Potential Transits | | | | | | | | | | | | | | |
| Forecast Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Percent of Potential Cargo | | | | | | | | | | | | | | |
| Economic Value of Canal for Potential Transits ($000s) | | | | | | | | | | | | | | |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Revenues | | | | | | | | | | | | | | |
| Average Toll Revenue per Forecasted Transit ($000) | | | | | | | | | | | | | | |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | | | | | | | | | | | | | | |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

**Table 6-7. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2010**

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| **Existing Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 |
| Potential Panama Canal Cargo (ton 000s) | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 |
| Forecast Panama Canal Transits (no.) | 1,223 | 1,223 | 1,223 | 1,188 | 1,188 | 1,188 | 1,096 | 1,086 | 945 | 945 | 1,133 | 1,187 | 1,134 | 1,096 |
| Percent of Potential Transits | 81.2% | 81.2% | 81.2% | 78.9% | 78.9% | 78.9% | 72.8% | 72.1% | 62.8% | 62.8% | 75.3% | 78.8% | 75.3% | 72.8% |
| Forecast Panama Canal Cargo (ton 000s) | 49,208 | 49,208 | 49,208 | 47,590 | 47,590 | 47,590 | 42,534 | 42,134 | 34,456 | 34,456 | 44,595 | 47,517 | 44,612 | 42,534 |
| Percent of Potential Cargo | 79.1% | 79.1% | 79.1% | 76.5% | 76.5% | 76.5% | 68.4% | 67.7% | 55.4% | 55.4% | 71.7% | 76.4% | 71.7% | 68.4% |
| Economic Value of Canal for Potential Transits ($000s) | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 9,809 | 9,809 | 9,809 | 12,984 | 12,984 | 12,984 | 28,733 | 30,236 | 60,944 | 60,944 | 22,445 | 13,215 | 22,390 | 28,733 |
| Forecast Panama Canal Revenues ($000S) | 75,336 | 81,513 | 85,364 | 103,212 | 123,854 | 144,497 | 148,250 | 165,149 | 145,440 | 149,939 | 152,325 | 151,405 | 147,527 | 147,188 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 70 | 87 | 104 | 122 | 135 | 152 | 154 | 159 | 134 | 128 | 130 | 134 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.53 | 1.66 | 1.73 | 2.17 | 2.60 | 3.04 | 3.49 | 3.92 | 4.22 | 4.35 | 3.42 | 3.19 | 3.31 | 3.46 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 |
| Potential Panama Canal Cargo (ton 000s) | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 |
| Forecast Panama Canal Transits (no.) | 1,174 | 1,174 | 1,174 | 1,140 | 1,140 | 1,132 | 1,049 | 1,026 | 956 | 912 | 1,074 | 1,116 | 1,074 | 1,049 |
| Percent of Potential Transits | 80.0% | 80.0% | 80.0% | 77.7% | 77.7% | 77.1% | 71.5% | 69.9% | 65.2% | 62.1% | 73.2% | 76.1% | 73.2% | 71.5% |
| Forecast Panama Canal Cargo (ton 000s) | 49,176 | 49,176 | 49,176 | 47,575 | 47,575 | 46,970 | 41,960 | 40,647 | 36,569 | 33,786 | 43,502 | 46,070 | 43,516 | 41,960 |
| Percent of Potential Cargo | 77.7% | 77.7% | 77.7% | 75.2% | 75.2% | 74.3% | 66.3% | 64.3% | 57.8% | 53.4% | 68.8% | 72.8% | 68.8% | 66.3% |
| Economic Value of Canal for Potential Transits ($000s) | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 9,652 | 9,652 | 9,652 | 12,721 | 12,721 | 14,299 | 28,344 | 32,946 | 47,899 | 57,875 | 24,140 | 16,813 | 24,092 | 28,344 |
| Forecast Panama Canal Revenues | 71,868 | 77,756 | 81,428 | 98,433 | 118,119 | 136,121 | 140,410 | 153,029 | 148,050 | 142,406 | 142,396 | 140,312 | 137,899 | 139,337 |
| Average Toll Revenue per Forecasted Transit ($000) | 61 | 66 | 69 | 86 | 104 | 120 | 134 | 149 | 155 | 156 | 133 | 126 | 128 | 133 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.46 | 1.58 | 1.66 | 2.07 | 2.48 | 2.90 | 3.35 | 3.76 | 4.05 | 4.21 | 3.27 | 3.05 | 3.17 | 3.32 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

**Table 6-8. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2025**

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 |
| Potential Panama Canal Cargo (ton 000s) | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 |
| Forecast Panama Canal Transits (no.) | 1,416 | 1,416 | 1,416 | 1,394 | 1,381 | 1,365 | 1,312 | 1,236 | 1,234 | 1,234 | 1,365 | 1,365 | 1,365 | 1,365 |
| Percent of Potential Transits | 76.5% | 76.5% | 76.5% | 75.3% | 74.6% | 73.7% | 70.8% | 66.7% | 66.6% | 66.6% | 73.7% | 73.7% | 73.7% | 73.7% |
| Forecast Panama Canal Cargo (ton 000s) | 58,940 | 58,940 | 58,940 | 57,793 | 57,286 | 56,442 | 53,497 | 49,490 | 49,431 | 49,431 | 56,442 | 56,442 | 56,442 | 56,442 |
| Percent of Potential Cargo | 74.4% | 74.4% | 74.4% | 72.9% | 72.3% | 71.2% | 67.5% | 62.5% | 62.4% | 62.4% | 71.2% | 71.2% | 71.2% | 71.2% |
| Economic Value of Canal for Potential Transits ($000s) | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 18,585 | 18,585 | 18,585 | 20,835 | 22,025 | 24,218 | 33,755 | 47,432 | 47,670 | 47,670 | 24,218 | 24,218 | 24,218 | 24,218 |
| Forecast Panama Canal Revenues ($000S) | 89,869 | 97,194 | 101,744 | 124,765 | 148,339 | 170,569 | 185,086 | 193,017 | 205,632 | 211,618 | 191,587 | 180,628 | 186,107 | 193,261 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 69 | 72 | 90 | 107 | 125 | 141 | 156 | 167 | 171 | 140 | 132 | 136 | 142 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.52 | 1.65 | 1.73 | 2.16 | 2.59 | 3.02 | 3.46 | 3.90 | 4.16 | 4.28 | 3.39 | 3.20 | 3.30 | 3.42 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 |
| Potential Panama Canal Cargo (ton 000s) | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 |
| Forecast Panama Canal Transits (no.) | 1,468 | 1,468 | 1,468 | 1,447 | 1,434 | 1,389 | 1,329 | 1,267 | 1,242 | 1,242 | 1,380 | 1,386 | 1,380 | 1,380 |
| Percent of Potential Transits | 76.9% | 76.9% | 76.9% | 75.7% | 75.1% | 72.7% | 69.6% | 66.3% | 65.0% | 65.0% | 72.3% | 72.5% | 72.3% | 72.3% |
| Forecast Panama Canal Cargo (ton 000s) | 62,180 | 62,180 | 62,180 | 61,044 | 60,541 | 57,880 | 53,966 | 50,356 | 48,460 | 48,460 | 57,191 | 57,622 | 57,191 | 57,191 |
| Percent of Potential Cargo | 74.1% | 74.1% | 74.1% | 72.7% | 72.1% | 69.0% | 64.3% | 60.0% | 57.7% | 57.7% | 68.1% | 68.7% | 68.1% | 68.1% |
| Economic Value of Canal for Potential Transits ($000s) | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 20,725 | 20,725 | 20,725 | 22,873 | 24,055 | 30,465 | 41,744 | 53,049 | 59,822 | 59,822 | 32,376 | 31,167 | 32,376 | 32,376 |
| Forecast Panama Canal Revenues | 88,902 | 96,155 | 100,674 | 123,554 | 146,894 | 164,299 | 176,161 | 185,864 | 191,195 | 196,837 | 181,965 | 173,088 | 176,928 | 183,804 |
| Average Toll Revenue per Forecasted Transit ($000) | 61 | 65 | 69 | 85 | 102 | 118 | 133 | 147 | 154 | 159 | 132 | 125 | 128 | 133 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.43 | 1.55 | 1.62 | 2.02 | 2.43 | 2.84 | 3.26 | 3.69 | 3.95 | 4.06 | 3.18 | 3.00 | 3.09 | 3.21 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

Second, with the Expanded Canal, there is a trend toward using larger vessels and hence the number of grain vessels needed is reduced. The Expanded Canal scenario is shown to have 1,468 potential transits in 2010 versus 1,506 potential transits for the Existing Canal. As Canal tolls provide discounted rates for larger vessels, Canal toll revenues for the same annual volume of grain cargo will be less for the Expanded Canal versus the Existing Canal.

Third, the Expanded Canal is shown to have a smaller total economic value than the Existing Canal. In 2010, the Expanded Canal has a total economic value of $310.6 million as compared to $323.4 million for the Existing Canal. The economic value of the Canal defined for study purposes is the transportation cost savings of the use of the Canal as compared to the least-cost alternative routing. Decisions on whether to use the Canal or an alternative route are made taking into account the shipping characteristics and corresponding costs of each routing. For the Existing Canal scenario, the decision is based on the shipping characteristics and costs associated with that scenario. These were described fully in *Volume 3: Vessel Transit and Fleet Analysis*. With the Expanded Canal scenario, again decisions to use the Canal are determined by the shipping characteristics and costs for the Canal and alternative routings associated with that scenario.

The reason that the economic value of the Canal is lower for the Expanded Canal scenario is that the cost differentials between the Expanded Canal and its least-cost alternative routings are lower than those estimated for the Existing Canal. With the Expanded Canal, there will be a trend toward use of larger vessels and some originating and receiving ports will develop facilities to accommodate the larger vessels. However, the use of larger vessel will reduce the transport cost of both Canal and least-cost alternative routings. As the mileages for the least-cost alternative routings are greater than for Canal routes, the cost saving of using larger vessels is greater in absolute terms. Thus the Expanded Canal has a smaller transportation cost differential or economic value between the Canal and the least-cost alternative routing[28].

This finding directly impacts the results of the Canal toll pricing options for the Expanded Canal as more traffic is shown to be diverted from the Canal to alternative routings compared to the same toll level for the Existing Canal.

## IDENTIFICATION OF PREFERRED PANAMA CANAL TOLL PRICING

The preferred Panama Canal toll pricing option was selected for the Existing and Expanded Canal scenarios separately by applying the following criteria:

- Maximization of Canal's earnings
- Maximization of the Canal market share for the grain bulk segment, and
- Non-discriminatory within the grain bulk segment

---

[28] Please note that the treatment of economic used herein for the toll pricing analysis differs from that presented in *Volume 4: Economic Value of Panama Canal.* In Volume 4, the terms of reference called for a direct comparison of the economic value of the Existing Canal and Expanded Canal. Thus for that analysis, transportation costs of routes through the Existing and Expanded Canals were both compared to the transportation costs of the alternative routes under the Existing Canal scenario.

- Administrative simplicity (easy to measure and apply without cumbersome verification)
- Ease of understanding and transparency to shipping community
- Stability from one year to next with gradual variations

All of the tolls pricing options analyzed were considered to be non-discriminatory within the grain bulk segment. Precedents set at comparable facilities allow for differentiation of tolls by size of vessel and by commodity as long as they are applied to all such vessels on a consistent basis. First priority was given to maximization of toll revenues, closely followed by maximization of Canal market share. A preferred Canal toll pricing option was identified for each year and each Canal scenario (Table 6-9).

## Existing Canal

For the Existing Canal, the preferred option for all years is PCUMS Option 3 which corresponds to Panama Canal tolls increased by 75 percent from July 1, 2003 levels. This pricing option allows the Canal to retain approximately 80 percent of total potential transits as compared to 83 percent under current tolls. Panama Canal toll revenues, however, increase by nearly 70 percent under PCUMS Option 3.

**Table 6-9. Preferred and Alternative Canal Toll Pricing Options, Existing and Expanded Canal , Most Probable Case, 2001-2025**

| | Existing Canal | | Expanded Canal | |
|---|---|---|---|---|
| Year | Preferred Toll Pricing Option | Alternative Toll Pricing Option | Preferred Toll Pricing Option | Alternative Toll Pricing Option |
| 2001-2009 | PCUMS Option 3 (75% increase) | Commodity Option 2 tolls (100% increase with 10% discount for wheat and corn) | n.a. | n.a. |
| 2010-2011 | PCUMS Option 3 (75% increase) | Commodity Option 2 tolls (100% increase with 10% discount for wheat and corn) | Commodity Option 3 tolls (100% increase with 10% discount for wheat and 5% discount for corn) | PCUMS Option 3 (75% increase) |
| 2012–2019 | PCUMS Option 3 (75% increase) | Commodity Option 3 tolls (100% increase with 10% discount for wheat and 5% discount for corn) | Commodity Option 3 tolls (100% increase with 10% discount for wheat and 5% discount for corn) | PCUMS Option 3 (75% increase) |
| 2020-2024 | PCUMS Option 3 (75% increase) | Commodity Option 3 tolls (100% increase with 10% discount for wheat and 5% discount for corn) | Commodity Option 4 tolls (100% increase with 5% discount for wheat) | PCUMS Option 3 (75% increase) |
| 2025 | PCUMS Option 3 (75% increase) | Commodity Option 4 tolls (100% increase with 5% discount for wheat) | Commodity Option 4 tolls (100% increase with 5% discount for wheat) | PCUMS Option 3 (75% increase) |

Source: Appendix C.

The preferred option is PCUMS Option 3 which corresponds to Panama Canal tolls increased by 75 percent from July 1, 2003 levels. This pricing option allows the Canal to retain approximately 80 percent of total potential transits (with not tolls) and in fact has additional diversions of around 3

percent of the forecasted transits under July 1, 2003 tolls. Panama Canal revenues, however, increase by nearly 70 percent under PCUMS Option 3.

While there are other Canal pricing options that yield up to 20 percent more revenue, they involve much higher levels of toll increases (140 percent increase over July 1, 2003 rates) and result in additional diversion of at least 10 percent more of potential transits.
Consideration for the preferred Canal pricing option was given to Panama Canal tolls with a 100 percent increase over July 1, 2003 rates. This generates up to 5 percent more revenue but also results in additional diversions of more than 6 percent of potential cargo. The dual objectives of maximizing earnings while maximizing Canal market share led us to select the 75 percent increase option as the preferred Canal pricing option.

An interesting alternative is the 100 percent increase from July 1, 2003 rates combined with selected discounts of 5 to 10 percent of Canal tolls for wheat and corn shipments. These discounts allow the Canal to increase toll revenue by 5 percent as compared to the preferred 75 percent increase option without any significant further diversion of traffic[29]. However, this option was considered as secondary to the preferred option due to the additional administrative burden of identifying specific grain traffic and the divergence from traditional Panama Canal toll policies.

### Expanded Canal

For the Expanded Canal, the preferred option for 2010-2019 is Commodity Option 3 which corresponds to Panama Canal tolls increased by 100 percent from July 1, 2003 levels with a 10 percent discount for wheat and 5 percent discount for corn. This pricing option allows the Canal to retain approximately 72 percent of total potential transits in 2011 as compared to 77 percent under current tolls. Panama Canal toll revenues, however, increase by nearly 78 percent under Commodity Option 3.

The preferred pricing option for the Existing Canal of PCUMS Option 3 (75 percent increase) was identified as an alternative. However, for the Expanded Canal, additional weight was placed on the revenue maximization criterion. Thus Commodity Option 3 was selected as the preferred Canal toll pricing option as it generates additional toll revenue.

From 2020-2025, Commodity Option 4 (100 percent increase with a 5 percent discount for wheat) was selected as the preferred Canal toll pricing option. During these years, the elimination of the discount for corn and the reduction in the discount for wheat from 10 percent to 5 percent generates additional Canal toll revenue without no further diversion of transits[30].

---

[29] The discount to Canal tolls applied to bulk wheat vessels permits the Canal to retain this traffic under pricing scenarios that charge higher tolls to other grains. For example, the wheat discount permits the Canal to retain wheat shipments of more than 2 million tons in 2015 from North America East to South Korea that would otherwise be diverted to alternative routes.

[30] The only minor exception is in 2020, when 17 transits are diverted under Commodity Option 4 as compared to Commodity Option 3. However, toll revenues are still higher under Commodity Option 4 that year.

## FORECAST OF PANAMA CANAL TRANSITS, TOLL REVENUE AND CARGO

Table 6-10 through Table 6-11 present comparisons of Panama Canal transits, cargo and laden toll revenues under the preferred toll pricing option and current Panama Canal tolls for the Existing Canal and Expanded Canal scenarios.

For the Existing Canal under the preferred toll pricing option, forecasted Canal transits increase from 968 vessels in 2001 to 1,188 vessels in 2010 and reach 1,365 vessels by 2025. Forecasted canal revenues increase from $112 million in 2001 to $144 million in 2010 and $170 million by 2025. Throughout the period Canal toll revenues under the preferred toll pricing option are approximately 70 percent above those forecast under current Canal tolls.

**Table 6-10. Panama Canal Laden Transits, Cargo and Revenue under Preferred Toll Option and Current Canal Tolls Existing Canal, Most Probable Case, 2001-2025**

| Year | Forecast with Preferred Tolls | | | Forecast with Current Tolls | | |
|---|---|---|---|---|---|---|
| | Transits (no.) | Cargo (ton 000s) | Toll Revenue ('$000) | Transits (no.) | Cargo (ton 000s) | Toll Revenue ('$000) |
| 2001 | 968 | 36,792 | 112,202 | 1,001 | 38,314 | 66,749 |
| 2002 | 973 | 37,102 | 113,131 | 1,006 | 38,633 | 67,295 |
| 2003 | 979 | 37,411 | 114,092 | 1,013 | 38,951 | 67,860 |
| 2004 | 985 | 37,720 | 115,049 | 1,019 | 39,270 | 68,422 |
| 2005 | 991 | 38,029 | 116,002 | 1,025 | 39,588 | 68,983 |
| 2006 | 1,030 | 39,941 | 121,694 | 1,064 | 41,512 | 72,255 |
| 2007 | 1,070 | 41,854 | 127,391 | 1,104 | 43,436 | 75,530 |
| 2008 | 1,110 | 43,766 | 133,093 | 1,144 | 45,360 | 78,808 |
| 2009 | 1,150 | 45,678 | 138,802 | 1,184 | 47,284 | 82,090 |
| 2010 | 1,188 | 47,590 | 144,497 | 1,223 | 49,208 | 85,364 |
| 2011 | 1,198 | 48,283 | 146,471 | 1,233 | 49,900 | 86,490 |
| 2012 | 1,209 | 48,976 | 148,445 | 1,244 | 50,592 | 87,616 |
| 2013 | 1,219 | 49,669 | 150,419 | 1,254 | 51,285 | 88,743 |
| 2014 | 1,230 | 50,362 | 152,393 | 1,265 | 51,977 | 89,869 |
| 2015 | 1,241 | 51,055 | 154,366 | 1,276 | 52,669 | 90,995 |
| 2016 | 1,256 | 51,831 | 156,621 | 1,292 | 53,507 | 92,388 |
| 2017 | 1,273 | 52,606 | 158,931 | 1,310 | 54,345 | 93,814 |
| 2018 | 1,292 | 53,382 | 161,286 | 1,330 | 55,183 | 95,264 |
| 2019 | 1,311 | 54,157 | 163,644 | 1,350 | 56,021 | 96,717 |
| 2020 | 1,330 | 54,933 | 166,006 | 1,371 | 56,859 | 98,172 |
| 2021 | 1,337 | 55,235 | 166,913 | 1,379 | 57,275 | 98,883 |
| 2022 | 1,343 | 55,537 | 167,823 | 1,388 | 57,692 | 99,596 |
| 2023 | 1,350 | 55,838 | 168,736 | 1,397 | 58,108 | 100,310 |
| 2024 | 1,357 | 56,140 | 169,651 | 1,407 | 58,524 | 101,026 |
| 2025 | 1,365 | 56,442 | 170,569 | 1,416 | 58,940 | 101,744 |

Source: Appendix C.

For the Expanded Canal under the preferred toll pricing option, forecasted Canal transits increase from 1,074 vessels in 2010 to 1,380 vessels by 2025. Forecasted canal revenues increase $138 million in 2010 to $184 million by 2025. Canal toll revenues under the preferred toll pricing option are approximately 70 percent above those forecast under current Canal tolls in 2010 increasing to 83 percent above current tolls by 2025.

**Table 6-11. Panama Canal Laden Transits, Cargo and Revenue under Preferred Toll Option and Current Canal Tolls Expanded Canal, Most Probable Case, 2010-2025**

| Year | Forecast with Preferred Toll Pricing Option | | | Forecast with Current Canal Tolls | | |
|---|---|---|---|---|---|---|
| | Transits (no.) | Cargo (ton 000s) | Toll Revenue ('$000) | Transits (no.) | Cargo (ton 000s) | Toll Revenue ('$000) |
| 2010 | 1,074 | 43,516 | 137,899 | 1,174 | 49,176 | 81,428 |
| 2011 | 1,122 | 46,511 | 146,429 | 1,183 | 49,861 | 82,447 |
| 2012 | 1,131 | 47,195 | 148,457 | 1,193 | 50,545 | 83,467 |
| 2013 | 1,141 | 47,878 | 150,484 | 1,202 | 51,230 | 84,487 |
| 2014 | 1,151 | 48,562 | 152,511 | 1,212 | 51,915 | 85,507 |
| 2015 | 1,164 | 49,244 | 154,543 | 1,235 | 53,155 | 87,395 |
| 2016 | 1,203 | 51,067 | 160,072 | 1,260 | 54,166 | 89,045 |
| 2017 | 1,228 | 51,874 | 162,656 | 1,288 | 55,177 | 90,718 |
| 2018 | 1,253 | 52,681 | 165,249 | 1,317 | 56,188 | 92,395 |
| 2019 | 1,279 | 53,488 | 167,849 | 1,347 | 57,199 | 94,077 |
| 2020 | 1,290 | 54,217 | 174,334 | 1,377 | 59,141 | 95,765 |
| 2021 | 1,321 | 55,630 | 178,665 | 1,394 | 59,748 | 96,739 |
| 2022 | 1,334 | 56,020 | 179,936 | 1,411 | 60,356 | 97,716 |
| 2023 | 1,349 | 56,410 | 181,216 | 1,430 | 60,964 | 98,698 |
| 2024 | 1,364 | 56,801 | 182,505 | 1,448 | 61,572 | 99,683 |
| 2025 | 1,380 | 57,191 | 183,804 | 1,468 | 62,180 | 100,674 |

Source: Appendix C.

Table 6-12 through Table 6-15 present summaries of transits, laden toll revenues, cargo and PCUMS by DWT range for the Existing Canal and Expanded Canal for the three global macroeconomic and trade scenarios. Table 6-16 and 6-17 present similar summaries of ballast transit and ballast toll revenues.

For the Most Probable Case, grain carried on dry bulk vessels is forecast to increase from 36.8 million tons in 2001 to 56.4 million tons in 2025 for the Existing Canal scenario (Table 6-14). For the Best Case, grain cargo is forecast to increase from 36.8 million tons in 2001 to 59.9 million tons in 2025. For the Worst Case, grain cargo is forecast to increase from 36.8 million tons in 2001 to 50.3 million tons in 2025.

Total PCUMS of grain dry bulk vessel transits are shown in Table 6-15. These track closely the forecast of transits by Canal scenario and global macroeconomic and trade case. In 2005, total PCUMS of grain dry bulk transits is forecast at 23.2 million PCUMS, increasing to 34.4 million PCUMS by 2025.

## Table 6-12 Laden Transits by Year, DWT Range and Direction, Existing and Expanded Canal, All Scenarios,Selected Years, 2001-2025 (Transits)

| Scenario and | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **Most Probable Case** | | | | | | | | | | |
| 0 TO 10K | 3 | - | - | - | - | - | - | - | - | - |
| 10 TO 15K | 27 | 29 | 84 | 95 | 126 | 154 | 94 | 115 | 168 | 222 |
| 15 TO 20K | 23 | 21 | 60 | 65 | 83 | 100 | 68 | 82 | 119 | 157 |
| 20 TO 25K | 66 | 72 | 54 | 15 | 0 | 0 | 49 | 4 | 0 | 0 |
| 25 TO 30K | 195 | 155 | 33 | 32 | 27 | 11 | 33 | 32 | 27 | 11 |
| 30 TO 40K | 114 | 152 | 177 | 170 | 132 | 78 | 168 | 154 | 111 | 50 |
| 40 TO 50K | 165 | 178 | 244 | 258 | 287 | 301 | 244 | 259 | 294 | 319 |
| 50 TO 60K | 16 | 23 | 43 | 59 | 73 | 84 | 39 | 53 | 66 | 77 |
| 60 TO 70K | 225 | 202 | 253 | 259 | 263 | 256 | 174 | 192 | 190 | 199 |
| 70 TO 80K | 135 | 158 | 241 | 288 | 340 | 379 | 169 | 228 | 263 | 289 |
| 80 TO 90K | - | - | - | - | - | - | 29 | 34 | 38 | 42 |
| 90 TO 100K | - | - | - | - | - | - | 7 | 11 | 13 | 14 |
| Total | 968 | 991 | 1,188 | 1,241 | 1,330 | 1,365 | 1,074 | 1,164 | 1,290 | 1,380 |
| **Best Case** | | | | | | | | | | |
| 0 TO 10K | 3 | - | - | - | - | - | - | - | - | - |
| 10 TO 15K | 27 | 33 | 94 | 133 | 137 | 192 | 102 | 143 | 204 | 273 |
| 15 TO 20K | 23 | 24 | 68 | 95 | 93 | 132 | 76 | 105 | 151 | 202 |
| 20 TO 25K | 66 | 72 | 51 | 1 | 0 | 0 | 47 | 0 | 0 | 0 |
| 25 TO 30K | 195 | 155 | 32 | 31 | 23 | 1 | 32 | 31 | 23 | 1 |
| 30 TO 40K | 114 | 153 | 175 | 160 | 107 | 49 | 168 | 146 | 79 | 7 |
| 40 TO 50K | 165 | 184 | 249 | 279 | 284 | 314 | 248 | 278 | 300 | 335 |
| 50 TO 60K | 16 | 23 | 43 | 57 | 75 | 90 | 39 | 51 | 67 | 83 |
| 60 TO 70K | 225 | 206 | 259 | 257 | 279 | 278 | 176 | 188 | 198 | 214 |
| 70 TO 80K | 135 | 163 | 250 | 297 | 360 | 412 | 174 | 231 | 273 | 310 |
| 80 TO 90K | - | - | - | - | - | - | 29 | 34 | 39 | 46 |
| 90 TO 100K | - | - | - | - | - | - | 7 | 9 | 13 | 15 |
| Total | 968 | 1,013 | 1,221 | 1,309 | 1,359 | 1,468 | 1,098 | 1,218 | 1,348 | 1,486 |
| **Worst Case** | | | | | | | | | | |
| 0 TO 10K | 3 | - | - | - | - | - | - | - | - | - |
| 10 TO 15K | 27 | 39 | 47 | 52 | 40 | 41 | 49 | 51 | 53 | 44 |
| 15 TO 20K | 23 | 31 | 31 | 29 | 13 | 7 | 34 | 30 | 26 | 12 |
| 20 TO 25K | 66 | 58 | 52 | 27 | 9 | 0 | 47 | 24 | 0 | 0 |
| 25 TO 30K | 195 | 103 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 30 TO 40K | 114 | 126 | 158 | 158 | 172 | 170 | 146 | 146 | 146 | 152 |
| 40 TO 50K | 165 | 182 | 201 | 204 | 213 | 223 | 211 | 213 | 225 | 232 |
| 50 TO 60K | 16 | 34 | 49 | 57 | 73 | 92 | 44 | 51 | 65 | 81 |
| 60 TO 70K | 225 | 288 | 271 | 235 | 235 | 243 | 201 | 173 | 175 | 193 |
| 70 TO 80K | 135 | 203 | 237 | 247 | 282 | 328 | 162 | 189 | 218 | 251 |
| 80 TO 90K | - | - | - | - | - | - | 31 | 32 | 36 | 40 |
| 90 TO 100K | - | - | - | - | - | - | 10 | 11 | 14 | 18 |
| Total | 968 | 1,063 | 1,050 | 1,010 | 1,038 | 1,106 | 935 | 920 | 958 | 1,024 |

Source: Richardson Lawrie Associates

## Table 6-13 Ladden Toll Revenue by Year, DWT Range and Direction, Existing and Expanded Canal All Scenarios,Selected Years, 2001-2025 ($000s)

| Scenario and | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **Most Probable Case** | | | | | | | | | | |
| 0 TO 10K | 32 | - | - | - | - | - | - | - | - | - |
| 10 TO 15K | 518 | 1,138 | 3,241 | 3,675 | 4,879 | 5,956 | 3,622 | 4,427 | 6,512 | 8,570 |
| 15 TO 20K | 586 | 1,070 | 3,012 | 3,285 | 4,177 | 5,063 | 3,441 | 4,157 | 6,018 | 7,938 |
| 20 TO 25K | 2,321 | 5,115 | 3,825 | 1,049 | 22 | 23 | 3,486 | 282 | 22 | 23 |
| 25 TO 30K | 7,239 | 11,529 | 2,435 | 2,400 | 1,991 | 814 | 2,435 | 2,400 | 1,991 | 814 |
| 30 TO 40K | 5,378 | 14,312 | 16,669 | 16,010 | 12,418 | 7,365 | 15,849 | 14,475 | 10,500 | 4,683 |
| 40 TO 50K | 10,255 | 21,989 | 30,085 | 31,808 | 35,430 | 37,165 | 30,122 | 31,989 | 36,270 | 39,311 |
| 50 TO 60K | 1,145 | 3,338 | 6,115 | 8,353 | 10,377 | 12,015 | 5,563 | 7,564 | 9,376 | 11,025 |
| 60 TO 70K | 17,916 | 31,737 | 39,720 | 40,717 | 41,249 | 40,278 | 27,286 | 30,226 | 29,910 | 31,237 |
| 70 TO 80K | 11,138 | 25,773 | 39,395 | 47,069 | 55,461 | 61,891 | 27,611 | 37,198 | 42,959 | 47,169 |
| 80 TO 90K | - | - | - | - | - | - | 5,877 | 6,925 | 7,737 | 8,566 |
| 90 TO 100K | - | - | - | - | - | - | 1,626 | 2,289 | 2,760 | 3,103 |
| Total | 56,528 | 116,002 | 144,497 | 154,366 | 166,006 | 170,569 | 126,919 | 141,933 | 154,056 | 162,438 |
| **Best Case** | | | | | | | | | | |
| 0 TO 10K | 32 | - | - | - | - | - | - | - | - | - |
| 10 TO 15K | 518 | 1,264 | 3,618 | 5,130 | 5,312 | 7,423 | 3,944 | 5,545 | 7,872 | 10,533 |
| 15 TO 20K | 586 | 1,225 | 3,442 | 4,799 | 4,704 | 6,672 | 3,810 | 5,298 | 7,618 | 10,178 |
| 20 TO 25K | 2,320 | 5,137 | 3,649 | 42 | 22 | 22 | 3,360 | 21 | 22 | 22 |
| 25 TO 30K | 7,239 | 11,549 | 2,382 | 2,323 | 1,725 | 51 | 2,382 | 2,323 | 1,727 | 51 |
| 30 TO 40K | 5,378 | 14,420 | 16,490 | 15,090 | 10,053 | 4,579 | 15,785 | 13,731 | 7,481 | 683 |
| 40 TO 50K | 10,255 | 22,653 | 30,665 | 34,346 | 35,073 | 38,772 | 30,592 | 34,284 | 36,957 | 41,364 |
| 50 TO 60K | 1,145 | 3,320 | 6,143 | 8,070 | 10,663 | 12,825 | 5,598 | 7,312 | 9,605 | 11,797 |
| 60 TO 70K | 17,916 | 32,359 | 40,691 | 40,389 | 43,788 | 43,644 | 27,624 | 29,573 | 31,045 | 33,628 |
| 70 TO 80K | 11,138 | 26,597 | 40,842 | 48,445 | 58,789 | 67,247 | 28,418 | 37,766 | 44,575 | 50,660 |
| 80 TO 90K | - | - | - | - | - | - | 6,012 | 6,869 | 8,044 | 9,298 |
| 90 TO 100K | - | - | - | - | - | - | 1,605 | 2,039 | 2,847 | 3,333 |
| Total | 56,527 | 118,523 | 147,922 | 158,632 | 170,130 | 181,237 | 129,129 | 144,759 | 157,793 | 171,547 |
| **Worst Case** | | | | | | | | | | |
| 0 TO 10K | 32 | - | - | - | - | - | - | - | - | - |
| 10 TO 15K | 518 | 1,498 | 1,820 | 1,992 | 1,564 | 1,572 | 1,910 | 1,988 | 2,057 | 1,687 |
| 15 TO 20K | 586 | 1,539 | 1,583 | 1,482 | 669 | 378 | 1,716 | 1,525 | 1,306 | 608 |
| 20 TO 25K | 2,321 | 4,132 | 3,663 | 1,897 | 613 | 22 | 3,307 | 1,672 | 21 | 22 |
| 25 TO 30K | 7,239 | 7,656 | 217 | 46 | 50 | 51 | 45 | 46 | 50 | 51 |
| 30 TO 40K | 5,378 | 11,884 | 14,929 | 14,886 | 16,239 | 16,013 | 13,722 | 13,748 | 13,753 | 14,293 |
| 40 TO 50K | 10,255 | 22,431 | 24,788 | 25,178 | 26,232 | 27,546 | 25,995 | 26,208 | 27,709 | 28,605 |
| 50 TO 60K | 1,145 | 4,915 | 7,032 | 8,138 | 10,407 | 13,124 | 6,280 | 7,258 | 9,241 | 11,625 |
| 60 TO 70K | 17,916 | 45,231 | 42,556 | 36,946 | 36,861 | 38,247 | 31,565 | 27,175 | 27,505 | 30,368 |
| 70 TO 80K | 11,138 | 33,096 | 38,690 | 40,379 | 46,110 | 53,530 | 26,498 | 30,936 | 35,563 | 40,931 |
| 80 TO 90K | - | - | - | - | - | - | 6,268 | 6,477 | 7,288 | 8,194 |
| 90 TO 100K | - | - | - | - | - | - | 2,227 | 2,383 | 3,082 | 3,995 |
| Total | 56,528 | 132,383 | 135,279 | 130,943 | 138,746 | 150,482 | 119,532 | 119,414 | 127,575 | 140,380 |

Source: Richardson Lawrie Associates

## Table 6-14 Cargo by Year, DWT Range and Direction, Existing and Expanded Canal, All Scenarios,Selected Years, 2001-2025 (000 long tons)

| Scenario and | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **Most Probable Case** | | | | | | | | | | |
| 0 TO 10K | 9 | - | - | - | - | - | - | - | - | - |
| 10 TO 15K | 272 | 297 | 845 | 958 | 1,271 | 1,552 | 944 | 1,154 | 1,697 | 2,233 |
| 15 TO 20K | 359 | 325 | 917 | 1,000 | 1,272 | 1,541 | 1,047 | 1,265 | 1,832 | 2,417 |
| 20 TO 25K | 1,275 | 1,402 | 1,048 | 287 | 5 | 6 | 955 | 77 | 5 | 6 |
| 25 TO 30K | 4,529 | 3,593 | 727 | 717 | 595 | 243 | 727 | 717 | 595 | 243 |
| 30 TO 40K | 3,495 | 4,658 | 5,425 | 5,211 | 4,041 | 2,397 | 5,159 | 4,712 | 3,417 | 1,524 |
| 40 TO 50K | 6,413 | 6,925 | 9,475 | 10,018 | 11,159 | 11,705 | 9,490 | 10,078 | 11,427 | 12,385 |
| 50 TO 60K | 762 | 1,122 | 2,056 | 2,809 | 3,489 | 4,040 | 1,870 | 2,543 | 3,153 | 3,707 |
| 60 TO 70K | 12,179 | 10,919 | 13,665 | 14,008 | 14,192 | 13,857 | 10,404 | 11,525 | 11,404 | 11,910 |
| 70 TO 80K | 7,498 | 8,787 | 13,431 | 16,048 | 18,909 | 21,101 | 10,802 | 14,553 | 16,806 | 18,454 |
| 80 TO 90K | - | - | - | - | - | - | 2,170 | 2,557 | 2,857 | 3,163 |
| 90 TO 100K | - | - | - | - | - | - | 603 | 849 | 1,024 | 1,151 |
| Total | 36,792 | 38,029 | 47,590 | 51,055 | 54,933 | 56,442 | 44,171 | 50,028 | 54,217 | 57,191 |
| **Best Case** | | | | | | | | | | |
| 0 TO 10K | 9 | - | - | - | - | - | - | - | - | - |
| 10 TO 15K | 272 | 329 | 943 | 1,336 | 1,384 | 1,934 | 1,027 | 1,445 | 2,051 | 2,744 |
| 15 TO 20K | 359 | 372 | 1,048 | 1,461 | 1,432 | 2,032 | 1,160 | 1,613 | 2,320 | 3,099 |
| 20 TO 25K | 1,275 | 1,408 | 1,000 | 11 | 5 | 5 | 921 | 5 | 5 | 5 |
| 25 TO 30K | 4,529 | 3,600 | 711 | 694 | 515 | 15 | 711 | 694 | 516 | 15 |
| 30 TO 40K | 3,495 | 4,693 | 5,367 | 4,911 | 3,272 | 1,490 | 5,138 | 4,469 | 2,435 | 222 |
| 40 TO 50K | 6,413 | 7,134 | 9,658 | 10,818 | 11,046 | 12,212 | 9,638 | 10,801 | 11,643 | 13,032 |
| 50 TO 60K | 762 | 1,116 | 2,066 | 2,713 | 3,585 | 4,312 | 1,882 | 2,459 | 3,229 | 3,967 |
| 60 TO 70K | 12,179 | 11,133 | 13,999 | 13,896 | 15,065 | 15,016 | 10,532 | 11,276 | 11,837 | 12,822 |
| 70 TO 80K | 7,498 | 9,068 | 13,925 | 16,517 | 20,044 | 22,928 | 11,118 | 14,775 | 17,439 | 19,819 |
| 80 TO 90K | - | - | - | - | - | - | 2,220 | 2,536 | 2,970 | 3,433 |
| 90 TO 100K | - | - | - | - | - | - | 595 | 756 | 1,056 | 1,236 |
| Total | 36,792 | 38,854 | 48,717 | 52,357 | 56,349 | 59,943 | 44,943 | 50,828 | 55,501 | 60,394 |
| **Worst Case** | | | | | | | | | | |
| 0 TO 10K | 9 | - | - | - | - | - | - | - | - | - |
| 10 TO 15K | 272 | 390 | 474 | 519 | 407 | 410 | 498 | 518 | 536 | 439 |
| 15 TO 20K | 359 | 468 | 481 | 451 | 203 | 114 | 522 | 464 | 397 | 184 |
| 20 TO 25K | 1,275 | 1,133 | 1,004 | 520 | 168 | 5 | 906 | 458 | 5 | 5 |
| 25 TO 30K | 4,529 | 2,411 | 68 | 14 | 15 | 15 | 13 | 14 | 15 | 15 |
| 30 TO 40K | 3,495 | 3,868 | 4,859 | 4,845 | 5,285 | 5,212 | 4,466 | 4,475 | 4,477 | 4,652 |
| 40 TO 50K | 6,413 | 7,064 | 7,806 | 7,929 | 8,261 | 8,674 | 8,189 | 8,256 | 8,729 | 9,011 |
| 50 TO 60K | 762 | 1,653 | 2,364 | 2,736 | 3,499 | 4,413 | 2,112 | 2,440 | 3,107 | 3,909 |
| 60 TO 70K | 12,179 | 15,561 | 14,641 | 12,711 | 12,682 | 13,159 | 12,035 | 10,361 | 10,487 | 11,579 |
| 70 TO 80K | 7,498 | 11,284 | 13,191 | 13,767 | 15,721 | 18,251 | 10,366 | 12,102 | 13,913 | 16,013 |
| 80 TO 90K | - | - | - | - | - | - | 2,314 | 2,391 | 2,691 | 3,025 |
| 90 TO 100K | - | - | - | - | - | - | 826 | 884 | 1,143 | 1,482 |
| Total | 36,792 | 43,832 | 44,889 | 43,490 | 46,241 | 50,252 | 42,248 | 42,363 | 45,499 | 50,316 |

Source: Richardson Lawrie Associates

## Table 6-15 Laden PCUMS by Year, DWT Range and Direction, Existing and Expanded Canal, All Scenarios,Selected Years, 2001-2025 (000 PCUMS)

| Scenario and | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **Most Probable Case** | | | | | | | | | | |
| 0 TO 10K | 7 | - | - | - | - | - | - | - | - | - |
| 10 TO 15K | 197 | 215 | 611 | 693 | 920 | 1,123 | 683 | 835 | 1,228 | 1,616 |
| 15 TO 20K | 228 | 206 | 580 | 633 | 805 | 976 | 663 | 801 | 1,160 | 1,530 |
| 20 TO 25K | 900 | 990 | 740 | 203 | 4 | 4 | 675 | 55 | 4 | 4 |
| 25 TO 30K | 2,813 | 2,237 | 472 | 466 | 386 | 158 | 472 | 466 | 386 | 158 |
| 30 TO 40K | 2,171 | 2,893 | 3,369 | 3,236 | 2,510 | 1,489 | 3,203 | 2,926 | 2,122 | 946 |
| 40 TO 50K | 3,918 | 4,230 | 5,788 | 6,119 | 6,816 | 7,150 | 5,795 | 6,154 | 6,978 | 7,563 |
| 50 TO 60K | 464 | 684 | 1,253 | 1,711 | 2,126 | 2,462 | 1,140 | 1,550 | 1,921 | 2,259 |
| 60 TO 70K | 7,139 | 6,400 | 8,010 | 8,211 | 8,319 | 8,123 | 5,685 | 6,297 | 6,231 | 6,508 |
| 70 TO 80K | 4,581 | 5,369 | 8,207 | 9,806 | 11,554 | 12,893 | 5,865 | 7,901 | 9,125 | 10,019 |
| 80 TO 90K | - | - | - | - | - | - | 1,166 | 1,374 | 1,535 | 1,700 |
| 90 TO 100K | - | - | - | - | - | - | 322 | 453 | 546 | 614 |
| Total | 22,418 | 23,224 | 29,031 | 31,078 | 33,441 | 34,378 | 25,669 | 28,811 | 31,237 | 32,917 |
| **Best Case** | | | | | | | | | | |
| 0 TO 10K | 7 | - | - | - | - | - | - | - | - | - |
| 10 TO 15K | 197 | 238 | 682 | 967 | 1,002 | 1,400 | 744 | 1,046 | 1,485 | 1,986 |
| 15 TO 20K | 228 | 236 | 663 | 925 | 907 | 1,286 | 734 | 1,021 | 1,468 | 1,961 |
| 20 TO 25K | 900 | 994 | 706 | 8 | 4 | 4 | 650 | 4 | 4 | 4 |
| 25 TO 30K | 2,813 | 2,241 | 462 | 451 | 335 | 10 | 462 | 451 | 335 | 10 |
| 30 TO 40K | 2,171 | 2,915 | 3,333 | 3,050 | 2,032 | 926 | 3,191 | 2,775 | 1,512 | 138 |
| 40 TO 50K | 3,918 | 4,358 | 5,899 | 6,607 | 6,747 | 7,459 | 5,885 | 6,595 | 7,110 | 7,958 |
| 50 TO 60K | 464 | 680 | 1,259 | 1,653 | 2,185 | 2,628 | 1,147 | 1,498 | 1,968 | 2,417 |
| 60 TO 70K | 7,139 | 6,526 | 8,206 | 8,145 | 8,831 | 8,802 | 5,755 | 6,161 | 6,468 | 7,006 |
| 70 TO 80K | 4,581 | 5,541 | 8,508 | 10,092 | 12,247 | 14,009 | 6,036 | 8,022 | 9,468 | 10,760 |
| 80 TO 90K | - | - | - | - | - | - | 1,193 | 1,363 | 1,596 | 1,845 |
| 90 TO 100K | - | - | - | - | - | - | 317 | 403 | 563 | 659 |
| Total | 22,418 | 23,728 | 29,719 | 31,899 | 34,289 | 36,523 | 26,115 | 29,339 | 31,977 | 34,745 |
| **Worst Case** | | | | | | | | | | |
| 0 TO 10K | 7 | - | - | - | - | - | - | - | - | - |
| 10 TO 15K | 197 | 282 | 343 | 376 | 295 | 297 | 360 | 375 | 388 | 318 |
| 15 TO 20K | 228 | 297 | 305 | 286 | 129 | 73 | 331 | 294 | 252 | 117 |
| 20 TO 25K | 900 | 800 | 709 | 367 | 119 | 4 | 640 | 324 | 4 | 4 |
| 25 TO 30K | 2,813 | 1,485 | 42 | 9 | 10 | 10 | 9 | 9 | 10 | 10 |
| 30 TO 40K | 2,171 | 2,402 | 3,018 | 3,009 | 3,282 | 3,237 | 2,774 | 2,779 | 2,780 | 2,889 |
| 40 TO 50K | 3,918 | 4,315 | 4,769 | 4,844 | 5,047 | 5,299 | 5,001 | 5,042 | 5,331 | 5,503 |
| 50 TO 60K | 464 | 1,007 | 1,441 | 1,667 | 2,132 | 2,689 | 1,287 | 1,487 | 1,893 | 2,382 |
| 60 TO 70K | 7,139 | 9,122 | 8,582 | 7,451 | 7,434 | 7,713 | 6,576 | 5,662 | 5,730 | 6,327 |
| 70 TO 80K | 4,581 | 6,895 | 8,060 | 8,412 | 9,606 | 11,152 | 5,628 | 6,571 | 7,554 | 8,694 |
| 80 TO 90K | - | - | - | - | - | - | 1,244 | 1,285 | 1,446 | 1,626 |
| 90 TO 100K | - | - | - | - | - | - | 440 | 471 | 610 | 790 |
| Total | 22,418 | 26,605 | 27,269 | 26,420 | 28,053 | 30,473 | 24,289 | 24,298 | 25,997 | 28,660 |

Source: Richardson Lawrie Associates

## Table 6-16 Ballast Transits by Year, DWT Range and Direction, Expanded and Expanded All Scenarios,Selected Years, 2001-2025 (Transits)

| Scenario and | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **Most Probable Case** | | | | | | | | | | |
| 0 TO 10K | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 10 TO 15K | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| 15 TO 20K | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 4 |
| 20 TO 25K | 8 | 9 | 10 | 10 | 10 | 9 | 10 | 10 | 11 | 12 |
| 25 TO 30K | 25 | 27 | 30 | 29 | 30 | 31 | 30 | 30 | 35 | 38 |
| 30 TO 40K | 16 | 18 | 20 | 20 | 21 | 21 | 20 | 21 | 25 | 27 |
| 40 TO 50K | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 6 | 6 |
| 50 TO 60K | - | - | - | - | - | - | - | - | - | - |
| 60 TO 70K | 5 | 4 | 4 | 6 | 7 | 8 | 4 | 6 | 7 | 7 |
| 70 TO 80K | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 |
| 80 TO 90K | - | - | - | - | - | - | - | - | - | - |
| 90 TO 100K | - | - | - | - | - | - | - | - | - | - |
| Total | 72 | 72 | 78 | 80 | 84 | 83 | 79 | 81 | 94 | 103 |
| **Best Case** | | | | | | | | | | |
| 0 TO 10K | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 10 TO 15K | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 |
| 15 TO 20K | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 4 | 4 | 4 |
| 20 TO 25K | 8 | 9 | 10 | 11 | 9 | 9 | 10 | 11 | 12 | 13 |
| 25 TO 30K | 25 | 28 | 31 | 33 | 30 | 33 | 31 | 33 | 37 | 42 |
| 30 TO 40K | 16 | 19 | 21 | 22 | 20 | 23 | 21 | 23 | 26 | 30 |
| 40 TO 50K | 4 | 5 | 5 | 6 | 5 | 5 | 5 | 6 | 6 | 7 |
| 50 TO 60K | - | - | - | - | - | - | - | - | - | - |
| 60 TO 70K | 5 | 4 | 4 | 5 | 8 | 8 | 3 | 4 | 7 | 7 |
| 70 TO 80K | 2 | 2 | 1 | 2 | 2 | 3 | 1 | 2 | 2 | 2 |
| 80 TO 90K | - | - | - | - | - | - | - | - | - | - |
| 90 TO 100K | - | - | - | - | - | - | - | - | - | - |
| Total | 72 | 73 | 80 | 86 | 81 | 90 | 80 | 87 | 100 | 112 |
| **Worst Case** | | | | | | | | | | |
| 0 TO 10K | 6 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10 TO 15K | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 15 TO 20K | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 20 TO 25K | 8 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 25 TO 30K | 25 | 23 | 22 | 21 | 20 | 20 | 21 | 21 | 20 | 20 |
| 30 TO 40K | 16 | 16 | 15 | 15 | 15 | 16 | 15 | 15 | 15 | 15 |
| 40 TO 50K | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 3 |
| 50 TO 60K | - | - | - | - | - | - | - | - | - | - |
| 60 TO 70K | 5 | 6 | 7 | 7 | 9 | 12 | 6 | 6 | 8 | 11 |
| 70 TO 80K | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 |
| 80 TO 90K | - | - | - | - | - | - | - | - | - | - |
| 90 TO 100K | - | - | - | - | - | - | - | - | - | - |
| Total | 72 | 64 | 62 | 60 | 61 | 65 | 61 | 59 | 60 | 63 |

Source: Richardson Lawrie Associates

## Table 6-17 Ballast Toll Revenue by Year, DWT Range and Direction, Existing and Expanded All Scenarios,Selected Years, 2001-2025 ($000s)

| Scenario and | Existing Canal | | | | | | Expanded Canal | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 | 2010 | 2015 | 2020 | 2025 |
| **Most Probable Case** | | | | | | | | | | |
| 0 TO 10K | 54 | 29 | 32 | 30 | 34 | 37 | 33 | 31 | 36 | 40 |
| 10 TO 15K | 33 | 70 | 80 | 75 | 83 | 86 | 81 | 77 | 93 | 102 |
| 15 TO 20K | 53 | 126 | 131 | 134 | 122 | 106 | 133 | 138 | 148 | 154 |
| 20 TO 25K | 227 | 512 | 559 | 546 | 542 | 505 | 568 | 563 | 636 | 672 |
| 25 TO 30K | 732 | 1,603 | 1,780 | 1,715 | 1,802 | 1,810 | 1,799 | 1,761 | 2,056 | 2,251 |
| 30 TO 40K | 605 | 1,383 | 1,506 | 1,526 | 1,563 | 1,557 | 1,528 | 1,568 | 1,837 | 2,046 |
| 40 TO 50K | 212 | 478 | 507 | 506 | 497 | 484 | 504 | 511 | 576 | 633 |
| 50 TO 60K | - | - | - | - | - | - | - | - | - | - |
| 60 TO 70K | 340 | 535 | 492 | 782 | 935 | 1,004 | 440 | 695 | 827 | 887 |
| 70 TO 80K | 141 | 207 | 193 | 268 | 306 | 323 | 174 | 239 | 272 | 287 |
| 80 TO 90K | - | - | - | - | - | - | - | - | - | - |
| 90 TO 100K | - | - | - | - | - | - | - | - | - | - |
| Total | 2,398 | 4,943 | 5,281 | 5,582 | 5,884 | 5,913 | 5,259 | 5,583 | 6,482 | 7,071 |
| **Best Case** | | | | | | | | | | |
| 0 TO 10K | 54 | 29 | 33 | 34 | 36 | 40 | 33 | 35 | 38 | 43 |
| 10 TO 15K | 33 | 71 | 82 | 86 | 82 | 94 | 83 | 88 | 98 | 112 |
| 15 TO 20K | 53 | 127 | 133 | 141 | 110 | 109 | 135 | 143 | 158 | 165 |
| 20 TO 25K | 227 | 518 | 571 | 601 | 508 | 531 | 578 | 612 | 672 | 724 |
| 25 TO 30K | 732 | 1,633 | 1,830 | 1,936 | 1,755 | 1,963 | 1,843 | 1,961 | 2,191 | 2,469 |
| 30 TO 40K | 605 | 1,400 | 1,543 | 1,667 | 1,489 | 1,700 | 1,561 | 1,693 | 1,971 | 2,267 |
| 40 TO 50K | 212 | 486 | 521 | 550 | 473 | 527 | 517 | 549 | 618 | 701 |
| 50 TO 60K | - | - | - | - | - | - | - | - | - | - |
| 60 TO 70K | 340 | 517 | 475 | 625 | 971 | 1,047 | 425 | 556 | 859 | 924 |
| 70 TO 80K | 141 | 203 | 190 | 228 | 317 | 335 | 171 | 204 | 281 | 297 |
| 80 TO 90K | - | - | - | - | - | - | - | - | - | - |
| 90 TO 100K | - | - | - | - | - | - | - | - | - | - |
| Total | 2,398 | 4,984 | 5,376 | 5,868 | 5,741 | 6,348 | 5,346 | 5,842 | 6,887 | 7,702 |
| **Worst Case** | | | | | | | | | | |
| 0 TO 10K | 54 | 29 | 27 | 26 | 24 | 24 | 27 | 26 | 25 | 24 |
| 10 TO 15K | 33 | 64 | 59 | 58 | 55 | 55 | 59 | 58 | 56 | 55 |
| 15 TO 20K | 53 | 85 | 81 | 79 | 75 | 74 | 80 | 78 | 76 | 74 |
| 20 TO 25K | 227 | 383 | 360 | 353 | 333 | 329 | 357 | 349 | 340 | 330 |
| 25 TO 30K | 732 | 1,375 | 1,284 | 1,251 | 1,180 | 1,162 | 1,268 | 1,233 | 1,198 | 1,160 |
| 30 TO 40K | 605 | 1,198 | 1,158 | 1,132 | 1,119 | 1,167 | 1,138 | 1,111 | 1,124 | 1,147 |
| 40 TO 50K | 212 | 402 | 379 | 367 | 347 | 339 | 368 | 356 | 344 | 332 |
| 50 TO 60K | - | - | - | - | - | - | - | - | - | - |
| 60 TO 70K | 340 | 733 | 895 | 835 | 1,109 | 1,487 | 798 | 743 | 982 | 1,316 |
| 70 TO 80K | 141 | 257 | 296 | 278 | 348 | 445 | 265 | 249 | 309 | 394 |
| 80 TO 90K | - | - | - | - | - | - | - | - | - | - |
| 90 TO 100K | - | - | - | - | - | - | - | - | - | - |
| Total | 2,398 | 4,525 | 4,538 | 4,381 | 4,589 | 5,081 | 4,360 | 4,202 | 4,456 | 4,832 |

Source: Richardson Lawrie Associates

## PANAMA CANAL MARKETING IMPLEMENTATION STRATEGY

In this section we discuss issues and strategies for the introduction and implementation of the preferred toll option. It should be noted that the preferred Canal toll pricing option discussed above is "preferred" from the perspective of the study's terms of reference and the specified Canal toll pricing objectives. The timing and phasing of the revised toll levels must be carefully planned taking into consideration the perception of canal users, trends in Canal traffic and markets, and pricing developments of alternatives to use of the Canal. Another consideration is the matching of increased tolls with improved Canal service and the expansion of canal capacity.

Clearly, an increase in tolls to the preferred option of 75 percent above the July 1, 2003 rates for the Existing Canal would need to be implemented over an extended time-frame and in conjunction with service improvements. For example, tolls could be raised and the increased revenue set-aside in a capital improvement fund in conjunction with the announcement of a decision to proceed with the construction of the Expanded Canal. Toll increases associated with the expansion of the Canal could be justified to Canal users' as a way of sustaining the long-term viability of the Canal and the avoidance of costly delays to users due capacity constraints.

If the Existing Canal were to become close to reaching full capacity, toll increases could be implemented as a way of reducing demand, and reducing Canal waiting time to acceptable levels. The ACP has embraced service to its clients as a core element of its operating goals. The implementation of significant increases in Canal toll rates will require regular communication and interaction with its principal clients. Indeed, visits to major clients by ACP senior officials and marketing personnel can provide insights as to the appropriate timing and phasing of toll increases and to service improvements or new pricing elements that would be desirable. The cost of such marketing trips would likely require an additional $200,000 to the ACP marketing budget. A significant toll increase will also require a public relations campaign targeted to the shipping industry and general business community. This would involve the retention of an experienced public relations firm and the preparation and placement of a variety of advertising and informational materials. The cost of such a campaign could approach $1 million over a two-year campaign.

The Delphi Panelists embraced the potential for introducing new pricing elements—such as variable tolls for peak and non-peak periods of Canal use, fees for preferential and/or reserved transit times, discount for the use of larger vessels, and discounts for large scale users or contract rates that might be negotiated. However, due to the general price inelasticity of demand for Canal services, there does not appear to be much advantage to the Canal for introducing such pricing elements such as discounts that would reduce its revenues. There may be greater interest though, in further development of the preferential transit slots with increased fees.

*Appendix A*

# WORLD GRAIN TRADE FLOWS BY COMMODITY, 2000/2001

## *Table A-1. Grain Trade in Soybeans, Marketing Year 2000/01*

| | *Exporting Country/Region* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Importing Country/Region*** | *US Total* | East C. | West C. | Gulf | *Canada East* | *Brazil* | *Peru* | *Chile* | *China* | *Argentina* | *Total Trade* |
| E. Europe | 0 | 0 | 0 | 0 | | 75 | | | | 10 | 85 |
| Western Europe ((EU) | 7,230 | 1,996 | 0 | 5,234 | | 7,271 | | | | 1,138 | 15,640 |
| FSU | 40 | 7 | 0 | 33 | | 2 | | | | 0 | 42 |
| *East Asia* | 12,014 | 527 | 1,109 | 10,378 | 352 | 1,051 | | | | 1,154 | 14,572 |
| China/Hong Kong | 5,159 | 347 | 198 | 4,614 | 280 | 621 | | | | 1,035 | 6,815 |
| Japan | 3,422 | 180 | 0 | 3,242 | 72 | 364 | | | | 26 | 4,165 |
| S. Korea | 1,401 | 0 | 104 | 1,297 | | 54 | | | | 0 | 1,455 |
| Taiwan | 2,032 | 0 | 807 | 1,225 | | 12 | | | | 93 | 2,137 |
| *S. Asia* | 0 | 0 | 0 | 0 | | 0 | | | | 0 | 0 |
| India | 0 | 0 | 0 | 0 | | 0 | | | | 0 | 0 |
| Pakistan | 0 | 0 | 0 | 0 | | 0 | | | | 0 | 0 |
| Bangladesh | 0 | 0 | 0 | 0 | | 0 | | | | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | | 0 | | | | 0 | 0 |
| *SE Asia* | 2,307 | 191 | 434 | 1,682 | | 115 | | | | 367 | 2,790 |
| Indonesia | 1,108 | 107 | 0 | 1,001 | | 0 | | | | 20 | 1,128 |
| Malaysia | 174 | 19 | 0 | 155 | | 59 | | | | 32 | 265 |
| Philippines | 375 | 0 | 186 | 189 | | 0 | | | | 0 | 375 |
| Singapore | 0 | 0 | 0 | 0 | | 0 | | | | 0 | 0 |
| Thailand | 645 | 65 | 248 | 332 | | 57 | | | | 315 | 1,017 |
| Vietnam | 5 | 0 | 0 | 5 | | 0 | | | | 0 | 5 |
| *Middle East* | 54 | 54 | 0 | 559 | | 110 | | | | 144 | 308 |
| *Africa* | 230 | 45 | 0 | 185 | | 106 | | | | 113 | 449 |
| North Africa | 210 | 45 | 0 | 165 | | 0 | | | | 0 | 210 |
| East Africa | 0 | 0 | 0 | 0 | | 0 | | | | 0 | 0 |
| West Africa | 0 | 0 | 0 | 0 | | 0 | | | | 0 | 0 |
| South Africa | 20 | 0 | 0 | 20 | | 0 | | | | 0 | 20 |
| Central Africa | 0 | 0 | 0 | 0 | | 0 | | | | 0 | 0 |
| *Latin America* | 2,241 | 41 | 0 | 2,200 | | 182 | 37 | 27 | 34 | 208 | 2,729 |
| Mexico | 1,508 | 41 | 0 | 1,467 | | | | | | 0 | 1,508 |
| Caribbean | 95 | 0 | 0 | 95 | | 11 | | | 22 | 0 | 128 |
| E.C. Cen America | 133 | 0 | 0 | 133 | | 26 | | | | 0 | 159 |
| W. C. Central America | 195 | 0 | 0 | 195 | | 0 | | | | 42 | 237 |
| E.C. S. America | 133 | 0 | 0 | 133 | | 30 | | 27 | | 29 | 219 |
| W. C. S. America | 101 | 0 | 0 | 101 | | 116 | | | | 55 | 272 |
| Chile | 11 | 0 | 0 | 11 | | 0 | | | | 55 | 66 |
| Venezuela | 65 | 0 | 0 | 65 | | 0 | 37 | | 12 | 28 | 142 |
| Total Exports from Above | 24,116 | 2,861 | 1,543 | 20,271 | 352 | 8,913 | 37 | 27 | 34 | 3,134 | 36,261 |
| | | | 1,543 | 20,815 | | 8,600 | 8,600 | | | 3,700 | 42,222 |
| | | | (0) | 544 | | (313) | 8,563 | | | 566 | 5,961 |
| Panama Shipments | 12,631 | | | 12,631 | 280 | 179 | 37 | 27 | 34 | 0 | 13,215 |
| Panama share | 52 | | | 62 | 80 | 2 | 100 | 100 | 100 | 0 | 36 |

## *Table A-2. Grain Trade in Wheat, Marketing Year 2000/01*

| | *Exporting Country/Region* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *US* | | | | *Canada* | | | *Europe* | *Australia* | *Mexico* | *Argentina* | *Total* |
| ***Importing Country/Region*** | Total | East C. | West C. | Gulf | Total | St. Law. | W. Coast | | | West | | *Trade* |
| E. Europe | 373 | 0 | 0 | 0 | 114 | 0 | 0 | 492 | 0 | | 0 | 979 |
| Western Europe ((EU) | 1,352 | 1,352 | 0 | 0 | 1,093 | 1,093 | 0 | 0 | 356 | | 65 | 2,866 |
| FSU | 1,195 | 0 | 28 | 1,167 | 0 | 0 | 0 | 552 | 0 | | 36 | 1,783 |
| *East Asia* | 6,094 | 0 | 5,729 | 365 | 2,362 | 55 | 2,307 | 211 | 2,553 | | 5 | 11,225 |
| China/Hong Kong | 1,210 | 0 | 1,057 | 153 | 684 | 55 | 629 | 0 | 191 | | 5 | 2,090 |
| Japan | 3,213 | 0 | 3,179 | 34 | 1,565 | 0 | 1,565 | 1 | 1,214 | | 0 | 5,993 |
| S. Korea | 1,671 | 0 | 1,492 | 179 | 113 | 0 | 113 | 210 | 1,148 | | 0 | 3,142 |
| Taiwan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| *S. Asia* | 1,409 | 0 | 597 | 760 | 496 | 102 | 96 | 571 | 2,166 | | 182 | 3,954 |
| India | 52 | 0 | 0 | 0 | 0 | 0 | 0 | 385 | 326 | | 84 | 847 |
| Pakistan | 432 | 0 | 432 | 0 | 35 | 0 | 0 | 7 | 1,285 | | 0 | 1,759 |
| Bangladesh | 433 | 0 | 165 | 268 | 198 | 102 | 96 | 166 | 453 | | 98 | 1,348 |
| Other | 492 | 0 | 0 | 492 | 263 | 0 | 0 | 13 | 102 | | | |
| *SE Asia* | 2,999 | 54 | 2,386 | 559 | 1,580 | 0 | 1,580 | 356 | 3,664 | | 157 | 8,756 |
| Indonesia | 422 | 29 | 223 | 169 | 700 | 0 | 700 | 314 | 1,917 | | 60 | 3,413 |
| Malaysia | 32 | 0 | 17 | 15 | 366 | 0 | 366 | 0 | 793 | | 46 | 1,237 |
| Philippines | 2,177 | 25 | 1,778 | 374 | 365 | 0 | 365 | 0 | 375 | | 0 | 2,917 |
| Singapore | 53 | 0 | 53 | 0 | 10 | 0 | 10 | 0 | 83 | | 0 | 146 |
| Thailand | 289 | 0 | 289 | 0 | 139 | 0 | 139 | 0 | 250 | | 5 | 683 |
| Vietnam | 26 | 0 | 26 | 0 | 0 | 0 | 0 | 42 | 246 | | 46 | 360 |
| *Middle East* | 2,470 | 125 | 61 | 2,284 | 4,114 | 435 | 3,679 | 2,747 | 5,538 | 28 | 843 | 15,740 |
| *Africa* | 7,534 | 328 | 658 | 6,549 | 3,013 | 2,334 | 679 | 5,191 | 2,016 | 497 | 1,541 | 25,280 |
| North Africa | 5,311 | 328 | 658 | 4,326 | 2,256 | 2,256 | 0 | 3,365 | 1,029 | 497 | 654 | 13,112 |
| East Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 2,078 |
| West Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 3,410 |
| South Africa | 2,223 | 0 | 0 | 2,223 | 757 | 78 | 679 | 1,826 | 987 | | 887 | 6,680 |
| Central Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| *Latin America* | 5,610 | 56 | 20 | 5,535 | 3,142 | 1,044 | 1,833 | 653 | 0 | | 7,542 | 16,947 |
| Mexico | 1,826 | 0 | 0 | 1,826 | 813 | 129 | 684 | 0 | 0 | | 0 | 2,639 |
| Caribbean | 1,686 | 12 | 0 | 1,674 | 54 | 54 | 0 | 622 | 0 | | 0 | 2,362 |
| E.C. Cen America | 202 | 0 | 0 | 202 | 265 | 0 | 0 | 0 | 0 | | 0 | 467 |
| W. C. Central America | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| E.C. S. America | 151 | 0 | 0 | 151 | 160 | 0 | 160 | 0 | 0 | | 6,691 | 7,002 |
| W. C. S. America | 1,089 | 20 | 0 | 1,069 | 775 | 75 | 700 | 0 | 0 | | 665 | 2,529 |
| Chile | 234 | 0 | 20 | 214 | 216 | 0 | 216 | 31 | 0 | | 182 | 663 |
| Venezuela | 422 | 24 | 0 | 398 | 859 | 786 | 73 | 0 | 0 | | 4 | 1,285 |
| Total Exports from Above | 29,036 | 1,914 | 9,478 | 17,219 | 15,914 | 5,063 | 10,174 | 10,773 | 16,293 | 525 | 10,371 | 87,530 |
| | | | | | 18,393 | | | 10,864 | 16,752 | | 10,480 | |
| | | | | | 2,479 | | | 91 | 459 | (525) | 109 | |
| Panama Shipments | 1,865 | | | 1,865 | 758 | 122 | 636 | | 0 | 525 | 0 | 3,946 |
| Panama share | 6 | 0 | 0 | 11 | 5 | 2 | 6 | 0 | 0 | 100 | 0 | 5 |

## *Table A-3. Grain Trade in Barley, Marketing Year 2000/01*

| | *Exporting Country/Region* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Importing Country/Region*** | *US Total* | East C. | West C. | Gulf | *Canada Total* | St. Law. | W. Coast | *Europe* | *Australia* | *Argentina* | *Total Trade* |
| E. Europe | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 211 | 0 | 0 | 211 |
| Western Europe ((EU) | 22 | 22 | 0 | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 47 |
| FSU | 0 | 0 | 0 | 0 | 4 | 4 | 0 | 239 | 0 | 0 | 243 |
| *East Asia* | 328 | 0 | 328 | 0 | 825 | 0 | 825 | 137 | 538 | 0 | 1,828 |
| China/Hong Kong | 0 | 0 | 0 | 0 | 428 | 0 | 428 | 118 | 0 | 0 | 546 |
| Japan | 328 | 0 | 328 | 0 | 376 | 0 | 376 | 0 | 527 | 0 | 1,231 |
| S. Korea | 0 | 0 | 0 | 0 | 21 | 0 | 21 | 19 | 11 | 0 | 51 |
| Taiwan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *S. Asia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| India | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pakistan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bangladesh | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *SE Asia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Indonesia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Malaysia | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Philippines | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Singapore | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thailand | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Vietnam | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Middle East* | 0 | 0 | 0 | 0 | 163 | 0 | 163 | 4,223 | 0 | 0 | 4,386 |
| *Africa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,045 | 0 | 0 | 1,045 |
| North Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,045 | 0 | 0 | 1,045 |
| East Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| West Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| South Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Central Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Latin America* | 103 | 0 | 0 | 0 | 0 | 0 | 0 | 148 | 52 | 92 | 395 |
| Mexico | 103 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 0 | 0 | 117 |
| Caribbean | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| E.C. Cen America | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| W. C. Central America | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 80 | 80 |
| E.C. S. America | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 58 | 0 | 0 | 58 |
| W. C. S. America | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 76 | 52 | 0 | 128 |
| Chile | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 12 |
| Venezuela | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Exports from Above | 453 | 22 | 328 | 0 | 992 | 4 | 988 | 6,028 | 590 | 92 | 8,155 |
| | | | | 0 | 1,755 | 258 | 1,060 | 10,117 | 3,283 | 0 | 15,748 |
| | | | | 0 | 763 | 254 | 72 | 4,089 | 2,693 | (92) | 7,593 |
| Panama Shipments | 285 | 0 | 0 | 285 | 13 | 0 | 13 | 36 | 0 | 0 | 334 |
| Panama share | 48 | 0 | 0 | | 1 | 0 | 1 | 0 | 0 | 0 | 2 |

## *Table A-4. Grain Trade in Sorghum, Marketing Year 2000/01*

| | *Exporting Country/Region* | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Importing Country/Region*** | *US* Total | East C. | West C. | Gulf | Australia | *Argentina* | *Total Trade* |
| E. Europe | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Western Europe ((EU) | 178 | 0 | 0 | 178 | 1 | 30 | 209 |
| FSU | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *East Asia* | 1,197 | 0 | 79 | 1,126 | 297 | 336 | 1,830 |
| China/Hong Kong | 9 | 0 | 9 | 0 | 0 | 0 | 9 |
| Japan | 1,188 | 0 | 70 | 1,118 | 297 | 336 | 1,821 |
| S. Korea | 0 | 0 | 0 | 8 | 0 | 0 | 0 |
| Taiwan | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *S. Asia* | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| India | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pakistan | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bangladesh | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *SE Asia* | 55 | 0 | 0 | 55 | 4 | 0 | 59 |
| Indonesia | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Malaysia | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Philippines | 55 | 0 | 0 | 55 | 4 | 0 | 59 |
| Singapore | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Thailand | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Vietnam | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Middle East* | 118 | 0 | 0 | 118 | 1 | 4 | 123 |
| *Africa* | 0 | 0 | 0 | 0 | 25 | 11 | 36 |
| North Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| East Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| West Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| South Africa | 0 | 0 | 0 | 0 | 25 | 11 | 36 |
| Central Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Latin America* | 4,715 | 0 | 0 | 4,715 | 1 | 145 | 4,861 |
| Mexico | 4,715 | 0 | 0 | 4,715 | 0 | 0 | 4,715 |
| Caribbean | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| E.C. Cen America | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| W. C. Central America | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| E.C. S. America | 0 | 0 | 0 | 0 | 0 | 82 | 82 |
| W. C. S. America | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Chile | 0 | 0 | 0 | 0 | 0 | 63 | 63 |
| Venezuela | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Exports from Above | 6,263 | 0 | 79 | 6,192 | 328 | 526 | 7,117 |
| | | | | | 367 | 527 | 7,180 |
| | | | | | 39 | 1 | 63 |
| Panama Shipments | 871 | 0 | 0 | 871 | 0 | 0 | 871 |
| Panama share | 14 | 0 | 0 | 14 | 0 | 0 | 12 |

***Table A-5. Grain Trade In Rice, Marketing Year 2000/01***

| | | | | ***Exporting Country/Region*** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Importing Country/Region*** | *US Total* | East C. | West C. | Gulf | Australia | *Argentina* | *China* | *Thailand* | *Vietnam* | *Total Trade* |
| E. Europe | 5 | 0 | 0 | 5 | 0 | 0 | 127 | 30 | 98 | 260 |
| Western Europe ((EU) | 384 | 0 | 5 | 379 | 0 | 1 | 0 | 278 | 9 | 667 |
| FSU | 37 | 0 | 0 | 37 | 0 | 0 | 238 | 7 | 46 | 329 |
| *East Asia* | 353 | 0 | 353 | 0 | 0 | 0 | 198 | 449 | 10 | 1010 |
| China/Hong Kong | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 275 | 0 | 276 |
| Japan | 350 | 0 | 350 | 0 | 0 | 0 | 67 | 144 | 10 | 571 |
| S. Korea | 2 | 0 | 2 | 0 | 0 | 0 | 131 | 31 | 0 | 164 |
| Taiwan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *S. Asia* | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 63 | 66 |
| India | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 |
| Pakistan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bangladesh | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 63 | 63 |
| Other | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *SE Asia* | 215 | 0 | 4 | 211 | 0 | 0 | 635 | 872 | 1454 | 3177 |
| Indonesia | 129 | 0 | 0 | 129 | 0 | 0 | 445 | 250 | 563 | 1,388 |
| Malaysia | 0 | 0 | 0 | 0 | 0 | 0 | 119 | 330 | 133 | 583 |
| Philippines | 82 | 0 | 0 | 82 | 0 | 0 | 64 | 27 | 746 | 919 |
| Singapore | 4 | 0 | 4 | 0 | 0 | 0 | 2 | 263 | 11 | 281 |
| Thailand | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Vietnam | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 0 | 6 |
| *Middle East* | 508 | 0 | 85 | 423 | 0 | 168 | 266 | 1,407 | 665 | 2,929 |
| *Africa* | 204 | 0 | 0 | 204 | 0 | 0 | 1286 | 2533 | 736 | 4759 |
| North Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| East Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| West Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| South Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Central Africa | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Latin America* | 931 | 0 | 0 | 931 | 0 | 357 | 246 | 2 | 146 | 1682 |
| Mexico | 414 | 0 | 0 | 414 | 0 | 0 | 0 | 0 | 0 | 414 |
| Caribbean | 343 | 0 | 0 | 343 | 0 | 20 | 226 | 2 | 146 | 736 |
| E.C. Cen America | 12 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 12 |
| W. C. Central America | 138 | 0 | 0 | 138 | 0 | 0 | 0 | 0 | 0 | 138 |
| E.C. S. America | 2 | 0 | 0 | 2 | 0 | 260 | 21 | 0 | 0 | 282 |
| W. C. S. America | 20 | 0 | 0 | 20 | 0 | 16 | 0 | 0 | 0 | 36 |
| Chile | 0 | 0 | 0 | 0 | 0 | 62 | 0 | 0 | 0 | 62 |
| Venezuela | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total Exports from Above | 2,641 | 0 | 447 | 2,194 | 0 | 526 | 2,998 | 5,579 | 3,225 | 14,879 |
| | | | | | 0 | 527 | 3,075 | 6,545 | 3,273 | 16,276 |
| | | | | | 0 | 1 | 77 | 966 | 47 | 1,397 |
| Panama Shipments | 398 | 0 | 91 | 308 | 0 | 0 | 204 | 0 | 130 | 731 |
| Panama share | 14 | 0 | 20 | 14 | 0 | 0 | 7 | 0 | 4 | 4 |

## *Table A-6. Grain Trade in Corn, Marketing Year 2000/01*

| | *Exporting Country/Region* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ***Importing Country/Region*** | *US* Total | East C. | West C. | Gulf | *Canada* 100% east | *Mexico* 100% west | *Argentina* | *China* | *Total Trade* |
| E. Europe | 63 | 0 | 0 | 63 | 22 | | 0 | 0 | 85 |
| Western Europe ((EU) | 381 | 0 | 0 | 381 | | | 1,684 | 0 | 2,065 |
| FSU | 660 | 0 | 56 | 604 | | | 49 | 3 | 712 |
| *East Asia* | 24,378 | 290 | 8,262 | 15,826 | | | 376 | 3,175 | 27,929 |
| China/Hong Kong | 58 | 0 | 0 | 58 | | | 0 | 0 | 58 |
| Japan | 15,287 | 218 | 4,274 | 10,795 | | | 320 | 84 | 15,691 |
| S. Korea | 3,864 | 72 | 1,889 | 1,903 | | | 56 | 3,091 | 7,011 |
| Taiwan | 5,169 | 0 | 2,099 | 3,070 | | | 0 | 0 | 5,169 |
| *S. Asia* | 0 | 0 | 0 | 0 | | | 0 | 507 | 507 |
| India | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 |
| Pakistan | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 |
| Bangladesh | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 |
| *SE Asia* | 540 | 0 | 93 | 447 | | | 0 | 2,607 | 3,147 |
| Indonesia | 0 | 0 | 0 | 0 | | | 0 | 739 | 739 |
| Malaysia | 323 | 0 | 0 | 323 | | | 0 | 1,652 | 1,975 |
| Philippines | 217 | 0 | 93 | 124 | | | 0 | 216 | 433 |
| Singapore | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 |
| Thailand | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 |
| Vietnam | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 |
| *Middle East* | 3,816 | 81 | 0 | 3,735 | 85 | | 294 | 214 | 4,409 |
| *Africa* | 5,253 | 653 | 0 | 4,600 | 6 | | 1,116 | 0 | 6,375 |
| North Africa | 4,857 | 4,677 | 0 | 180 | 6 | | 1,066 | 0 | 5,929 |
| East Africa | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 |
| West Africa | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 |
| South Africa | 396 | 0 | 0 | 0 | | | 50 | 0 | 446 |
| Central Africa | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 |
| *Latin America* | 13,444 | 16 | 0 | 13,428 | 246 | 88 | 2,722 | 0 | 16,500 |
| Mexico | 4,791 | 0 | 0 | 4,791 | | 88 | 25 | 0 | 4,904 |
| Caribbean | 2,232 | 0 | 0 | 2,232 | 230 | | 0 | 0 | 2,462 |
| E.C. Cen America | 249 | 0 | 0 | 249 | | | 0 | 0 | 249 |
| W. C. Central America | 2,140 | 0 | 0 | 2,140 | | | 0 | 0 | 2,140 |
| E.C. S. America | 59 | 0 | 0 | 59 | 16 | | 1,319 | 0 | 1,394 |
| W. C. S. America | 2,255 | 0 | 0 | 2,255 | | | 547 | 0 | 2,802 |
| Chile | 613 | 0 | 0 | 613 | | | 671 | 0 | 1,284 |
| Venezuela | 1,105 | 16 | 0 | 1,089 | | | 160 | 0 | 1,265 |
| Total Exports from Above | 48,535 | 1,040 | 8,412 | 39,083 | 359 | 88 | 6,241 | 6,506 | 61,729 |
| | | 2,106 | 8,956 | 39,032 | 377 | 0 | 7,936 | 7,163 | 65,571 |
| | | 1,066 | 545 | (51) | 17 | (88) | 1,695 | 657 | 3,841 |
| Panama Shipments | 19,099 | | | 19,099 | 221 | 88 | 0 | 27 | 19,448 |
| Panama share | 39 | | | 49 | 62 | 100 | 0 | 0 | 32 |

*Appendix B*

# CARGO ALLOCATION BY ROUTE AND DWT SIZE RANGE, EXISTING CANAL AND EXPANDED CANAL, MOST PROBABLE CASE

## Table B-1. Cargo Allocation by Route and DWT Size Range, Existing Canal Most Probable Case, No Tolls, Selected Years 2001-2025 (percent)

| Origin | Destination | DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|
| North America East | Central America West | Greater than 10,000–Less than 15,000 | 6.3 | 6.2 | 15.5 | 17.7 | 21.3 | 25.0 |
| North America East | Central America West | Greater or equal to 20,000–Less than 25,000 | 16.2 | 16.2 | 10.7 | 2.9 | - | - |
| North America East | Central America West | Greater or equal to 25,000–Less than 30,000 | 36.8 | 26.2 | - | - | - | - |
| North America East | Central America West | Greater or equal to 30,000–Less than 40,000 | 14.4 | 17.5 | 18.3 | 16.9 | 12.3 | 7.1 |
| North America East | Central America West | Greater or equal to 40,000–Less than 50,000 | 26.3 | 33.9 | 55.5 | 62.6 | 66.4 | 68.0 |
| North America East | South America West | Greater than 10,000–Less than 15,000 | 6.7 | 6.4 | 15.2 | 18.4 | 23.8 | 30.1 |
| North America East | South America West | Greater or equal to 15,000–Less than 20,000 | 4.7 | 3.8 | 9.0 | 10.0 | 12.7 | 16.1 |
| North America East | South America West | Greater or equal to 20,000–Less than 25,000 | 16.9 | 16.2 | 10.2 | 2.9 | - | - |
| North America East | South America West | Greater or equal to 25,000–Less than 30,000 | 23.1 | 15.8 | - | - | - | - |
| North America East | South America West | Greater or equal to 30,000–Less than 40,000 | 38.1 | 44.7 | 44.3 | 43.3 | 33.9 | 21.1 |
| North America East | South America West | Greater or equal to 40,000–Less than 50,000 | 10.6 | 13.1 | 21.3 | 25.4 | 29.6 | 32.7 |
| North America East | Oceania | Greater or equal to 30,000–Less than 40,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| North America East | South East Asia | Greater or equal to 15,000–Less than 20,000 | 2.8 | 1.8 | 3.2 | 3.1 | 3.5 | 4.2 |
| North America East | South East Asia | Greater or equal to 30,000–Less than 40,000 | 19.6 | 19.0 | 13.7 | 11.5 | 8.2 | 4.8 |
| North America East | South East Asia | Greater or equal to 40,000–Less than 50,000 | 77.6 | 79.2 | 83.2 | 85.5 | 88.2 | 91.0 |
| North America East | China | Greater or equal to 40,000–Less than 50,000 | 14.1 | 14.1 | 13.4 | 13.2 | 12.8 | 12.5 |
| North America East | China | Greater or equal to 60,000–Less than 70,000 | 56.4 | 50.8 | 46.1 | 42.0 | 38.7 | 35.7 |
| North America East | China | Greater or equal to 70,000–Less than 80,000 | 29.5 | 35.1 | 40.5 | 44.8 | 48.5 | 51.7 |
| North America East | Taiwan | Greater or equal to 25,000–Less than 30,000 | 1.8 | 0.9 | - | - | - | - |
| North America East | Taiwan | Greater or equal to 40,000–Less than 50,000 | - | - | 0.1 | 0.1 | 0.1 | 0.1 |
| North America East | Taiwan | Greater or equal to 60,000–Less than 70,000 | 14.0 | 11.1 | 9.0 | 7.5 | 6.5 | 5.7 |
| North America East | Taiwan | Greater or equal to 70,000–Less than 80,000 | 84.2 | 88.0 | 90.9 | 92.4 | 93.5 | 94.3 |
| North America East | Japan | Greater or equal to 25,000–Less than 30,000 | 28.7 | 17.8 | - | - | - | - |
| North America East | Japan | Greater or equal to 30,000–Less than 40,000 | 22.9 | 24.3 | 20.2 | 16.4 | 11.4 | 6.4 |
| North America East | Japan | Greater or equal to 40,000–Less than 50,000 | 13.8 | 15.5 | 20.9 | 20.7 | 20.7 | 20.8 |
| North America East | Japan | Greater or equal to 60,000–Less than 70,000 | 11.3 | 11.4 | 13.2 | 12.1 | 11.5 | 10.9 |
| North America East | Japan | Greater or equal to 70,000–Less than 80,000 | 23.2 | 30.9 | 45.6 | 50.8 | 56.4 | 61.9 |
| North America East | South Korea | Greater or equal to 40,000–Less than 50,000 | 16.3 | 15.7 | 14.3 | 13.7 | 13.0 | 12.5 |
| North America East | South Korea | Greater or equal to 60,000–Less than 70,000 | 40.2 | 34.8 | 30.4 | 27.0 | 24.2 | 21.9 |
| North America East | South Korea | Greater or equal to 70,000–Less than 80,000 | 43.5 | 49.5 | 55.3 | 59.3 | 62.7 | 65.6 |
| North America East | Other Far East | Greater or equal to 25,000–Less than 30,000 | 28.7 | 17.8 | - | - | - | - |
| North America East | Other Far East | Greater or equal to 30,000–Less than 40,000 | 22.9 | 24.3 | 20.2 | 16.4 | 11.4 | 6.4 |
| North America East | Other Far East | Greater or equal to 40,000–Less than 50,000 | 13.8 | 15.5 | 20.9 | 20.7 | 20.7 | 20.8 |
| North America East | Other Far East | Greater or equal to 60,000–Less than 70,000 | 11.3 | 11.4 | 13.2 | 12.1 | 11.5 | 10.9 |
| North America East | Other Far East | Greater or equal to 70,000–Less than 80,000 | 23.2 | 30.9 | 45.6 | 50.8 | 56.4 | 61.9 |
| North America Gulf | North America West | Greater or equal to 70,000–Less than 80,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| North America Gulf | Central America West | Greater than 10,000–Less than 15,000 | 2.3 | 2.3 | 6.1 | 7.4 | 9.9 | 13.1 |
| North America Gulf | Central America West | Greater or equal to 15,000–Less than 20,000 | 3.5 | 2.9 | 7.8 | 8.7 | 11.4 | 15.1 |
| North America Gulf | Central America West | Greater or equal to 20,000–Less than 25,000 | 12.6 | 12.4 | 8.8 | 2.5 | - | - |
| North America Gulf | Central America West | Greater or equal to 25,000–Less than 30,000 | 33.3 | 23.4 | - | - | - | - |
| North America Gulf | Central America West | Greater or equal to 30,000–Less than 40,000 | 38.3 | 46.0 | 51.4 | 50.0 | 40.4 | 26.4 |

## Table B-1. Cargo Allocation by Route and DWT Size Range, Existing Canal Most Probable Case, No Tolls, Selected Years 2001-2025 (percent)

| Origin | Destination | DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|
| North America Gulf | Central America West | Greater or equal to 40,000–Less than 50,000 | 8.3 | 10.5 | 20.9 | 24.8 | 29.7 | 34.4 |
| North America Gulf | Central America West | Greater or equal to 50,000–Less than 60,000 | 1.1 | 1.9 | 4.0 | 5.6 | 7.4 | 9.6 |
| North America Gulf | Central America West | Greater or equal to 60,000–Less than 70,000 | 0.6 | 0.7 | 1.1 | 1.2 | 1.3 | 1.4 |
| North America Gulf | South America West | Greater than 10,000–Less than 15,000 | 3.0 | 2.9 | 7.0 | 7.9 | 9.9 | 12.1 |
| North America Gulf | South America West | Greater or equal to 15,000–Less than 20,000 | 3.0 | 2.4 | 5.9 | 6.2 | 7.6 | 9.3 |
| North America Gulf | South America West | Greater or equal to 20,000–Less than 25,000 | 12.0 | 11.6 | 7.4 | 2.0 | - | - |
| North America Gulf | South America West | Greater or equal to 25,000–Less than 30,000 | 32.0 | 22.1 | - | - | - | - |
| North America Gulf | South America West | Greater or equal to 30,000–Less than 40,000 | 26.0 | 30.7 | 31.1 | 28.6 | 21.5 | 12.9 |
| North America Gulf | South America West | Greater or equal to 40,000–Less than 50,000 | 22.0 | 27.4 | 43.7 | 49.1 | 53.8 | 57.5 |
| North America Gulf | South America West | Greater or equal to 50,000–Less than 60,000 | 1.0 | 1.8 | 3.3 | 4.4 | 5.5 | 6.5 |
| North America Gulf | South America West | Greater or equal to 60,000–Less than 70,000 | 1.0 | 1.1 | 1.6 | 1.7 | 1.7 | 1.7 |
| North America Gulf | Oceania | Greater or equal to 15,000–Less than 20,000 | 4.2 | 2.9 | 5.4 | 5.2 | 6.0 | 7.0 |
| North America Gulf | Oceania | Greater or equal to 25,000–Less than 30,000 | 10.2 | 6.1 | - | - | - | - |
| North America Gulf | Oceania | Greater or equal to 30,000–Less than 40,000 | 17.0 | 17.3 | 13.0 | 11.0 | 7.8 | 4.5 |
| North America Gulf | Oceania | Greater or equal to 40,000–Less than 50,000 | 68.6 | 73.7 | 81.6 | 83.9 | 86.2 | 88.5 |
| North America Gulf | South East Asia | Greater or equal to 25,000–Less than 30,000 | 2.0 | 1.1 | - | - | - | - |
| North America Gulf | South East Asia | Greater or equal to 30,000–Less than 40,000 | 10.0 | 9.3 | 6.2 | 4.9 | 3.3 | 1.8 |
| North America Gulf | South East Asia | Greater or equal to 40,000–Less than 50,000 | 35.0 | 34.3 | 33.5 | 32.6 | 31.8 | 31.1 |
| North America Gulf | South East Asia | Greater or equal to 50,000–Less than 60,000 | 2.0 | 2.8 | 3.4 | 4.0 | 4.4 | 4.8 |
| North America Gulf | South East Asia | Greater or equal to 60,000–Less than 70,000 | 24.0 | 21.2 | 19.7 | 17.8 | 16.4 | 15.1 |
| North America Gulf | South East Asia | Greater or equal to 70,000–Less than 80,000 | 27.0 | 31.4 | 37.3 | 40.8 | 44.1 | 47.2 |
| North America Gulf | China | Greater or equal to 25,000–Less than 30,000 | 1.2 | 0.7 | - | - | - | - |
| North America Gulf | China | Greater or equal to 30,000–Less than 40,000 | 1.5 | 1.4 | 0.9 | 0.7 | 0.5 | 0.3 |
| North America Gulf | China | Greater or equal to 40,000–Less than 50,000 | 4.7 | 4.7 | 4.6 | 4.5 | 4.3 | 4.2 |
| North America Gulf | China | Greater or equal to 50,000–Less than 60,000 | 5.0 | 7.0 | 8.5 | 9.9 | 11.0 | 11.8 |
| North America Gulf | China | Greater or equal to 60,000–Less than 70,000 | 61.9 | 55.7 | 50.6 | 46.0 | 42.2 | 38.9 |
| North America Gulf | China | Greater or equal to 70,000–Less than 80,000 | 25.7 | 30.5 | 35.4 | 38.9 | 42.0 | 44.8 |
| North America Gulf | Taiwan | Greater or equal to 30,000–Less than 40,000 | 1.7 | 1.6 | 1.0 | 0.8 | 0.5 | 0.3 |
| North America Gulf | Taiwan | Greater or equal to 40,000–Less than 50,000 | 2.0 | 1.9 | 1.8 | 1.7 | 1.7 | 1.6 |
| North America Gulf | Taiwan | Greater or equal to 50,000–Less than 60,000 | 0.3 | 0.5 | 0.5 | 0.6 | 0.7 | 0.7 |
| North America Gulf | Taiwan | Greater or equal to 60,000–Less than 70,000 | 53.3 | 46.7 | 41.2 | 36.8 | 33.3 | 30.3 |
| North America Gulf | Taiwan | Greater or equal to 70,000–Less than 80,000 | 42.7 | 49.3 | 55.5 | 60.0 | 63.8 | 67.1 |
| North America Gulf | Japan | Greater or equal to 15,000–Less than 20,000 | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 |
| North America Gulf | Japan | Greater or equal to 20,000–Less than 25,000 | 0.1 | 0.1 | 0.0 | 0.0 | - | - |
| North America Gulf | Japan | Greater or equal to 25,000–Less than 30,000 | 2.7 | 1.5 | - | - | - | - |
| North America Gulf | Japan | Greater or equal to 30,000–Less than 40,000 | 0.8 | 0.8 | 0.5 | 0.4 | 0.3 | 0.1 |
| North America Gulf | Japan | Greater or equal to 40,000–Less than 50,000 | 23.7 | 23.4 | 22.3 | 21.5 | 20.7 | 20.0 |
| North America Gulf | Japan | Greater or equal to 50,000–Less than 60,000 | 2.6 | 3.6 | 4.4 | 5.0 | 5.5 | 5.9 |
| North America Gulf | Japan | Greater or equal to 60,000–Less than 70,000 | 39.5 | 35.1 | 31.7 | 28.4 | 25.8 | 23.6 |
| North America Gulf | Japan | Greater or equal to 70,000–Less than 80,000 | 30.4 | 35.5 | 41.0 | 44.5 | 47.6 | 50.2 |
| North America Gulf | South Korea | Greater or equal to 20,000–Less than 25,000 | 0.5 | 0.4 | 0.2 | 0.0 | - | - |

## Table B-1. Cargo Allocation by Route and DWT Size Range, Existing Canal Most Probable Case, No Tolls, Selected Years 2001-2025 (percent)

| Origin | Destination | DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|
| North America Gulf | South Korea | Greater or equal to 25,000–Less than 30,000 | 1.0 | 0.6 | - | - | - | - |
| North America Gulf | South Korea | Greater or equal to 30,000–Less than 40,000 | 1.4 | 1.4 | 0.9 | 0.8 | 0.5 | 0.3 |
| North America Gulf | South Korea | Greater or equal to 40,000–Less than 50,000 | 16.1 | 16.7 | 16.7 | 16.9 | 17.0 | 17.0 |
| North America Gulf | South Korea | Greater or equal to 50,000–Less than 60,000 | 2.2 | 3.2 | 4.0 | 4.8 | 5.5 | 6.1 |
| North America Gulf | South Korea | Greater or equal to 60,000–Less than 70,000 | 65.6 | 61.4 | 58.4 | 54.9 | 51.9 | 49.2 |
| North America Gulf | South Korea | Greater or equal to 70,000–Less than 80,000 | 13.2 | 16.3 | 19.8 | 22.5 | 25.1 | 27.4 |
| North America Gulf | Other Far East | Greater or equal to 20,000–Less than 25,000 | 21.3 | 17.7 | 9.1 | 2.2 | - | - |
| North America Gulf | Other Far East | Greater or equal to 25,000–Less than 30,000 | 13.9 | 8.3 | - | - | - | - |
| North America Gulf | Other Far East | Greater or equal to 30,000–Less than 40,000 | 15.4 | 15.7 | 12.6 | 10.7 | 7.3 | 4.0 |
| North America Gulf | Other Far East | Greater or equal to 40,000–Less than 50,000 | 22.7 | 24.4 | 29.6 | 30.6 | 30.8 | 30.1 |
| North America Gulf | Other Far East | Greater or equal to 70,000–Less than 80,000 | 26.6 | 34.0 | 48.6 | 56.5 | 61.8 | 65.9 |
| Central America East | South America West | Greater or equal to 20,000–Less than 25,000 | 83.5 | 80.5 | 72.4 | 43.1 | - | - |
| Central America East | South America West | Greater or equal to 30,000–Less than 40,000 | 16.5 | 19.5 | 27.6 | 56.9 | 76.1 | 64.1 |
| Central America East | South America West | Greater or equal to 40,000–Less than 50,000 | - | - | - | - | 23.9 | 35.9 |
| Brazil | South America West | Less or equal to 10,000 | 23.9 | - | - | - | - | - |
| Brazil | South America West | Greater or equal to 20,000–Less than 25,000 | 3.3 | 2.2 | 0.9 | 0.2 | - | - |
| Brazil | South America West | Greater or equal to 25,000–Less than 30,000 | 9.3 | 4.5 | - | - | - | - |
| Brazil | South America West | Greater or equal to 30,000–Less than 40,000 | 11.8 | 9.7 | 6.1 | 4.4 | 2.8 | 1.5 |
| Brazil | South America West | Greater or equal to 40,000–Less than 50,000 | - | 20.7 | 19.4 | 17.2 | 15.8 | 14.7 |
| Brazil | South America West | Greater or equal to 50,000–Less than 60,000 | 51.7 | 63.0 | 73.6 | 78.1 | 81.4 | 83.8 |
| Brazil | China | Greater or equal to 40,000–Less than 50,000 | 40.0 | 37.8 | 35.1 | 33.4 | 31.9 | 30.6 |
| Brazil | China | Greater or equal to 50,000–Less than 60,000 | 17.2 | 22.9 | 27.1 | 30.7 | 33.4 | 35.6 |
| Brazil | China | Greater or equal to 60,000–Less than 70,000 | 32.1 | 27.3 | 24.2 | 21.4 | 19.3 | 17.5 |
| Brazil | China | Greater or equal to 70,000–Less than 80,000 | 10.7 | 12.0 | 13.6 | 14.5 | 15.4 | 16.2 |
| Brazil | Taiwan | Greater or equal to 40,000–Less than 50,000 | 40.0 | 37.8 | 35.1 | 33.4 | 31.9 | 30.6 |
| Brazil | Taiwan | Greater or equal to 50,000–Less than 60,000 | 17.2 | 22.9 | 27.1 | 30.7 | 33.4 | 35.6 |
| Brazil | Taiwan | Greater or equal to 60,000–Less than 70,000 | 32.1 | 27.3 | 24.2 | 21.4 | 19.3 | 17.5 |
| Brazil | Taiwan | Greater or equal to 70,000–Less than 80,000 | 10.7 | 12.0 | 13.6 | 14.5 | 15.4 | 16.2 |
| Brazil | Japan | Greater or equal to 40,000–Less than 50,000 | 40.0 | 37.8 | 35.1 | 33.4 | 31.9 | 30.6 |
| Brazil | Japan | Greater or equal to 50,000–Less than 60,000 | 17.2 | 22.9 | 27.1 | 30.7 | 33.4 | 35.6 |
| Brazil | Japan | Greater or equal to 60,000–Less than 70,000 | 32.1 | 27.3 | 24.2 | 21.4 | 19.3 | 17.5 |
| Brazil | Japan | Greater or equal to 70,000–Less than 80,000 | 10.7 | 12.0 | 13.6 | 14.5 | 15.4 | 16.2 |
| Brazil | South Korea | Greater or equal to 40,000–Less than 50,000 | 40.0 | 37.8 | 35.1 | 33.4 | 31.9 | 30.6 |
| Brazil | South Korea | Greater or equal to 50,000–Less than 60,000 | 17.2 | 22.9 | 27.1 | 30.7 | 33.4 | 35.6 |
| Brazil | South Korea | Greater or equal to 60,000–Less than 70,000 | 32.1 | 27.3 | 24.2 | 21.4 | 19.3 | 17.5 |
| Brazil | South Korea | Greater or equal to 70,000–Less than 80,000 | 10.7 | 12.0 | 13.6 | 14.5 | 15.4 | 16.2 |
| South America East | Central America West | Less or equal to 10,000 | 62.7 | - | - | - | - | - |
| South America East | Central America West | Greater or equal to 30,000–Less than 40,000 | 37.3 | 36.0 | 27.9 | 24.1 | 18.0 | 11.0 |
| South America East | Central America West | Greater or equal to 40,000–Less than 50,000 | - | 64.0 | 72.1 | 75.9 | 82.0 | 89.0 |
| South America East | South America West | Less or equal to 10,000 | 23.9 | - | - | - | - | - |
| South America East | South America West | Greater or equal to 20,000–Less than 25,000 | 3.3 | 2.9 | 1.4 | 0.4 | - | - |

## Table B-1. Cargo Allocation by Route and DWT Size Range, Existing Canal Most Probable Case, No Tolls, Selected Years 2001-2025 (percent)

| Origin | Destination | DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|
| South America East | South America West | Greater or equal to 25,000–Less than 30,000 | 9.3 | 5.8 | - | - | - | - |
| South America East | South America West | Greater or equal to 30,000–Less than 40,000 | 11.8 | 12.5 | 9.9 | 8.7 | 6.4 | 3.9 |
| South America East | South America West | Greater or equal to 40,000–Less than 50,000 | - | 26.7 | 31.4 | 33.8 | 36.1 | 38.4 |
| South America East | South America West | Greater or equal to 60,000–Less than 70,000 | 51.7 | 52.1 | 57.2 | 57.1 | 57.4 | 57.8 |
| Caribbean | Central America West | Greater or equal to 25,000–Less than 30,000 | 100.0 | 100.0 | - | - | - | - |
| Caribbean | Central America West | Greater or equal to 40,000–Less than 50,000 | - | - | 100.0 | 100.0 | 100.0 | 100.0 |
| Caribbean | Far East | Greater or equal to 40,000–Less than 50,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Europe | North America West | Greater or equal to 40,000–Less than 50,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Europe | Central America West | Greater or equal to 30,000–Less than 40,000 | 88.0 | 87.4 | 82.7 | 79.6 | 73.1 | 60.4 |
| Europe | Central America West | Greater or equal to 40,000–Less than 50,000 | 12.0 | 12.6 | 17.3 | 20.4 | 26.9 | 39.6 |
| Europe | South America West | Less or equal to 10,000 | 2.0 | - | - | - | - | - |
| Europe | South America West | Greater or equal to 15,000–Less than 20,000 | 6.0 | 4.7 | 11.3 | 12.0 | 15.5 | 20.4 |
| Europe | South America West | Greater or equal to 20,000–Less than 25,000 | 7.0 | 6.5 | 4.1 | 1.1 | - | - |
| Europe | South America West | Greater or equal to 25,000–Less than 30,000 | 25.0 | 16.7 | - | - | - | - |
| Europe | South America West | Greater or equal to 30,000–Less than 40,000 | 42.0 | 48.0 | 47.5 | 44.4 | 35.4 | 23.0 |
| Europe | South America West | Greater or equal to 40,000–Less than 50,000 | 18.0 | 24.1 | 37.2 | 42.5 | 49.1 | 56.6 |
| Europe | Oceania | Greater or equal to 30,000–Less than 40,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Europe | Far East | Greater or equal to 40,000–Less than 50,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Africa | Central America West | Greater or equal to 15,000–Less than 20,000 | 60.3 | 55.9 | 82.9 | 95.0 | 98.7 | 98.8 |
| Africa | Central America West | Greater or equal to 20,000–Less than 25,000 | 39.7 | 44.1 | 17.1 | 5.0 | - | - |
| Africa | Central America West | Greater or equal to 40,000–Less than 50,000 | - | - | - | - | 1.3 | 1.2 |
| Africa | South America West | Greater or equal to 25,000–Less than 30,000 | 62.7 | 49.6 | - | - | - | - |
| Africa | South America West | Greater or equal to 30,000–Less than 40,000 | 37.3 | 50.4 | 87.4 | 85.0 | 79.8 | 69.0 |
| Africa | South America West | Greater or equal to 40,000–Less than 50,000 | - | - | 12.6 | 15.0 | 20.2 | 31.0 |
| Middle East | South America West | Greater or equal to 25,000–Less than 30,000 | 100.0 | 100.0 | - | - | - | - |
| Middle East | South America West | Greater or equal to 40,000–Less than 50,000 | - | - | 100.0 | 100.0 | 100.0 | 100.0 |
| North America West | North America East | Greater or equal to 30,000–Less than 40,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| North America West | North America Gulf | Greater or equal to 25,000–Less than 30,000 | 23.0 | 22.5 | 22.1 | 21.7 | 21.4 | 21.0 |
| North America West | North America Gulf | Greater or equal to 30,000–Less than 40,000 | 6.0 | 5.9 | 5.9 | 5.8 | 5.7 | 5.4 |
| North America West | North America Gulf | Greater or equal to 40,000–Less than 50,000 | 71.0 | 71.5 | 72.0 | 72.5 | 72.9 | 73.5 |
| North America West | Central America East | Greater or equal to 20,000–Less than 25,000 | 12.0 | 12.3 | 12.5 | 12.7 | 12.9 | 13.0 |
| North America West | Central America East | Greater or equal to 25,000–Less than 30,000 | 33.0 | 32.7 | 32.3 | 32.0 | 32.0 | 32.3 |
| North America West | Central America East | Greater or equal to 30,000–Less than 40,000 | 44.0 | 43.9 | 43.9 | 43.7 | 43.4 | 42.5 |
| North America West | Central America East | Greater or equal to 40,000–Less than 50,000 | 11.0 | 11.2 | 11.4 | 11.5 | 11.8 | 12.2 |
| North America West | South America East | Greater than 10,000–Less than 15,000 | 16.0 | 16.4 | 16.7 | 17.1 | 17.6 | 18.5 |
| North America West | South America East | Greater or equal to 15,000–Less than 20,000 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| North America West | South America East | Greater or equal to 20,000–Less than 25,000 | 7.4 | 7.5 | 7.6 | 7.7 | 7.7 | 7.7 |
| North America West | South America East | Greater or equal to 25,000–Less than 30,000 | 19.0 | 18.7 | 18.3 | 18.0 | 17.8 | 17.8 |
| North America West | South America East | Greater or equal to 30,000–Less than 40,000 | 43.7 | 43.2 | 42.8 | 42.4 | 41.7 | 40.3 |
| North America West | South America East | Greater or equal to 40,000–Less than 50,000 | 9.7 | 9.8 | 9.8 | 9.9 | 10.0 | 10.3 |
| North America West | South America East | Greater or equal to 50,000–Less than 60,000 | 3.8 | - | - | - | - | - |

## Table B-1. Cargo Allocation by Route and DWT Size Range, Existing Canal Most Probable Case, No Tolls, Selected Years 2001-2025 (percent)

| Origin | Destination | DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|
| North America West | South America East | Greater or equal to 70,000–Less than 80,000 | - | 4.1 | 4.3 | 4.5 | 4.7 | 5.0 |
| North America West | Caribbean | Greater or equal to 20,000–Less than 25,000 | 24.2 | 24.7 | 25.3 | 25.7 | 26.0 | 26.1 |
| North America West | Caribbean | Greater or equal to 25,000–Less than 30,000 | 48.5 | 48.0 | 47.5 | 47.1 | 47.1 | 47.5 |
| North America West | Caribbean | Greater or equal to 30,000–Less than 40,000 | 27.3 | 27.2 | 27.2 | 27.2 | 26.9 | 26.4 |
| North America West | Europe | Greater or equal to 15,000–Less than 20,000 | 8.0 | 8.1 | 8.2 | 8.2 | 8.3 | 8.3 |
| North America West | Europe | Greater or equal to 20,000–Less than 25,000 | 7.0 | 7.1 | 7.1 | 7.1 | 7.0 | 6.9 |
| North America West | Europe | Greater or equal to 25,000–Less than 30,000 | 21.3 | 20.7 | 20.1 | 19.6 | 19.2 | 18.8 |
| North America West | Europe | Greater or equal to 30,000–Less than 40,000 | 10.5 | 10.3 | 10.1 | 9.9 | 9.6 | 9.1 |
| North America West | Europe | Greater or equal to 40,000–Less than 50,000 | 37.2 | 37.1 | 37.1 | 37.0 | 37.1 | 37.2 |
| North America West | Europe | Greater or equal to 60,000–Less than 70,000 | 7.7 | - | - | - | - | - |
| North America West | Europe | Greater or equal to 70,000–Less than 80,000 | 8.2 | 16.8 | 17.5 | 18.2 | 18.8 | 19.6 |
| North America West | Africa | Greater or equal to 15,000–Less than 20,000 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| North America West | Africa | Greater or equal to 20,000–Less than 25,000 | 1.3 | 1.3 | 1.3 | 1.2 | 1.2 | 1.1 |
| North America West | Africa | Greater or equal to 25,000–Less than 30,000 | 2.4 | 2.2 | 2.1 | 2.0 | 1.9 | 1.9 |
| North America West | Africa | Greater or equal to 30,000–Less than 40,000 | 18.0 | 17.3 | 16.5 | 15.9 | 15.1 | 14.0 |
| North America West | Africa | Greater or equal to 40,000–Less than 50,000 | 10.6 | 10.3 | 10.1 | 9.8 | 9.6 | 9.5 |
| North America West | Africa | Greater or equal to 50,000–Less than 60,000 | 1.1 | - | - | - | - | - |
| North America West | Africa | Greater or equal to 60,000–Less than 70,000 | 36.9 | - | - | - | - | - |
| North America West | Africa | Greater or equal to 70,000–Less than 80,000 | 29.4 | 68.4 | 69.6 | 70.6 | 71.7 | 73.1 |
| North America West | Middle East | Greater or equal to 25,000–Less than 30,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Central America West | Central America East | Greater or equal to 20,000–Less than 25,000 | 7.0 | 7.1 | 7.3 | 7.4 | 7.5 | 7.5 |
| Central America West | Central America East | Greater or equal to 25,000–Less than 30,000 | 17.1 | 16.9 | 16.6 | 16.5 | 16.4 | 16.6 |
| Central America West | Central America East | Greater or equal to 30,000–Less than 40,000 | 53.1 | 52.8 | 52.7 | 52.4 | 51.9 | 50.9 |
| Central America West | Central America East | Greater or equal to 40,000–Less than 50,000 | 22.8 | 23.1 | 23.4 | 23.7 | 24.2 | 25.1 |
| Central America West | South America East | Greater than 10,000–Less than 15,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Central America West | Europe | Greater than 10,000–Less than 15,000 | 3.1 | 3.2 | 3.3 | 3.4 | 3.6 | 3.8 |
| Central America West | Europe | Greater or equal to 15,000–Less than 20,000 | 3.9 | 4.0 | 4.1 | 4.2 | 4.4 | 4.5 |
| Central America West | Europe | Greater or equal to 20,000–Less than 25,000 | 6.2 | 6.4 | 6.5 | 6.6 | 6.7 | 6.8 |
| Central America West | Europe | Greater or equal to 25,000–Less than 30,000 | 45.8 | 45.4 | 45.0 | 44.7 | 44.7 | 45.2 |
| Central America West | Europe | Greater or equal to 30,000–Less than 40,000 | 41.0 | 40.9 | 41.0 | 41.0 | 40.6 | 39.8 |
| Central America West | Africa | Greater or equal to 20,000–Less than 25,000 | 4.9 | 5.0 | 5.1 | 5.2 | 5.3 | 5.2 |
| Central America West | Africa | Greater or equal to 25,000–Less than 30,000 | 53.2 | 52.7 | 52.1 | 51.7 | 51.5 | 51.5 |
| Central America West | Africa | Greater or equal to 30,000–Less than 40,000 | 18.7 | 18.7 | 18.7 | 18.7 | 18.4 | 17.9 |
| Central America West | Africa | Greater or equal to 40,000–Less than 50,000 | 23.2 | 23.6 | 24.0 | 24.4 | 24.8 | 25.4 |
| Central America West | Middle East | Greater or equal to 20,000–Less than 25,000 | 4.9 | 5.0 | 5.1 | 5.2 | 5.3 | 5.2 |
| Central America West | Middle East | Greater or equal to 25,000–Less than 30,000 | 53.2 | 52.7 | 52.1 | 51.7 | 51.5 | 51.5 |
| Central America West | Middle East | Greater or equal to 30,000–Less than 40,000 | 18.7 | 18.7 | 18.7 | 18.7 | 18.4 | 17.9 |
| Central America West | Middle East | Greater or equal to 40,000–Less than 50,000 | 23.2 | 23.6 | 24.0 | 24.4 | 24.8 | 25.4 |
| South America West | North America East | Greater or equal to 20,000–Less than 25,000 | 26.1 | 26.7 | 27.4 | 27.9 | 28.1 | 28.0 |
| South America West | North America East | Greater or equal to 25,000–Less than 30,000 | 73.9 | 73.3 | 72.6 | 72.1 | 71.9 | 72.0 |
| South America West | North America Gulf | Greater or equal to 20,000–Less than 25,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

## Table B-1. Cargo Allocation by Route and DWT Size Range, Existing Canal Most Probable Case, No Tolls, Selected Years 2001-2025 (percent)

| Origin | Destination | DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|
| South America West | Central America East | Greater or equal to 20,000–Less than 25,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| South America West | South America East | Greater than 10,000–Less than 15,000 | 35.2 | 35.8 | 36.3 | 36.8 | 37.5 | 38.5 |
| South America West | South America East | Greater or equal to 15,000–Less than 20,000 | 18.5 | 18.7 | 18.9 | 19.0 | 19.1 | 19.1 |
| South America West | South America East | Greater or equal to 20,000–Less than 25,000 | 16.8 | 16.9 | 17.0 | 17.0 | 16.9 | 16.4 |
| South America West | South America East | Greater or equal to 25,000–Less than 30,000 | 29.4 | 28.6 | 27.8 | 27.2 | 26.6 | 26.0 |
| South America West | Caribbean | Greater or equal to 20,000–Less than 25,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| South America West | Europe | Less or equal to 10,000 | 100.0 | - | - | - | - | - |
| South America West | Europe | Greater or equal to 30,000–Less than 40,000 | - | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| South America West | Africa | Less or equal to 10,000 | 100.0 | - | - | - | - | - |
| South America West | Africa | Greater or equal to 30,000–Less than 40,000 | - | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Oceania | Central America East | Greater or equal to 20,000–Less than 25,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Oceania | South America East | Greater or equal to 15,000–Less than 20,000 | 3.4 | 3.5 | 3.5 | 3.6 | 3.7 | 3.8 |
| Oceania | South America East | Greater or equal to 20,000–Less than 25,000 | 33.2 | 33.7 | 34.3 | 34.7 | 35.1 | 35.4 |
| Oceania | South America East | Greater or equal to 25,000–Less than 30,000 | 19.2 | 18.9 | 18.6 | 18.4 | 18.3 | 18.6 |
| Oceania | South America East | Greater or equal to 30,000–Less than 40,000 | 44.2 | 43.9 | 43.6 | 43.3 | 42.9 | 42.2 |
| Oceania | Caribbean | Greater or equal to 15,000–Less than 20,000 | 41.0 | 41.9 | 42.8 | 43.5 | 44.2 | 44.8 |
| Oceania | Caribbean | Greater or equal to 25,000–Less than 30,000 | 59.0 | 58.1 | 57.2 | 56.5 | 55.8 | 55.2 |
| Oceania | Europe | Greater or equal to 25,000–Less than 30,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Far East | North America Gulf | Greater or equal to 15,000–Less than 20,000 | 23.0 | 23.5 | 24.0 | 24.4 | 25.1 | 26.1 |
| Far East | North America Gulf | Greater or equal to 30,000–Less than 40,000 | 77.0 | 76.5 | 76.0 | 75.6 | 74.9 | 73.9 |
| Far East | Central America East | Greater or equal to 50,000–Less than 60,000 | 100.0 | - | - | - | - | - |
| Far East | Central America East | Greater or equal to 70,000–Less than 80,000 | - | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Far East | South America East | Greater or equal to 30,000–Less than 40,000 | 69.8 | 68.2 | 66.9 | 65.7 | 64.2 | 62.0 |
| Far East | South America East | Greater or equal to 50,000–Less than 60,000 | 30.2 | - | - | - | - | - |
| Far East | South America East | Greater or equal to 70,000–Less than 80,000 | - | 31.8 | 33.1 | 34.3 | 35.8 | 38.0 |
| Far East | Caribbean | Greater or equal to 15,000–Less than 20,000 | 33.6 | 34.0 | 34.4 | 34.7 | 35.2 | 36.0 |
| Far East | Caribbean | Greater or equal to 20,000–Less than 25,000 | 34.8 | 35.0 | 35.3 | 35.4 | 35.5 | 35.2 |
| Far East | Caribbean | Greater or equal to 25,000–Less than 30,000 | 17.3 | 16.9 | 16.4 | 16.1 | 15.9 | 15.9 |
| Far East | Caribbean | Greater or equal to 30,000–Less than 40,000 | 14.4 | 14.1 | 13.9 | 13.7 | 13.5 | 13.0 |
| Far East | Europe | Greater or equal to 15,000–Less than 20,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| South East Asia | North America Gulf | Greater or equal to 20,000–Less than 25,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| South East Asia | Central America East | Greater or equal to 30,000–Less than 40,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| South East Asia | South America East | Greater or equal to 15,000–Less than 20,000 | 70.5 | 70.6 | 70.6 | 70.8 | 71.0 | 71.6 |
| South East Asia | South America East | Greater or equal to 20,000–Less than 25,000 | 29.5 | 29.4 | 29.4 | 29.2 | 29.0 | 28.4 |
| South East Asia | Caribbean | Greater or equal to 25,000–Less than 30,000 | 68.9 | 68.7 | 68.5 | 68.4 | 68.5 | 69.2 |
| South East Asia | Caribbean | Greater or equal to 30,000–Less than 40,000 | 31.1 | 31.3 | 31.5 | 31.6 | 31.5 | 30.8 |

Source: Richardson Lawrie Associates

## Table B-2. Cargo Allocation by Route and DWT Size Range, Expanded Canal Most Probable Case, No Tolls, Selected Years 2001-2025 (percent)

| Origin | Destination | DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|
| North America East | Central America West | Greater than 10,000–Less than 15,000 | 6.3 | 6.2 | 17.1 | 20.8 | 25.2 | 29.2 |
| North America East | Central America West | Greater or equal to 20,000–Less than 25,000 | 16.2 | 16.2 | 9.7 | 0.7 | - | - |
| North America East | Central America West | Greater or equal to 25,000–Less than 30,000 | 36.8 | 26.2 | - | - | - | - |
| North America East | Central America West | Greater or equal to 30,000–Less than 40,000 | 14.4 | 17.5 | 17.3 | 14.9 | 9.0 | 3.5 |
| North America East | Central America West | Greater or equal to 40,000–Less than 50,000 | 26.3 | 33.9 | 56.0 | 63.6 | 65.8 | 67.3 |
| North America East | South America West | Greater than 10,000–Less than 15,000 | 6.7 | 6.4 | 16.9 | 21.9 | 28.6 | 36.0 |
| North America East | South America West | Greater or equal to 15,000–Less than 20,000 | 4.7 | 3.8 | 10.3 | 12.6 | 16.3 | 20.4 |
| North America East | South America West | Greater or equal to 20,000–Less than 25,000 | 16.9 | 16.2 | 9.2 | 0.7 | - | - |
| North America East | South America West | Greater or equal to 25,000–Less than 30,000 | 23.1 | 15.8 | - | - | - | - |
| North America East | South America West | Greater or equal to 30,000–Less than 40,000 | 38.1 | 44.7 | 42.0 | 38.7 | 25.3 | 10.6 |
| North America East | South America West | Greater or equal to 40,000–Less than 50,000 | 10.6 | 13.1 | 21.6 | 26.1 | 29.7 | 32.9 |
| North America East | Oceania | Greater or equal to 30,000–Less than 40,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| North America East | South East Asia | Greater or equal to 15,000–Less than 20,000 | 2.8 | 1.8 | 3.6 | 3.7 | 4.6 | 5.3 |
| North America East | South East Asia | Greater or equal to 30,000–Less than 40,000 | 19.6 | 19.0 | 12.9 | 10.1 | 6.2 | 2.4 |
| North America East | South East Asia | Greater or equal to 40,000–Less than 50,000 | 77.6 | 79.2 | 83.5 | 86.2 | 89.3 | 92.3 |
| North America East | China | Greater or equal to 40,000–Less than 50,000 | 14.1 | 14.1 | 13.3 | 13.0 | 12.6 | 12.3 |
| North America East | China | Greater or equal to 60,000–Less than 70,000 | 56.4 | 50.8 | 46.1 | 42.1 | 38.8 | 35.8 |
| North America East | China | Greater or equal to 70,000–Less than 80,000 | 29.5 | 35.1 | 40.6 | 44.9 | 48.6 | 51.9 |
| North America East | Taiwan | Greater or equal to 25,000–Less than 30,000 | 1.8 | 0.9 | - | - | - | - |
| North America East | Taiwan | Greater or equal to 40,000–Less than 50,000 | - | - | 0.1 | 0.1 | 0.1 | 0.1 |
| North America East | Taiwan | Greater or equal to 60,000–Less than 70,000 | 14.0 | 11.1 | 9.0 | 7.5 | 6.5 | 5.7 |
| North America East | Taiwan | Greater or equal to 70,000–Less than 80,000 | 84.2 | 88.0 | 90.9 | 92.4 | 93.5 | 94.3 |
| North America East | Japan | Greater or equal to 25,000–Less than 30,000 | 28.7 | 17.8 | - | - | - | - |
| North America East | Japan | Greater or equal to 30,000–Less than 40,000 | 22.9 | 24.3 | 19.1 | 14.4 | 8.6 | 3.3 |
| North America East | Japan | Greater or equal to 40,000–Less than 50,000 | 13.8 | 15.5 | 21.1 | 21.0 | 21.1 | 21.2 |
| North America East | Japan | Greater or equal to 60,000–Less than 70,000 | 11.3 | 11.4 | 13.4 | 12.5 | 11.9 | 11.3 |
| North America East | Japan | Greater or equal to 70,000–Less than 80,000 | 23.2 | 30.9 | 46.4 | 52.1 | 58.5 | 64.2 |
| North America East | South Korea | Greater or equal to 40,000–Less than 50,000 | 16.3 | 15.7 | 12.8 | 12.1 | 11.4 | 10.8 |
| North America East | South Korea | Greater or equal to 60,000–Less than 70,000 | 40.2 | 34.8 | 27.4 | 24.1 | 21.5 | 19.4 |
| North America East | South Korea | Greater or equal to 70,000–Less than 80,000 | 43.5 | 49.5 | 49.8 | 53.1 | 55.7 | 57.9 |
| North America East | South Korea | Greater or equal to 80,000–Less than 90,000 | - | - | 5.0 | 5.4 | 5.7 | 5.9 |
| North America East | South Korea | Greater or equal to 90,000–Less than 100,000 | - | - | 5.0 | 5.4 | 5.7 | 5.9 |
| North America East | Other Far East | Greater or equal to 25,000–Less than 30,000 | 28.7 | 17.8 | - | - | - | - |
| North America East | Other Far East | Greater or equal to 30,000–Less than 40,000 | 22.9 | 24.3 | 19.1 | 14.4 | 8.6 | 3.3 |
| North America East | Other Far East | Greater or equal to 40,000–Less than 50,000 | 13.8 | 15.5 | 21.1 | 21.0 | 21.1 | 21.2 |
| North America East | Other Far East | Greater or equal to 60,000–Less than 70,000 | 11.3 | 11.4 | 13.4 | 12.5 | 11.9 | 11.3 |
| North America East | Other Far East | Greater or equal to 70,000–Less than 80,000 | 23.2 | 30.9 | 46.4 | 52.1 | 58.5 | 64.2 |
| North America Gulf | North America West | Greater or equal to 70,000–Less than 80,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| North America Gulf | Central America West | Greater than 10,000–Less than 15,000 | 2.3 | 2.3 | 6.9 | 9.0 | 12.5 | 16.7 |
| North America Gulf | Central America West | Greater or equal to 15,000–Less than 20,000 | 3.5 | 2.9 | 9.0 | 11.1 | 15.3 | 20.4 |
| North America Gulf | Central America West | Greater or equal to 20,000–Less than 25,000 | 12.6 | 12.4 | 8.1 | 0.6 | - | - |
| North America Gulf | Central America West | Greater or equal to 25,000–Less than 30,000 | 33.3 | 23.4 | - | - | - | - |
| North America Gulf | Central America West | Greater or equal to 30,000–Less than 40,000 | 38.3 | 46.0 | 49.5 | 45.9 | 31.7 | 14.2 |
| North America Gulf | Central America West | Greater or equal to 40,000–Less than 50,000 | 8.3 | 10.5 | 21.4 | 26.1 | 31.3 | 37.0 |

## Table B-2. Cargo Allocation by Route and DWT Size Range, Expanded Canal Most Probable Case, No Tolls, Selected Years 2001-2025 (percent)

| Origin | Destination | DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|
| North America Gulf | Central America West | Greater or equal to 50,000–Less than 60,000 | 1.1 | 1.9 | 4.1 | 5.9 | 7.9 | 10.3 |
| North America Gulf | Central America West | Greater or equal to 60,000–Less than 70,000 | 0.6 | 0.7 | 1.1 | 1.2 | 1.4 | 1.5 |
| North America Gulf | South America West | Greater than 10,000–Less than 15,000 | 3.0 | 2.9 | 7.8 | 9.4 | 12.0 | 14.6 |
| North America Gulf | South America West | Greater or equal to 15,000–Less than 20,000 | 3.0 | 2.4 | 6.8 | 7.8 | 9.8 | 11.9 |
| North America Gulf | South America West | Greater or equal to 20,000–Less than 25,000 | 12.0 | 11.6 | 6.8 | 0.5 | - | - |
| North America Gulf | South America West | Greater or equal to 25,000–Less than 30,000 | 32.0 | 22.1 | - | - | - | - |
| North America Gulf | South America West | Greater or equal to 30,000–Less than 40,000 | 26.0 | 30.7 | 29.5 | 25.6 | 16.2 | 6.6 |
| North America Gulf | South America West | Greater or equal to 40,000–Less than 50,000 | 22.0 | 27.4 | 44.3 | 50.4 | 54.7 | 58.6 |
| North America Gulf | South America West | Greater or equal to 50,000–Less than 60,000 | 1.0 | 1.8 | 3.3 | 4.5 | 5.5 | 6.6 |
| North America Gulf | South America West | Greater or equal to 60,000–Less than 70,000 | 1.0 | 1.1 | 1.6 | 1.7 | 1.8 | 1.8 |
| North America Gulf | Oceania | Greater or equal to 15,000–Less than 20,000 | 4.2 | 2.9 | 6.0 | 6.3 | 7.6 | 8.8 |
| North America Gulf | Oceania | Greater or equal to 25,000–Less than 30,000 | 10.2 | 6.1 | - | - | - | - |
| North America Gulf | Oceania | Greater or equal to 30,000–Less than 40,000 | 17.0 | 17.3 | 12.2 | 9.6 | 5.8 | 2.3 |
| North America Gulf | Oceania | Greater or equal to 40,000–Less than 50,000 | 68.6 | 73.7 | 81.7 | 84.1 | 86.6 | 88.9 |
| North America Gulf | South East Asia | Greater or equal to 25,000–Less than 30,000 | 2.0 | 1.1 | - | - | - | - |
| North America Gulf | South East Asia | Greater or equal to 30,000–Less than 40,000 | 10.0 | 9.3 | 5.1 | 3.7 | 2.1 | 0.8 |
| North America Gulf | South East Asia | Greater or equal to 40,000–Less than 50,000 | 35.0 | 34.3 | 32.3 | 31.1 | 30.1 | 29.2 |
| North America Gulf | South East Asia | Greater or equal to 50,000–Less than 60,000 | 2.0 | 2.8 | 3.0 | 3.4 | 3.7 | 4.0 |
| North America Gulf | South East Asia | Greater or equal to 60,000–Less than 70,000 | 24.0 | 21.2 | 17.3 | 15.5 | 14.2 | 13.1 |
| North America Gulf | South East Asia | Greater or equal to 70,000–Less than 80,000 | 27.0 | 31.4 | 32.7 | 35.6 | 38.3 | 40.7 |
| North America Gulf | South East Asia | Greater or equal to 80,000–Less than 90,000 | - | - | 4.8 | 5.3 | 5.8 | 6.1 |
| North America Gulf | South East Asia | Greater or equal to 90,000–Less than 100,000 | - | - | 4.8 | 5.3 | 5.7 | 6.1 |
| North America Gulf | China | Greater or equal to 25,000–Less than 30,000 | 1.2 | 0.7 | - | - | - | - |
| North America Gulf | China | Greater or equal to 30,000–Less than 40,000 | 1.5 | 1.4 | 0.8 | 0.6 | 0.3 | 0.1 |
| North America Gulf | China | Greater or equal to 40,000–Less than 50,000 | 4.7 | 4.7 | 4.5 | 4.3 | 4.2 | 4.0 |
| North America Gulf | China | Greater or equal to 50,000–Less than 60,000 | 5.0 | 7.0 | 7.5 | 8.6 | 9.4 | 10.1 |
| North America Gulf | China | Greater or equal to 60,000–Less than 70,000 | 61.9 | 55.7 | 45.5 | 40.9 | 37.2 | 34.1 |
| North America Gulf | China | Greater or equal to 70,000–Less than 80,000 | 25.7 | 30.5 | 31.8 | 34.6 | 37.1 | 39.2 |
| North America Gulf | China | Greater or equal to 80,000–Less than 90,000 | - | - | 5.0 | 5.5 | 5.9 | 6.3 |
| North America Gulf | China | Greater or equal to 90,000–Less than 100,000 | - | - | 5.0 | 5.5 | 5.9 | 6.3 |
| North America Gulf | Taiwan | Greater or equal to 30,000–Less than 40,000 | 1.7 | 1.6 | 0.8 | 0.6 | 0.3 | 0.1 |
| North America Gulf | Taiwan | Greater or equal to 40,000–Less than 50,000 | 2.0 | 1.9 | 1.6 | 1.5 | 1.4 | 1.4 |
| North America Gulf | Taiwan | Greater or equal to 50,000–Less than 60,000 | 0.3 | 0.5 | 0.5 | 0.5 | 0.6 | 0.6 |
| North America Gulf | Taiwan | Greater or equal to 60,000–Less than 70,000 | 53.3 | 46.7 | 37.1 | 32.9 | 29.5 | 26.7 |
| North America Gulf | Taiwan | Greater or equal to 70,000–Less than 80,000 | 42.7 | 49.3 | 50.0 | 53.6 | 56.6 | 59.1 |
| North America Gulf | Taiwan | Greater or equal to 80,000–Less than 90,000 | - | - | 5.0 | 5.4 | 5.8 | 6.0 |
| North America Gulf | Taiwan | Greater or equal to 90,000–Less than 100,000 | - | - | 5.0 | 5.4 | 5.7 | 6.0 |
| North America Gulf | Japan | Greater or equal to 15,000–Less than 20,000 | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 |
| North America Gulf | Japan | Greater or equal to 20,000–Less than 25,000 | 0.1 | 0.1 | 0.0 | 0.0 | - | - |
| North America Gulf | Japan | Greater or equal to 25,000–Less than 30,000 | 2.7 | 1.5 | - | - | - | - |
| North America Gulf | Japan | Greater or equal to 30,000–Less than 40,000 | 0.8 | 0.8 | 0.4 | 0.3 | 0.2 | 0.1 |
| North America Gulf | Japan | Greater or equal to 40,000–Less than 50,000 | 23.7 | 23.4 | 21.7 | 20.7 | 19.7 | 18.9 |
| North America Gulf | Japan | Greater or equal to 50,000–Less than 60,000 | 2.6 | 3.6 | 3.8 | 4.3 | 4.7 | 5.0 |
| North America Gulf | Japan | Greater or equal to 60,000–Less than 70,000 | 39.5 | 35.1 | 28.0 | 24.9 | 22.5 | 20.4 |

## Table B-2. Cargo Allocation by Route and DWT Size Range, Expanded Canal Most Probable Case, No Tolls, Selected Years 2001-2025 (percent)

| Origin | Destination | DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|
| North America Gulf | Japan | Greater or equal to 70,000–Less than 80,000 | 30.4 | 35.5 | 36.2 | 39.1 | 41.5 | 43.5 |
| North America Gulf | Japan | Greater or equal to 80,000–Less than 90,000 | - | - | 9.8 | 10.6 | 11.4 | 12.0 |
| North America Gulf | South Korea | Greater or equal to 20,000–Less than 25,000 | 0.5 | 0.4 | 0.1 | 0.0 | - | - |
| North America Gulf | South Korea | Greater or equal to 25,000–Less than 30,000 | 1.0 | 0.6 | - | - | - | - |
| North America Gulf | South Korea | Greater or equal to 30,000–Less than 40,000 | 1.4 | 1.4 | 0.8 | 0.6 | 0.3 | 0.1 |
| North America Gulf | South Korea | Greater or equal to 40,000–Less than 50,000 | 16.1 | 16.7 | 16.3 | 16.2 | 16.0 | 15.8 |
| North America Gulf | South Korea | Greater or equal to 50,000–Less than 60,000 | 2.2 | 3.2 | 3.5 | 4.2 | 4.7 | 5.1 |
| North America Gulf | South Korea | Greater or equal to 60,000–Less than 70,000 | 65.6 | 61.4 | 51.8 | 48.1 | 44.9 | 42.1 |
| North America Gulf | South Korea | Greater or equal to 70,000–Less than 80,000 | 13.2 | 16.3 | 17.6 | 19.8 | 21.7 | 23.5 |
| North America Gulf | South Korea | Greater or equal to 80,000–Less than 90,000 | - | - | 4.9 | 5.6 | 6.2 | 6.7 |
| North America Gulf | South Korea | Greater or equal to 90,000–Less than 100,000 | - | - | 4.9 | 5.6 | 6.2 | 6.7 |
| North America Gulf | Other Far East | Greater or equal to 20,000–Less than 25,000 | 21.3 | 17.7 | 8.2 | 0.6 | - | - |
| North America Gulf | Other Far East | Greater or equal to 25,000–Less than 30,000 | 13.9 | 8.3 | - | - | - | - |
| North America Gulf | Other Far East | Greater or equal to 30,000–Less than 40,000 | 15.4 | 15.7 | 12.0 | 9.5 | 5.4 | 2.0 |
| North America Gulf | Other Far East | Greater or equal to 40,000–Less than 50,000 | 22.7 | 24.4 | 30.0 | 31.3 | 31.0 | 30.2 |
| North America Gulf | Other Far East | Greater or equal to 70,000–Less than 80,000 | 26.6 | 34.0 | 49.7 | 58.6 | 63.6 | 67.8 |
| Central America East | South America West | Greater or equal to 20,000–Less than 25,000 | 83.5 | 80.5 | 71.4 | 17.5 | - | - |
| Central America East | South America West | Greater or equal to 30,000–Less than 40,000 | 16.5 | 19.5 | 28.6 | 82.5 | 73.5 | 51.3 |
| Central America East | South America West | Greater or equal to 40,000–Less than 50,000 | - | - | - | - | 26.5 | 48.7 |
| Brazil | South America West | Less or equal to 10,000 | 23.9 | - | - | - | - | - |
| Brazil | South America West | Greater or equal to 20,000–Less than 25,000 | 3.3 | 2.2 | 0.8 | 0.0 | - | - |
| Brazil | South America West | Greater or equal to 25,000–Less than 30,000 | 9.3 | 4.5 | - | - | - | - |
| Brazil | South America West | Greater or equal to 30,000–Less than 40,000 | 11.8 | 9.7 | 5.8 | 3.9 | 2.1 | 0.7 |
| Brazil | South America West | Greater or equal to 40,000–Less than 50,000 | - | 20.7 | 19.5 | 17.4 | 16.0 | 14.8 |
| Brazil | South America West | Greater or equal to 50,000–Less than 60,000 | 51.7 | 63.0 | 73.9 | 78.6 | 81.9 | 84.4 |
| Brazil | China | Greater or equal to 40,000–Less than 50,000 | 40.0 | 37.8 | 35.0 | 33.2 | 31.7 | 30.4 |
| Brazil | China | Greater or equal to 50,000–Less than 60,000 | 17.2 | 22.9 | 26.9 | 30.5 | 33.1 | 35.3 |
| Brazil | China | Greater or equal to 60,000–Less than 70,000 | 32.1 | 27.3 | 24.4 | 21.6 | 19.6 | 17.8 |
| Brazil | China | Greater or equal to 70,000–Less than 80,000 | 10.7 | 12.0 | 13.7 | 14.7 | 15.6 | 16.4 |
| Brazil | Taiwan | Greater or equal to 40,000–Less than 50,000 | 40.0 | 37.8 | 35.0 | 33.2 | 31.7 | 30.4 |
| Brazil | Taiwan | Greater or equal to 50,000–Less than 60,000 | 17.2 | 22.9 | 26.9 | 30.5 | 33.1 | 35.3 |
| Brazil | Taiwan | Greater or equal to 60,000–Less than 70,000 | 32.1 | 27.3 | 24.4 | 21.6 | 19.6 | 17.8 |
| Brazil | Taiwan | Greater or equal to 70,000–Less than 80,000 | 10.7 | 12.0 | 13.7 | 14.7 | 15.6 | 16.4 |
| Brazil | Japan | Greater or equal to 40,000–Less than 50,000 | 40.0 | 37.8 | 35.0 | 33.2 | 31.7 | 30.4 |
| Brazil | Japan | Greater or equal to 50,000–Less than 60,000 | 17.2 | 22.9 | 26.9 | 30.5 | 33.1 | 35.3 |
| Brazil | Japan | Greater or equal to 60,000–Less than 70,000 | 32.1 | 27.3 | 24.4 | 21.6 | 19.6 | 17.8 |
| Brazil | Japan | Greater or equal to 70,000–Less than 80,000 | 10.7 | 12.0 | 13.7 | 14.7 | 15.6 | 16.4 |
| Brazil | South Korea | Greater or equal to 40,000–Less than 50,000 | 40.0 | 37.8 | 35.0 | 33.2 | 31.7 | 30.4 |
| Brazil | South Korea | Greater or equal to 50,000–Less than 60,000 | 17.2 | 22.9 | 26.9 | 30.5 | 33.1 | 35.3 |
| Brazil | South Korea | Greater or equal to 60,000–Less than 70,000 | 32.1 | 27.3 | 24.4 | 21.6 | 19.6 | 17.8 |
| Brazil | South Korea | Greater or equal to 70,000–Less than 80,000 | 10.7 | 12.0 | 13.7 | 14.7 | 15.6 | 16.4 |
| South America East | Central America West | Less or equal to 10,000 | 62.7 | - | - | - | - | - |
| South America East | Central America West | Greater or equal to 30,000–Less than 40,000 | 37.3 | 36.0 | 26.6 | 21.6 | 14.0 | 5.8 |
| South America East | Central America West | Greater or equal to 40,000–Less than 50,000 | - | 64.0 | 73.4 | 78.4 | 86.0 | 94.2 |

## Table B-2. Cargo Allocation by Route and DWT Size Range, Expanded Canal Most Probable Case, No Tolls, Selected Years 2001-2025 (percent)

| Origin | Destination | DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|
| South America East | South America West | Less or equal to 10,000 | 23.9 | - | - | - | - | - |
| South America East | South America West | Greater or equal to 20,000–Less than 25,000 | 3.3 | 2.9 | 1.3 | 0.1 | - | - |
| South America East | South America West | Greater or equal to 25,000–Less than 30,000 | 9.3 | 5.8 | - | - | - | - |
| South America East | South America West | Greater or equal to 30,000–Less than 40,000 | 11.8 | 12.5 | 9.3 | 7.6 | 4.8 | 1.9 |
| South America East | South America West | Greater or equal to 40,000–Less than 50,000 | - | 26.7 | 31.5 | 34.0 | 36.3 | 38.7 |
| South America East | South America West | Greater or equal to 60,000–Less than 70,000 | 51.7 | 52.1 | 57.9 | 58.3 | 58.9 | 59.4 |
| Caribbean | Central America West | Greater or equal to 25,000–Less than 30,000 | 100.0 | 100.0 | - | - | - | - |
| Caribbean | Central America West | Greater or equal to 40,000–Less than 50,000 | - | - | 100.0 | 100.0 | 100.0 | 100.0 |
| Caribbean | Far East | Greater or equal to 40,000–Less than 50,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Europe | North America West | Greater or equal to 40,000–Less than 50,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Europe | Central America West | Greater or equal to 30,000–Less than 40,000 | 88.0 | 87.4 | 81.7 | 77.3 | 66.7 | 43.2 |
| Europe | Central America West | Greater or equal to 40,000–Less than 50,000 | 12.0 | 12.6 | 18.3 | 22.7 | 33.3 | 56.8 |
| Europe | South America West | Less or equal to 10,000 | 2.0 | - | - | - | - | - |
| Europe | South America West | Greater or equal to 15,000–Less than 20,000 | 6.0 | 4.7 | 12.9 | 15.2 | 20.7 | 27.3 |
| Europe | South America West | Greater or equal to 20,000–Less than 25,000 | 7.0 | 6.5 | 3.8 | 0.3 | - | - |
| Europe | South America West | Greater or equal to 25,000–Less than 30,000 | 25.0 | 16.7 | - | - | - | - |
| Europe | South America West | Greater or equal to 30,000–Less than 40,000 | 42.0 | 48.0 | 45.4 | 40.3 | 27.6 | 12.2 |
| Europe | South America West | Greater or equal to 40,000–Less than 50,000 | 18.0 | 24.1 | 37.9 | 44.2 | 51.7 | 60.4 |
| Europe | Oceania | Greater or equal to 30,000–Less than 40,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Europe | Far East | Greater or equal to 40,000–Less than 50,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Africa | Central America West | Greater or equal to 15,000–Less than 20,000 | 60.3 | 55.9 | 85.9 | 99.0 | 99.1 | 99.2 |
| Africa | Central America West | Greater or equal to 20,000–Less than 25,000 | 39.7 | 44.1 | 14.1 | 1.0 | - | - |
| Africa | Central America West | Greater or equal to 40,000–Less than 50,000 | - | - | - | - | 0.9 | 0.8 |
| Africa | South America West | Greater or equal to 25,000–Less than 30,000 | 62.7 | 49.6 | - | - | - | - |
| Africa | South America West | Greater or equal to 30,000–Less than 40,000 | 37.3 | 50.4 | 86.7 | 83.2 | 74.4 | 52.5 |
| Africa | South America West | Greater or equal to 40,000–Less than 50,000 | - | - | 13.3 | 16.8 | 25.6 | 47.5 |
| Middle East | South America West | Greater or equal to 25,000–Less than 30,000 | 100.0 | 100.0 | - | - | - | - |
| Middle East | South America West | Greater or equal to 40,000–Less than 50,000 | - | - | 100.0 | 100.0 | 100.0 | 100.0 |
| North America West | North America East | Greater or equal to 30,000–Less than 40,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| North America West | North America Gulf | Greater or equal to 25,000–Less than 30,000 | 23.0 | 22.5 | 22.1 | 21.7 | 21.4 | 21.0 |
| North America West | North America Gulf | Greater or equal to 30,000–Less than 40,000 | 6.0 | 5.9 | 5.9 | 5.8 | 5.7 | 5.4 |
| North America West | North America Gulf | Greater or equal to 40,000–Less than 50,000 | 71.0 | 71.5 | 72.0 | 72.5 | 72.9 | 73.5 |
| North America West | Central America East | Greater or equal to 20,000–Less than 25,000 | 12.0 | 12.3 | 12.5 | 12.7 | 12.9 | 13.0 |
| North America West | Central America East | Greater or equal to 25,000–Less than 30,000 | 33.0 | 32.7 | 32.3 | 32.0 | 32.0 | 32.3 |
| North America West | Central America East | Greater or equal to 30,000–Less than 40,000 | 44.0 | 43.9 | 43.9 | 43.7 | 43.4 | 42.5 |
| North America West | Central America East | Greater or equal to 40,000–Less than 50,000 | 11.0 | 11.2 | 11.4 | 11.5 | 11.8 | 12.2 |
| North America West | South America East | Greater than 10,000–Less than 15,000 | 16.0 | 16.4 | 16.7 | 17.1 | 17.6 | 18.5 |
| North America West | South America East | Greater or equal to 15,000–Less than 20,000 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| North America West | South America East | Greater or equal to 20,000–Less than 25,000 | 7.4 | 7.5 | 7.6 | 7.7 | 7.7 | 7.7 |
| North America West | South America East | Greater or equal to 25,000–Less than 30,000 | 19.0 | 18.7 | 18.3 | 18.0 | 17.8 | 17.8 |
| North America West | South America East | Greater or equal to 30,000–Less than 40,000 | 43.7 | 43.2 | 42.8 | 42.4 | 41.7 | 40.3 |
| North America West | South America East | Greater or equal to 40,000–Less than 50,000 | 9.7 | 9.8 | 9.8 | 9.9 | 10.0 | 10.3 |
| North America West | South America East | Greater or equal to 50,000–Less than 60,000 | 3.8 | - | - | - | - | - |
| North America West | South America East | Greater or equal to 70,000–Less than 80,000 | - | 4.1 | 4.3 | 4.5 | 4.7 | 5.0 |

## Table B-2. Cargo Allocation by Route and DWT Size Range, Expanded Canal Most Probable Case, No Tolls, Selected Years 2001-2025 (percent)

| Origin | Destination | DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|
| North America West | Caribbean | Greater or equal to 20,000–Less than 25,000 | 24.2 | 24.7 | 25.3 | 25.7 | 26.0 | 26.1 |
| North America West | Caribbean | Greater or equal to 25,000–Less than 30,000 | 48.5 | 48.0 | 47.5 | 47.1 | 47.1 | 47.5 |
| North America West | Caribbean | Greater or equal to 30,000–Less than 40,000 | 27.3 | 27.2 | 27.2 | 27.2 | 26.9 | 26.4 |
| North America West | Europe | Greater or equal to 15,000–Less than 20,000 | 8.0 | 8.1 | 8.2 | 8.2 | 8.3 | 8.3 |
| North America West | Europe | Greater or equal to 20,000–Less than 25,000 | 7.0 | 7.1 | 7.1 | 7.1 | 7.0 | 6.9 |
| North America West | Europe | Greater or equal to 25,000–Less than 30,000 | 21.3 | 20.7 | 20.1 | 19.6 | 19.2 | 18.8 |
| North America West | Europe | Greater or equal to 30,000–Less than 40,000 | 10.5 | 10.3 | 10.1 | 9.9 | 9.6 | 9.1 |
| North America West | Europe | Greater or equal to 40,000–Less than 50,000 | 37.2 | 37.1 | 37.1 | 37.0 | 37.1 | 37.2 |
| North America West | Europe | Greater or equal to 60,000–Less than 70,000 | 7.7 | - | - | - | - | - |
| North America West | Europe | Greater or equal to 70,000–Less than 80,000 | 8.2 | 16.8 | 17.5 | 18.2 | 18.8 | 19.6 |
| North America West | Africa | Greater or equal to 15,000–Less than 20,000 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| North America West | Africa | Greater or equal to 20,000–Less than 25,000 | 1.3 | 1.3 | 1.3 | 1.2 | 1.2 | 1.1 |
| North America West | Africa | Greater or equal to 25,000–Less than 30,000 | 2.4 | 2.2 | 2.1 | 2.0 | 1.9 | 1.9 |
| North America West | Africa | Greater or equal to 30,000–Less than 40,000 | 18.0 | 17.3 | 16.5 | 15.9 | 15.1 | 14.0 |
| North America West | Africa | Greater or equal to 40,000–Less than 50,000 | 10.6 | 10.3 | 10.1 | 9.8 | 9.6 | 9.5 |
| North America West | Africa | Greater or equal to 50,000–Less than 60,000 | 1.1 | - | - | - | - | - |
| North America West | Africa | Greater or equal to 60,000–Less than 70,000 | 36.9 | - | - | - | - | - |
| North America West | Africa | Greater or equal to 70,000–Less than 80,000 | 29.4 | 68.4 | 69.6 | 70.6 | 71.7 | 73.1 |
| North America West | Middle East | Greater or equal to 25,000–Less than 30,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Central America West | Central America East | Greater or equal to 20,000–Less than 25,000 | 7.0 | 7.1 | 7.3 | 7.4 | 7.5 | 7.5 |
| Central America West | Central America East | Greater or equal to 25,000–Less than 30,000 | 17.1 | 16.9 | 16.6 | 16.5 | 16.4 | 16.6 |
| Central America West | Central America East | Greater or equal to 30,000–Less than 40,000 | 53.1 | 52.8 | 52.7 | 52.4 | 51.9 | 50.9 |
| Central America West | Central America East | Greater or equal to 40,000–Less than 50,000 | 22.8 | 23.1 | 23.4 | 23.7 | 24.2 | 25.1 |
| Central America West | South America East | Greater than 10,000–Less than 15,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Central America West | Europe | Greater than 10,000–Less than 15,000 | 3.1 | 3.2 | 3.3 | 3.4 | 3.6 | 3.8 |
| Central America West | Europe | Greater or equal to 15,000–Less than 20,000 | 3.9 | 4.0 | 4.1 | 4.2 | 4.4 | 4.5 |
| Central America West | Europe | Greater or equal to 20,000–Less than 25,000 | 6.2 | 6.4 | 6.5 | 6.6 | 6.7 | 6.8 |
| Central America West | Europe | Greater or equal to 25,000–Less than 30,000 | 45.8 | 45.4 | 45.0 | 44.7 | 44.7 | 45.2 |
| Central America West | Europe | Greater or equal to 30,000–Less than 40,000 | 41.0 | 40.9 | 41.0 | 41.0 | 40.6 | 39.8 |
| Central America West | Africa | Greater or equal to 20,000–Less than 25,000 | 4.9 | 5.0 | 5.1 | 5.2 | 5.3 | 5.2 |
| Central America West | Africa | Greater or equal to 25,000–Less than 30,000 | 53.2 | 52.7 | 52.1 | 51.7 | 51.5 | 51.5 |
| Central America West | Africa | Greater or equal to 30,000–Less than 40,000 | 18.7 | 18.7 | 18.7 | 18.7 | 18.4 | 17.9 |
| Central America West | Africa | Greater or equal to 40,000–Less than 50,000 | 23.2 | 23.6 | 24.0 | 24.4 | 24.8 | 25.4 |
| Central America West | Middle East | Greater or equal to 20,000–Less than 25,000 | 4.9 | 5.0 | 5.1 | 5.2 | 5.3 | 5.2 |
| Central America West | Middle East | Greater or equal to 25,000–Less than 30,000 | 53.2 | 52.7 | 52.1 | 51.7 | 51.5 | 51.5 |
| Central America West | Middle East | Greater or equal to 30,000–Less than 40,000 | 18.7 | 18.7 | 18.7 | 18.7 | 18.4 | 17.9 |
| Central America West | Middle East | Greater or equal to 40,000–Less than 50,000 | 23.2 | 23.6 | 24.0 | 24.4 | 24.8 | 25.4 |
| South America West | North America East | Greater or equal to 20,000–Less than 25,000 | 26.1 | 26.7 | 27.4 | 27.9 | 28.1 | 28.0 |
| South America West | North America East | Greater or equal to 25,000–Less than 30,000 | 73.9 | 73.3 | 72.6 | 72.1 | 71.9 | 72.0 |
| South America West | North America Gulf | Greater or equal to 20,000–Less than 25,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| South America West | Central America East | Greater or equal to 20,000–Less than 25,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| South America West | South America East | Greater than 10,000–Less than 15,000 | 35.2 | 35.8 | 36.3 | 36.8 | 37.5 | 38.5 |
| South America West | South America East | Greater or equal to 15,000–Less than 20,000 | 18.5 | 18.7 | 18.9 | 19.0 | 19.1 | 19.1 |
| South America West | South America East | Greater or equal to 20,000–Less than 25,000 | 16.8 | 16.9 | 17.0 | 17.0 | 16.9 | 16.4 |

## Table B-2. Cargo Allocation by Route and DWT Size Range, Expanded Canal Most Probable Case, No Tolls, Selected Years 2001-2025 (percent)

| Origin | Destination | DWT Range | 2001 | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|---|---|---|
| South America West | South America East | Greater or equal to 25,000–Less than 30,000 | 29.4 | 28.6 | 27.8 | 27.2 | 26.6 | 26.0 |
| South America West | Caribbean | Greater or equal to 20,000–Less than 25,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| South America West | Europe | Less or equal to 10,000 | 100.0 | - | - | - | - | - |
| South America West | Europe | Greater or equal to 30,000–Less than 40,000 | - | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Oceania | Central America East | Greater or equal to 20,000–Less than 25,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Oceania | South America East | Greater or equal to 15,000–Less than 20,000 | 3.4 | 3.5 | 3.5 | 3.6 | 3.7 | 3.8 |
| Oceania | South America East | Greater or equal to 20,000–Less than 25,000 | 33.2 | 33.7 | 34.3 | 34.7 | 35.1 | 35.4 |
| Oceania | South America East | Greater or equal to 25,000–Less than 30,000 | 19.2 | 18.9 | 18.6 | 18.4 | 18.3 | 18.6 |
| Oceania | South America East | Greater or equal to 30,000–Less than 40,000 | 44.2 | 43.9 | 43.6 | 43.3 | 42.9 | 42.2 |
| Oceania | Caribbean | Greater or equal to 15,000–Less than 20,000 | 41.0 | 41.9 | 42.8 | 43.5 | 44.2 | 44.8 |
| Oceania | Caribbean | Greater or equal to 25,000–Less than 30,000 | 59.0 | 58.1 | 57.2 | 56.5 | 55.8 | 55.2 |
| Oceania | Europe | Greater or equal to 25,000–Less than 30,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Far East | North America Gulf | Greater or equal to 15,000–Less than 20,000 | 23.0 | 23.5 | 24.0 | 24.4 | 25.1 | 26.1 |
| Far East | North America Gulf | Greater or equal to 30,000–Less than 40,000 | 77.0 | 76.5 | 76.0 | 75.6 | 74.9 | 73.9 |
| Far East | Central America East | Greater or equal to 50,000–Less than 60,000 | 100.0 | - | - | - | - | - |
| Far East | Central America East | Greater or equal to 70,000–Less than 80,000 | - | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Far East | South America East | Greater or equal to 30,000–Less than 40,000 | 69.8 | 68.2 | 66.9 | 65.7 | 64.2 | 62.0 |
| Far East | South America East | Greater or equal to 50,000–Less than 60,000 | 30.2 | - | - | - | - | - |
| Far East | South America East | Greater or equal to 70,000–Less than 80,000 | - | 31.8 | 33.1 | 34.3 | 35.8 | 38.0 |
| Far East | Caribbean | Greater or equal to 15,000–Less than 20,000 | 33.6 | 34.0 | 34.4 | 34.7 | 35.2 | 36.0 |
| Far East | Caribbean | Greater or equal to 20,000–Less than 25,000 | 34.8 | 35.0 | 35.3 | 35.4 | 35.5 | 35.2 |
| Far East | Caribbean | Greater or equal to 25,000–Less than 30,000 | 17.3 | 16.9 | 16.4 | 16.1 | 15.9 | 15.9 |
| Far East | Caribbean | Greater or equal to 30,000–Less than 40,000 | 14.4 | 14.1 | 13.9 | 13.7 | 13.5 | 13.0 |
| Far East | Europe | Greater or equal to 15,000–Less than 20,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| South East Asia | North America Gulf | Greater or equal to 20,000–Less than 25,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| South East Asia | Central America East | Greater or equal to 30,000–Less than 40,000 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| South East Asia | South America East | Greater or equal to 15,000–Less than 20,000 | 70.5 | 70.6 | 70.6 | 70.8 | 71.0 | 71.6 |
| South East Asia | South America East | Greater or equal to 20,000–Less than 25,000 | 29.5 | 29.4 | 29.4 | 29.2 | 29.0 | 28.4 |
| South East Asia | Caribbean | Greater or equal to 25,000–Less than 30,000 | 68.9 | 68.7 | 68.5 | 68.4 | 68.5 | 69.2 |
| South East Asia | Caribbean | Greater or equal to 30,000–Less than 40,000 | 31.1 | 31.3 | 31.5 | 31.6 | 31.5 | 30.8 |

Source: Richardson Lawrie Associates

*Appendix C*

# PANAMA CANAL TOLL PRICING ANALYSIS FOR EXISTING AND EXPANDED CANAL

## Table C-1. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing Canal, Most Probable Case, 2001

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 | 1,205 |
| Potential Panama Canal Cargo (ton 000s) | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 | 47,400 |
| Forecast Panama Canal Transits (no.) | 1,001 | 1,001 | 1,001 | 968 | 968 | 968 | 916 | 914 | 863 | 862 | 916 | 967 | 916 | 916 |
| Percent of Potential Transits | 83.1% | 83.1% | 83.1% | 80.4% | 80.4% | 80.4% | 76.0% | 75.9% | 71.6% | 71.5% | 76.0% | 80.3% | 76.0% | 76.0% |
| Forecast Panama Canal Cargo (ton 000s) | 38,314 | 38,314 | 38,314 | 36,792 | 36,792 | 36,792 | 33,921 | 33,862 | 31,100 | 31,049 | 33,921 | 36,738 | 33,921 | 33,921 |
| Percent of Potential Cargo | 80.8% | 80.8% | 80.8% | 77.6% | 77.6% | 77.6% | 71.6% | 71.4% | 65.6% | 65.5% | 71.6% | 77.5% | 71.6% | 71.6% |
| Economic Value of Canal for Potential Transits ($000s) | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 | 259,529 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 4,618 | 4,618 | 4,618 | 7,591 | 7,591 | 7,591 | 16,539 | 16,763 | 27,703 | 27,924 | 16,539 | 7,762 | 16,539 | 16,539 |
| Forecast Panama Canal Toll Revenues ($000s) | 58,855 | 63,707 | 66,749 | 80,145 | 96,174 | 112,202 | 118,654 | 133,243 | 131,076 | 135,050 | 117,305 | 118,493 | 113,671 | 117,979 |
| Average Toll Revenue per Forecasted Transit ($000) | 59 | 64 | 67 | 83 | 99 | 116 | 130 | 146 | 152 | 157 | 128 | 122 | 124 | 129 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.54 | 1.66 | 1.74 | 2.18 | 2.61 | 3.05 | 3.50 | 3.93 | 4.21 | 4.35 | 3.46 | 3.23 | 3.35 | 3.48 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Potential Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Percent of Potential Transits | | | | | | | | | | | | | | |
| Forecast Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Percent of Potential Cargo | | | | | | | | | | | | | | |
| Economic Value of Canal for Potential Transits ($000s) | | | | | | | | | | | | | | |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Revenues | | | | | | | | | | | | | | |
| Average Toll Revenue per Forecasted Transit ($000) | | | | | | | | | | | | | | |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | | | | | | | | | | | | | | |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-2. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing Canal, Most Probable Case, 2002

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| **Existing Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,206 | 1,206 | 1,206 | 1,206 | 1,206 | 1,206 | 1,206 | 1,206 | 1,206 | 1,206 | 1,206 | 1,206 | 1,206 | 1,206 |
| Potential Panama Canal Cargo (ton 000s) | 47,626 | 47,626 | 47,626 | 47,626 | 47,626 | 47,626 | 47,626 | 47,626 | 47,626 | 47,626 | 47,626 | 47,626 | 47,626 | 47,626 |
| Forecast Panama Canal Transits (no.) | 1,006 | 1,006 | 1,006 | 973 | 973 | 973 | 919 | 918 | 867 | 865 | 920 | 972 | 920 | 920 |
| Percent of Potential Transits | 83.4% | 83.4% | 83.4% | 80.7% | 80.7% | 80.7% | 76.2% | 76.1% | 71.9% | 71.7% | 76.3% | 80.6% | 76.3% | 76.3% |
| Forecast Panama Canal Cargo (ton 000s) | 38,633 | 38,633 | 38,633 | 37,102 | 37,102 | 37,102 | 34,186 | 34,126 | 31,356 | 31,307 | 34,218 | 37,046 | 34,218 | 34,191 |
| Percent of Potential Cargo | 81.1% | 81.1% | 81.1% | 77.9% | 77.9% | 77.9% | 71.8% | 71.7% | 65.8% | 65.7% | 71.8% | 77.8% | 71.8% | 71.8% |
| Economic Value of Canal for Potential Transits ($000s) | 257,612 | 257,612 | 257,612 | 257,612 | 257,612 | 257,612 | 257,612 | 257,612 | 257,612 | 257,612 | 257,612 | 257,612 | 257,612 | 257,612 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 4,946 | 4,946 | 4,946 | 7,805 | 7,805 | 7,805 | 16,908 | 17,125 | 28,094 | 28,305 | 16,809 | 7,979 | 16,809 | 16,890 |
| Forecast Panama Canal Revenues ($000S) | 59,337 | 64,229 | 67,295 | 80,808 | 96,970 | 113,131 | 119,564 | 134,267 | 132,132 | 136,143 | 118,183 | 119,416 | 114,554 | 118,842 |
| Average Toll Revenue per Forecasted Transit ($000) | 59 | 64 | 67 | 83 | 100 | 116 | 130 | 146 | 152 | 157 | 128 | 123 | 125 | 129 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.54 | 1.66 | 1.74 | 2.18 | 2.61 | 3.05 | 3.50 | 3.93 | 4.21 | 4.35 | 3.45 | 3.22 | 3.35 | 3.48 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Potential Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Percent of Potential Transits | | | | | | | | | | | | | | |
| Forecast Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Percent of Potential Cargo | | | | | | | | | | | | | | |
| Economic Value of Canal for Potential Transits ($000s) | | | | | | | | | | | | | | |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Revenues | | | | | | | | | | | | | | |
| Average Toll Revenue per Forecasted Transit ($000) | | | | | | | | | | | | | | |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | | | | | | | | | | | | | | |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-3. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing Canal, Most Probable Case, 2003

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,210 | 1,210 | 1,210 | 1,210 | 1,210 | 1,210 | 1,210 | 1,210 | 1,210 | 1,210 | 1,210 | 1,210 | 1,210 | 1,210 |
| Potential Panama Canal Cargo (ton 000s) | 47,853 | 47,853 | 47,853 | 47,853 | 47,853 | 47,853 | 47,853 | 47,853 | 47,853 | 47,853 | 47,853 | 47,853 | 47,853 | 47,853 |
| Forecast Panama Canal Transits (no.) | 1,013 | 1,013 | 1,013 | 979 | 979 | 979 | 925 | 924 | 876 | 872 | 925 | 977 | 926 | 925 |
| Percent of Potential Transits | 83.7% | 83.7% | 83.7% | 80.9% | 80.9% | 80.9% | 76.5% | 76.3% | 72.4% | 72.1% | 76.5% | 80.8% | 76.5% | 76.5% |
| Forecast Panama Canal Cargo (ton 000s) | 38,951 | 38,951 | 38,951 | 37,411 | 37,411 | 37,411 | 34,461 | 34,391 | 31,794 | 31,613 | 34,461 | 37,300 | 34,473 | 34,461 |
| Percent of Potential Cargo | 81.4% | 81.4% | 81.4% | 78.2% | 78.2% | 78.2% | 72.0% | 71.9% | 66.4% | 66.1% | 72.0% | 77.9% | 72.0% | 72.0% |
| Economic Value of Canal for Potential Transits ($000s) | 266,835 | 266,835 | 266,835 | 266,835 | 266,835 | 266,835 | 266,835 | 266,835 | 266,835 | 266,835 | 266,835 | 266,835 | 266,835 | 266,835 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 5,640 | 5,640 | 5,640 | 8,623 | 8,623 | 8,623 | 17,779 | 18,042 | 28,257 | 29,002 | 17,779 | 8,962 | 17,741 | 17,779 |
| Forecast Panama Canal Revenues ($000S) | 59,836 | 64,769 | 67,860 | 81,494 | 97,793 | 114,092 | 120,547 | 135,332 | 133,970 | 137,497 | 118,936 | 120,215 | 115,351 | 119,742 |
| Average Toll Revenue per Forecasted Transit ($000) | 59 | 64 | 67 | 83 | 100 | 117 | 130 | 147 | 153 | 158 | 129 | 123 | 125 | 129 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.54 | 1.66 | 1.74 | 2.18 | 2.61 | 3.05 | 3.50 | 3.94 | 4.21 | 4.35 | 3.45 | 3.22 | 3.35 | 3.47 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Potential Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Percent of Potential Transits | | | | | | | | | | | | | | |
| Forecast Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Percent of Potential Cargo | | | | | | | | | | | | | | |
| Economic Value of Canal for Potential Transits ($000s) | | | | | | | | | | | | | | |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Revenues | | | | | | | | | | | | | | |
| Average Toll Revenue per Forecasted Transit ($000) | | | | | | | | | | | | | | |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | | | | | | | | | | | | | | |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-4. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing Canal, Most Probable Case, 2004

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,213 | 1,213 | 1,213 | 1,213 | 1,213 | 1,213 | 1,213 | 1,213 | 1,213 | 1,213 | 1,213 | 1,213 | 1,213 | 1,213 |
| Potential Panama Canal Cargo (ton 000s) | 48,079 | 48,079 | 48,079 | 48,079 | 48,079 | 48,079 | 48,079 | 48,079 | 48,079 | 48,079 | 48,079 | 48,079 | 48,079 | 48,079 |
| Forecast Panama Canal Transits (no.) | 1,019 | 1,019 | 1,019 | 985 | 985 | 985 | 931 | 929 | 881 | 877 | 931 | 983 | 931 | 931 |
| Percent of Potential Transits | 84.0% | 84.0% | 84.0% | 81.2% | 81.2% | 81.2% | 76.7% | 76.6% | 72.6% | 72.3% | 76.7% | 81.0% | 76.7% | 76.7% |
| Forecast Panama Canal Cargo (ton 000s) | 39,270 | 39,270 | 39,270 | 37,720 | 37,720 | 37,720 | 34,730 | 34,656 | 32,065 | 31,870 | 34,730 | 37,581 | 34,743 | 34,730 |
| Percent of Potential Cargo | 81.7% | 81.7% | 81.7% | 78.5% | 78.5% | 78.5% | 72.2% | 72.1% | 66.7% | 66.3% | 72.2% | 78.2% | 72.3% | 72.2% |
| Economic Value of Canal for Potential Transits ($000s) | 268,726 | 268,726 | 268,726 | 268,726 | 268,726 | 268,726 | 268,726 | 268,726 | 268,726 | 268,726 | 268,726 | 268,726 | 268,726 | 268,726 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 6,136 | 6,136 | 6,136 | 9,120 | 9,120 | 9,120 | 18,349 | 18,628 | 28,764 | 29,566 | 18,349 | 9,542 | 18,308 | 18,349 |
| Forecast Panama Canal Revenues ($000S) | 60,333 | 65,306 | 68,422 | 82,178 | 98,613 | 115,049 | 121,507 | 136,393 | 135,127 | 138,627 | 119,767 | 121,090 | 116,189 | 120,637 |
| Average Toll Revenue per Forecasted Transit ($000) | 59 | 64 | 67 | 83 | 100 | 117 | 131 | 147 | 153 | 158 | 129 | 123 | 125 | 130 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.54 | 1.66 | 1.74 | 2.18 | 2.61 | 3.05 | 3.50 | 3.94 | 4.21 | 4.35 | 3.45 | 3.22 | 3.34 | 3.47 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Potential Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Percent of Potential Transits | | | | | | | | | | | | | | |
| Forecast Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Percent of Potential Cargo | | | | | | | | | | | | | | |
| Economic Value of Canal for Potential Transits ($000s) | | | | | | | | | | | | | | |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Revenues | | | | | | | | | | | | | | |
| Average Toll Revenue per Forecasted Transit ($000) | | | | | | | | | | | | | | |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | | | | | | | | | | | | | | |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-5. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing Canal, Most Probable Case, 2005

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,216 | 1,216 | 1,216 | 1,216 | 1,216 | 1,216 | 1,216 | 1,216 | 1,216 | 1,216 | 1,216 | 1,216 | 1,216 | 1,216 |
| Potential Panama Canal Cargo (ton 000s) | 48,305 | 48,305 | 48,305 | 48,305 | 48,305 | 48,305 | 48,305 | 48,305 | 48,305 | 48,305 | 48,305 | 48,305 | 48,305 | 48,305 |
| Forecast Panama Canal Transits (no.) | 1,025 | 1,025 | 1,025 | 991 | 991 | 991 | 936 | 934 | 886 | 882 | 936 | 988 | 936 | 936 |
| Percent of Potential Transits | 84.2% | 84.2% | 84.2% | 81.5% | 81.5% | 81.5% | 76.9% | 76.8% | 72.9% | 72.5% | 76.9% | 81.2% | 76.9% | 76.9% |
| Forecast Panama Canal Cargo (ton 000s) | 39,588 | 39,588 | 39,588 | 38,029 | 38,029 | 38,029 | 35,000 | 34,921 | 32,336 | 32,127 | 35,000 | 37,862 | 35,014 | 35,000 |
| Percent of Potential Cargo | 82.0% | 82.0% | 82.0% | 78.7% | 78.7% | 78.7% | 72.5% | 72.3% | 66.9% | 66.5% | 72.5% | 78.4% | 72.5% | 72.5% |
| Economic Value of Canal for Potential Transits ($000s) | 273,678 | 273,678 | 273,678 | 273,678 | 273,678 | 273,678 | 273,678 | 273,678 | 273,678 | 273,678 | 273,678 | 273,678 | 273,678 | 273,678 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 6,704 | 6,704 | 6,704 | 9,727 | 9,727 | 9,727 | 19,138 | 19,436 | 29,616 | 30,482 | 19,138 | 10,236 | 19,093 | 19,138 |
| Forecast Panama Canal Revenues ($000S) | 60,828 | 65,842 | 68,983 | 82,859 | 99,430 | 116,002 | 122,463 | 137,449 | 136,277 | 139,752 | 120,592 | 121,960 | 117,023 | 121,528 |
| Average Toll Revenue per Forecasted Transit ($000) | 59 | 64 | 67 | 84 | 100 | 117 | 131 | 147 | 154 | 158 | 129 | 123 | 125 | 130 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.54 | 1.66 | 1.74 | 2.18 | 2.61 | 3.05 | 3.50 | 3.94 | 4.21 | 4.35 | 3.45 | 3.22 | 3.34 | 3.47 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Potential Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Percent of Potential Transits | | | | | | | | | | | | | | |
| Forecast Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Percent of Potential Cargo | | | | | | | | | | | | | | |
| Economic Value of Canal for Potential Transits ($000s) | | | | | | | | | | | | | | |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Revenues | | | | | | | | | | | | | | |
| Average Toll Revenue per Forecasted Transit ($000) | | | | | | | | | | | | | | |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | | | | | | | | | | | | | | |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-6. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing Canal, Most Probable Case, 2006

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,275 | 1,275 | 1,275 | 1,275 | 1,275 | 1,275 | 1,275 | 1,275 | 1,275 | 1,275 | 1,275 | 1,275 | 1,275 | 1,275 |
| Potential Panama Canal Cargo (ton 000s) | 51,083 | 51,083 | 51,083 | 51,083 | 51,083 | 51,083 | 51,083 | 51,083 | 51,083 | 51,083 | 51,083 | 51,083 | 51,083 | 51,083 |
| Forecast Panama Canal Transits (no.) | 1,064 | 1,064 | 1,064 | 1,030 | 1,030 | 1,030 | 968 | 964 | 898 | 892 | 977 | 1,029 | 977 | 968 |
| Percent of Potential Transits | 83.5% | 83.5% | 83.5% | 80.8% | 80.8% | 80.8% | 75.9% | 75.6% | 70.5% | 70.0% | 76.6% | 80.8% | 76.7% | 75.9% |
| Forecast Panama Canal Cargo (ton 000s) | 41,512 | 41,512 | 41,512 | 39,941 | 39,941 | 39,941 | 36,511 | 36,363 | 32,759 | 32,452 | 37,005 | 39,879 | 37,019 | 36,511 |
| Percent of Potential Cargo | 81.3% | 81.3% | 81.3% | 78.2% | 78.2% | 78.2% | 71.5% | 71.2% | 64.1% | 63.5% | 72.4% | 78.1% | 72.5% | 71.5% |
| Economic Value of Canal for Potential Transits ($000s) | 283,189 | 283,189 | 283,189 | 283,189 | 283,189 | 283,189 | 283,189 | 283,189 | 283,189 | 283,189 | 283,189 | 283,189 | 283,189 | 283,189 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 7,307 | 7,307 | 7,307 | 10,354 | 10,354 | 10,354 | 20,987 | 21,539 | 35,757 | 37,025 | 19,501 | 10,548 | 19,454 | 20,987 |
| Forecast Panama Canal Revenues ($000S) | 63,725 | 68,972 | 72,255 | 86,925 | 104,310 | 121,694 | 127,629 | 142,979 | 138,095 | 141,206 | 127,191 | 128,102 | 123,376 | 126,667 |
| Average Toll Revenue per Forecasted Transit ($000) | 60 | 65 | 68 | 84 | 101 | 118 | 132 | 148 | 154 | 158 | 130 | 124 | 126 | 131 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.54 | 1.66 | 1.74 | 2.18 | 2.61 | 3.05 | 3.50 | 3.93 | 4.22 | 4.35 | 3.44 | 3.21 | 3.33 | 3.47 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Potential Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Percent of Potential Transits | | | | | | | | | | | | | | |
| Forecast Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Percent of Potential Cargo | | | | | | | | | | | | | | |
| Economic Value of Canal for Potential Transits ($000s) | | | | | | | | | | | | | | |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Revenues | | | | | | | | | | | | | | |
| Average Toll Revenue per Forecasted Transit ($000) | | | | | | | | | | | | | | |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | | | | | | | | | | | | | | |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-7. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing Canal, Most Probable Case, 2007

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,333 | 1,333 | 1,333 | 1,333 | 1,333 | 1,333 | 1,333 | 1,333 | 1,333 | 1,333 | 1,333 | 1,333 | 1,333 | 1,333 |
| Potential Panama Canal Cargo (ton 000s) | 53,861 | 53,861 | 53,861 | 53,861 | 53,861 | 53,861 | 53,861 | 53,861 | 53,861 | 53,861 | 53,861 | 53,861 | 53,861 | 53,861 |
| Forecast Panama Canal Transits (no.) | 1,104 | 1,104 | 1,104 | 1,070 | 1,070 | 1,070 | 1,000 | 995 | 910 | 901 | 1,016 | 1,069 | 1,016 | 1,000 |
| Percent of Potential Transits | 82.9% | 82.9% | 82.9% | 80.3% | 80.3% | 80.3% | 75.0% | 74.6% | 68.3% | 67.6% | 76.2% | 80.2% | 76.3% | 75.0% |
| Forecast Panama Canal Cargo (ton 000s) | 43,436 | 43,436 | 43,436 | 41,854 | 41,854 | 41,854 | 38,020 | 37,806 | 33,182 | 32,771 | 38,902 | 41,789 | 38,917 | 38,020 |
| Percent of Potential Cargo | 80.6% | 80.6% | 80.6% | 77.7% | 77.7% | 77.7% | 70.6% | 70.2% | 61.6% | 60.8% | 72.2% | 77.6% | 72.3% | 70.6% |
| Economic Value of Canal for Potential Transits ($000s) | 293,288 | 293,288 | 293,288 | 293,288 | 293,288 | 293,288 | 293,288 | 293,288 | 293,288 | 293,288 | 293,288 | 293,288 | 293,288 | 293,288 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 7,927 | 7,927 | 7,927 | 11,006 | 11,006 | 11,006 | 22,895 | 23,694 | 41,999 | 43,703 | 20,231 | 11,209 | 20,182 | 22,895 |
| Forecast Panama Canal Revenues ($000S) | 66,625 | 72,104 | 75,530 | 90,994 | 109,192 | 127,391 | 132,791 | 148,515 | 139,920 | 142,632 | 133,469 | 133,924 | 129,409 | 131,804 |
| Average Toll Revenue per Forecasted Transit ($000) | 60 | 65 | 68 | 85 | 102 | 119 | 133 | 149 | 154 | 158 | 131 | 125 | 127 | 132 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.53 | 1.66 | 1.74 | 2.17 | 2.61 | 3.04 | 3.49 | 3.93 | 4.22 | 4.35 | 3.43 | 3.20 | 3.33 | 3.47 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Potential Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Percent of Potential Transits | | | | | | | | | | | | | | |
| Forecast Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Percent of Potential Cargo | | | | | | | | | | | | | | |
| Economic Value of Canal for Potential Transits ($000s) | | | | | | | | | | | | | | |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Revenues | | | | | | | | | | | | | | |
| Average Toll Revenue per Forecasted Transit ($000) | | | | | | | | | | | | | | |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | | | | | | | | | | | | | | |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-8. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing Canal, Most Probable Case, 2008

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,391 | 1,391 | 1,391 | 1,391 | 1,391 | 1,391 | 1,391 | 1,391 | 1,391 | 1,391 | 1,391 | 1,391 | 1,391 | 1,391 |
| Potential Panama Canal Cargo (ton 000s) | 56,639 | 56,639 | 56,639 | 56,639 | 56,639 | 56,639 | 56,639 | 56,639 | 56,639 | 56,639 | 56,639 | 56,639 | 56,639 | 56,639 |
| Forecast Panama Canal Transits (no.) | 1,144 | 1,144 | 1,144 | 1,110 | 1,110 | 1,110 | 1,032 | 1,025 | 922 | 911 | 1,056 | 1,108 | 1,056 | 1,032 |
| Percent of Potential Transits | 82.3% | 82.3% | 82.3% | 79.8% | 79.8% | 79.8% | 74.2% | 73.7% | 66.3% | 65.5% | 75.9% | 79.7% | 75.9% | 74.2% |
| Forecast Panama Canal Cargo (ton 000s) | 45,360 | 45,360 | 45,360 | 43,766 | 43,766 | 43,766 | 39,527 | 39,248 | 33,604 | 33,083 | 40,800 | 43,698 | 40,815 | 39,527 |
| Percent of Potential Cargo | 80.1% | 80.1% | 80.1% | 77.3% | 77.3% | 77.3% | 69.8% | 69.3% | 59.3% | 58.4% | 72.0% | 77.2% | 72.1% | 69.8% |
| Economic Value of Canal for Potential Transits ($000s) | 303,540 | 303,540 | 303,540 | 303,540 | 303,540 | 303,540 | 303,540 | 303,540 | 303,540 | 303,540 | 303,540 | 303,540 | 303,540 | 303,540 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 8,555 | 8,555 | 8,555 | 11,667 | 11,667 | 11,667 | 24,833 | 25,874 | 48,306 | 50,473 | 20,975 | 11,879 | 20,924 | 24,833 |
| Forecast Panama Canal Revenues ($000S) | 69,528 | 75,240 | 78,808 | 95,066 | 114,080 | 133,093 | 137,951 | 154,059 | 141,749 | 144,034 | 139,754 | 139,751 | 135,448 | 136,938 |
| Average Toll Revenue per Forecasted Transit ($000) | 61 | 66 | 69 | 86 | 103 | 120 | 134 | 150 | 154 | 158 | 132 | 126 | 128 | 133 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.53 | 1.66 | 1.74 | 2.17 | 2.61 | 3.04 | 3.49 | 3.93 | 4.22 | 4.35 | 3.43 | 3.20 | 3.32 | 3.46 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Potential Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Percent of Potential Transits | | | | | | | | | | | | | | |
| Forecast Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Percent of Potential Cargo | | | | | | | | | | | | | | |
| Economic Value of Canal for Potential Transits ($000s) | | | | | | | | | | | | | | |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Revenues | | | | | | | | | | | | | | |
| Average Toll Revenue per Forecasted Transit ($000) | | | | | | | | | | | | | | |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | | | | | | | | | | | | | | |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-9. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing Canal, Most Probable Case, 2009

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| **Existing Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,449 | 1,449 | 1,449 | 1,449 | 1,449 | 1,449 | 1,449 | 1,449 | 1,449 | 1,449 | 1,449 | 1,449 | 1,449 | 1,449 |
| Potential Panama Canal Cargo (ton 000s) | 59,417 | 59,417 | 59,417 | 59,417 | 59,417 | 59,417 | 59,417 | 59,417 | 59,417 | 59,417 | 59,417 | 59,417 | 59,417 | 59,417 |
| Forecast Panama Canal Transits (no.) | 1,184 | 1,184 | 1,184 | 1,150 | 1,150 | 1,150 | 1,065 | 1,056 | 934 | 921 | 1,095 | 1,148 | 1,096 | 1,065 |
| Percent of Potential Transits | 81.7% | 81.7% | 81.7% | 79.3% | 79.3% | 79.3% | 73.5% | 72.9% | 64.5% | 63.6% | 75.6% | 79.3% | 75.6% | 73.5% |
| Forecast Panama Canal Cargo (ton 000s) | 47,284 | 47,284 | 47,284 | 45,678 | 45,678 | 45,678 | 41,031 | 40,691 | 34,025 | 33,390 | 42,698 | 45,608 | 42,713 | 41,031 |
| Percent of Potential Cargo | 79.6% | 79.6% | 79.6% | 76.9% | 76.9% | 76.9% | 69.1% | 68.5% | 57.3% | 56.2% | 71.9% | 76.8% | 71.9% | 69.1% |
| Economic Value of Canal for Potential Transits ($000s) | 313,505 | 313,505 | 313,505 | 313,505 | 313,505 | 313,505 | 313,505 | 313,505 | 313,505 | 313,505 | 313,505 | 313,505 | 313,505 | 313,505 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 9,178 | 9,178 | 9,178 | 12,320 | 12,320 | 12,320 | 26,766 | 28,041 | 54,609 | 57,266 | 21,702 | 12,541 | 21,649 | 26,766 |
| Forecast Panama Canal Revenues ($000S) | 72,435 | 78,380 | 82,090 | 99,144 | 118,973 | 138,802 | 143,112 | 159,613 | 143,586 | 145,412 | 146,047 | 145,585 | 141,494 | 142,074 |
| Average Toll Revenue per Forecasted Transit ($000) | 61 | 66 | 69 | 86 | 103 | 121 | 134 | 151 | 154 | 158 | 133 | 127 | 129 | 133 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.53 | 1.66 | 1.74 | 2.17 | 2.60 | 3.04 | 3.49 | 3.92 | 4.22 | 4.36 | 3.42 | 3.19 | 3.31 | 3.46 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Potential Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Transits (no.) | | | | | | | | | | | | | | |
| Percent of Potential Transits | | | | | | | | | | | | | | |
| Forecast Panama Canal Cargo (ton 000s) | | | | | | | | | | | | | | |
| Percent of Potential Cargo | | | | | | | | | | | | | | |
| Economic Value of Canal for Potential Transits ($000s) | | | | | | | | | | | | | | |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | | | | | | | | | | | | | | |
| Forecast Panama Canal Revenues | | | | | | | | | | | | | | |
| Average Toll Revenue per Forecasted Transit ($000) | | | | | | | | | | | | | | |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | | | | | | | | | | | | | | |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-10. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2010

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 | 1,506 |
| Potential Panama Canal Cargo (ton 000s) | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 | 62,195 |
| Forecast Panama Canal Transits (no.) | 1,223 | 1,223 | 1,223 | 1,188 | 1,188 | 1,188 | 1,096 | 1,086 | 945 | 945 | 1,133 | 1,187 | 1,134 | 1,096 |
| Percent of Potential Transits | 81.2% | 81.2% | 81.2% | 78.9% | 78.9% | 78.9% | 72.8% | 72.1% | 62.8% | 62.8% | 75.3% | 78.8% | 75.3% | 72.8% |
| Forecast Panama Canal Cargo (ton 000s) | 49,208 | 49,208 | 49,208 | 47,590 | 47,590 | 47,590 | 42,534 | 42,134 | 34,456 | 34,456 | 44,595 | 47,517 | 44,612 | 42,534 |
| Percent of Potential Cargo | 79.1% | 79.1% | 79.1% | 76.5% | 76.5% | 76.5% | 68.4% | 67.7% | 55.4% | 55.4% | 71.7% | 76.4% | 71.7% | 68.4% |
| Economic Value of Canal for Potential Transits ($000s) | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 | 323,405 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 9,809 | 9,809 | 9,809 | 12,984 | 12,984 | 12,984 | 28,733 | 30,236 | 60,944 | 60,944 | 22,445 | 13,215 | 22,390 | 28,733 |
| Forecast Panama Canal Revenues ($000S) | 75,336 | 81,513 | 85,364 | 103,212 | 123,854 | 144,497 | 148,250 | 165,149 | 145,440 | 149,939 | 152,325 | 151,405 | 147,527 | 147,188 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 70 | 87 | 104 | 122 | 135 | 152 | 154 | 159 | 134 | 128 | 130 | 134 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.53 | 1.66 | 1.73 | 2.17 | 2.60 | 3.04 | 3.49 | 3.92 | 4.22 | 4.35 | 3.42 | 3.19 | 3.31 | 3.46 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 | 1,468 |
| Potential Panama Canal Cargo (ton 000s) | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 | 63,258 |
| Forecast Panama Canal Transits (no.) | 1,174 | 1,174 | 1,174 | 1,140 | 1,140 | 1,132 | 1,049 | 1,026 | 956 | 912 | 1,074 | 1,116 | 1,074 | 1,049 |
| Percent of Potential Transits | 80.0% | 80.0% | 80.0% | 77.7% | 77.7% | 77.1% | 71.5% | 69.9% | 65.2% | 62.1% | 73.2% | 76.1% | 73.2% | 71.5% |
| Forecast Panama Canal Cargo (ton 000s) | 49,176 | 49,176 | 49,176 | 47,575 | 47,575 | 46,970 | 41,960 | 40,647 | 36,569 | 33,786 | 43,502 | 46,070 | 43,516 | 41,960 |
| Percent of Potential Cargo | 77.7% | 77.7% | 77.7% | 75.2% | 75.2% | 74.3% | 66.3% | 64.3% | 57.8% | 53.4% | 68.8% | 72.8% | 68.8% | 66.3% |
| Economic Value of Canal for Potential Transits ($000s) | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 | 310,610 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 9,652 | 9,652 | 9,652 | 12,721 | 12,721 | 14,299 | 28,344 | 32,946 | 47,899 | 57,875 | 24,140 | 16,813 | 24,092 | 28,344 |
| Forecast Panama Canal Revenues | 71,868 | 77,756 | 81,428 | 98,433 | 118,119 | 136,121 | 140,410 | 153,029 | 148,050 | 142,406 | 142,396 | 140,312 | 137,899 | 139,337 |
| Average Toll Revenue per Forecasted Transit ($000) | 61 | 66 | 69 | 86 | 104 | 120 | 134 | 149 | 155 | 156 | 133 | 126 | 128 | 133 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.46 | 1.58 | 1.66 | 2.07 | 2.48 | 2.90 | 3.35 | 3.76 | 4.05 | 4.21 | 3.27 | 3.05 | 3.17 | 3.32 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-11. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2011

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 | 1,520 |
| Potential Panama Canal Cargo (ton 000s) | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 | 63,071 |
| Forecast Panama Canal Transits (no.) | 1,233 | 1,233 | 1,233 | 1,198 | 1,198 | 1,198 | 1,106 | 1,095 | 1,095 | 945 | 1,143 | 1,197 | 1,143 | 1,106 |
| Percent of Potential Transits | 81.2% | 81.2% | 81.2% | 78.9% | 78.9% | 78.9% | 72.8% | 72.1% | 72.1% | 62.2% | 75.2% | 78.8% | 75.2% | 72.8% |
| Forecast Panama Canal Cargo (ton 000s) | 49,900 | 49,900 | 49,900 | 48,283 | 48,283 | 48,283 | 43,183 | 42,786 | 42,786 | 34,571 | 45,249 | 48,209 | 45,266 | 43,183 |
| Percent of Potential Cargo | 79.1% | 79.1% | 79.1% | 76.6% | 76.6% | 76.6% | 68.5% | 67.8% | 67.8% | 54.8% | 71.7% | 76.4% | 71.8% | 68.5% |
| Economic Value of Canal for Potential Transits ($000s) | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 | 326,825 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 9,997 | 9,997 | 9,997 | 13,182 | 13,182 | 13,182 | 29,125 | 30,623 | 30,623 | 63,595 | 22,799 | 13,416 | 22,742 | 29,125 |
| Forecast Panama Canal Revenues ($000S) | 76,337 | 82,591 | 86,490 | 104,622 | 125,546 | 146,471 | 150,358 | 167,532 | 178,701 | 150,329 | 154,416 | 153,675 | 149,652 | 149,280 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 70 | 87 | 105 | 122 | 136 | 153 | 163 | 159 | 135 | 128 | 131 | 135 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.53 | 1.66 | 1.73 | 2.17 | 2.60 | 3.03 | 3.48 | 3.92 | 4.18 | 4.35 | 3.41 | 3.19 | 3.31 | 3.46 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 | 1,483 |
| Potential Panama Canal Cargo (ton 000s) | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 | 64,257 |
| Forecast Panama Canal Transits (no.) | 1,183 | 1,183 | 1,183 | 1,149 | 1,149 | 1,141 | 1,058 | 1,034 | 963 | 912 | 1,097 | 1,140 | 1,122 | 1,058 |
| Percent of Potential Transits | 79.8% | 79.8% | 79.8% | 77.5% | 77.5% | 76.9% | 71.3% | 69.7% | 64.9% | 61.5% | 74.0% | 76.9% | 75.6% | 71.3% |
| Forecast Panama Canal Cargo (ton 000s) | 49,861 | 49,861 | 49,861 | 48,260 | 48,260 | 47,641 | 42,599 | 41,208 | 37,088 | 33,887 | 44,980 | 47,576 | 46,511 | 42,599 |
| Percent of Potential Cargo | 77.6% | 77.6% | 77.6% | 75.1% | 75.1% | 74.1% | 66.3% | 64.1% | 57.7% | 52.7% | 70.0% | 74.0% | 72.4% | 66.3% |
| Economic Value of Canal for Potential Transits ($000s) | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 | 313,818 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 9,855 | 9,855 | 9,855 | 12,933 | 12,933 | 14,555 | 28,737 | 33,618 | 48,739 | 60,299 | 22,174 | 14,741 | 17,825 | 28,737 |
| Forecast Panama Canal Revenues | 72,774 | 78,733 | 82,447 | 99,708 | 119,649 | 137,865 | 142,312 | 154,891 | 149,908 | 142,718 | 146,604 | 144,658 | 146,429 | 141,224 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 70 | 87 | 104 | 121 | 134 | 150 | 156 | 156 | 134 | 127 | 131 | 133 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.46 | 1.58 | 1.65 | 2.07 | 2.48 | 2.89 | 3.34 | 3.76 | 4.04 | 4.21 | 3.26 | 3.04 | 3.15 | 3.32 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-12. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2012

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,534 | 1,534 | 1,534 | 1,534 | 1,534 | 1,534 | 1,534 | 1,534 | 1,534 | 1,534 | 1,534 | 1,534 | 1,534 | 1,534 |
| Potential Panama Canal Cargo (ton 000s) | 63,947 | 63,947 | 63,947 | 63,947 | 63,947 | 63,947 | 63,947 | 63,947 | 63,947 | 63,947 | 63,947 | 63,947 | 63,947 | 63,947 |
| Forecast Panama Canal Transits (no.) | 1,244 | 1,244 | 1,244 | 1,209 | 1,209 | 1,209 | 1,115 | 1,105 | 1,105 | 945 | 1,153 | 1,207 | 1,207 | 1,115 |
| Percent of Potential Transits | 81.1% | 81.1% | 81.1% | 78.8% | 78.8% | 78.8% | 72.7% | 72.1% | 72.1% | 61.6% | 75.2% | 78.7% | 78.7% | 72.7% |
| Forecast Panama Canal Cargo (ton 000s) | 50,592 | 50,592 | 50,592 | 48,976 | 48,976 | 48,976 | 43,832 | 43,438 | 43,438 | 34,688 | 45,903 | 48,902 | 48,902 | 43,832 |
| Percent of Potential Cargo | 79.1% | 79.1% | 79.1% | 76.6% | 76.6% | 76.6% | 68.5% | 67.9% | 67.9% | 54.2% | 71.8% | 76.5% | 76.5% | 68.5% |
| Economic Value of Canal for Potential Transits ($000s) | 330,238 | 330,238 | 330,238 | 330,238 | 330,238 | 330,238 | 330,238 | 330,238 | 330,238 | 330,238 | 330,238 | 330,238 | 330,238 | 330,238 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 10,186 | 10,186 | 10,186 | 13,379 | 13,379 | 13,379 | 29,515 | 31,008 | 31,008 | 66,248 | 23,153 | 13,616 | 13,616 | 29,515 |
| Forecast Panama Canal Revenues ($000S) | 77,337 | 83,670 | 87,616 | 106,032 | 127,238 | 148,445 | 152,467 | 169,916 | 181,243 | 150,726 | 156,508 | 155,944 | 161,233 | 151,373 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 70 | 88 | 105 | 123 | 137 | 154 | 164 | 159 | 136 | 129 | 134 | 136 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.53 | 1.65 | 1.73 | 2.16 | 2.60 | 3.03 | 3.48 | 3.91 | 4.17 | 4.35 | 3.41 | 3.19 | 3.30 | 3.45 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,499 | 1,499 | 1,499 | 1,499 | 1,499 | 1,499 | 1,499 | 1,499 | 1,499 | 1,499 | 1,499 | 1,499 | 1,499 | 1,499 |
| Potential Panama Canal Cargo (ton 000s) | 65,255 | 65,255 | 65,255 | 65,255 | 65,255 | 65,255 | 65,255 | 65,255 | 65,255 | 65,255 | 65,255 | 65,255 | 65,255 | 65,255 |
| Forecast Panama Canal Transits (no.) | 1,193 | 1,193 | 1,193 | 1,159 | 1,159 | 1,151 | 1,067 | 1,042 | 968 | 913 | 1,106 | 1,150 | 1,131 | 1,067 |
| Percent of Potential Transits | 79.6% | 79.6% | 79.6% | 77.3% | 77.3% | 76.8% | 71.2% | 69.5% | 64.6% | 60.9% | 73.8% | 76.7% | 75.5% | 71.2% |
| Forecast Panama Canal Cargo (ton 000s) | 50,545 | 50,545 | 50,545 | 48,945 | 48,945 | 48,312 | 43,238 | 41,766 | 37,461 | 33,989 | 45,622 | 48,247 | 47,195 | 43,238 |
| Percent of Potential Cargo | 77.5% | 77.5% | 77.5% | 75.0% | 75.0% | 74.0% | 66.3% | 64.0% | 57.4% | 52.1% | 69.9% | 73.9% | 72.3% | 66.3% |
| Economic Value of Canal for Potential Transits ($000s) | 317,026 | 317,026 | 317,026 | 317,026 | 317,026 | 317,026 | 317,026 | 317,026 | 317,026 | 317,026 | 317,026 | 317,026 | 317,026 | 317,026 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 10,058 | 10,058 | 10,058 | 13,146 | 13,146 | 14,810 | 29,128 | 34,295 | 50,151 | 62,726 | 22,537 | 14,998 | 18,053 | 29,128 |
| Forecast Panama Canal Revenues | 73,680 | 79,710 | 83,467 | 100,983 | 121,180 | 139,612 | 144,216 | 156,748 | 151,197 | 143,035 | 148,480 | 146,674 | 148,457 | 143,111 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 70 | 87 | 105 | 121 | 135 | 150 | 156 | 157 | 134 | 128 | 131 | 134 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.46 | 1.58 | 1.65 | 2.06 | 2.48 | 2.89 | 3.34 | 3.75 | 4.04 | 4.21 | 3.25 | 3.04 | 3.15 | 3.31 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-13. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2013

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,548 | 1,548 | 1,548 | 1,548 | 1,548 | 1,548 | 1,548 | 1,548 | 1,548 | 1,548 | 1,548 | 1,548 | 1,548 | 1,548 |
| Potential Panama Canal Cargo (ton 000s) | 64,824 | 64,824 | 64,824 | 64,824 | 64,824 | 64,824 | 64,824 | 64,824 | 64,824 | 64,824 | 64,824 | 64,824 | 64,824 | 64,824 |
| Forecast Panama Canal Transits (no.) | 1,254 | 1,254 | 1,254 | 1,219 | 1,219 | 1,219 | 1,125 | 1,115 | 1,115 | 946 | 1,163 | 1,218 | 1,218 | 1,125 |
| Percent of Potential Transits | 81.0% | 81.0% | 81.0% | 78.8% | 78.8% | 78.8% | 72.7% | 72.0% | 72.0% | 61.1% | 75.1% | 78.7% | 78.7% | 72.7% |
| Forecast Panama Canal Cargo (ton 000s) | 51,285 | 51,285 | 51,285 | 49,669 | 49,669 | 49,669 | 44,482 | 44,090 | 44,090 | 34,807 | 46,557 | 49,594 | 49,594 | 44,482 |
| Percent of Potential Cargo | 79.1% | 79.1% | 79.1% | 76.6% | 76.6% | 76.6% | 68.6% | 68.0% | 68.0% | 53.7% | 71.8% | 76.5% | 76.5% | 68.6% |
| Economic Value of Canal for Potential Transits ($000s) | 333,732 | 333,732 | 333,732 | 333,732 | 333,732 | 333,732 | 333,732 | 333,732 | 333,732 | 333,732 | 333,732 | 333,732 | 333,732 | 333,732 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 10,377 | 10,377 | 10,377 | 13,580 | 13,580 | 13,580 | 29,912 | 31,401 | 31,401 | 68,921 | 23,513 | 13,820 | 13,820 | 29,912 |
| Forecast Panama Canal Revenues ($000S) | 78,337 | 84,749 | 88,743 | 107,442 | 128,930 | 150,419 | 154,576 | 172,299 | 183,785 | 151,130 | 158,599 | 158,214 | 163,478 | 153,466 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 68 | 71 | 88 | 106 | 123 | 137 | 155 | 165 | 160 | 136 | 130 | 134 | 136 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.53 | 1.65 | 1.73 | 2.16 | 2.60 | 3.03 | 3.48 | 3.91 | 4.17 | 4.34 | 3.41 | 3.19 | 3.30 | 3.45 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,515 | 1,515 | 1,515 | 1,515 | 1,515 | 1,515 | 1,515 | 1,515 | 1,515 | 1,515 | 1,515 | 1,515 | 1,515 | 1,515 |
| Potential Panama Canal Cargo (ton 000s) | 66,254 | 66,254 | 66,254 | 66,254 | 66,254 | 66,254 | 66,254 | 66,254 | 66,254 | 66,254 | 66,254 | 66,254 | 66,254 | 66,254 |
| Forecast Panama Canal Transits (no.) | 1,202 | 1,202 | 1,202 | 1,169 | 1,169 | 1,160 | 1,076 | 1,050 | 973 | 913 | 1,115 | 1,159 | 1,141 | 1,076 |
| Percent of Potential Transits | 79.4% | 79.4% | 79.4% | 77.2% | 77.2% | 76.6% | 71.1% | 69.3% | 64.2% | 60.3% | 73.6% | 76.5% | 75.3% | 71.1% |
| Forecast Panama Canal Cargo (ton 000s) | 51,230 | 51,230 | 51,230 | 49,631 | 49,631 | 48,984 | 43,877 | 42,324 | 37,839 | 34,093 | 46,264 | 48,918 | 47,878 | 43,877 |
| Percent of Potential Cargo | 77.3% | 77.3% | 77.3% | 74.9% | 74.9% | 73.9% | 66.2% | 63.9% | 57.1% | 51.5% | 69.8% | 73.8% | 72.3% | 66.2% |
| Economic Value of Canal for Potential Transits ($000s) | 320,321 | 320,321 | 320,321 | 320,321 | 320,321 | 320,321 | 320,321 | 320,321 | 320,321 | 320,321 | 320,321 | 320,321 | 320,321 | 320,321 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 10,264 | 10,264 | 10,264 | 13,361 | 13,361 | 15,068 | 29,526 | 34,988 | 51,556 | 65,173 | 22,905 | 15,258 | 18,287 | 29,526 |
| Forecast Panama Canal Revenues | 74,586 | 80,687 | 84,487 | 102,259 | 122,711 | 141,359 | 146,120 | 158,598 | 152,509 | 143,357 | 150,359 | 148,691 | 150,484 | 145,000 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 70 | 87 | 105 | 122 | 136 | 151 | 157 | 157 | 135 | 128 | 132 | 135 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.46 | 1.57 | 1.65 | 2.06 | 2.47 | 2.89 | 3.33 | 3.75 | 4.03 | 4.20 | 3.25 | 3.04 | 3.14 | 3.30 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-14. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2014

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,563 | 1,563 | 1,563 | 1,563 | 1,563 | 1,563 | 1,563 | 1,563 | 1,563 | 1,563 | 1,563 | 1,563 | 1,563 | 1,563 |
| Potential Panama Canal Cargo (ton 000s) | 65,700 | 65,700 | 65,700 | 65,700 | 65,700 | 65,700 | 65,700 | 65,700 | 65,700 | 65,700 | 65,700 | 65,700 | 65,700 | 65,700 |
| Forecast Panama Canal Transits (no.) | 1,265 | 1,265 | 1,265 | 1,230 | 1,230 | 1,230 | 1,135 | 1,125 | 1,125 | 946 | 1,173 | 1,229 | 1,229 | 1,135 |
| Percent of Potential Transits | 81.0% | 81.0% | 81.0% | 78.7% | 78.7% | 78.7% | 72.6% | 72.0% | 72.0% | 60.5% | 75.1% | 78.6% | 78.6% | 72.6% |
| Forecast Panama Canal Cargo (ton 000s) | 51,977 | 51,977 | 51,977 | 50,362 | 50,362 | 50,362 | 45,131 | 44,742 | 44,742 | 34,927 | 47,211 | 50,286 | 50,286 | 45,131 |
| Percent of Potential Cargo | 79.1% | 79.1% | 79.1% | 76.7% | 76.7% | 76.7% | 68.7% | 68.1% | 68.1% | 53.2% | 71.9% | 76.5% | 76.5% | 68.7% |
| Economic Value of Canal for Potential Transits ($000s) | 337,276 | 337,276 | 337,276 | 337,276 | 337,276 | 337,276 | 337,276 | 337,276 | 337,276 | 337,276 | 337,276 | 337,276 | 337,276 | 337,276 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 10,571 | 10,571 | 10,571 | 13,783 | 13,783 | 13,783 | 30,313 | 31,798 | 31,798 | 71,610 | 23,876 | 14,027 | 14,027 | 30,313 |
| Forecast Panama Canal Revenues ($000S) | 79,337 | 85,828 | 89,869 | 108,852 | 130,622 | 152,393 | 156,685 | 174,682 | 186,327 | 151,540 | 160,691 | 160,483 | 165,723 | 155,560 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 68 | 71 | 88 | 106 | 124 | 138 | 155 | 166 | 160 | 137 | 131 | 135 | 137 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.53 | 1.65 | 1.73 | 2.16 | 2.59 | 3.03 | 3.47 | 3.90 | 4.16 | 4.34 | 3.40 | 3.19 | 3.30 | 3.45 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,531 | 1,531 | 1,531 | 1,531 | 1,531 | 1,531 | 1,531 | 1,531 | 1,531 | 1,531 | 1,531 | 1,531 | 1,531 | 1,531 |
| Potential Panama Canal Cargo (ton 000s) | 67,253 | 67,253 | 67,253 | 67,253 | 67,253 | 67,253 | 67,253 | 67,253 | 67,253 | 67,253 | 67,253 | 67,253 | 67,253 | 67,253 |
| Forecast Panama Canal Transits (no.) | 1,212 | 1,212 | 1,212 | 1,179 | 1,179 | 1,170 | 1,086 | 1,058 | 978 | 914 | 1,125 | 1,169 | 1,151 | 1,086 |
| Percent of Potential Transits | 79.2% | 79.2% | 79.2% | 77.0% | 77.0% | 76.4% | 70.9% | 69.2% | 63.9% | 59.7% | 73.5% | 76.4% | 75.2% | 70.9% |
| Forecast Panama Canal Cargo (ton 000s) | 51,915 | 51,915 | 51,915 | 50,316 | 50,316 | 49,656 | 44,517 | 42,879 | 38,224 | 34,197 | 46,906 | 49,589 | 48,562 | 44,517 |
| Percent of Potential Cargo | 77.2% | 77.2% | 77.2% | 74.8% | 74.8% | 73.8% | 66.2% | 63.8% | 56.8% | 50.8% | 69.7% | 73.7% | 72.2% | 66.2% |
| Economic Value of Canal for Potential Transits ($000s) | 323,672 | 323,672 | 323,672 | 323,672 | 323,672 | 323,672 | 323,672 | 323,672 | 323,672 | 323,672 | 323,672 | 323,672 | 323,672 | 323,672 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 10,472 | 10,472 | 10,472 | 13,579 | 13,579 | 15,327 | 29,927 | 35,692 | 52,953 | 67,635 | 23,276 | 15,519 | 18,524 | 29,927 |
| Forecast Panama Canal Revenues | 75,493 | 81,664 | 85,507 | 103,535 | 124,242 | 143,108 | 148,025 | 160,443 | 153,840 | 143,682 | 152,238 | 150,709 | 152,511 | 146,889 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 71 | 88 | 105 | 122 | 136 | 152 | 157 | 157 | 135 | 129 | 132 | 135 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.45 | 1.57 | 1.65 | 2.06 | 2.47 | 2.88 | 3.33 | 3.74 | 4.02 | 4.20 | 3.25 | 3.04 | 3.14 | 3.30 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-15 Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2015

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| **Existing Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,577 | 1,577 | 1,577 | 1,577 | 1,577 | 1,577 | 1,577 | 1,577 | 1,577 | 1,577 | 1,577 | 1,577 | 1,577 | 1,577 |
| Potential Panama Canal Cargo (ton 000s) | 66,576 | 66,576 | 66,576 | 66,576 | 66,576 | 66,576 | 66,576 | 66,576 | 66,576 | 66,576 | 66,576 | 66,576 | 66,576 | 66,576 |
| Forecast Panama Canal Transits (no.) | 1,276 | 1,276 | 1,276 | 1,241 | 1,241 | 1,241 | 1,145 | 1,135 | 1,135 | 946 | 1,183 | 1,240 | 1,240 | 1,145 |
| Percent of Potential Transits | 80.9% | 80.9% | 80.9% | 78.7% | 78.7% | 78.7% | 72.6% | 72.0% | 72.0% | 60.0% | 75.0% | 78.6% | 78.6% | 72.6% |
| Forecast Panama Canal Cargo (ton 000s) | 52,669 | 52,669 | 52,669 | 51,055 | 51,055 | 51,055 | 45,781 | 45,394 | 45,394 | 35,049 | 47,865 | 50,978 | 50,978 | 45,781 |
| Percent of Potential Cargo | 79.1% | 79.1% | 79.1% | 76.7% | 76.7% | 76.7% | 68.8% | 68.2% | 68.2% | 52.6% | 71.9% | 76.6% | 76.6% | 68.8% |
| Economic Value of Canal for Potential Transits ($000s) | 340,865 | 340,865 | 340,865 | 340,865 | 340,865 | 340,865 | 340,865 | 340,865 | 340,865 | 340,865 | 340,865 | 340,865 | 340,865 | 340,865 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 10,766 | 10,766 | 10,766 | 13,988 | 13,988 | 13,988 | 30,717 | 32,199 | 32,199 | 74,313 | 24,243 | 14,235 | 14,235 | 30,717 |
| Forecast Panama Canal Revenues ($000S) | 80,337 | 86,907 | 90,995 | 110,261 | 132,314 | 154,366 | 158,794 | 177,064 | 188,868 | 151,955 | 162,782 | 162,752 | 167,967 | 157,653 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 68 | 71 | 89 | 107 | 124 | 139 | 156 | 166 | 161 | 138 | 131 | 136 | 138 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.53 | 1.65 | 1.73 | 2.16 | 2.59 | 3.02 | 3.47 | 3.90 | 4.16 | 4.34 | 3.40 | 3.19 | 3.29 | 3.44 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,559 | 1,559 | 1,559 | 1,559 | 1,559 | 1,559 | 1,559 | 1,559 | 1,559 | 1,559 | 1,559 | 1,559 | 1,559 | 1,559 |
| Potential Panama Canal Cargo (ton 000s) | 68,806 | 68,806 | 68,806 | 68,806 | 68,806 | 68,806 | 68,806 | 68,806 | 68,806 | 68,806 | 68,806 | 68,806 | 68,806 | 68,806 |
| Forecast Panama Canal Transits (no.) | 1,235 | 1,235 | 1,235 | 1,201 | 1,193 | 1,183 | 1,098 | 1,069 | 1,069 | 918 | 1,137 | 1,181 | 1,164 | 1,098 |
| Percent of Potential Transits | 79.2% | 79.2% | 79.2% | 77.1% | 76.5% | 75.9% | 70.4% | 68.6% | 68.6% | 58.9% | 72.9% | 75.8% | 74.7% | 70.4% |
| Forecast Panama Canal Cargo (ton 000s) | 53,155 | 53,155 | 53,155 | 51,556 | 51,075 | 50,327 | 45,154 | 43,431 | 43,431 | 34,296 | 47,547 | 50,260 | 49,244 | 45,154 |
| Percent of Potential Cargo | 77.3% | 77.3% | 77.3% | 74.9% | 74.2% | 73.1% | 65.6% | 63.1% | 63.1% | 49.8% | 69.1% | 73.0% | 71.6% | 65.6% |
| Economic Value of Canal for Potential Transits ($000s) | 328,788 | 328,788 | 328,788 | 328,788 | 328,788 | 328,788 | 328,788 | 328,788 | 328,788 | 328,788 | 328,788 | 328,788 | 328,788 | 328,788 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 10,680 | 10,680 | 10,680 | 13,797 | 14,852 | 16,862 | 31,608 | 37,685 | 37,685 | 71,405 | 24,925 | 17,056 | 20,039 | 31,608 |
| Forecast Panama Canal Revenues | 77,168 | 83,472 | 87,395 | 105,897 | 125,980 | 144,865 | 149,935 | 162,288 | 173,107 | 143,997 | 154,123 | 152,735 | 154,543 | 148,783 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 68 | 71 | 88 | 106 | 123 | 137 | 152 | 162 | 157 | 136 | 129 | 133 | 136 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.45 | 1.57 | 1.64 | 2.05 | 2.47 | 2.88 | 3.32 | 3.74 | 3.99 | 4.20 | 3.24 | 3.04 | 3.14 | 3.29 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-16. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2016

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,604 | 1,604 | 1,604 | 1,604 | 1,604 | 1,604 | 1,604 | 1,604 | 1,604 | 1,604 | 1,604 | 1,604 | 1,604 | 1,604 |
| Potential Panama Canal Cargo (ton 000s) | 67,887 | 67,887 | 67,887 | 67,887 | 67,887 | 67,887 | 67,887 | 67,887 | 67,887 | 67,887 | 67,887 | 67,887 | 67,887 | 67,887 |
| Forecast Panama Canal Transits (no.) | 1,292 | 1,292 | 1,292 | 1,257 | 1,257 | 1,256 | 1,157 | 1,147 | 1,147 | 951 | 1,198 | 1,255 | 1,255 | 1,157 |
| Percent of Potential Transits | 80.6% | 80.6% | 80.6% | 78.4% | 78.4% | 78.3% | 72.2% | 71.5% | 71.5% | 59.3% | 74.7% | 78.3% | 78.3% | 72.2% |
| Forecast Panama Canal Cargo (ton 000s) | 53,507 | 53,507 | 53,507 | 51,889 | 51,838 | 51,831 | 46,362 | 45,955 | 45,955 | 35,226 | 48,601 | 51,752 | 51,752 | 46,362 |
| Percent of Potential Cargo | 78.8% | 78.8% | 78.8% | 76.4% | 76.4% | 76.3% | 68.3% | 67.7% | 67.7% | 51.9% | 71.6% | 76.2% | 76.2% | 68.3% |
| Economic Value of Canal for Potential Transits ($000s) | 346,018 | 346,018 | 346,018 | 346,018 | 346,018 | 346,018 | 346,018 | 346,018 | 346,018 | 346,018 | 346,018 | 346,018 | 346,018 | 346,018 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 11,403 | 11,403 | 11,403 | 14,645 | 14,768 | 14,791 | 32,194 | 33,760 | 33,760 | 77,599 | 25,214 | 15,044 | 15,044 | 32,194 |
| Forecast Panama Canal Revenues ($000S) | 81,573 | 88,240 | 92,388 | 111,995 | 134,267 | 156,621 | 160,721 | 179,148 | 191,091 | 152,638 | 165,162 | 165,182 | 170,437 | 159,574 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 68 | 71 | 89 | 107 | 125 | 139 | 156 | 167 | 161 | 138 | 132 | 136 | 138 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.52 | 1.65 | 1.73 | 2.16 | 2.59 | 3.02 | 3.47 | 3.90 | 4.16 | 4.33 | 3.40 | 3.19 | 3.29 | 3.44 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,595 | 1,595 | 1,595 | 1,595 | 1,595 | 1,595 | 1,595 | 1,595 | 1,595 | 1,595 | 1,595 | 1,595 | 1,595 | 1,595 |
| Potential Panama Canal Cargo (ton 000s) | 70,324 | 70,324 | 70,324 | 70,324 | 70,324 | 70,324 | 70,324 | 70,324 | 70,324 | 70,324 | 70,324 | 70,324 | 70,324 | 70,324 |
| Forecast Panama Canal Transits (no.) | 1,260 | 1,260 | 1,260 | 1,227 | 1,216 | 1,205 | 1,117 | 1,088 | 1,088 | 932 | 1,158 | 1,203 | 1,203 | 1,117 |
| Percent of Potential Transits | 79.0% | 79.0% | 79.0% | 76.9% | 76.3% | 75.5% | 70.0% | 68.2% | 68.2% | 58.5% | 72.6% | 75.5% | 75.5% | 70.0% |
| Forecast Panama Canal Cargo (ton 000s) | 54,166 | 54,166 | 54,166 | 52,563 | 51,937 | 51,135 | 45,794 | 43,996 | 43,996 | 34,637 | 48,324 | 51,067 | 51,067 | 45,794 |
| Percent of Potential Cargo | 77.0% | 77.0% | 77.0% | 74.7% | 73.9% | 72.7% | 65.1% | 62.6% | 62.6% | 49.3% | 68.7% | 72.6% | 72.6% | 65.1% |
| Economic Value of Canal for Potential Transits ($000s) | 336,472 | 336,472 | 336,472 | 336,472 | 336,472 | 336,472 | 336,472 | 336,472 | 336,472 | 336,472 | 336,472 | 336,472 | 336,472 | 336,472 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 11,304 | 11,304 | 11,304 | 14,439 | 15,817 | 17,983 | 33,258 | 39,620 | 39,620 | 74,283 | 26,164 | 18,182 | 18,182 | 33,258 |
| Forecast Panama Canal Revenues | 78,626 | 85,048 | 89,045 | 107,951 | 128,115 | 147,197 | 152,096 | 164,442 | 175,405 | 145,522 | 156,613 | 155,236 | 160,072 | 150,922 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 71 | 88 | 105 | 122 | 136 | 151 | 161 | 156 | 135 | 129 | 133 | 135 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.45 | 1.57 | 1.64 | 2.05 | 2.47 | 2.88 | 3.32 | 3.74 | 3.99 | 4.20 | 3.24 | 3.04 | 3.13 | 3.30 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-17. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2017

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,631 | 1,631 | 1,631 | 1,631 | 1,631 | 1,631 | 1,631 | 1,631 | 1,631 | 1,631 | 1,631 | 1,631 | 1,631 | 1,631 |
| Potential Panama Canal Cargo (ton 000s) | 69,198 | 69,198 | 69,198 | 69,198 | 69,198 | 69,198 | 69,198 | 69,198 | 69,198 | 69,198 | 69,198 | 69,198 | 69,198 | 69,198 |
| Forecast Panama Canal Transits (no.) | 1,310 | 1,310 | 1,310 | 1,275 | 1,273 | 1,273 | 1,170 | 1,159 | 1,159 | 956 | 1,213 | 1,271 | 1,271 | 1,170 |
| Percent of Potential Transits | 80.3% | 80.3% | 80.3% | 78.2% | 78.1% | 78.0% | 71.7% | 71.1% | 71.1% | 58.6% | 74.4% | 77.9% | 77.9% | 71.7% |
| Forecast Panama Canal Cargo (ton 000s) | 54,345 | 54,345 | 54,345 | 52,723 | 52,621 | 52,606 | 46,943 | 46,515 | 46,515 | 35,404 | 49,336 | 52,526 | 52,526 | 46,943 |
| Percent of Potential Cargo | 78.5% | 78.5% | 78.5% | 76.2% | 76.0% | 76.0% | 67.8% | 67.2% | 67.2% | 51.2% | 71.3% | 75.9% | 75.9% | 67.8% |
| Economic Value of Canal for Potential Transits ($000s) | 351,453 | 351,453 | 351,453 | 351,453 | 351,453 | 351,453 | 351,453 | 351,453 | 351,453 | 351,453 | 351,453 | 351,453 | 351,453 | 351,453 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 12,046 | 12,046 | 12,046 | 15,308 | 15,556 | 15,601 | 33,684 | 35,333 | 35,333 | 80,910 | 26,193 | 15,860 | 15,860 | 33,684 |
| Forecast Panama Canal Revenues ($000S) | 82,836 | 89,604 | 93,814 | 113,769 | 136,268 | 158,931 | 162,710 | 181,303 | 193,390 | 153,403 | 167,604 | 167,671 | 172,967 | 161,557 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 68 | 72 | 89 | 107 | 125 | 139 | 156 | 167 | 160 | 138 | 132 | 136 | 138 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.52 | 1.65 | 1.73 | 2.16 | 2.59 | 3.02 | 3.47 | 3.90 | 4.16 | 4.33 | 3.40 | 3.19 | 3.29 | 3.44 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,633 | 1,633 | 1,633 | 1,633 | 1,633 | 1,633 | 1,633 | 1,633 | 1,633 | 1,633 | 1,633 | 1,633 | 1,633 | 1,633 |
| Potential Panama Canal Cargo (ton 000s) | 71,842 | 71,842 | 71,842 | 71,842 | 71,842 | 71,842 | 71,842 | 71,842 | 71,842 | 71,842 | 71,842 | 71,842 | 71,842 | 71,842 |
| Forecast Panama Canal Transits (no.) | 1,288 | 1,288 | 1,288 | 1,255 | 1,242 | 1,231 | 1,139 | 1,108 | 1,108 | 949 | 1,182 | 1,228 | 1,228 | 1,139 |
| Percent of Potential Transits | 78.9% | 78.9% | 78.9% | 76.8% | 76.1% | 75.4% | 69.7% | 67.9% | 67.9% | 58.1% | 72.4% | 75.2% | 75.2% | 69.7% |
| Forecast Panama Canal Cargo (ton 000s) | 55,177 | 55,177 | 55,177 | 53,570 | 52,798 | 52,127 | 46,433 | 44,560 | 44,560 | 34,978 | 49,101 | 51,874 | 51,874 | 46,433 |
| Percent of Potential Cargo | 76.8% | 76.8% | 76.8% | 74.6% | 73.5% | 72.6% | 64.6% | 62.0% | 62.0% | 48.7% | 68.3% | 72.2% | 72.2% | 64.6% |
| Economic Value of Canal for Potential Transits ($000s) | 344,730 | 344,730 | 344,730 | 344,730 | 344,730 | 344,730 | 344,730 | 344,730 | 344,730 | 344,730 | 344,730 | 344,730 | 344,730 | 344,730 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 11,932 | 11,932 | 11,932 | 15,088 | 16,791 | 18,612 | 34,921 | 41,571 | 41,571 | 77,183 | 27,413 | 19,316 | 19,316 | 34,921 |
| Forecast Panama Canal Revenues | 80,103 | 86,646 | 90,718 | 110,033 | 130,284 | 150,072 | 154,304 | 166,648 | 177,758 | 147,110 | 159,147 | 157,780 | 162,656 | 153,107 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 70 | 88 | 105 | 122 | 135 | 150 | 160 | 155 | 135 | 128 | 132 | 134 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.45 | 1.57 | 1.64 | 2.05 | 2.47 | 2.88 | 3.32 | 3.74 | 3.99 | 4.21 | 3.24 | 3.04 | 3.14 | 3.30 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-18. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2018

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,661 | 1,661 | 1,661 | 1,661 | 1,661 | 1,661 | 1,661 | 1,661 | 1,661 | 1,661 | 1,661 | 1,661 | 1,661 | 1,661 |
| Potential Panama Canal Cargo (ton 000s) | 70,509 | 70,509 | 70,509 | 70,509 | 70,509 | 70,509 | 70,509 | 70,509 | 70,509 | 70,509 | 70,509 | 70,509 | 70,509 | 70,509 |
| Forecast Panama Canal Transits (no.) | 1,330 | 1,330 | 1,330 | 1,308 | 1,292 | 1,292 | 1,186 | 1,174 | 1,174 | 1,074 | 1,232 | 1,290 | 1,290 | 1,186 |
| Percent of Potential Transits | 80.1% | 80.1% | 80.1% | 78.8% | 77.8% | 77.8% | 71.4% | 70.7% | 70.7% | 64.7% | 74.2% | 77.7% | 77.7% | 71.4% |
| Forecast Panama Canal Cargo (ton 000s) | 55,183 | 55,183 | 55,183 | 54,085 | 53,405 | 53,382 | 47,546 | 47,076 | 47,076 | 41,519 | 50,094 | 53,301 | 53,301 | 47,546 |
| Percent of Potential Cargo | 78.3% | 78.3% | 78.3% | 76.7% | 75.7% | 75.7% | 67.4% | 66.8% | 66.8% | 58.9% | 71.0% | 75.6% | 75.6% | 67.4% |
| Economic Value of Canal for Potential Transits ($000s) | 357,475 | 357,475 | 357,475 | 357,475 | 357,475 | 357,475 | 357,475 | 357,475 | 357,475 | 357,475 | 357,475 | 357,475 | 357,475 | 357,475 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 12,694 | 12,694 | 12,694 | 14,778 | 16,351 | 16,419 | 35,112 | 36,921 | 36,921 | 59,902 | 27,106 | 16,681 | 16,681 | 35,112 |
| Forecast Panama Canal Revenues ($000S) | 84,120 | 90,991 | 95,264 | 116,769 | 138,307 | 161,286 | 164,824 | 183,515 | 195,749 | 178,572 | 170,170 | 170,207 | 175,546 | 163,664 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 68 | 72 | 89 | 107 | 125 | 139 | 156 | 167 | 166 | 138 | 132 | 136 | 138 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.52 | 1.65 | 1.73 | 2.16 | 2.59 | 3.02 | 3.47 | 3.90 | 4.16 | 4.30 | 3.40 | 3.19 | 3.29 | 3.44 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 | 1,672 |
| Potential Panama Canal Cargo (ton 000s) | 73,360 | 73,360 | 73,360 | 73,360 | 73,360 | 73,360 | 73,360 | 73,360 | 73,360 | 73,360 | 73,360 | 73,360 | 73,360 | 73,360 |
| Forecast Panama Canal Transits (no.) | 1,317 | 1,317 | 1,317 | 1,297 | 1,268 | 1,257 | 1,162 | 1,129 | 1,129 | 1,042 | 1,208 | 1,253 | 1,253 | 1,162 |
| Percent of Potential Transits | 78.8% | 78.8% | 78.8% | 77.6% | 75.9% | 75.2% | 69.5% | 67.6% | 67.6% | 62.3% | 72.2% | 75.0% | 75.0% | 69.5% |
| Forecast Panama Canal Cargo (ton 000s) | 56,188 | 56,188 | 56,188 | 55,102 | 53,660 | 52,939 | 47,091 | 45,123 | 45,123 | 40,000 | 49,898 | 52,681 | 52,681 | 47,091 |
| Percent of Potential Cargo | 76.6% | 76.6% | 76.6% | 75.1% | 73.1% | 72.2% | 64.2% | 61.5% | 61.5% | 54.5% | 68.0% | 71.8% | 71.8% | 64.2% |
| Economic Value of Canal for Potential Transits ($000s) | 353,203 | 353,203 | 353,203 | 353,203 | 353,203 | 353,203 | 353,203 | 353,203 | 353,203 | 353,203 | 353,203 | 353,203 | 353,203 | 353,203 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 12,566 | 12,566 | 12,566 | 14,549 | 17,774 | 19,739 | 36,534 | 43,541 | 43,541 | 62,864 | 28,608 | 20,460 | 20,460 | 36,534 |
| Forecast Panama Canal Revenues | 81,585 | 88,247 | 92,395 | 113,311 | 132,460 | 152,465 | 156,586 | 168,863 | 180,121 | 165,917 | 161,757 | 160,334 | 165,249 | 155,366 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 70 | 87 | 104 | 121 | 135 | 150 | 159 | 159 | 134 | 128 | 132 | 134 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.45 | 1.57 | 1.64 | 2.06 | 2.47 | 2.88 | 3.33 | 3.74 | 3.99 | 4.15 | 3.24 | 3.04 | 3.14 | 3.30 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-19. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2019

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,691 | 1,691 | 1,691 | 1,691 | 1,691 | 1,691 | 1,691 | 1,691 | 1,691 | 1,691 | 1,691 | 1,691 | 1,691 | 1,691 |
| Potential Panama Canal Cargo (ton 000s) | 71,819 | 71,819 | 71,819 | 71,819 | 71,819 | 71,819 | 71,819 | 71,819 | 71,819 | 71,819 | 71,819 | 71,819 | 71,819 | 71,819 |
| Forecast Panama Canal Transits (no.) | 1,350 | 1,350 | 1,350 | 1,329 | 1,311 | 1,311 | 1,201 | 1,189 | 1,189 | 1,189 | 1,250 | 1,309 | 1,309 | 1,201 |
| Percent of Potential Transits | 79.8% | 79.8% | 79.8% | 78.6% | 77.5% | 77.5% | 71.0% | 70.3% | 70.3% | 70.3% | 73.9% | 77.4% | 77.4% | 71.0% |
| Forecast Panama Canal Cargo (ton 000s) | 56,021 | 56,021 | 56,021 | 54,915 | 54,188 | 54,157 | 48,127 | 47,637 | 47,637 | 47,637 | 50,830 | 54,075 | 54,075 | 48,127 |
| Percent of Potential Cargo | 78.0% | 78.0% | 78.0% | 76.5% | 75.4% | 75.4% | 67.0% | 66.3% | 66.3% | 66.3% | 70.8% | 75.3% | 75.3% | 67.0% |
| Economic Value of Canal for Potential Transits ($000s) | 363,618 | 363,618 | 363,618 | 363,618 | 363,618 | 363,618 | 363,618 | 363,618 | 363,618 | 363,618 | 363,618 | 363,618 | 363,618 | 363,618 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 13,349 | 13,349 | 13,349 | 15,456 | 17,153 | 17,244 | 36,630 | 38,523 | 38,523 | 38,523 | 28,102 | 17,512 | 17,512 | 36,630 |
| Forecast Panama Canal Revenues ($000S) | 85,406 | 92,380 | 96,717 | 118,569 | 140,348 | 163,644 | 166,867 | 185,732 | 198,114 | 203,987 | 172,666 | 172,746 | 178,127 | 165,700 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 68 | 72 | 89 | 107 | 125 | 139 | 156 | 167 | 172 | 138 | 132 | 136 | 138 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.52 | 1.65 | 1.73 | 2.16 | 2.59 | 3.02 | 3.47 | 3.90 | 4.16 | 4.28 | 3.40 | 3.19 | 3.29 | 3.44 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,711 | 1,711 | 1,711 | 1,711 | 1,711 | 1,711 | 1,711 | 1,711 | 1,711 | 1,711 | 1,711 | 1,711 | 1,711 | 1,711 |
| Potential Panama Canal Cargo (ton 000s) | 74,878 | 74,878 | 74,878 | 74,878 | 74,878 | 74,878 | 74,878 | 74,878 | 74,878 | 74,878 | 74,878 | 74,878 | 74,878 | 74,878 |
| Forecast Panama Canal Transits (no.) | 1,347 | 1,347 | 1,347 | 1,326 | 1,295 | 1,283 | 1,185 | 1,152 | 1,152 | 1,063 | 1,233 | 1,279 | 1,279 | 1,185 |
| Percent of Potential Transits | 78.7% | 78.7% | 78.7% | 77.5% | 75.7% | 75.0% | 69.3% | 67.3% | 67.3% | 62.1% | 72.1% | 74.8% | 74.8% | 69.3% |
| Forecast Panama Canal Cargo (ton 000s) | 57,199 | 57,199 | 57,199 | 56,105 | 54,521 | 53,751 | 47,730 | 45,686 | 45,686 | 40,524 | 50,675 | 53,488 | 53,488 | 47,730 |
| Percent of Potential Cargo | 76.4% | 76.4% | 76.4% | 74.9% | 72.8% | 71.8% | 63.7% | 61.0% | 61.0% | 54.1% | 67.7% | 71.4% | 71.4% | 63.7% |
| Economic Value of Canal for Potential Transits ($000s) | 361,897 | 361,897 | 361,897 | 361,897 | 361,897 | 361,897 | 361,897 | 361,897 | 361,897 | 361,897 | 361,897 | 361,897 | 361,897 | 361,897 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 13,206 | 13,206 | 13,206 | 15,213 | 18,766 | 20,877 | 38,227 | 45,531 | 45,531 | 65,075 | 29,880 | 21,616 | 21,616 | 38,227 |
| Forecast Panama Canal Revenues | 83,070 | 89,854 | 94,077 | 115,398 | 134,643 | 154,866 | 158,812 | 171,088 | 182,494 | 168,202 | 164,310 | 162,894 | 167,849 | 157,570 |
| Average Toll Revenue per Forecasted Transit ($000) | 62 | 67 | 70 | 87 | 104 | 121 | 134 | 149 | 158 | 158 | 133 | 127 | 131 | 133 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.45 | 1.57 | 1.64 | 2.06 | 2.47 | 2.88 | 3.33 | 3.74 | 3.99 | 4.15 | 3.24 | 3.05 | 3.14 | 3.30 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-20. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2020

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,722 | 1,722 | 1,722 | 1,722 | 1,722 | 1,722 | 1,722 | 1,722 | 1,722 | 1,722 | 1,722 | 1,722 | 1,722 | 1,722 |
| Potential Panama Canal Cargo (ton 000s) | 73,130 | 73,130 | 73,130 | 73,130 | 73,130 | 73,130 | 73,130 | 73,130 | 73,130 | 73,130 | 73,130 | 73,130 | 73,130 | 73,130 |
| Forecast Panama Canal Transits (no.) | 1,371 | 1,371 | 1,371 | 1,349 | 1,331 | 1,330 | 1,217 | 1,204 | 1,204 | 1,204 | 1,269 | 1,329 | 1,329 | 1,217 |
| Percent of Potential Transits | 79.6% | 79.6% | 79.6% | 78.4% | 77.3% | 77.3% | 70.7% | 69.9% | 69.9% | 69.9% | 73.7% | 77.2% | 77.2% | 70.7% |
| Forecast Panama Canal Cargo (ton 000s) | 56,859 | 56,859 | 56,859 | 55,746 | 54,971 | 54,933 | 48,708 | 48,198 | 48,198 | 48,198 | 51,566 | 54,850 | 54,850 | 48,708 |
| Percent of Potential Cargo | 77.8% | 77.8% | 77.8% | 76.2% | 75.2% | 75.1% | 66.6% | 65.9% | 65.9% | 65.9% | 70.5% | 75.0% | 75.0% | 66.6% |
| Economic Value of Canal for Potential Transits ($000s) | 369,893 | 369,893 | 369,893 | 369,893 | 369,893 | 369,893 | 369,893 | 369,893 | 369,893 | 369,893 | 369,893 | 369,893 | 369,893 | 369,893 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 14,010 | 14,010 | 14,010 | 16,140 | 17,964 | 18,078 | 38,164 | 40,141 | 40,141 | 40,141 | 29,108 | 18,351 | 18,351 | 38,164 |
| Forecast Panama Canal Revenues ($000S) | 86,693 | 93,771 | 98,172 | 120,373 | 142,393 | 166,006 | 168,913 | 187,954 | 200,484 | 206,412 | 175,166 | 175,288 | 180,713 | 167,739 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 68 | 72 | 89 | 107 | 125 | 139 | 156 | 166 | 171 | 138 | 132 | 136 | 138 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.52 | 1.65 | 1.73 | 2.16 | 2.59 | 3.02 | 3.47 | 3.90 | 4.16 | 4.28 | 3.40 | 3.20 | 3.29 | 3.44 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,752 | 1,752 | 1,752 | 1,752 | 1,752 | 1,752 | 1,752 | 1,752 | 1,752 | 1,752 | 1,752 | 1,752 | 1,752 | 1,752 |
| Potential Panama Canal Cargo (ton 000s) | 77,532 | 77,532 | 77,532 | 77,532 | 77,532 | 77,532 | 77,532 | 77,532 | 77,532 | 77,532 | 77,532 | 77,532 | 77,532 | 77,532 |
| Forecast Panama Canal Transits (no.) | 1,377 | 1,377 | 1,377 | 1,356 | 1,343 | 1,312 | 1,240 | 1,185 | 1,175 | 1,175 | 1,290 | 1,307 | 1,307 | 1,290 |
| Percent of Potential Transits | 78.6% | 78.6% | 78.6% | 77.4% | 76.7% | 74.9% | 70.8% | 67.6% | 67.1% | 67.1% | 73.7% | 74.6% | 74.6% | 73.7% |
| Forecast Panama Canal Cargo (ton 000s) | 59,141 | 59,141 | 59,141 | 58,040 | 57,522 | 55,639 | 51,061 | 47,747 | 46,930 | 46,930 | 54,217 | 55,215 | 55,215 | 54,217 |
| Percent of Potential Cargo | 76.3% | 76.3% | 76.3% | 74.9% | 74.2% | 71.8% | 65.9% | 61.6% | 60.5% | 60.5% | 69.9% | 71.2% | 71.2% | 69.9% |
| Economic Value of Canal for Potential Transits ($000s) | 374,684 | 374,684 | 374,684 | 374,684 | 374,684 | 374,684 | 374,684 | 374,684 | 374,684 | 374,684 | 374,684 | 374,684 | 374,684 | 374,684 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 13,971 | 13,971 | 13,971 | 16,001 | 17,188 | 21,731 | 34,865 | 45,528 | 48,387 | 48,387 | 25,887 | 22,904 | 22,904 | 25,887 |
| Forecast Panama Canal Revenues | 84,560 | 91,465 | 95,765 | 117,492 | 139,581 | 157,817 | 166,780 | 176,156 | 184,879 | 190,412 | 172,604 | 165,607 | 170,601 | 174,334 |
| Average Toll Revenue per Forecasted Transit ($000) | 61 | 66 | 70 | 87 | 104 | 120 | 135 | 149 | 157 | 162 | 134 | 127 | 131 | 135 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.43 | 1.55 | 1.62 | 2.02 | 2.43 | 2.84 | 3.27 | 3.69 | 3.94 | 4.06 | 3.18 | 3.00 | 3.09 | 3.22 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-21. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2021

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| **Existing Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,747 | 1,747 | 1,747 | 1,747 | 1,747 | 1,747 | 1,747 | 1,747 | 1,747 | 1,747 | 1,747 | 1,747 | 1,747 | 1,747 |
| Potential Panama Canal Cargo (ton 000s) | 74,350 | 74,350 | 74,350 | 74,350 | 74,350 | 74,350 | 74,350 | 74,350 | 74,350 | 74,350 | 74,350 | 74,350 | 74,350 | 74,350 |
| Forecast Panama Canal Transits (no.) | 1,379 | 1,379 | 1,379 | 1,358 | 1,338 | 1,337 | 1,223 | 1,210 | 1,210 | 1,210 | 1,275 | 1,335 | 1,335 | 1,275 |
| Percent of Potential Transits | 79.0% | 79.0% | 79.0% | 77.7% | 76.6% | 76.5% | 70.0% | 69.2% | 69.2% | 69.2% | 73.0% | 76.4% | 76.4% | 73.0% |
| Forecast Panama Canal Cargo (ton 000s) | 57,275 | 57,275 | 57,275 | 56,155 | 55,286 | 55,235 | 48,953 | 48,445 | 48,445 | 48,445 | 51,829 | 55,151 | 55,151 | 51,829 |
| Percent of Potential Cargo | 77.0% | 77.0% | 77.0% | 75.5% | 74.4% | 74.3% | 65.8% | 65.2% | 65.2% | 65.2% | 69.7% | 74.2% | 74.2% | 69.7% |
| Economic Value of Canal for Potential Transits ($000s) | 373,666 | 373,666 | 373,666 | 373,666 | 373,666 | 373,666 | 373,666 | 373,666 | 373,666 | 373,666 | 373,666 | 373,666 | 373,666 | 373,666 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 14,907 | 14,907 | 14,907 | 17,061 | 19,125 | 19,282 | 39,634 | 41,615 | 41,615 | 41,615 | 30,484 | 19,558 | 19,558 | 30,484 |
| Forecast Panama Canal Revenues ($000S) | 87,326 | 94,453 | 98,883 | 121,247 | 143,208 | 166,913 | 169,761 | 188,912 | 201,506 | 207,446 | 176,064 | 176,293 | 181,728 | 177,721 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 68 | 72 | 89 | 107 | 125 | 139 | 156 | 167 | 171 | 138 | 132 | 136 | 139 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.52 | 1.65 | 1.73 | 2.16 | 2.59 | 3.02 | 3.47 | 3.90 | 4.16 | 4.28 | 3.40 | 3.20 | 3.30 | 3.43 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,782 | 1,782 | 1,782 | 1,782 | 1,782 | 1,782 | 1,782 | 1,782 | 1,782 | 1,782 | 1,782 | 1,782 | 1,782 | 1,782 |
| Potential Panama Canal Cargo (ton 000s) | 78,811 | 78,811 | 78,811 | 78,811 | 78,811 | 78,811 | 78,811 | 78,811 | 78,811 | 78,811 | 78,811 | 78,811 | 78,811 | 78,811 |
| Forecast Panama Canal Transits (no.) | 1,394 | 1,394 | 1,394 | 1,373 | 1,360 | 1,326 | 1,270 | 1,208 | 1,187 | 1,187 | 1,321 | 1,321 | 1,321 | 1,321 |
| Percent of Potential Transits | 78.2% | 78.2% | 78.2% | 77.1% | 76.3% | 74.4% | 71.3% | 67.8% | 66.6% | 66.6% | 74.1% | 74.1% | 74.1% | 74.1% |
| Forecast Panama Canal Cargo (ton 000s) | 59,748 | 59,748 | 59,748 | 58,640 | 58,125 | 56,037 | 52,461 | 48,913 | 47,236 | 47,236 | 55,630 | 55,630 | 55,630 | 55,630 |
| Percent of Potential Cargo | 75.8% | 75.8% | 75.8% | 74.4% | 73.8% | 71.1% | 66.6% | 62.1% | 59.9% | 59.9% | 70.6% | 70.6% | 70.6% | 70.6% |
| Economic Value of Canal for Potential Transits ($000s) | 381,348 | 381,348 | 381,348 | 381,348 | 381,348 | 381,348 | 381,348 | 381,348 | 381,348 | 381,348 | 381,348 | 381,348 | 381,348 | 381,348 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 15,296 | 15,296 | 15,296 | 17,349 | 18,535 | 23,577 | 33,755 | 44,754 | 50,627 | 50,627 | 24,702 | 24,702 | 24,702 | 24,702 |
| Forecast Panama Canal Revenues | 85,422 | 92,396 | 96,739 | 118,694 | 141,032 | 158,965 | 171,092 | 180,318 | 186,122 | 191,678 | 176,913 | 166,908 | 171,911 | 178,665 |
| Average Toll Revenue per Forecasted Transit ($000) | 61 | 66 | 69 | 86 | 104 | 120 | 135 | 149 | 157 | 162 | 134 | 126 | 130 | 135 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.43 | 1.55 | 1.62 | 2.02 | 2.43 | 2.84 | 3.26 | 3.69 | 3.94 | 4.06 | 3.18 | 3.00 | 3.09 | 3.21 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-22. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2022

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,773 | 1,773 | 1,773 | 1,773 | 1,773 | 1,773 | 1,773 | 1,773 | 1,773 | 1,773 | 1,773 | 1,773 | 1,773 | 1,773 |
| Potential Panama Canal Cargo (ton 000s) | 75,570 | 75,570 | 75,570 | 75,570 | 75,570 | 75,570 | 75,570 | 75,570 | 75,570 | 75,570 | 75,570 | 75,570 | 75,570 | 75,570 |
| Forecast Panama Canal Transits (no.) | 1,388 | 1,388 | 1,388 | 1,366 | 1,345 | 1,343 | 1,228 | 1,215 | 1,215 | 1,215 | 1,281 | 1,342 | 1,342 | 1,281 |
| Percent of Potential Transits | 78.3% | 78.3% | 78.3% | 77.1% | 75.9% | 75.8% | 69.3% | 68.6% | 68.6% | 68.6% | 72.2% | 75.7% | 75.7% | 72.2% |
| Forecast Panama Canal Cargo (ton 000s) | 57,692 | 57,692 | 57,692 | 56,564 | 55,602 | 55,537 | 49,199 | 48,692 | 48,692 | 48,692 | 52,092 | 55,452 | 55,452 | 52,092 |
| Percent of Potential Cargo | 76.3% | 76.3% | 76.3% | 74.9% | 73.6% | 73.5% | 65.1% | 64.4% | 64.4% | 64.4% | 68.9% | 73.4% | 73.4% | 68.9% |
| Economic Value of Canal for Potential Transits ($000s) | 377,540 | 377,540 | 377,540 | 377,540 | 377,540 | 377,540 | 377,540 | 377,540 | 377,540 | 377,540 | 377,540 | 377,540 | 377,540 | 377,540 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 15,813 | 15,813 | 15,813 | 17,990 | 20,297 | 20,497 | 41,119 | 43,104 | 43,104 | 43,104 | 31,874 | 20,777 | 20,777 | 31,874 |
| Forecast Panama Canal Revenues ($000S) | 87,960 | 95,136 | 99,596 | 122,123 | 144,026 | 167,823 | 170,612 | 189,874 | 202,532 | 208,484 | 176,965 | 177,300 | 182,746 | 178,626 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 69 | 72 | 89 | 107 | 125 | 139 | 156 | 167 | 172 | 138 | 132 | 136 | 139 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.52 | 1.65 | 1.73 | 2.16 | 2.59 | 3.02 | 3.47 | 3.90 | 4.16 | 4.28 | 3.40 | 3.20 | 3.30 | 3.43 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,813 | 1,813 | 1,813 | 1,813 | 1,813 | 1,813 | 1,813 | 1,813 | 1,813 | 1,813 | 1,813 | 1,813 | 1,813 | 1,813 |
| Potential Panama Canal Cargo (ton 000s) | 80,090 | 80,090 | 80,090 | 80,090 | 80,090 | 80,090 | 80,090 | 80,090 | 80,090 | 80,090 | 80,090 | 80,090 | 80,090 | 80,090 |
| Forecast Panama Canal Transits (no.) | 1,411 | 1,411 | 1,411 | 1,391 | 1,377 | 1,340 | 1,284 | 1,222 | 1,199 | 1,199 | 1,334 | 1,337 | 1,334 | 1,334 |
| Percent of Potential Transits | 77.9% | 77.9% | 77.9% | 76.7% | 76.0% | 73.9% | 70.8% | 67.4% | 66.2% | 66.2% | 73.6% | 73.7% | 73.6% | 73.6% |
| Forecast Panama Canal Cargo (ton 000s) | 60,356 | 60,356 | 60,356 | 59,241 | 58,729 | 56,436 | 52,837 | 49,262 | 47,542 | 47,542 | 56,020 | 56,223 | 56,020 | 56,020 |
| Percent of Potential Cargo | 75.4% | 75.4% | 75.4% | 74.0% | 73.3% | 70.5% | 66.0% | 61.5% | 59.4% | 59.4% | 69.9% | 70.2% | 69.9% | 69.9% |
| Economic Value of Canal for Potential Transits ($000s) | 388,205 | 388,205 | 388,205 | 388,205 | 388,205 | 388,205 | 388,205 | 388,205 | 388,205 | 388,205 | 388,205 | 388,205 | 388,205 | 388,205 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 16,633 | 16,633 | 16,633 | 18,710 | 19,894 | 25,440 | 35,723 | 46,847 | 52,890 | 52,890 | 26,593 | 26,030 | 26,593 | 26,593 |
| Forecast Panama Canal Revenues | 86,287 | 93,330 | 97,716 | 119,900 | 142,488 | 160,119 | 172,346 | 181,638 | 187,375 | 192,953 | 178,163 | 168,703 | 173,152 | 179,936 |
| Average Toll Revenue per Forecasted Transit ($000) | 61 | 66 | 69 | 86 | 103 | 120 | 134 | 149 | 156 | 161 | 134 | 126 | 130 | 135 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.43 | 1.55 | 1.62 | 2.02 | 2.43 | 2.84 | 3.26 | 3.69 | 3.94 | 4.06 | 3.18 | 3.00 | 3.09 | 3.21 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-23. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2023

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| **Existing Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,799 | 1,799 | 1,799 | 1,799 | 1,799 | 1,799 | 1,799 | 1,799 | 1,799 | 1,799 | 1,799 | 1,799 | 1,799 | 1,799 |
| Potential Panama Canal Cargo (ton 000s) | 76,790 | 76,790 | 76,790 | 76,790 | 76,790 | 76,790 | 76,790 | 76,790 | 76,790 | 76,790 | 76,790 | 76,790 | 76,790 | 76,790 |
| Forecast Panama Canal Transits (no.) | 1,397 | 1,397 | 1,397 | 1,375 | 1,356 | 1,350 | 1,234 | 1,221 | 1,221 | 1,221 | 1,287 | 1,349 | 1,349 | 1,287 |
| Percent of Potential Transits | 77.7% | 77.7% | 77.7% | 76.4% | 75.4% | 75.0% | 68.6% | 67.9% | 67.9% | 67.9% | 71.5% | 75.0% | 75.0% | 71.5% |
| Forecast Panama Canal Cargo (ton 000s) | 58,108 | 58,108 | 58,108 | 56,974 | 56,147 | 55,838 | 49,445 | 48,938 | 48,938 | 48,938 | 52,355 | 55,753 | 55,753 | 52,355 |
| Percent of Potential Cargo | 75.7% | 75.7% | 75.7% | 74.2% | 73.1% | 72.7% | 64.4% | 63.7% | 63.7% | 63.7% | 68.2% | 72.6% | 72.6% | 68.2% |
| Economic Value of Canal for Potential Transits ($000s) | 381,508 | 381,508 | 381,508 | 381,508 | 381,508 | 381,508 | 381,508 | 381,508 | 381,508 | 381,508 | 381,508 | 381,508 | 381,508 | 381,508 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 16,727 | 16,727 | 16,727 | 18,928 | 20,909 | 21,724 | 42,619 | 44,608 | 44,608 | 44,608 | 33,278 | 22,008 | 22,008 | 33,278 |
| Forecast Panama Canal Revenues ($000S) | 88,595 | 95,820 | 100,310 | 123,001 | 145,418 | 168,736 | 171,466 | 190,839 | 203,562 | 209,525 | 177,868 | 178,310 | 183,767 | 179,534 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 69 | 72 | 89 | 107 | 125 | 139 | 156 | 167 | 172 | 138 | 132 | 136 | 139 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.52 | 1.65 | 1.73 | 2.16 | 2.59 | 3.02 | 3.47 | 3.90 | 4.16 | 4.28 | 3.40 | 3.20 | 3.30 | 3.43 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,845 | 1,845 | 1,845 | 1,845 | 1,845 | 1,845 | 1,845 | 1,845 | 1,845 | 1,845 | 1,845 | 1,845 | 1,845 | 1,845 |
| Potential Panama Canal Cargo (ton 000s) | 81,369 | 81,369 | 81,369 | 81,369 | 81,369 | 81,369 | 81,369 | 81,369 | 81,369 | 81,369 | 81,369 | 81,369 | 81,369 | 81,369 |
| Forecast Panama Canal Transits (no.) | 1,430 | 1,430 | 1,430 | 1,409 | 1,395 | 1,354 | 1,298 | 1,235 | 1,213 | 1,213 | 1,349 | 1,352 | 1,349 | 1,349 |
| Percent of Potential Transits | 77.5% | 77.5% | 77.5% | 76.4% | 75.6% | 73.4% | 70.4% | 67.0% | 65.7% | 65.7% | 73.1% | 73.3% | 73.1% | 73.1% |
| Forecast Panama Canal Cargo (ton 000s) | 60,964 | 60,964 | 60,964 | 59,842 | 59,333 | 56,835 | 53,213 | 49,610 | 47,848 | 47,848 | 56,410 | 56,617 | 56,410 | 56,410 |
| Percent of Potential Cargo | 74.9% | 74.9% | 74.9% | 73.5% | 72.9% | 69.8% | 65.4% | 61.0% | 58.8% | 58.8% | 69.3% | 69.6% | 69.3% | 69.3% |
| Economic Value of Canal for Potential Transits ($000s) | 395,256 | 395,256 | 395,256 | 395,256 | 395,256 | 395,256 | 395,256 | 395,256 | 395,256 | 395,256 | 395,256 | 395,256 | 395,256 | 395,256 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 17,983 | 17,983 | 17,983 | 20,083 | 21,266 | 27,320 | 37,709 | 48,959 | 55,175 | 55,175 | 28,502 | 27,924 | 28,502 | 28,502 |
| Forecast Panama Canal Revenues | 87,155 | 94,267 | 98,698 | 121,112 | 143,950 | 161,282 | 173,608 | 182,968 | 188,638 | 194,237 | 179,421 | 169,956 | 174,402 | 181,216 |
| Average Toll Revenue per Forecasted Transit ($000) | 61 | 66 | 69 | 86 | 103 | 119 | 134 | 148 | 156 | 160 | 133 | 126 | 129 | 134 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.43 | 1.55 | 1.62 | 2.02 | 2.43 | 2.84 | 3.26 | 3.69 | 3.94 | 4.06 | 3.18 | 3.00 | 3.09 | 3.21 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-24. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2024

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| **Existing Canal** | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| Potential Panama Canal Transits (no.) | 1,825 | 1,825 | 1,825 | 1,825 | 1,825 | 1,825 | 1,825 | 1,825 | 1,825 | 1,825 | 1,825 | 1,825 | 1,825 | 1,825 |
| Potential Panama Canal Cargo (ton 000s) | 78,011 | 78,011 | 78,011 | 78,011 | 78,011 | 78,011 | 78,011 | 78,011 | 78,011 | 78,011 | 78,011 | 78,011 | 78,011 | 78,011 |
| Forecast Panama Canal Transits (no.) | 1,407 | 1,407 | 1,407 | 1,385 | 1,371 | 1,357 | 1,241 | 1,228 | 1,228 | 1,228 | 1,294 | 1,356 | 1,356 | 1,294 |
| Percent of Potential Transits | 77.1% | 77.1% | 77.1% | 75.9% | 75.1% | 74.4% | 68.0% | 67.3% | 67.3% | 67.3% | 70.9% | 74.3% | 74.3% | 70.9% |
| Forecast Panama Canal Cargo (ton 000s) | 58,524 | 58,524 | 58,524 | 57,383 | 56,874 | 56,140 | 49,690 | 49,185 | 49,185 | 49,185 | 52,618 | 56,054 | 56,054 | 52,618 |
| Percent of Potential Cargo | 75.0% | 75.0% | 75.0% | 73.6% | 72.9% | 72.0% | 63.7% | 63.0% | 63.0% | 63.0% | 67.5% | 71.9% | 71.9% | 67.5% |
| Economic Value of Canal for Potential Transits ($000s) | 385,582 | 385,582 | 385,582 | 385,582 | 385,582 | 385,582 | 385,582 | 385,582 | 385,582 | 385,582 | 385,582 | 385,582 | 385,582 | 385,582 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 17,651 | 17,651 | 17,651 | 19,876 | 21,066 | 22,964 | 44,135 | 46,130 | 46,130 | 46,130 | 34,698 | 23,251 | 23,251 | 34,698 |
| Forecast Panama Canal Revenues ($000S) | 89,231 | 96,506 | 101,026 | 123,882 | 147,273 | 169,651 | 172,323 | 191,808 | 204,595 | 210,570 | 178,775 | 179,322 | 184,791 | 180,445 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 69 | 72 | 89 | 107 | 125 | 139 | 156 | 167 | 172 | 138 | 132 | 136 | 139 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.52 | 1.65 | 1.73 | 2.16 | 2.59 | 3.02 | 3.47 | 3.90 | 4.16 | 4.28 | 3.40 | 3.20 | 3.30 | 3.43 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,877 | 1,877 | 1,877 | 1,877 | 1,877 | 1,877 | 1,877 | 1,877 | 1,877 | 1,877 | 1,877 | 1,877 | 1,877 | 1,877 |
| Potential Panama Canal Cargo (ton 000s) | 82,648 | 82,648 | 82,648 | 82,648 | 82,648 | 82,648 | 82,648 | 82,648 | 82,648 | 82,648 | 82,648 | 82,648 | 82,648 | 82,648 |
| Forecast Panama Canal Transits (no.) | 1,448 | 1,448 | 1,448 | 1,427 | 1,414 | 1,373 | 1,313 | 1,250 | 1,227 | 1,227 | 1,364 | 1,370 | 1,364 | 1,364 |
| Percent of Potential Transits | 77.2% | 77.2% | 77.2% | 76.0% | 75.3% | 73.1% | 70.0% | 66.6% | 65.4% | 65.4% | 72.7% | 73.0% | 72.7% | 72.7% |
| Forecast Panama Canal Cargo (ton 000s) | 61,572 | 61,572 | 61,572 | 60,443 | 59,937 | 57,478 | 53,590 | 49,958 | 48,154 | 48,154 | 56,801 | 57,223 | 56,801 | 56,801 |
| Percent of Potential Cargo | 74.5% | 74.5% | 74.5% | 73.1% | 72.5% | 69.5% | 64.8% | 60.4% | 58.3% | 58.3% | 68.7% | 69.2% | 68.7% | 68.7% |
| Economic Value of Canal for Potential Transits ($000s) | 402,525 | 402,525 | 402,525 | 402,525 | 402,525 | 402,525 | 402,525 | 402,525 | 402,525 | 402,525 | 402,525 | 402,525 | 402,525 | 402,525 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 19,347 | 19,347 | 19,347 | 21,470 | 22,653 | 28,557 | 39,716 | 51,095 | 57,485 | 57,485 | 30,429 | 29,248 | 30,429 | 30,429 |
| Forecast Panama Canal Revenues | 88,027 | 95,209 | 99,683 | 122,330 | 145,419 | 163,111 | 174,879 | 184,308 | 189,911 | 195,532 | 180,688 | 171,806 | 175,660 | 182,505 |
| Average Toll Revenue per Forecasted Transit ($000) | 61 | 66 | 69 | 86 | 103 | 119 | 133 | 147 | 155 | 159 | 132 | 125 | 129 | 134 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.43 | 1.55 | 1.62 | 2.02 | 2.43 | 2.84 | 3.26 | 3.69 | 3.94 | 4.06 | 3.18 | 3.00 | 3.09 | 3.21 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal tolll pricing option

Alternative Canal toll pricing option

## Table C-25. Grains Market Segment: Summary of Panama Canal Toll Pricing Options, Existing and Expanded Canal, Most Probable Case, 2025

| Canal Scenario and Item | Panama Canal Toll Pricing Option | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ACP tolls prior to Oct 2002 | ACP tolls Oct 2002-June 2003 | ACP tolls from July 2003 | PCUMS Option 1 (25% increase) | PCUMS Option 2 (50% increase) | PCUMS Option 3 75% increase) | PCUMS Option 4 (100% increase) | PCUMS Option 5 (125% increase) | PCUMS Option 6 (140% increase) | PCUMS Option 7 (150% increase) | Commodity Option 1 & PCUMS (100% increase) | Commodity Option 2 & PCUMS (100% increase) | Commodity Option 3 & PCUMS (100% increase) | Commodity Option 4 & PCUMS (100% increase) |
| | | | | | | | | | | *wheat* | *10%* | *10%* | *10%* | *5%* |
| | | | | | | | | | | *corn* | *0%* | *10%* | *5%* | *0%* |
| **Existing Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 | 1,852 |
| Potential Panama Canal Cargo (ton 000s) | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 | 79,231 |
| Forecast Panama Canal Transits (no.) | 1,416 | 1,416 | 1,416 | 1,394 | 1,381 | 1,365 | 1,312 | 1,236 | 1,234 | 1,234 | 1,365 | 1,365 | 1,365 | 1,365 |
| Percent of Potential Transits | 76.5% | 76.5% | 76.5% | 75.3% | 74.6% | 73.7% | 70.8% | 66.7% | 66.6% | 66.6% | 73.7% | 73.7% | 73.7% | 73.7% |
| Forecast Panama Canal Cargo (ton 000s) | 58,940 | 58,940 | 58,940 | 57,793 | 57,286 | 56,442 | 53,497 | 49,490 | 49,431 | 49,431 | 56,442 | 56,442 | 56,442 | 56,442 |
| Percent of Potential Cargo | 74.4% | 74.4% | 74.4% | 72.9% | 72.3% | 71.2% | 67.5% | 62.5% | 62.4% | 62.4% | 71.2% | 71.2% | 71.2% | 71.2% |
| Economic Value of Canal for Potential Transits ($000s) | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 | 389,775 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 18,585 | 18,585 | 18,585 | 20,835 | 22,025 | 24,218 | 33,755 | 47,432 | 47,670 | 47,670 | 24,218 | 24,218 | 24,218 | 24,218 |
| Forecast Panama Canal Revenues ($000S) | 89,869 | 97,194 | 101,744 | 124,765 | 148,339 | 170,569 | 185,086 | 193,017 | 205,632 | 211,618 | 191,587 | 180,628 | 186,107 | 193,261 |
| Average Toll Revenue per Forecasted Transit ($000) | 63 | 69 | 72 | 90 | 107 | 125 | 141 | 156 | 167 | 171 | 140 | 132 | 136 | 142 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.52 | 1.65 | 1.73 | 2.16 | 2.59 | 3.02 | 3.46 | 3.90 | 4.16 | 4.28 | 3.39 | 3.20 | 3.30 | 3.42 |
| **Expanded Canal** | | | | | | | | | | | | | | |
| Potential Panama Canal Transits (no.) | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 | 1,910 |
| Potential Panama Canal Cargo (ton 000s) | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 | 83,927 |
| Forecast Panama Canal Transits (no.) | 1,468 | 1,468 | 1,468 | 1,447 | 1,434 | 1,389 | 1,329 | 1,267 | 1,242 | 1,242 | 1,380 | 1,386 | 1,380 | 1,380 |
| Percent of Potential Transits | 76.9% | 76.9% | 76.9% | 75.7% | 75.1% | 72.7% | 69.6% | 66.3% | 65.0% | 65.0% | 72.3% | 72.5% | 72.3% | 72.3% |
| Forecast Panama Canal Cargo (ton 000s) | 62,180 | 62,180 | 62,180 | 61,044 | 60,541 | 57,880 | 53,966 | 50,356 | 48,460 | 48,460 | 57,191 | 57,622 | 57,191 | 57,191 |
| Percent of Potential Cargo | 74.1% | 74.1% | 74.1% | 72.7% | 72.1% | 69.0% | 64.3% | 60.0% | 57.7% | 57.7% | 68.1% | 68.7% | 68.1% | 68.1% |
| Economic Value of Canal for Potential Transits ($000s) | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 | 410,037 |
| Economic Value of Traffic Diverted Due to Tolls ($000s) | 20,725 | 20,725 | 20,725 | 22,873 | 24,055 | 30,465 | 41,744 | 53,049 | 59,822 | 59,822 | 32,376 | 31,167 | 32,376 | 32,376 |
| Forecast Panama Canal Revenues | 88,902 | 96,155 | 100,674 | 123,554 | 146,894 | 164,299 | 176,161 | 185,864 | 191,195 | 196,837 | 181,965 | 173,088 | 176,928 | 183,804 |
| Average Toll Revenue per Forecasted Transit ($000) | 61 | 65 | 69 | 85 | 102 | 118 | 133 | 147 | 154 | 159 | 132 | 125 | 128 | 133 |
| Average Toll Revenue per Ton of Forecasted Cargo ($/ton) | 1.43 | 1.55 | 1.62 | 2.02 | 2.43 | 2.84 | 3.26 | 3.69 | 3.95 | 4.06 | 3.18 | 3.00 | 3.09 | 3.21 |

Source: Prepared by Nathan Associates Inc.

Preferred Canal toll pricing option

Alternative Canal toll pricing option