IN THE COURT OF APPEAL OF BELIZE, A.D. 2003
NOTICE OF APPEAL

Civil Appeal No. 1 of 2003

BACONGO	Appellant
and	
The Queen	
and	
The Department of the Environment	1st Respondent
Belize Electric Company Limited	2nd Respondent

Affidavit of Richard Goodman
Dated the day of June 2003

I, Richard Goodman of Mendocino, California, U.S., MAKE OATH AND SAY as follows:

1. I am a geological engineer with nearly forty years of professional experience. From 1964 to 1994 I was a Professor of Geological Engineering at the University of California at Berkeley, and independent professional consultant in geological engineering and rock mechanics; from 1994 to the present I have been principally engaged as a professional consultant on geological engineering and rock mechanics aspects of engineering projects. I am frequently called upon to examine the safety and viability of proposed dam projects for leading construction companies, engineering companies and the two major dam-building agencies in the United States government - - the Bureau of Reclamation and the Army Corps of Engineers. In addition, I am the author of five books on engineering geology, geological engineering, rock mechanics, and the experience

record in applied geotechnical engineering, and more than a hundred additional publications. My resume is attached as exhibit R.G. 1.

2. I make this affidavit without any payment or expectation of payment from any of the parties interested in this issue, as a matter of professional and public interest.

3. I have read the affidavit of James Code (JC) sworn on 30th April 2002 and his affidavit of 28th May 2003 and ask leave of the Court to refer thereto.

4. In paragraph 8 of Mr. Code's affidavit he refers to the "samples of the feasibility report" for the Chalillo dam which I received and have reviewed. In fact, the document which I reviewed is labeled "Issued for Tender", and appears to be a document provided to potential contractors for the dam construction.

5. I stated in my letter to Anthony Tillett that the document was dated September 2002. At paragraph 14, Mr. Code states "No such 2002 report exists." It does in fact exist, and bears the name of AMEC, the company for which Mr. Code formerly worked. The report is exhibited as R.G. 2.

6. Mr. Garel subsequently provided me with the entire feasibility report as included in the Environmental Impact Assessment for the project. As far as I can judge, the feasibility report is identical to the report I reviewed. The feasibility report is exhibited as R.G. 3.

7. At paragraph 21, Mr. Code makes the assertion that "*it is my professional view that all aspects of the dam investigation and design have been fully addressed in accordance with international engineering practice, and that the site is suitable for the construction of the proposed dam*."

8. It is my continued professional opinion that neither the information included in the geological report that I reviewed, nor Mr. Code's affidavit, contains sufficient information to draw this conclusion, and that this information is inadequate to ensure the safety or viability of the Chalillo dam project.

9. Mr. Code may have available to him additional studies and data that lead him to make this judgement, but to my knowledge if these studies exist, they are not in the public domain.

10. In my research and experience, an essential part of ensuring the safety and viability of any large-scale infrastructure project is the opportunity for a public review of the essential geological and engineering data. That appears to be missing in this case, and could lead to dangerous consequences.

11. The failures of Vajont Dam, Italy, and of the dam responsible for the Johnstown Flood (Pennsylvania) resulted in large measure from inattentiveness and/or dishonesty of public agencies charged with permitting and approvals. The painful mistakes of Vajont Dam were

described in the book *Il racconto del Vajont [Editione Garzanti, Milano 1997]* by Marco Paolini and Gabriele Vacis. The case of the Johnstown Flood was described in detail in the book *The Johnstown Flood* (Simon and Schuster, year?) by David McCullough.

12. The affidavit of Mr. Code dated May 28, 2003, paragraph 9.(11), indicates that testing and evaluation of rock "provided the basis for the dam design". This point of view was expressed also in the affidavit of Mr. Jeremy Gilbert-Green, April 2002 in reference to Action No. 61 in the Supreme Court of Belize; paragraph 7 of that affidavit states "the dam design is based not on the classification of the rock but the laboratory analysis of its load bearing characteristics and water permeability. Dams can be built on many types of foundation material and are designed based on the properties of the material in question."

13. These statements are incorrect. The properties of rock determined by laboratory tests can not provide sufficient information for design of a dam. The design must be based on "rock mass" properties at the scale of the dam foundation, which embrace structural features and defects of the rock mass that are not captured by rock samples from drill holes. The water conductivity of the rock foundation is a function not only of the permeability of the rock core, but of the system of conductive discontinuities (bedding plane joints, other joints shear zones, faults, and fractures), cavities, and pervious strata in the foundation, as well as the foundation treatment and impermeabilization measures constructed. (The designers must know

this because they authorized water flow measurements into boreholes which provides a more meaningful measurement of rock permeability than the testing of permeability in rock core samples.)

14. Similarly, the strength of the foundation cannot be expressed or evaluated simply in terms of the dam's bearing pressure against the rock foundation in relation to sustainable compressive loading on laboratory core samples, no matter how many of these have been tested. The foundation and abutment strengths for the dam are instead properties of the system of interconnected or partially interconnected surfaces along discontinuities (bedding joints, other joints, faults and fractures) in the foundation. Therefore to evaluate the strength of the dam requires sufficient knowledge of the orientations and locations of major discontinuities and their shearing resistance. Interpretation of this information requires evaluation of constructed geological sections, extending downstream, and showing the path of important bedding planes and main discontinuity traces.

15. The geological maps provided to me to review do not contain information about the system of discontinuities. There are no orientation data in any of the maps provided for my reading. Mr. Code states that there are some statistical joint data in the Swiss Boring Reports, but the EIA report that I reviewed does not contain these, so I therefore can not comment on the sufficiency, or relevancy of the data referred to in Mr. Code's May 28, 2000 affidavit, paragraph 9.(25). The studies included in the EIA, which I reviewed,

do not provide sufficient information to form part of a geotechnical model enabling evaluation of the shear strength of the foundation.

16. With reference to Mr. Gilbert-Green's statement quoted in paragraph 12 of this affidavit, rock classification is very important and forms a better basis for feasibility study of a dam site than a laboratory test of rock core strength. While "classification" of the rock as such does not assure adequate description of the potentials for different failure modes in the foundation, it is far more helpful in this regard than simply having at hand the results of a discrete number of core strength tests. My book *Engineering Geology - - Rock in Engineering Construction* (John Wiley & Sons, 1993), is organized according to rock classification, with different chapters for rocks of different geological classifications, i.e. sandstones and shales, granites, etc.. Engineering experience with the construction of works, including dams, can better be conveyed in terms of rock classification than in terms of compressive strength of small samples. This is because the many facets of rock mass behavior that affect the engineering outcome are at least inferred by a rock classification whereas only one aspect is inferred by the core compressive strength distribution.

17. In view of the above, it is important to classify the rock correctly, at least in the major divisions of the geologic classification system. A site in granitic rocks - - as this one was represented to be in major part according to the geological map provided to me as part of the package provided for Tenderers - - is quite different than one in sandstones and shales. I view it as a major, and potentially disastrous

mistake if the foundation of this dam was incorrectly classified as granite. The rock strength measures to which Mr. Code refers can not, in the absence of an adequate classification of the rock, ensure the safety of a proposed dam at this site.

18. Mr. Code's item 15 apparently misunderstood my use of the word "improbable" with respect to intrusion of granite into sediments. I referred specifically to a rare structure of layered rocks in which granitic intrusions form a series of parallel layers interspersed with sediments - - the so called "lit par lit" injection structure. The geological map of the site showed a mass of granite without layers of sandstone or shale within. What was represented on the map was not in accord with what was found in the core borings. The map submitted for review in the EIA was therefore not reflective of the true rock mass properties of the site and would contribute to an overly optimistic interpretation of the site's adequacy by a casual reviewer.

19. Analysis of reservoir water retentiveness was based on an over-flight by an expert and a follow-up ground survey. No particulars or reports of these surveys were provided for review. The realization that the engineers had misrepresented a sandstone and shale sequence as belonging to a granitic rock mass, in a significant part of the foundation, utterly eroded my confidence in the geological conclusions presented in the engineering reports. Accordingly I cannot blindly accept the engineers' statement that the foundation rock is free of limestone. To gain confidence in such a conclusion, I

would need to see core logs as re-logged, fresh, by a competent independent engineering geologist.

20. In my opinion, to be reasonably assured of a successful and safe water retention project at the site of Chalillo Dam requires:

(1) preparation and presentation of a site map and cross sections showing the three dimensional structure and stratigraphy of the rocks throughout the foundation;

(2) examination of the possible modes of failure and evaluation of the probability of safety for each;

(3) preparation of a stratigraphic section identifying calcareous shales, calcareous sandstones, and any limestone lenses or layers that might be found after relogging the core and collecting outcrop data;

(4) detailed study of the reservoir rim by aerial photo interpretation to identify and locate sinkholes; and, according to the results of this study

(5) limited drilling near the reservoir rim to determine static groundwater elevations in relation to the maximum water surface.

21. It continues to be my professional opinion that an independent assessment of all the existing geological and geological engineering studies, along with the proposed construction design of the project, should be undertaken. Without such an assessment, it can not be asserted that the construction of the Chalillo dam poses no significant risk to the environment and to the lives of people living downstream.

Sworn to by the above-named)
Richard Goodman on the 16th)
day of June 2003)

_____
Richard Goodman

Before me,

_____
Notary Public

This affidavit is filed on behalf of the Applicant (Appellant) AND TAKE NOTICE that it is intended to be used at the hearing of the Motion for an injunction.