



Evaluation of Lock Channel Alignments

Evaluación de Alineamientos de los Cauces de las Esclusas

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Resumen Ejecutivo

EXECUTIVE SUMMARY

This report describes the evaluation of 24 alignment alternatives for proposed new Panama Canal lock channels and recommends four alignments (two each at the Atlantic and Pacific entrances) for further feasibility study. The report consists of four parts, summarized below in Table ES-1, that contain the results of six phases of study.

Table ES-1
Summary of Report Parts

Part	Contents
1	Report Summary
2	Review of Existing Information Development of Evaluation Criteria Initial Evaluation
3	Final Evaluation (including excavation cost estimates) Optimization
4	Review of Excavation Methodologies

Background

The Panama Canal has operated since its opening in 1914 using two lanes to transport vessels between the Atlantic and Pacific Oceans. During the past 86 years, three developments have brought the Canal to its present near capacity condition. First, the existing water supply has become insufficient to reliably accommodate the number of lock passages each year. Second, the size of ocean-going ships has grown steadily and surpassed the maximum size able to pass the current locks, known as Panamax. Third, steadily increasing ship traffic has neared Canal capacity. Delays result from lock closures during regular maintenance of the nearly 90 year old structures. To date, the delays have been addressed by removing the bottlenecks from the Canal. Currently, the Gaillard Cut is being widened to allow two-way traffic of Panamax vessels through the entire Canal. When the Gaillard Cut widening is completed by mid 2001, the locks capacity and water supply will become the limiting factors for increasing Canal traffic. This study addresses measures to relieve the locks capacity limitations.

The report documents each level of study made to arrive at the two recommended lock channel alignments for both the Atlantic and Pacific Entrances. The Panama Canal Authority's Oficina de Proyectos de Capacidad del Canal (OPCC) actively directed and participated in each phase of the study. The OPCC foresees an incremental approach to expansion. The first step involves increasing the supply of water available for Canal operations. Then a one-way traffic third lane (currently proposed for post-Panamax vessels) would be constructed, possibly accompanied by a shiplift for smaller vessels. Finally, as traffic demands, a fourth lane would be added.

Study Process

The study began with the collection and review of available data. The OPCC provided geotechnical information, hydrography and topography. The geotechnical data, largely gathered in the planning stages of the 1939 Third Locks Project, were compiled and analyzed to determine which data were useful for this study. The hydrographic and topographic information were merged and a digital terrain model was created using InRoads software to permit data analysis and calculation of the amount of excavation required for each alignment.

Prior to the initial evaluation, the Kepner-Tregoe methodology was chosen to evaluate the alignments. This method provides a numerical basis for comparing alternatives. It employs criteria, or distinguishing characteristics, that are weighted according to their relative importance. Each alignment is then scored for each criterion. The highest ranked criteria were Construction Impacts on Existing Canal Operations, Navigational Safety and Ship Maneuverability, Excavation Cost, and Future Expansion Potential.

The initial evaluation began with a review and selection of design criteria. Then, in order to quantify the excavation cost criteria scoring, excavation volume calculations were performed for the 20 alignment concepts developed by the OPCC and four developed by Harza/TAMS. Next, the alignments were scored in each of the other 14 categories on the basis of the initial layouts and the initial design parameters.

The initial evaluation identified three alignments for the Atlantic Entrance (A1, A2 and A3) and five alignments for the Pacific Entrance (P1, P2, P3, P4 and P5) to be analyzed in the final evaluation stage. For the Atlantic Entrance, two of the alignments carried forward were located east of the existing Gatun locks and one was west of them, through the Gatun Dam (see Exhibits 2-4). For the Pacific Entrance, one alignment carried

forward was on the east side of the existing Pedro Miguel and Miraflores locks and the remainder were on the west side. Three of the final Pacific alignments mirrored the current layout of separate locks at Miraflores and Pedro Miguel. The other two utilized a single lock at Miraflores and a separate channel bypassing Lake Miraflores (see Exhibits 5-9).

The eight alignments resulting from the initial evaluation underwent a final evaluation in order to identify the two best alignments for each entrance. The final evaluation included qualitative and quantitative elements based on more fully developed alignments. As a result of the partial optimization of alignments P1 and P2 performed in the initial evaluation, those two alignments moved to the top of the Pacific alignment ranking based on their superior operational characteristics. Specifically, these two alignments both utilize a single three-lift lock, bypassing Lake Miraflores and increasing operational efficiency when compared to separate locks at Miraflores and Pedro Miguel. Alignments A1 and A2 remained the top ranking Atlantic entrance alignments because they also combine good operational qualities and ease of construction.

Because excavation cost may comprise half or more of total project costs, excavation cost estimates were refined for each of the eight alignments studied. The estimates began with a review of existing and future excavation methodologies to determine which equipment was best suited for the project. Then, estimates were developed that took into account the quantity of overburden, weathered rock and sound rock in each alignment. The costs were further broken down according to whether the excavation of each material type would take place in the wet or in the dry and by which type of equipment. Special features such as barrier dams and cofferdams were included in the estimates if they were necessary for excavation. These estimates are presented in Part 3, Appendix A. Preliminary excavation quantities and costs for the recommended alignments are provided below in Table ES-2.

Table ES-2

Summary of Excavation Quantities and Costs for Recommended Alignments

Alignment	Location	Quantity (millions of m³)	Preliminary Excavation Cost (\$ millions)
A1	Gatun	12.4	120
A2	Gatun	12.1	180
P1	Pacific	70	660
P2	Pacific	37	830

Following the final evaluation, the four recommended alignments were further analyzed in the optimization phase. Layouts were prepared for Post-Panamax, Panamax and smaller-than-Panamax locks. Additionally, an initial review identified possible locations for a proposed shiplift. The lock site geology should be further analyzed as part of future studies to confirm the suitability of the proposed lock and shiplift locations.

Recommendations and Conclusions

This study lays the groundwork for a feasibility study of the recommended alignments. The feasibility study would include a review of foundation geology, an analysis and recommendation on channel side slopes, and a cost estimate for the proposed new locks. The feasibility study should address the foundation conditions, particularly in the Cucaracha formation for the barrier dam proposed for Alignment P2. Topography should also be verified to confirm preliminary quantity calculations and cost estimates.

The evaluation of lock channel alignments has reduced 24 alignment concepts for a new lock channel to two recommended alignments and lock sites for each entrance. These four alignments show the most promise for expansion of Canal capacity while maintaining the flexibility of accommodating any one of the variety of lock sizes that future traffic forecasts will recommend. The four recommended alignments may be constructed without interference with existing operations and have superior operational and navigational characteristics. They allow for an incremental approach to expanding Canal capacity. Each alignment is designed for initial construction of a third lane with one-way traffic approach channels. As future traffic outstrips capacity, these approaches can be widened to allow two-way traffic and thus expand capacity. Finally, as traffic demand further increases, each alignment would accommodate a fourth lane of locks allowing the Panama Canal Authority to serve the needs of marine traffic well into the 21st Century.