Panama Canal reconnaissance study - Identification, definition and evaluation of water supply projects

Estudio de reconocimiento del Canal de Panamá - Identificación, definición y evaluación de proyectos de fuentes de agua

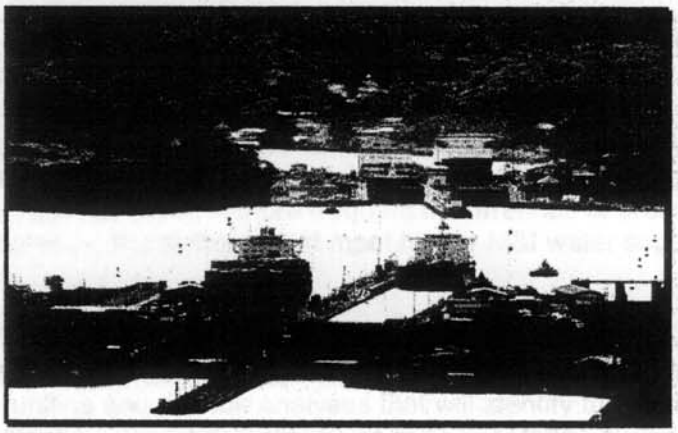
USACE

31 de diciembre de 1999

Contrato No. 97003

Resumen Ejecutivo

US Army Corps
of Engineers
Mobile District



PANAMA CANAL

Reconnaissance Study

Identification, Definition and Evaluation of Water Supply Projects

Volume I

31 December 1999

Environmental evaluations provided under Panama Canal Commission contract by Black & Veatch.

Executive Summary

Since the opening of the Panama Canal in 1914, the number of ships and the associated tonnage that transit the Panama Canal have increased dramatically. Ship traffic has increased to an average of 36 vessels daily, and increased traffic brings limitations and delays. The transit of ships across the Isthmus of Panama depends on the availability of the freshwater stored within Madden and Gatun Lakes. Water availability for operation of the Panama Canal is limited and even at present traffic levels, is not sufficient to meet traffic demand during prolonged dry periods, as highlighted during the 1998 drought. Inadequate water supply requires the Lakes to be lowered below design levels and thus induces draft restrictions on vessels passing through the Panama Canal. Considering all factors (lockage water, Municipal and Industrial (M&I) withdrawals, hydropower generation, etc.), the current daily average demand on the system is equivalent to 38.68 lockages per day.

The Panama Canal Commission (PCC) began system improvements in the early 1990s, such as the widening of the Gaillard Cut and upgrading the locks. Those improvements are expected to increase capacity to the equivalent of 43 lockages per day by 2002. Continued world economic growth and domestic development within Panama will result in even greater pressure to accommodate more vessels through the Panama Canal system. Without appropriate measures, this increase in demand will result in more frequent occurrences of draft restrictions, limitations, and delays. Concurrently, the system must meet higher M&I water supply needs for Panama.

The PCC, through its Canal Capacity Projects Office, is in the process of developing a long-term plan to address the future needs of the Panama Canal. Through this program, objectives have been set forth to reveal opportunities and provide analyses that will identify the optimum economic and engineering solutions. The new operating agency, the Panama Canal Authority, will continue the effort after control of Panama Canal operations is officially transferred from the United States to the Republic of Panama on December 31, 1999. These objectives include:

1. To satisfy long-term (through the year 2050) M&I water supply needs without adversely affecting the operation of the Panama Canal.

2. To provide sufficient navigation waters to meet existing and future Panama Canal transit demands without restricting vessel operation and to maintain historical reliability levels of 99.6 percent.

3. To take advantage of projects by supplementing hydropower production as demands for other water uses increase. If possible, increase current capacity and energy production as solutions are implemented.

Based on these objectives, the PCC initiated this study to define opportunities to supplement the supply of water to the system, evaluate these opportunities, and identify the most promising alternatives to be carried forward for more detailed analysis and possible implementation.

The PCC and the Department of the Army of the United States of America entered into an Interagency Services Support Agreement (Number 97003) in 1997. In October 1998, the PCC issued Work Order Number GS-16 under the Agreement to the U.S. Army Corps of Engineers, Mobile District for the identification, definition, initial assessment, and screening of potential projects to provide additional sources of water for Panama Canal operations and identify

additional hydropower generation opportunities. These projects were strictly focused on water supply or reduction in the use of water for the existing Panama Canal system and sources of water for expanding the capacity of the Panama Canal. No expansion of the navigation facilities of the Panama Canal was considered.

The work order defined the following tasks for the U.S. Army Corps of Engineers, Mobile District in conjunction and coordination with the PCC Canal Capacity Projects Office staff:

- Identify water supply project types and locations,
- Perform water yield calculations,
- Define project concepts and main features,
- Develop criteria and methodology for evaluation,
- Conduct preliminary evaluation of water projects,
- Perform initial screening of projects,
- Prepare a report, and
- Transfer technology.

Investigations included, literature reviews, assembly of existing data, development of data for the project sites, site visits and application of simulation models to determine the water yield for proposed projects. Hydrologic data were derived from existing records with standard hydrologic techniques applied to generate equivalent periods of record. Geotechnical field investigations were not conducted for this reconnaissance study. Geologic conditions were derived from existing publications and site visits. Structural studies included in this report may be categorized as dam and lake projects, existing lake modification projects, and miscellaneous water saving measures. Types and configurations of structures were kept the same as much as possible, allowing for variations based on such things as size and number of water passages required, and dimensions required to fit the features to the proposed project site.

As a starting point, the PCC provided a composite list of approximately 33 projects and measures that could provide additional water for the operation of the Panama Canal. Some of these had been proposed or suggested by previous studies, technical experts, the staff of the Canal Capacity Projects Office of the PCC, or other interested parties during the life of the project. This list reflected the most reasonable and popular measures. After initial review and screening of the list, the U.S. Army Corps of Engineers Mobile District design team eliminated some, modified some, and added others. The final list contained 30 projects that were subjected to a reconnaissance level analysis and evaluation.

For each project, the project site was identified, project features defined, and water yield determined. Once the sufficient project features were defined and the water yield determined, the results were compared to the minimum requirements that were established by the Canal Capacity Projects Office. At a minimum, each project was required to provide the equivalent of one lockage, be implemented with current technologies, not shut down or significantly impact the operation of the Panama Canal during the construction, and be economically feasible (the necessary resources can be obtained). Of the 30 projects, 19 met the minimum objectives and design and construction cost were developed and economic analysis applied for those that met the minimum objectives. These efforts were accomplished with the goal to present each project at an equal level for evaluation. The PCC through a separate contract with Black & Veatch Special Projects Corp, Kansas City, Missouri provided reconnaissance level environmental evaluations of projects that met the minimum objectives including positive cost/benefit analysis. Environmental and socio-economic evaluations at a reconnaissance level do not identify mitigation measures to a sufficient degree that allows determination of expected costs.

Therefore, some added mitigation costs could be expected for alternatives that are subjected to feasibility level studies.

The 19 projects that met the minimum objectives were compared and ranked. The ranking process was based on the water yield, technical viability, operational requirements, economic feasibility, environmental impacts, and socio-economic impacts of each project. The ranking was accomplished by a committee, comprised of representatives from the U.S. Army Corps of Engineers, Mobile District design team, the PCC - Canal Capacity Office staff, and technical personnel from Black & Veatch, Special Project Corp Office. The committee developed the measure of effectiveness for each project through consensus, based on their experience and knowledge of the projects and the resources of the Panama Canal and the Republic of Panama. The relative significance of each of these factors was recognized in the ranking process. The final composite score was scaled by significance in this way: 26.5 percent water yield, 9.1 percent technical viability, 7.6 percent operational requirements, 6.8 percent economic feasibility, 25 percent socio-economic effects and 25 percent environmental effects. The ranking process is explained in more detail in Section 35 of this report. Documentation of the project features and the analysis of each project are presented in the respective sections. Table 1 lists the 19 projects sorted in descending order from the highest ranking to the lowest.

Projects on the Rio Cocle del Norte, Rio Toabre, Rio Caño Sucio and the Rio Indio are located west of the Panama Canal watershed. These western projects consist of combinations of dams, lakes, tunnels, and hydropowerplants. The Rio Cocle del Norte watershed is the greatest distance from the Panama Canal with the Rio Caño Sucio and Rio Indio watersheds lying between the Rio Cocle del Norte and the Panama Canal. The Rio Toabre is a tributary to the Rio Cocle del Norte. The Rio Indio watershed is adjacent to the west side of the Panama Canal watershed. Therefore, the projects on the Cocle del Norte require combinations of the Indio Lake and the Caño Sucio Lake and / or large tunnels through the mountain ridges to transfer the water to the Panama Canal watershed. Lakes on the Cocle del Norte at elevations 65 and 80 m MSL would utilize an 18 km tunnel that would extend under the Rio Caño Sucio watershed to connect the Cocle del Norte Lake to the Indio Lake. Then the Indio Lake would be connected, in turn, to the Panama Canal by another tunnel. The Rio Cocle del Norte project, with a lake at elevation 100 m MSL, and the Rio Toabre projects connect to the Caño Sucio Lake by a channel cut through the ridge that divides the Rio Toabre watershed and the Rio Caño Sucio watershed, then through a tunnel connecting the Caño Sucio Lake to the Indio Lake. The Rio Lagarto and Rio Salud projects are dams and lakes located in small watersheds adjacent to the northwest corner of the Panama Canal watershed, with the Rio Lagarto between the Rio Salud and the Panama Canal. The Rio Charges project is a proposed dam and lake in the mountains above the existing Madden Lake. The Rio Ciri Grande project is a proposed dam and lake in the southwest hills above the Gatun Lake inside the Panama Canal watershed. The Lower Rio Trinidad project places a dam within the Gatun Lake on the Trinidad arm and raises the water level to create additional storage. The Rio Pacora and Rio Caimito projects are small independent watersheds that drain to the Pacific. These projects would provide water to local M&I users to offset the expected future increases in M&I water supply withdrawals from the Panama Canal by these communities. Other projects, such as the raising of Gatun and Madden Lakes, deepening of the navigation channel in Gatun Lake, recycling of lockage water by pumping water from the lowest lock chambers to the upper chambers and the pumping of seawater to Gatun Lake, consider modification of existing structures in the Panama Canal system and / or modification of the operating procedures.

Table 1 Project Ranking

Rank	Section Number	Project	Water Yield (Lockages)	First Cost ($ Millions)	Net Benefits ($ Millions)	Benefit Cost Ratio
1	8	Rio Cocle del Norte - Lake at Elevation 100 (Operated in conjunction with Caño Sucio and Indio Lakes)	25.29	665.81	357.60	1.9
2	7	Rio Cocle del Norte - Lake at Elevation 80 (Operated in conjunction with Indio Lake)	25.29	834.48	300.66	1.9
3	9	Rio Toabre and Rio Caño Sucio (Operated in conjunction with Indio Lake)	23.37	398.07	292.30	2.5
4	6	Rio Cocle del Norte - Lake at Elevation 65 - Option 1 (Operated in conjunction with Indio Lake)	25.08	501.02	344.49	2.4
5	22	Rio Caño Sucio - Option 1 (Operated in conjunction with Indio Lake)	13.85	40.23	328.95	4.7
6	29	Pump Storage From Cocle Del Norte Lake to Rio Toabre Lake (Operated in conjunction with Caño Sucio and Indio Lakes)	25.29	839.19	192.96	1.8
7	18	Rio Chagres - Option 2	7.91	318.98	117.94	3
8	5	Rio Indio - Option 2	10.87	245.87	143.11	4.1
9	24	Deepen Gatun Lake	5.62	200.66	85.00	3.3
10	20	Rio Ciri Grande - Option 1	3.10	71.86	53.28	4.5
11	25	Raise Madden Lake - Option 2	1.24	0.63	24.80	246.5
12	10	Rio Lagarto	1.10	32.04	15.24	3.1
13	16	Lower Rio Trinidad - Option 1	4.06	351.69	26.44	1.4
14	15	Rio Pacora	1.00	291.72	(26.71)	0.4
15	14	Rio Caimito	1.06	277.95	(23.45)	0.5
16	11	Rio Salud (Operated in conjunction with Lagarto Lake)	1.90	66.51	42.74	2.5
17	23	Raise Gatun Lake	1.65	77.24	22.68	2.6
18	34	Recycling Ponds at Gatun Lock	4.24	165.00	48.69	2.4
19	33	Pump Saltwater into Gatun Lake - 1 Lockage	1.00	471.33	(58.64)	0.3

Projects with benefit to cost ratios less than one would clearly not be recommended for further consideration. Also, the recycling ponds at Gatun Locks and Pump Saltwater into Gatun Lake are ranked very low and are not recommended because of the potentially significant environmental impacts. The Lower Rio Trinidad and Raise Gatun Lake elevation projects are also not recommended because of the significant uncertainties of design requirements for the project features. These uncertainties are explained in the respective sections.

The U.S. Army Corps of Engineers, Mobile District study team worked closely with the technical staff of the Canal Capacity Projects Office during this study and the technical evaluations of the water supply projects that were analyzed. Their extensive, first hand knowledge of the Panama

Canal and its operation, their technical abilities and their dedication and enthusiasm for the work proved invaluable to the success of this study.

Based on the analyses and findings of this study, the first 13 projects ranked in Table 1 are recommended as feasible alternatives for further consideration to develop a long-term plan to meet future needs for M&I water supply, operation of the Panama Canal, and possible modifications or expansion of the Panama Canal.