April 21, 2002

Mr. Agustín Arias
Director of Engineering and Projects Department
Autoridad del Canal de Panamá
Balboa Heights, Republic of Panama

Dear Mr. Arias:

Re: Geotechnical Advisory Board, Meeting No. 12

The 12th Meeting of the Board took place in Panama from April 18 to 21, 2002. The agenda for the meeting is included as Attachment A.

The Board appreciated the opportunity to meet with the following people, and to brief them on its observations and preliminary recommendations, prior to completion of this report:

Dr. Luis D. Alfaro, Manager, Engineering Division, and Acting Director, Engineering and Projects Department

Mr. Jorge de la Guardia, Manager, Canal Capacity Projects Division

Mr. Maximiliano De Puy, Manager, Geotechnical Branch

The Board welcomed the opportunity to inspect selected sites within the Gaillard Cut, both by launch and foot, and a spoil storage area from the current phase of channel deepening.

Prior to arrival in Panama, the Board had been sent and reviewed certain materials related to the proposed Lower Trinidad Dam Project. These included Panama Canal Reconnaissance Study, Identification, Definition and Evaluation of Water Supply Projects, Vol. I, December 31, 1999; Vol. III (draft), March 1, 2002; letters commenting on the proposed Trinidad Project by David E. Kleiner and John Clark; memoranda commenting on Vol. III by ACP Staff, and the scope of work given to the U. S. Army Corps of Engineers for Vol. III.

While in Panama, the Board was briefed on selected activities of the Geotechnical Branch, including the Channel Deepening Program (CDP) and activities of the Landslide Control Program (LCP) related to the West Culebra Slide, the Southeast Cucaracha Slide and Purple Rock. In addition, the Board was briefed by Mr. Jorge de la Guardia on Water Studies and Channel Deepening Alternatives, and by Mr. Robert W. Chamlee, Chief, Geotechnical and Dam Safety Section, Mobile District, U.S. Army Corps of Engineers, on the proposed Lower Trinidad Dam.

The principal focus of the meeting was the Lower Trinidad Dam. In particular, focus was on consideration of the adequacy of work completed to date as a basis for determining the feasibility and cost of this project in comparison with other projects that the ACP is considering to increase the water supply to the Canal.

The oral presentations made by ACP Staff were of high quality. As always, the familiarity of the staff with many important details was impressive, and reinforced the confidence of the Board in the work of the staff.

This report consists of observations, comments, and recommendations under the following headings:

1. Progress on Recommendations of the 11th Meeting of the Board
2. Channel Deepening Program
3. Landslide Control Program (LCP)
4. Proposed Lower Trinidad Dam
5. Summary
6. Next meeting

## 1. PROGRESS ON RECOMMENDATIONS OF THE 11th MEETING OF THE BOARD

The 11th Meeting of the Board, held from October 28 to November 2, 2001, focused on the CWP, LCP and the Gatun Dam Seismic Study (GDSS).

The Board recommended:

(1) Additional geologic mapping, and analysis of remedial options for the West Culebra Landslide.
(2) Analysis of remedial options for Southeast Cucaracha Landslide and Purple Rock.
(3) Periodic survey traverses across the East Culebra Slide to determine whether the observed scarps are related to a single slide movement.
(4) Testing of Geographic Information System (GIS) and real-time global Positioning System (GPS) technology for use in the LCP.
(5) The development of a manual to establish design and operational protocols for the LCP.
(6) That studies of the impact of the CDP on slope stability proceed with high priority.
(7) That seismic risk assessment be extended to the Canal as a whole, viewed as a system.

At this, the 12th Meeting, the Board was briefed on:

(1) Remedial plans for the West Culebra and Southeast Cucaracha Landslides, and Purple Rock in response to items (1) and (2) above.

(2) An analysis of the impact of the CDP on slope stability within the Gaillard Cut in response to item (6) above.

In addition, the Board was informed that a baseline had been established across the East Culebra Slide in response to item (3) above. Additional surveys will be made during the rainy season.

No specific progress was reported on items (4), (5) and (7) above. In so far as the primary focus of the current meeting was on the proposed Lower Trinidad Dam and in view of the relatively short interval since the last meeting, the Board understands that there has been insufficient time to complete these tasks. However, the continuing need for an articulation of the strategy underlying the LCP is reiterated in Section 3.1 below.

## 2. CHANNEL DEEPENING PROGRAM

In January 2002, work was initiated to increase the depth of the Canal by lowering the bottom elevation from 37 ft PLD to 34 ft PLD. The purpose of the current work, which is being done with in-house forces, is to increase the reliability of the Canal for handling traffic with draft of 39.5 ft. This modest deepening of the channel is not expected to have a significant effect on slope stability in Gaillard Cut.

Two possible additional channel deepening projects are being considered to meet future demand. The first of these would reduce the channel bottom elevation to 29 ft PLD, and the second would lower the channel bottom elevation to 24 ft PLD. These greater reductions in channel bottom elevation would significantly affect the stability of many slopes in Gaillard Cut.

During the past few months the Geotechnical Branch has performed a study to evaluate the effects of the two possible additional deepening projects on the slopes. This study is summarized in a three-volume report entitled "Study on the effect of deepening on Gaillard Cut slopes," dated April 2002.

The primary purpose of the study was to identify those reaches of Gaillard Cut where deepening of the channel will de-stabilize the slopes sufficiently to require stabilization measures, and to estimate the extent of the required stabilization measures for budgeting purposes. The studies provide a solid basis for cost estimating, and they also serve as a suitable means of identifying those areas that would be most affected by channel deepening.

If the deepening projects are undertaken, detailed design studies will be required at each of the sections where the slopes require stabilization.

The studies included consideration of 10 different conditions for each slope, as shown in the table below:

| Case No. | Channel bottom elevation, and description |
|---|---|
| Case 1 | 32 ft PLD – current condition, allows for 2 ft of overdredging |
| Case 2 | 32 ft PLD – with very soft or weak (blasted) material from 32 ft to 27 ft PLD |
| Case 3 | 27 ft PLD – allows for 29 ft bottom elevation with 2 ft of overdredging |
| Case 4.1 | 27 ft PLD – with underwater excavation only |
| Case 4.2 | 27 ft PLD – with underwater and dry excavation to stabilize slopes where this was found to be necessary |
| Case 5 | 32 ft PLD – with very soft or weak (blasted) material from 32 ft to 22 ft PLD |
| Case 6 | 22 ft PLD – allows for 22 ft bottom elevation with 2 ft of overdredging |
| Case 7.1 | 22 ft PLD – with underwater excavation only |
| Case 7.2 | 22 ft PLD – with underwater and dry excavation to stabilize slopes where this was found to be necessary |
| Case 8 | 22 ft PLD – with very soft or weak (blasted) material from 22 ft to 16 ft PLD |

Consideration is being given to drilling and blasting below the depth of excavation to eliminate the necessity of a second or third phase of drilling and blasting should a second or third phase of channel deepening be undertaken. The "pre-blasted" material left in the bottom of the Canal would have low strength, a fact that was accounted for in the analyses of Cases 2, 5, and 8.

Deepening the channel bottom using a cutter-head dredge capable of excavating even the hardest materials without drilling and blasting would have the advantage that the strength of the material below the channel would not be affected.

The shear strengths and stability mechanisms used in the stability analyses were selected based on the geologic conditions in each reach. Separate stability models were used to represent each of the various geologic conditions along the Cut. Groundwater conditions used in the analyses were based on water levels observed in traveler pipes, multi-point piezometers, Casagrande piezometers, and core logs where available. Where information was lacking, piezometric levels were based on judgment. In cases where the average pore pressure ratio ($r_u$) was less than 0.3, the piezometric levels were raised to establish an average pore pressure ratio of 0.3.

The Board believes that the methods used in the study were appropriate for the purpose, and commends the Geotechnical Branch personnel for accomplishing such an extensive and highly effective study so efficiently.

The risk of triggering slope failures as a result of channel deepening are greatest where one or more of these conditions prevail:

1. Stability in the pre-deepening condition relies significantly on toe resistance, which will be diminished or eliminated by the deepening.
2. Stability in the pre-deepening condition relies on fully softened strength or higher strength, and slope failure has the potential to reduce the shear resistance to its lower residual value.
3. Stability in the pre-deepening condition is marginal, and the potential for improving stability by slope flattening is limited. Many slopes where past failures have occurred have marginal stability at present.

The hazard posed by channel deepening is greatest where slides have the greatest potential for high mobility, i.e., rapid movement of material into the navigation prism.

The study report identified three areas as problematic. These are the East Culebra Slide, the West Culebra Slide, and the Purple Rock Slide.

The stability of the East Culebra Slide is marginal (computed factor of safety = 0.9). The slide mass is moving slowly, with cracks and scarps visible in the moving mass. Excavation for channel deepening will reduce the factor of safety. Excavation to flatten the slope is contemplated as a remedy. The Board suggests that, in addition to the section perpendicular to the canal axis that has been analyzed, a diagonal section extending from the base of Gold Hill to the northwest should also be analyzed, to examine the possible consequences of the excavation on the stability of Gold Hill.

The stability of the West Culebra Slide is also marginal (computed factor of safety = 1.0). The area is undergoing slow movements toward the Canal, with cracks opening throughout the area between the Canal and the steeper upland slope. The mechanism apparent in the field casts doubt on the effectiveness of excavation as a remedy. The Board believes that sealing cracks, grading, and establishing vegetation to improve runoff and reduce infiltration of surface water will address the condition more effectively.

The stability of the slope in front of Purple Rock is also marginal (computed factor of safety = 0.8). Excavating the softer material in front of Purple Rock will expose more of the face, which shows signs of raveling. The Board believes that it will eventually be desirable to stabilize the face of the Purple Rock, and to establish a monument near the front of the rock to make it possible to determine if the massive part of Purple Rock is moving. The monument should be founded deep enough so that it will not be affected by superficial phenomena.

## 3. LANDSLIDE CONTROL PROGRAM (LCP)

### 3.1 Principles of Landslide Control Program (LCP)

While the LCP has not been a dominant portion on the agenda for this meeting, the Board is of the opinion that it would be timely and productive to review the principles and the general aspects of practice that guide the LCP.

In the view of the Board, the LCP has two objectives:

a. To avoid volumes of landslide debris entering the navigational channel of the Canal of such magnitude that it would impact traffic operations.
b. To contribute to the cost-effective management of the actual and potential landslides along the Canal right-of-way.

The major tools utilized in the LCP include the following:

a. landslide recognition
b. landslide monitoring
c. limit equilibrium analyses
d. calculated percentage change in factor of safety as a design criterion
e. re-grading, primarily slope flattening
f. ground water drainage
g. surface water drainage

The Board requests that Canal Staff summarize for discussion their views on the principles and practice that guide the LCP. This had been recommended in the report of Meeting No. 11.

Experience suggests that the risk to navigation only arises when landslides occur that display extreme mobility. The Board notes that an updated synthesis of Canal experience with regard to noteworthy runout events is lacking. Such a synthesis could be useful in guiding landslide risk assessment. The Board recommends that such a synthesis be assembled, to incorporate slope geometry, material type, rainfall history, and mobility. A discussion of some non-runout events during periods of high rainfall would also be of value. This synthesis should be an item of discussion at the next meeting of the Board.

### 3.2 West Culebra Landslide

In its November 2, 2001, report, the Board noted that underwater excavation for canal widening was probably the immediate trigger for the 2000 reactivation of this slide. By December 2000, horizontal displacement on the slide ranged from 1-2.5 m. Because

movement of the toe of the slide impinged upon the channel, maintenance forces immediately removed some of the toe portion, which undoubtedly reduced the stability of the slide mass. Preliminary remedial work consisted of excavation of surface load from the head and the toe of the slide. While removal of material from the head of the slide proved beneficial, this effort was limited by existing large basalt boulders in the area and by contact with a near-vertical basalt contact on Zion Hill at the head of the slide, which imposed serious limitations to excavation. Excavation of surface materials from the toe area of the slide had a negative effect on stability. New EDMs installed on the slide detected horizontal displacement of the excavated toe slopes on the order of 1-1.8 m within 3 months after the excavation was completed.

At present, the slide mass continues to exist in an unstable condition. Movement continues toward the channel. Cracks and grabens continue to form in the toe area of the slide.

The Board agrees with Geotechnical Branch plans to reduce the active load on the slide by additional excavation in the head area (estimated volume of excavation: 340,000 $m^3$). As part of this excavation, large basalt boulders derived from Zion Hill will have to be removed. It also will be necessary to install a protective barrier (probably a wire mesh) to control falling rock from the basalt and Pedro Miguel agglomerate faces of Zion and Hodges´ Hills during this excavation. The wire mesh will protect against minor rock falls. However, extreme caution should be exercised in this inherently hazardous work, and a safe work plan should be developed.

Assistance in establishing stability of the overall West Culebra landslide mass can also be gained by a slight re-grading of the currently almost flat toe area of the slide. The Board recommends that the toe area be re-graded to the following approximate specifications:

(1) Fill all cracks.
(2) Overall slope ~ 0.5% toward the canal and drainage swales.
(3) Fine-grained compacted and grassed surface soils.
(4) Grassy swales with good surface drainage.

One of the concerns voiced in the Board's report of November 2, 2001, was that the geology in the Zion/Hodges Hill area is only poorly understood. Thus, there remains the possibility that removal of material from the head of the landslide may lead to unforeseen head-wall instability and possible catastrophic failure. Thus, the geology, including mapping of joints, in the area at the head of the West Culebra slide (particularly at the north end of the slide) should be determined in detail before any substantial excavation is attempted from this part of the slide. It is important that the geologic structure of this mass be understood to the same degree as that of Gold Hill. Mapping of the geology in the Zion/Hodge's Hill area will be a low-cost endeavor that should be undertaken irrespective of which remedial measures are used.

3.3 Southeast Cucaracha Slide

The Southeast Cucaracha Slide (also known as the South Cucaracha Extension slide) occurred on November 27, 2001, with an approximate volume of 25,000 m³, of which about 7,000 m³ crossed into the navigation prism. However, traffic was not interrupted by the slide. The dredge Christensen removed slide material that had moved into the channel. The shallow, mobile slide (maximum thickness ~ 15 m) apparently occurred along a semicircular failure surface in the Cucaracha formation, with tension cracks in the head area and a head scarp abutting the Pedro Miguel agglomerate and some basalt, which prevented headward progression. EDM readings indicate that the landslide mass is continuing to move slowly toward the Canal; maximum lateral movement since November 27, 2001, has been approximately 80 mm during the dry season.

In its November 2, 2001, report, the Board recommended that the following remediation options be studied:

(1) Removal of material from the head of the slide.
(2) Installation of horizontal drains.
(3) Improvements in surface drainage.

Theoretical back analysis of this mobile mass by the Geotechnical Branch arrived at a remedial solution consisting primarily of costly excavation of Pedro Miguel agglomerate beyond the current head scarp. The Board believes that this excavation will be unnecessarily expensive, and that it is not warranted by the minor risk to the Canal entailed by this shallow landslide.

Instead of excavation of the mass of Pedro Miguel agglomerate above the head scarp, the Board recommends the following less-intrusive, and less-costly, remedial measures:

(1) Collect and direct upslope water away from the slide area.
(2) Construct a lateral surface drainage ditch immediately upslope from the tension cracks in the landslide head area to direct surface water away from the cracks.
(3) Remove potential Cucaracha landslide material from the crest, of the slide.
(4) Install a system of horizontal drains in the Pedro Miguel agglomerate.

The Board feels that these less costly measures will inhibit mobility at this site so that movement into the channel can be controlled at maintenance level.

3.4 Purple Rock

In its report on Meeting No. 11, the Board noted that the on-going movements at Purple Rock were shallow and suggested that they deserve additional study.
ACP Staff have evaluated the conditions at Purple Rock, and they observed that degradation has been by weathering, with much of the exposed rock ultimately entering the navigation channel. A number of limit equilibrium analyses of the slope in front of Purple Rock have been carried out; these analyses reveal only marginal stability. Ultimately, channel deepening would likely destabilize the frontal mass, exposing more of Purple Rock and leading to additional disintegration by surface fragmentation. ACP Staff proposed stabilization and protection of the current exposed face.

The Board does not regard the current raveling of Purple Rock to be a significant failure mode, unless is can be argued that it severely impacts Canal operations. Therefore, the Board judges the proposal to remedy ¨Purple Rock to be a low priority, given the current competition for available funds. The Board recommends that Purple Rock be kept under observation and that the need to implement stabilization measures be re-visited at a later time.

4. PROPOSED LOWER TRINIDAD DAM

4.1 Background

The Panama Canal Reconnaissance Study dated 31 December 1999, by the Mobile District, Corps of Engineers, evaluated some 34 options for increasing the water supply for the operation of the Canal, municipal use and power generation. This study ranked the Lower Trinidad Project 13th with a benefit/cost ratio of 1.4. As a result of this study and the relatively low ranking of the Trinidad Project, the ACP asked the Board to review the project, paying specific attention to work performed under contract to the PCC in the early 1960´s. The ACP called Board Meeting No. 10 with the main purpose being to review information related to the Lower Trinidad Dam Project. Copies of the 1963 reports on this project by Shannon and Wilson, Inc., and Tudor Engineering Co. were provided to the Board. During this 10th Meeting, the Board received briefings on site geology, on properties of the Atlantic Muck, and on foundation settlement, deformation, and stability. The Board suggested tentative design concepts and outlined a recommended approach. Step (1) of the recommended approach was to conduct a detailed feasibility study to be accomplished by a team experienced in dam design assisted by engineering personnel of the ACP.

Prior to this 12th Meeting, the Board received and reviewed:

1. Panama Canal Reconnaissance Study Vol. I, dated 31 Dec 1999 (Sections 1, 2, 3, 4, and 16), prepared by the Mobile District of the Corps of Engineers.

2. Panama Canal Reconnaissance Study vol. II (Section 35), prepared by the Mobile District of the Corps of Engineers.
3. Panama Canal Reconnaissance Study Vol. III (draft), dated 1 March 2002 (Sections 36 to 45), prepared by the Mobile District of the Corps of Engineers.
4. Letter from David E. Kleiner, dated February 8, 2002, with an addition to conclusion and recommendation on a separate undated sheet.
5. Updated letter from John Clark
6. Memorandum from ACP to IPC, dated Feb 13, 2002.
7. Memorandum from ACP to IPC, dated Mar 13, 2002.
8. Scope of work for the USACE, reconnaissance study of the Trinidad Dam project.
9. Compact disk (Power Point presentation), prepared by the ACP Geotechnical Branch.

Section 36 – Panama Canal Reconnaissance Study, Vol. III (draft), presents a reconnaissance-level assessment of Lower Rio Trinidad 22.9 m to 30.5 m., and estimates the total project first costs to be $812,304,000.

During the 12 th Meeting, a comparison among Indio, Lower Trinidad and Channel Deepening to 27.5 PLD was presented as competing options with project construction costs estimated to be $280,000,000; $812,000,000; and $300, 000,000, respectively. The Board also received a presentation by Robert W. Chamlee, Mobile District, Corps of Engineers, regarding the Corps´ recent reconnaissance study discussed in Draft Vol. III, dated 1 March 2002.

The Mobile District reconnaissance study proposed a dam with submerged slopes of 1(V) to 15 (H) and suggests that construction of the embankment might require phased construction allowing time for foundation consolidation and associated strength gain between phases.

4.2 Commentary

The Board is disappointed in the results of the Mobile District work. It does not seem to the Board that the study made sufficient use of the following:

1. The Tudor and Shannon & Wilson work of 1963,
2. the current literature regarding submarine construction on soft soils,
3. the input from ACP geotechnical staff,
4. experience with complex construction in similar geologic environments, involving construction techniques such as placing geotextiles and wick drains in a marine environment.

The Board believes that the necessary data exist to conduct a detailed feasibility study producing a cost estimate with a reliability similar to those for Indio and Channel Deepening. This is envisioned as a desk study requiring no further fieldwork. The Board also believes that the current cost estimate might be significantly reduced by more accurate embankment

material costs and more realistic embankment volumes. After study completion, valid comparisons among the three options (Indio, Trinidad and Channel Deepening) can be made. Such comparisons are not possible today.

4.3 Recommended Approach

The Board recommends that ACP assemble a Study Team consisting of ACP engineers and scientists, geotechnical engineering embankment design consultants, (the Study Team Consultant), contractors with experience in marine earthwork and dredging (the Study Team Contractor), and specialty contractors, such as wick drain contractors. This Study Team should have the experience and background needed to produce a bounded, reliable cost estimate and to design a test-fill which will be required to further refine the cost estimate.

The Board anticipates that this study would provide the following:

(1) Establish in a transparent manner whether or not the Lower Trinidad Dam is feasible based on existing proven technology.
(2) Provide a cost estimate for the proposed design(s) utilizing experience–based costs, appropriate to Panamanian conditions.
(3) Indicate the likely uncertainty associated with the cost estimates.
(4) Indicate the value of a test fill in reducing the uncertainty associated with the cost estimates.

The Board expects the feasibility study to evaluate, but not be restricted to, the following elements of design and construction:

(1) Grubbing, Shallow Dredging and Waste Storage, and Silt control: The Board anticipates that the submerged trees will have to be removed, and that shallow dredging of very soft sediments will be required from the footprint of the dam. The method statement and cost estimate are best obtained from ACP Staff and the Study Team Contractor.
(2) Separation layer: The Board anticipates that a geotextile or equivalent, will be placed between the Atlantic Muck and an overlying sand/gravel blanket. Experience with reclamation in Asia may be relevant. Some input is needed from the Study Team Consultant. The method statement and cost estimate will be obtained from the Study Team Contractor.
(3) Sand/Gravel Blanket: The Board anticipates that a sand/gravel blanket will be placed over the separation layer. It must provide drainage for the wick installation, and must not be liquefy under the design earthquake. The thickness, composition and density will be defined by the Study Team Consultant. The method statement and cost estimate are best obtained from the Study Team Contractor.

(4) Wick Drains: The Board anticipates that wick drains will be utilized, with wick drains installed at a pre-determined spacing and depth. Considerable experience with deep installations is available from Asian reclamation works and the Kennecott Tailings Dam, Salt Lake City. The Study Team Consultant will provide the design. The method statement and cost estimate are best obtained from a Specialist Contractor.

(5) Separation Layer: The Board anticipates that an additional separation layer will be used between the sand/gravel blanket and the overlying fill. This replicates the input described in (2) above.

(6) Fill Characterization: The characteristics of the fill and its scheduled availability control the design, construction and cost of the underwater fill (submerged berm). The Board anticipates that ACP strategic planning will guide the initial choice of fill sources and their availability. With this guidance, the Study Team Consultant can establish the likely material characteristics while the Study Team Contractor advises on the method statement and the unit cost estimate. The Board perceives two different conditions under which the dam may be constructed, but there may be more. They are:

(a) Construction of the dam without construction of new locks.
(b) Construction of the dam with new locks.

In the first instance, fill would be available from the current Channel Deepening Phase, previously accumulated spoil dumps, prescribed dry borrow areas, or advanced excavation for new locks and associated deepening. In the second, available fill from lock construction and associated deepening would likely be more attractive.

(7) Submerged Berm: The Board anticipates that the design of the submerged berm will indicate the required geometry to provide adequate stability and the measures, if any, required for seepage control. All submerged berm construction will be performed by means of floating plant. The Study Team Consultant will provide the design and the Study Team Contractor will provide the method statements and unit cost estimates. There may be a number of alternatives that merit consideration.

(8) Sub-aerial Dam: The sub-aerial dam will require special consideration of long term settlements and the provision of seepage control measures. Fill placement is expected to employ conventional measures, but hydraulic fill placement need not be excluded. The Study Team Consultant will provide the design while the Study Team Contractor provides the method statements and unit cost estimates.

(9) Specialty Measures: In addition to wick drains, a number of specialty measures may be needed, such as cutoff installation, non-traditional wave protection measures, vibro-densification, etc. The Board expects the Study Team to consult with experienced specialty contractors to establish acceptable method statements and unit cost estimates.

(10) Test Fill Design: The Board is of the view that a test-fill will be necessary as input to final design, and as a result, the design of a test-fill is a specific task for this Study Team. The Board expects that the Study Team will demonstrate that the Lower Trinidad Dam is feasible. In addition, the Board anticipates that there will remain an undesirably large uncertainty associated with the cost estimate, driven primarily by uncertainty regarding construction methods, dam foundation performance, and their impact on schedule. The primary objective of the test-fill would be to reduce this uncertainty.

The test fill would be constructed at a location on the dam center-line and at an appropriate scale. The test would pilot Items 1-6 outlined above. The Study Team would provide the design, construction method and cost estimate for the test-fill. Following the submission of the report by the Study Team, the ACP will be in a position to evaluate the merits of proceeding with the proposed test-fill.

The Board believes that a duration of one year is appropriate to complete the envisaged study. It involves no new fieldwork and could be accelerated, if that is in the interest of the ACP.

During this meeting, the Board orally briefed Dr. Luis Alfaro, Mr. Jorge de la Guardia and Mr. Maximiliano De Puy, and at that time suggested examples of firms that had the background and hands-on experience necessary to participate in the feasibility study as team members.

The Board recommends that the planning and contractual arrangement for this feasibility study include the following considerations:

1. The work should be procured in a manner that is based heavily on experience with similar marine earthwork construction and with similar soft foundation conditions.
2. The solicitation should contain a technical section which will require the bidder to discuss in some detail previous work experience directly related to marine construction, placement of dredged material, foundation stabilization/treatment using wick drains, etc.
3. Another portion of the Request for Proposals (RFP) should be a cost proposal for unit prices for labor.
4. A weighting scheme can be developed to weight various aspects of the proposal, to assure that team members have the needed capability.

The Board would be pleased to participate in the initial meeting of the Study Team to be sure that the objectives, scope, purpose and desired outcomes are effectively and articulately communicated. Additionally, the Board would welcome the opportunity to periodically review study progress and/or provide additional direction and focus.

## 5. SUMMARY

The Geotechnical Advisory Board met in Panama from April 18-21. Prior to arrival, the Board reviewed materials relevant to the proposed Lower Trinidad Dam. In Panama, the Board received additional presentations on Lower Trinidad Dam, on the Channel Deepening Program (CDP) and on the Landslide Control Program (LCP). The Board met with senior ACP Staff prior to preparation of the report.

The Board was impressed with the extent of analysis applied to potential slope stability problems associated with the CDP. Appropriate caution is being directed to the slopes with the largest potential for problems, particularly East Culebra, West Culebra and Purple Rock.

The Board remains concerned about the need for an overall strategy for decision making in the LCP and urges completion of a review and synthesis of experience and development of a integrated strategy.

The Board recommends that geologic studies be expanded in the area of Zion and Hodges Hill above the head of the current West Culebra Slide, and that the remediation efforts on that slide emphasize reducing infiltration on the lower portion of the slide.

The Board believes that the proposed excavation of the Southeast Cucaracha Slide is not warranted. Instead, the Board recommends an increased effort to improve drainage of the slope, and only minor excavation.

The Board recommends that Purple Rock be kept under observation and that the need to implement stabilization measures be reviewed at a future time.

The Board does not believe that the analysis carried out to date is adequate to compare the proposed Lower Trinidad Dam project with the other competing projects in terms of feasibility and cost.

The Board recommends the assembly of a Study Team consisting of experienced consultants, contractors and ACP Staff, to conduct a feasibility study and cost estimate of the proposed Lower Trinidad Dam project. The Board recommends that this Study Team be assembled with great care to insure that its members have modern experience in similar marine earthwork on a soft foundation. The Board recommends that the deliverables of this study consist of a refined conceptual design taking into account proven construction techniques, a definitive conclusion about the feasibility of construction, a cost estimate with significantly reduced uncertainty, and the design of a test-fill. Based on these results, the Board believes that the ACP would be in position to compare the Lower Trinidad Dam project with the other competing projects.

## 6. NEXT MEETING

The Board is prepared to meet within the next several months to participate in a startup meeting with the recommended Study Team for the Lower Trinidad Dam feasibility study, if the ACP accepts this recommendation. Otherwise, the Board anticipates that its next meeting would focus on the Landslide Control Program and would occur in Spring 2003.

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|---|---|
| James M. Duncan | Robert L. Schuster |
| William F. Marcuson III | Robert L. Wesson |
| Norbert R. Morgenstern | |

Attachment A

# 12th Geotechnical Advisory Board Meeting, April 16 – 22

Tuesday, April 16

GAB review of sent documents in USA

Wednesday, April 17

Travel

Thursday, April 18

Part I: **EFFECT OF CHANNEL DEEPENING ON GAILLARD CUT SLOPES**

| | |
|---|---|
| 8:00 a.m. | Pick up at Hotel El Panama |
| 8:30 a.m. | Welcome (L. D. Alfaro) |
| 9:00 a.m. | Introduction (M. De Puy) |
| 10:00 a.m. | Study on the Effects of Channel Deepening on the existing Gaillard Cut Slopes (staff) |
| 12:00 a.m. | Break for lunch |

Part II: **LANDSLIDE CONTROL PROGRAM**

| | |
|---|---|
| 1:00 p.m. | Stabilization Analysis of West Culebra Slide (C. Reyes) |
| 2:00 p.m. | Stabilization Analysis of South Cucaracha Slide (M. Barrelier) |
| 3:00 p.m. | Discussion |
| 4:00 p.m. | Return to Hotel |

Friday, April 19

Part III: **REVIEW OF LOWER TRINIDAD PROJECT**

| | |
|---|---|
| 8:00 a.m. | Pick up at Hotel |
| 8:30 a.m. | Canal Capacity Division presentation (J. de la Guardia) |
| 9:30 a.m. | Presentation of Lower Trinidad Project (USACE and Canal Capacity Division Staff) |
| 10:30 a.m. | Coffee Break |
| 11:00 a.m. | Discussion with USACE, CC and IPIG personnel |
| 12:00 a.m. | Break for Lunch |
| 1:00 p.m. | Discussion with USACE, CC and IPIG personnel |
| 4:00 p.m. | Return to Hotel |

Saturday, April 20

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|---|---|
| 8:00 a.m. | Pick up at Hotel |
| 8:30 a.m. | Field visit to South Cucaracha and West Culebra Slide |
| 11:00 a.m. | Return to Building |

Part IV: **REPORT PREPARATION**

| | |
|---|---|
| 11:00 a.m. | Discussion with Geotechnical Br. Staff |
| 12:00 a.m. | Break for lunch |
| 1:00 p.m. | Report Preparation |
| 4:00 p.m. | Return to Hotel |

Sunday, April 21

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|---|---|
| 8:00 a.m. | Pick up at Hotel |
| 8:30 a.m. | Report Preparation |
| 12:00 a.m. | Break For lunch |
| 1:00 p.m. | Report Preparation |
| 3:30 p.m. | Return to Hotel |

Monday, April 22

Travel