Pan American Health Organisation
Emergency Preparedness and Disaster Relief Coordination Programme
Barbados

Vulnerability Assessment
of the
Central Medical Laboratory

Belize City, Belize

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Tony Gibbs

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CONTENTS Page

1 INTRODUCTION

Located on level, low-lying ground adjacent to the new Karl Heusner Memorial Hospital in Belize city, the Central Medical Laboratory is the main testing facility for the country of Belize. The Laboratory was originally constructed in the 1960s[1] and is a single, 3-storey building (Photos 2 & 3). Photo 1 indicates that the building is also used, currently, as the national Blood Bank.

The Pan American Health Organisation's Emergency Preparedness and Disaster Relief Coordination Programme (PAHO-PED), through Dr Dana van Alphen, engaged Tony Gibbs to:

(a) inspect the premises of the Central Laboratory;

(b) prepare a report, with recommendations, on the vulnerability to natural hazards of the Central Laboratory.

2 HAZARDS

2.1 General

The primary natural hazards facing Belize are:

(i) earthquakes

(ii) hurricanes

(iii) torrential rains

2.2 Earthquakes

Seismic events in Belize are principally associated with the Cayman Fracture Zone which extends eastward from Honduras to Hispaniola and forms the boundary between the Caribbean and North American Plates in the area and is a tectonically active feature along which future seismic events may be expected. The Swan Fracture Zone (between the Cayman Trough and Honduras) is a strike-slip fault intersecting the mid-Cayman Rise about 200 km south of the Cayman Islands and is a transform fault. This is also known as the *Sistema de fallamiento Polochic-Motagua*. The northern side of the fault is moving westwards at about

[1] There is no certainty about the date. Mr Walwyn Tillet, a former director of the Laboratory said it was built in 1962. Mrs Leona Garbutt, who works at the Laboratory, thought that the building was about 30 years old. Mrs Joy Charlie, who also works in the building, said that the building was constructed in the 1960s.

25 mm per year relative to the southern side of the fault.

The Caribbean Uniform Building Code (CUBiC) recommends a Z-factor of 0.75 for areas of Belize within 100 kilometres of the southern border, *ie* including San Antonio and Punta Gorda but excluding Middlesex, Pomona and Stann Creek. For the rest of Belize (including Belize City) the recommendation in CUBiC is a Z-factor of 0.50.

2.3 Hurricanes

Belize lies in the North Atlantic Ocean, one of the six main tropical areas of the earth where hurricanes may develop every year. A general historical record of those hurricanes (and tropical storms) affecting Belize from the eighteenth century to 1979 is given in a table at the end of this sub-section. Since 1979 the following hurricane events were significant in Belize:

Tropical Storm Hermine - 22 September 1980
Tropical Storm Bret - 18 August 1993
Hurricane Mitch - 26 to 30 October 1998
Hurricane Keith - 30 September to 02 October 2000

The destructive potential of a hurricane is significant due to high wind speeds, torrential rains (which produce flooding) and storm surge (with potential heights of several metres above normal sea level).

The Caribbean Uniform Building Code sets out the basic wind parameters for the design of buildings in Belize. The normal requirement is the 1-in-50-year wind, *ie* a wind speed which on average is not expected to be exceeded more than once in 50 years. In the country of Belize this produces a basic 3-second gust wind speed between 45 and 54 metres per second (m/s). For a critical health-care facility, it is appropriate to adopt a wind speed which on average is not expected to be exceeded more than once in 100 years. This would be 61 m/s (3-second gust) for Belize City. This translates to a CUBiC (100-year) reference pressure of 1.00 kilopascals (kPa), based on a 10-minute average wind speed.

2.3.1 Catalogue[2] of Hurricane Events in Belize

The dollar values have not been adjusted for inflation. The reported frequency of events is clearly very dependent on the degree of post-Columbian, European involvement in the territory.

1700-1800

2 Compiled by CDPS Information Exchange, February 1980. Main sources – José Carlos Millas, Ray Tannehill, US Weather Bureau, CDPS, OFDA

1787 September 23	severe; great damage; many lives lost

1800-1900

1813 ??? ??	
1827 ??? ??	
1831 ??? ??	
1864 August 31	town inundated

1900-1979

1901 Jun19-Jul01	may have been affected by modest hurricane
1918 August 21-25	may have been affected by a storm
1921 June 18	
1922 June 13	floods from torrential rains
1931 September 10	1500 fatalities; damage totalled M$7.5
1932 Sep26-Oct03	entered Mexico near British Honduras[3]
1934 June 04-21	crossed British Honduras before reaching hurricane force
1942 November 08	9 deaths; M$4 damage
1945 October 02-04	great destruction
1954 September 27	slight damage
1955 September 28	(Janet) 16 killed; M$5 damage
1960 July 15	property damage slight; heavy damage to crops
1961 July 24	(Anna) considerable damage at Punta Gorda
1961 October 31	(Hattie) very severe in Belize and Stann Creek; 262 fatalities; M$60 damage
1964 November 09	tropical storm in dissipating stages
1969 September 03	flooding from torrential rains
1971 August 25	
1971 September 11	
1971 November 21	
1974 September 19	high tides and heavy rain
1977 October 18	tropical storm
1978 September 19	4 deaths

2.4 Torrential Rains

Although hurricanes are often accompanied by heavy rains, severe rainfall events resulting in flooding in Belize are also, and frequently, associated with troughs and tropical depressions. The risk of flooding is therefore not restricted to, nor more likely to occur during, hurricane events.

[3] The name for the colony before becoming independent Belize

Drainage systems and structures in Belize are generally designed for rainfall events having return periods of the order of 25 years. This means that such systems are likely to become overloaded and cause some degree of flooding when rainstorms are experienced with return periods greater than 25 years.

Generally, lower lying areas will be more susceptible to flooding than higher and sloping ground. Such is the condition in most of Belize City.

The damage caused by flooding depends on the type and elevation of facilities in the location. The results of flooding may range from the inconvenience of temporarily submerged driveways to the loss of equipment and finishes inside flooded buildings and consequential disruption of the functions.

3 INVESTIGATION PROCEDURE

3.1 General

On 28 November, at 15:30, Tony Gibbs made his first visit to the Central Laboratory. He was escorted by Mrs Geraldine Ebanks, Senior Medical Technologist.

On Wednesday 29 November Tony Gibbs undertook a detailed survey of the Central Laboratory.

During the following day (Thursday 30 November) the opportunity was taken to revisit the Laboratory to obtain clarifications on several points from the previous day's investigations.

3.2 Desk Studies

3.2.1 Documents

Drawings of the original construction were not available at the Laboratory. The only drawings found at the facility related to a renovation project undertaken by the US Uniform Services from Bethesda (Maryland) as part of a mosquito control exercise. That renovation project was completed in 1991. The renovation drawings were examined but nothing useful was found. A sample of those drawings (2nd floor preliminary layout) is reproduced in Appendix A.

Drawings of the original construction were requested from Cadet Henderson, Chief Engineer of the Public Works Department. To date these have not been received. It is not known whether copies of the drawings exist in Government archives[4].

[4] Information may be available from Mr Smith (father of Beverley of the Arts Council) or Mr Kent Cole, both former employees with the PWD. These persons could not be contacted at the time of the visit.

Once again the unavailability of as-built drawings is rendering difficult the satisfactory review of a critical facility. The importance of obtaining and archiving a comprehensive set of as-built documents cannot be over-emphasized.

3.2.2 Earthquake-resistant Design

There are a number of conceptual guidelines which can be followed to ensure that buildings and ancillary items offer adequate resistance to earthquakes. Although deviation from the following rules will not necessarily result in an unsafe structure, the basic principles are well-grounded in the observed performance of buildings impacted by earthquakes. Ideally, buildings should be:

(i) symmetrical;

(ii) not too elongated in plan (length-to-width ratio less than 3);

(iii) continuous and monolithic, with a uniform strength distribution;

(iv) designed so that vertical members will remain intact after horizontal members have "failed" or yielded;

(v) designed so that columns and walls are continuous from foundations to roof;

Features such as projecting towers, abrupt changes in section of structural elements and offset columns and beams should be avoided.

Non-structural items such as infill panels, windows, doors, suspended ceilings, services and fixtures also require careful consideration. Inappropriate detailing of stiff, infill panels could lead to premature failure of surrounding structural elements and/or the panel itself.

Similarly, windows and door frames should ideally be so detailed so as to lessen the chance of damage to the glass or the jamming of doors. In the case of services, excessive displacements could result in damage to pipes or other critical utility lines. Where possible, flexible joints should be used.

The subject building contains some of the inherent weaknesses mentioned above. The most critical issue could not be examined. It was said that the original building was elevated at 5+ feet above the then ground level. It stood in a mangrove swamp on columns, or possibly on a continuation of the reinforced-concrete walls which provide the main vertical load-bearing elements of the building above the present ground level. The adjacent ground level was gradually raised over the intervening years by filling.

3.2.3 Hurricane-resistant Design

Although there have been instances of block walls being blown over in hurricanes, adequately reinforced and tied wall panels usually perform well. Lightweight roof structures are generally the cause of greater concern. The provision of hurricane straps and adequate holding-down details is a must, and sheeting of 24 gauge or greater thickness is desirable. The corrugated roof sheets of the Laboratory are set at unfavourably shallow slopes (Photos 3 & 4). The loss of a few roof sheets is not usually costly in terms of replacement. However, collateral damage to equipment and fittings inside the building by rain can be substantial. The original roof construction is of reinforced concrete slabs which provide a useful second line of defence in the event that the roof sheeting (performing a waterproofing function) is lost.

The main areas of vulnerability of the Laboratory building are the windows and, to a lesser extent, the external doors.

3.3 Site Inspections and Interviews

As stated in section 3.1, three visits were made to the site. A number of photographs were taken and these form a major part of this report. These photos are included in Appendix B.

Inspections were limited to the superstructure and its ancillary fixtures, and to equipment vital to the maintenance of Laboratory operations. No specific examination of foundations has been undertaken; in the absence of structural plans this would require a much more intensive site investigation. It should be realized, however, that the type and condition of the foundations and the characteristics of the underlying soil will have a significant influence on the effects of earthquakes on the buildings.

Interviews were conducted with Mrs Trudy Tillet (the Director of Laboratory Services), Mrs Geraldine Ebanks (Senior Medical Technologist), Mr Walwyn Tillet (a former Director, now with the Chagas Disease Project), Mrs Marie Gomez (Medical Technician) and Mrs Joy Charlie (Blood Bank?).

In addition, the following persons were met briefly during the visit: Messrs Yah and Rosado (Chemistry), Dr Sanchez (Histology) and Mesdames Ramirez and Flowers (Microbiology).

Information on the history of the building and on its performance during (and before) Hurricane Keith[5] in October 2000 was obtained from the above-mentioned persons.

3.4 The Building

3.4.1 Water Ingress

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5 Hurricane Keith was a hurricane in the off-shore islands. In Belize City the event was measured as a tropical storm only.

The most severe problem being experienced at the Laboratory is leaking during rainstorms. Although the leaking was dramatic during Hurricane Keith, the building leaked noticeably before Keith. Those leaks were through both the windows (Photo 8) and the roof (Photo 16). Water damage in Cytology (Photo 12) was directly attributable to Keith.

As an emergency measure during and after Keith, sheets of cardboard were threaded through louvre blades (Photo 21) to stem the flow of rainwater. Some of the louvres cannot be closed (Photo 22) which aggravates the inherently unsatisfactory performance of this window type.

Several of the photographs in Appendix B illustrate the consequences of rainwater ingress. The captions of those photographs, and the photographs themselves, are self-explanatory.

3.4.2 Utility Services

The main refrigerator in the Blood Bank stopped working during Keith because of the lack of power. Up to the time of the visit this refrigerator had not been made functional.

The building has a standby generator (Photo 6) but it is not working. The Laboratory is a facility independent of the adjacent KHM Hospital. The standby power systems are not integrated.

Originally there was a high-level water tank on the roof (Photo 2). Evidence of this can be seen in Photos 10 and 11. The tank was taken out of use during the 1991 renovation project. The reason for so doing is not known.

The Electrical Switchgear and the Water Pump share the same room. The electrical wiring and the telecommunications cabling are in need of considerable tidying. Electrical wires are best put in conduits.

3.4.3 Egress

Although this subject is outside of the scope of the present report, it should be noted that there is only one means of egress from the top floor. This was pointed out by Mrs Charlie.

One of the two staircases leading from the second storey to the lowest level ends at an external door which has been "permanently" closed.

3.4.4 Storerooms

The situation is very unsatisfactory (Photos 27 & 28). In addition to the fire hazard, the congestion and the instability of stored items, there is the question of load concentration. Certainly the Laboratory has very strong floors. However, the very heavy loading concentrated at the top of the building (third storey) increases its earthquake vulnerability.

3.4.5 The Floors

The timber construction has hardwood[6] members. Favourable features include:

(i) herringbone struts (not everywhere) to spread localised loads to adjacent floor joists;

(ii) floor joists placed close together;

(iii) diagonally-laid floor boards to act efficiently as a diaphragm (horizontal beam) which serves to distribute earthquake (and wind) loads to the various vertical structural members (columns and walls). This does not occur everywhere.

In some cases the tongue-and-groove flooring is covered with plywood to receive asphalt tiles (Photo 13).

The timber components have been affected badly in the past by termites. This was dealt with by fumigation. However, there is some evidence of a return of the termites.

3.4.6 The Main Structure

According to Mr Tillet, the building is supported on piles. He thought that the columns below the existing ground floor were 12 inches square. If this is so, it could pose a significant problem for earthquake resistance.

The main frame is of reinforced concrete. Typically there are load-bearing walls and concrete girders which support the timber floor structure and tie the walls and columns together. The roof slabs appear to be of concrete. Non-structural partitions are mainly of gypsum plaster board. This is favourable for earthquake performance.

The lowest floor slab is of reinforced concrete construction.

The roof mounted water tank is unfavourable from a seismic-resistance standpoint.

The overall impression (from 3.4.6 & 3.4.7) is of a building that was thoughtfully designed. However, the inconsistencies indicate that the design may not have been carried through diligently into construction.

3.4.7 Loose Items

The high-level cupboards installed in Chemistry & Haematology (Photo 31) and Microbiology (Photo 32) are very suitable for protecting contents in earthquakes. However, they must be

[6]The wood is possibly zericote or sapodilla.

kept closed whenever they are not being accessed.

Gas cylinders (Photo 33) must be restrained against toppling during earthquakes with chains or other belts or clasps. Other high-level equipment (Photo 34) must be secured for the same reason.

Wheeled equipment must be fitted with brakes which must be maintained (Photo 35). Of course, the brakes must be "ON" whenever the equipment is stationary.

3.4.8 Flooding

There are no formal pavements in close proximity to the building. Flood waters lie everywhere. Little attention has been paid to stormwater drainage. Admittedly this problem poses a significant challenge but this is hardly a reason for ignoring it.

Storm surge from a hurricane making landfall south of Belize City would devastate this facility. Fortunately, more than 50% of the hurricanes striking Belize will make landfall north of Belize City. Therefore it is worthwhile reducing the vulnerability of the building to other events.

3.5 Other Issues

The issues below are outside the Terms of Reference for this assignment. They are listed here because they may affect decisions on what actions should be taken to address natural hazard vulnerability.

Dr Sanchez indicated the critical need for an extractor fan to be installed in the Trimming Room. This is a health issue.

Mrs Tillet has identified the need for a substantial amount of additional space. Proposals have been made for an annex. One of the options, prepared by CAREC[7], is shown in Appendix A.

Mention has already been made of the congestion in the Storerooms and the attendant fire hazard.

Apart from the lack of space in the Blood Bank, this facility has other problems. It is really unsatisfactory to have blood donors walking up and down a 3-storey building. (There is no elevator.) If it is decided that the Blood Bank should remain in its present location then an elevator should be provided. Also, the relocation of stored materials could provide vital additional space for the Blood Bank.

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[7]Caribbean Epidemiological Centre

4 CONCLUSIONS & RECOMMENDATIONS

4.1 General

The facilities are generally in poor condition. There is evidence of inadequate maintenance and widespread evidence of water damage.

The refurbishment of the building is clearly necessary.

Generally, remedial work can be divided into short-, medium-, and long-term objectives.

4.2 Short Term

The immediate goals would be:

(i) Installation of weather-proof, impact-resistant glazing as replacements for all windows

Alternatively, installation of shutters fixed permanently to the walls

(ii) Provision of supplementary hardware to secure external doors against hurricane winds

(iii) Providing formal pavements incorporating conscious stormwater drainage for the forecourt of the facility

Because of the difficult, low-lying nature of the site, a porous pavement should be considered for the parking areas (see Photo 36 taken at the CEP[8] offices in Barbados).

(iv) Relocating or reorganising the storerooms on the top floor

(v) Making the standby power generator functional

Alternatively, a new generator should be installed.

(vi) Surveying for roof leaks and making good defective areas

(vii) Refurbish the internal surfaces (flooring, wall finishes, ceilings)

(viii) Search the Government archives for information on the original construction

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[8]Consulting Engineers Partnership Ltd, where Tony Gibbs is based.

4.3 Medium Term

More medium-term in nature would be the following:

(i) Reorganise the electrical and telecommunications wiring, putting the former (at least) into conduits

(ii) Investigate the substructure (in particular) of the building and determine the vulnerability of the overall structure to earthquakes and decide on retrofitting options if so indicated

4.4 Long Term

Because of the impracticability of protecting the property from storm surge, the facility should be relocated (*ie* a new one should be constructed) and the present building reallocated for non-critical functions.

5 COST ESTIMATES

These will refer to the short-term measures only.

These have been prepared by local consultants Burrell & Burrell, after briefing by Tony Gibbs.

The estimates are conservative in view of the limited time available for this study.

All costs are given in Belizean dollars, except after the Total of local costs.
(BZ$2.00 = US$1.00; BZ$1.00 = US$0.50)

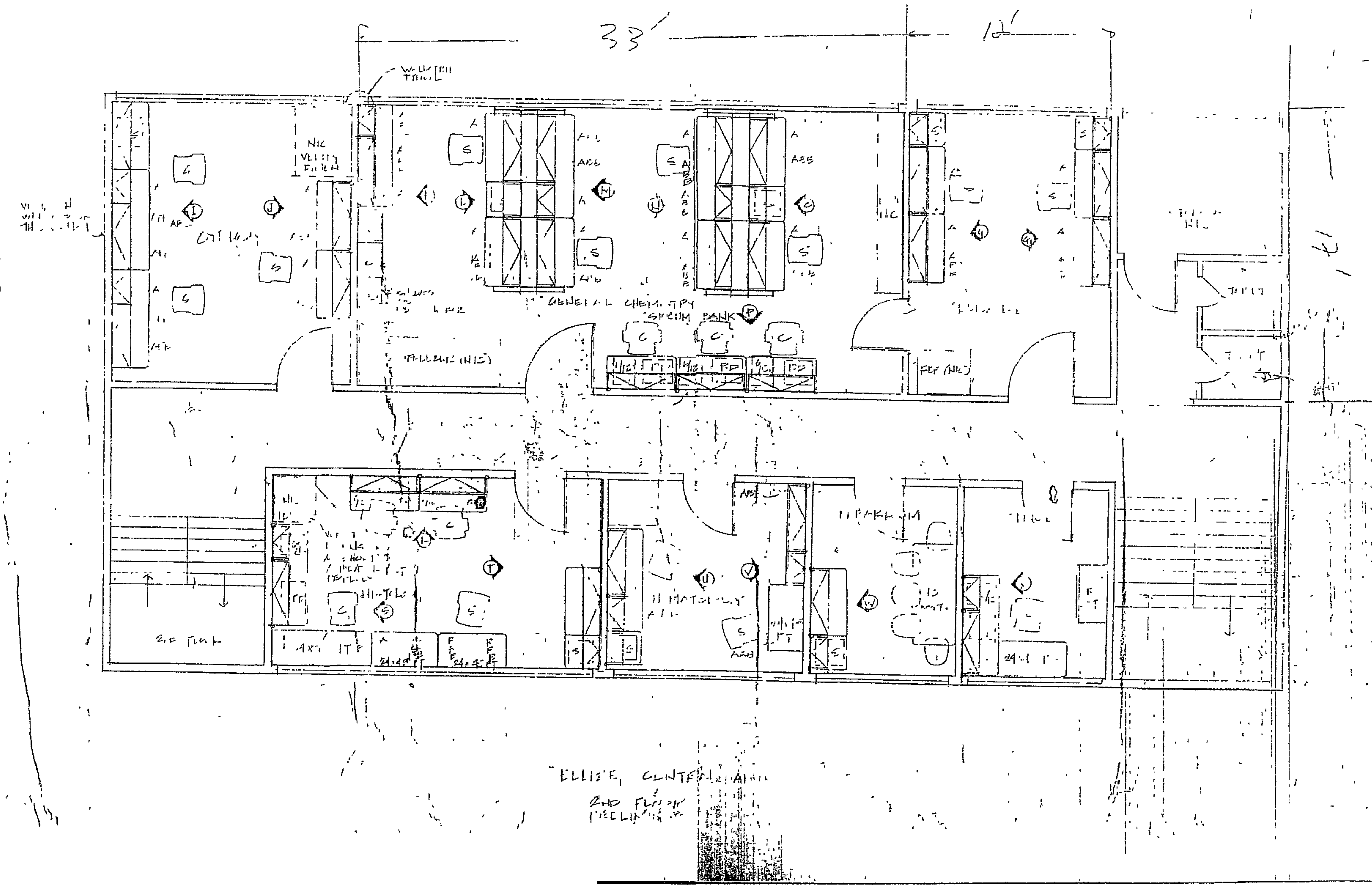
(i)	weather-proof, impact-resistant glazing	BZ$ 66,000
(ii)	supplementary work to external doors	BZ$ 300
(iii)	pavements incorporating stormwater drainage	BZ$ 39,000
(iv)	relocating the storerooms	by Government officers
(v)	repairing and enclosing the standby power generator[9]	BZ$ 6,000
(vi)	repairing roof leaks	BZ$ 7,000
(vii)	refurbishing the internal surfaces:	
	flooring	BZ$ 13,500
	wall finishes	BZ$ 27,000
	ceilings	BZ$ 10,000
(viii)	search the Government archives	by Government officers
	Sub-total	BZ$ 168,800
(ix)	Contingency	BZ$ 25,000
(x)	Local consultants' fees + expenses	BZ$ 29,000
	Total local costs	BZ$ 222,800 = US$ 111,400
(xi)	Monitoring consultant's fees + expenses[10]	US$ 9,000
	Overall project estimate	**US$ 120,400**

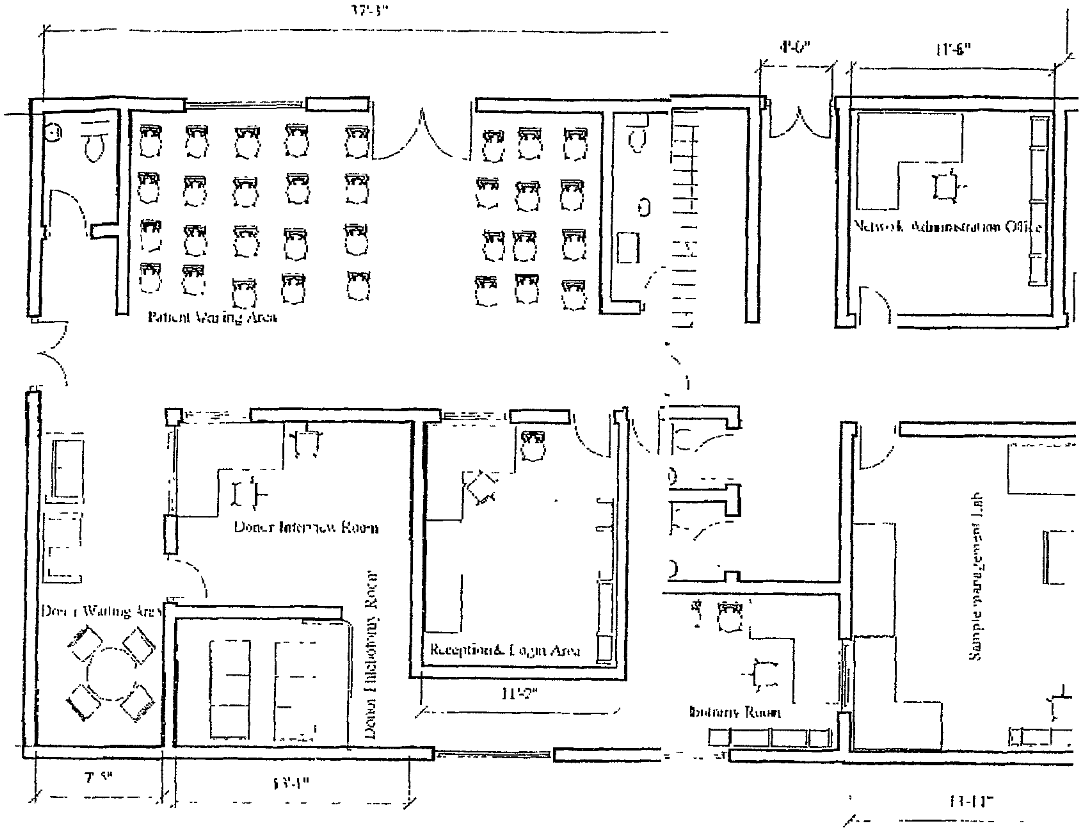
[9]There does not seem to be any major problems with the generator. However, the inspecting technician considered that a new generator should be obtained. That particular brand of generator is not available in Belize and obtaining parts could be both time-consuming and very expensive.

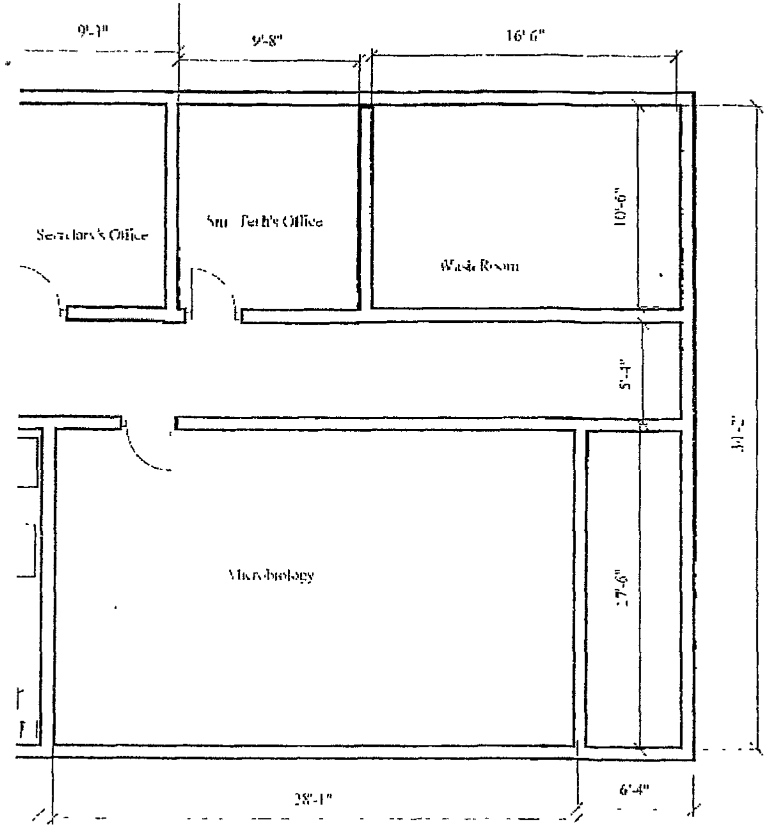
[10]This allows for 2 visits to Belize and additional monitoring by correspondence.

Appendix A

Drawings


33'
16'
GENERAL CHEMISTRY





Belize. Laboratory Extension - Option 2

Date November 20, 2000

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Appendix B

Photographs