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## **Haiti 2010 Earthquake Response**

### **Seismic, Geological and Building Hazards**

#### **Interim Risk Management Plan: March – December 2010**



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**A joint report from the Government of the Republic of Haiti  
and the United Nations**

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# EXECUTIVE SUMMARY

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## Introduction

This interim risk management plan has been produced by a joint United Nations, government and international academic team for use by all stakeholders present in Haiti and those outside of Haiti and engaged in the relief effort and recovery planning processes.

In the context of the January 12<sup>th</sup> 2010 earthquake and relief programme, its purpose is to launch a programme of action to directly protect the population of Haiti and international visitors, the economy and the relief effort from ongoing major and life threatening seismic, geological and building hazards. It is also designed to inform decision makers engaged in the recovery and reconstruction process.

There are essentially two types of hazard to be addressed:

- Regional scale hazards, (Enriquillo Fault aftershocks and triggered earthquake, earthquake on the Septentrional Fault and tsunamis) where the exposed/vulnerable population can be in the order of millions.
- Point source hazards (landslides, building collapse and debris falls), where the exposed vulnerable population for each potential incident is typically in the order of individuals to hundreds but for all of the buildings across the impact area this still adds up to over 2 million vulnerable people.

A plan of action is proposed with the following objectives:

- Reduce the vulnerability of nearly 3.0 million people to identified life threatening hazards;
- Avoid major disruption to the economy;
- Avoid major disruption to and where possible assist the relief programme;
- Inform and thereby influence the recovery planning process.

The planned main activities are:

- Communication and emergency preparedness;
- Landslide assessment and emergency works;
- Building assessments;
- Hazard marking and barricading;
- Emergency demolition;
- Emergency repairs;
- Seismic programme;
- Interim seismic risk zoning;
- Interim building code and permitting scheme;
- Participation in the Post Disaster Needs Assessment and recovery planning process

- Multi-hazard assessment and plan revision

The cost of the plan is approximately US\$ 19 million and can be implemented as part of the relief and recovery programme within 2010 under the oversight of the Ministry of Public Works. The most novel part of the plan is a proposed new programme on seismic risk, whilst the majority of the cost is linked to fairly straightforward but urgent engineering works. At present the plan is only 3% funded and so the next step is to secure funding.

Several documents are annexed to inform all parties of the UN position on these hazards and to continue the process of earthquake risk communication and education.

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## **1 Introduction**

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### **1.1 Purpose of this report**

This interim risk management plan has been produced by a joint United Nations, government and international academic team for use by all stakeholders present in Haiti and those outside of Haiti and engaged in the relief effort and recovery planning processes.

In the context of the January 12<sup>th</sup> 2010 earthquake, its purpose is to launch a programme of action to directly protect the population of Haiti and international visitors, the economy and the relief effort from ongoing major and life threatening seismic, geological and building hazards. It is also designed to inform decision makers engaged in the recovery and reconstruction process.

It is designed for rapid implementation and distribution and so is based on relatively limited information on some of the geological hazards. Nonetheless it is also based on a foundation of substantive recent fieldwork, national ownership and wide ranging international experience of post-earthquake hazards and appropriate risk management plans.

The United Nations was significantly affected by the earthquake and now has thousands of international and national staff engaged in the relief effort. Hence this report is also addressed to this workforce and can be considered also highly relevant for the 1000+ other international organisations working in Haiti.

Note that the science in this report is drawn from a number of technical sources. All key sources are referenced however it must be noted that many of the references are short reports from the relief effort, not technical documents.

### **1.2 Time validity of this report**

The risk factors present after an earthquake change substantially over time. In addition the risk management plan proposed includes a range of measures designed to gain a better understand some hazards and also to directly intervene to remove others. Finally the first wet season in Haiti commences in April and the hurricane risk season commences in June.

Hence this report is anticipated to be made obsolete in part by events and interventions and should be considered as valid only for the period **March to December 2010**. In the interim the teams within Haiti will develop solutions and provide input for a more comprehensive and fully informed risk management plan proposed for release later this year.

### **1.3 Science and information limits on hazard and risk assessments**

There are significant scientific and information limits on the assessment and risk management for earthquakes and other geological/natural hazards such as landslides and tsunamis. Analyses and forecasts made with the best available science and data may still have high levels of uncertainty. In this report, such forecasts are made to assist the risk management process, however readers should

also bear in mind the linked assessment of certainty – where possible expressed as percentage figures, but otherwise expressed as high, medium or low.

#### **1.4 Scope limits - exclusion of hydro-metrological hazards**

There are two main generic groups of natural hazards relevant to Haiti:

1. Hydro-metrological hazards – floods, strong winds, storm surges.
2. Geological hazards – Aftershocks, earthquakes, landslides, tsunamis

In addition as a result of the January 12<sup>th</sup> earthquake, people in the impacted are faced with a third type of hazard:

3. Building hazards – collapses and debris falls

This report covers only the management of hazard groups 2 and 3 as these are relatively new to the current population of Haiti, whilst the hazards from group 1 are severe but also better understood and well established.



## **2 Earth Science Background**

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### **1.1 Tectonics of Haiti**

Haiti is part of the Caribbean Plate, which in simplified terms is a section of the earth's crust which is bounded by major faults and changes in geological structure. Movement of the different plates along the fault boundaries causes earthquakes. Within plates, faults are also present and divide the plate into micro-plates.

On a geological timescale the Caribbean Plate is moving eastwards at approximately 20mm per year. This movement does not occur smoothly but as a series of short jumps and shifts, each such event signalled by an earthquake. The timing between shifts is not accurately predictable, however specialists can assess the scale of movement and energy stored in the system and thereby indicate what scale of earthquake is possible and on what major fault. Accurate prediction of earthquake locations is also not possible but again analysis can indicate likely risk areas, given sufficient data.

Haiti is on a micro- plate and has two major faults of concern for earthquake risk: the Enriquillo fault which crosses the southern peninsula from east to west and the Septentrional Fault which runs east to west along the northern coast of Haiti (See Figure 1). Both faults are part of larger systems and continue east and west of Haiti for over 1000km.

Both of these faults have generated earthquakes over the centuries, destroying Port-au Prince in 1751 and Cap Haitien in 1842. (See Figure 2)

### **2.1 Geology and topography of Haiti**

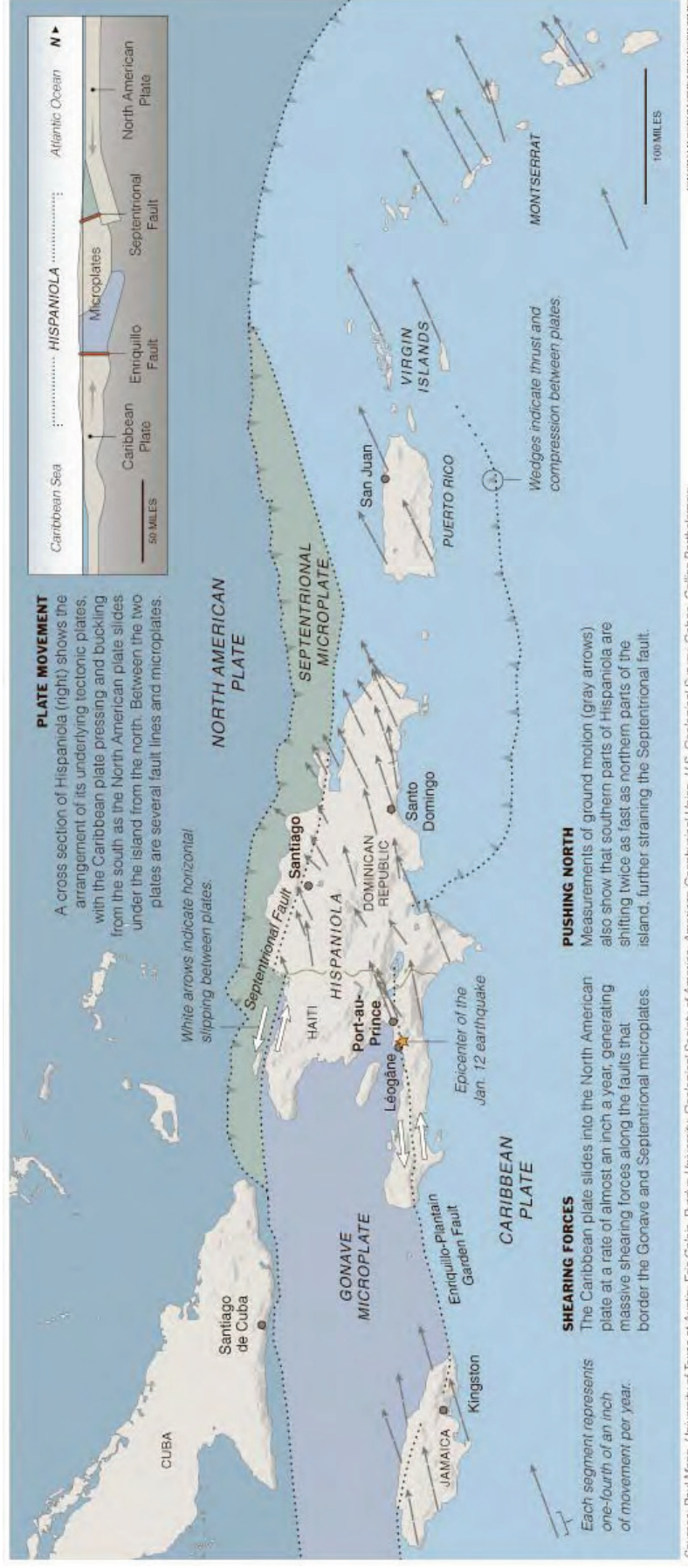
On a smaller scale geology and topography have strong links with earthquake and geological hazards.

In very simplistic terms, Haiti has three layers of geology. The bottom layer is very old (Jurassic/Cretaceous) metamorphic rocks, that form the backbone and basement of the island. These rocks are overlain in many areas by thick but variable layers more recent sediments such as limestone. Both of these formations are cut by faults. Finally erosion of both of these types of formation has resulted in the deposition of beds of loose sediments in the rivers, floodplains and coasts. These geologic variations are actually critical to earthquake vulnerability: in general it is better to have buildings on solid bedrock rather than loose sediment.

Haiti is a highly mountainous country, with steep mountains and narrow valleys and relatively few major regions of sediment and floodplains. This steep topography is directly linked to earthquake vulnerability and landslides.



**Figure 1 – Plate tectonics of the Northern Caribbean Region (From NY Times)**



Sources: Paul Mann, University of Texas at Austin, Eric Calais, Purdue University, Geological Society of America, American Geophysical Union, U.S. Geological Survey, Gebco, Collins Bartholomew

JONATHAN CORDON/THE NEW YORK TIMES

Figure 2 – History of major earthquakes in the Northern Caribbean Region (from NY Times)

The New York Times

January 26, 2010

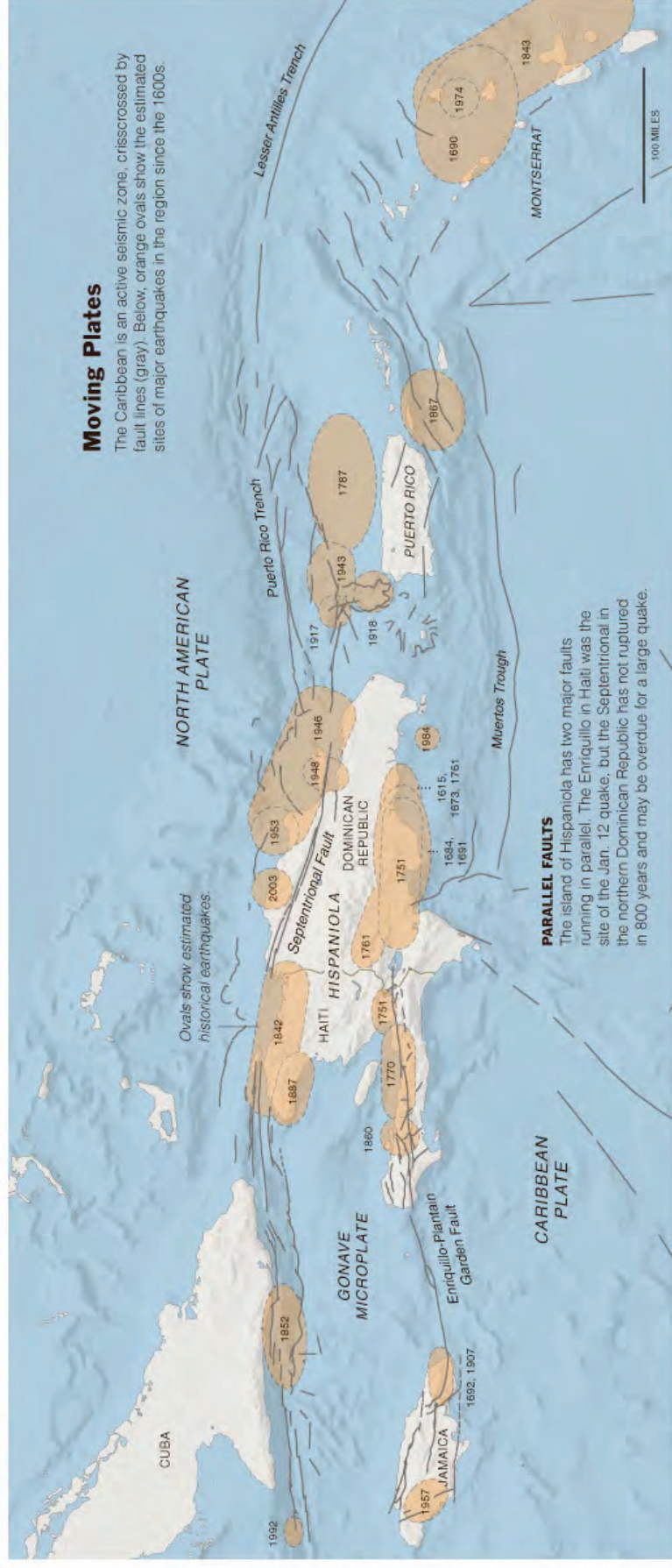
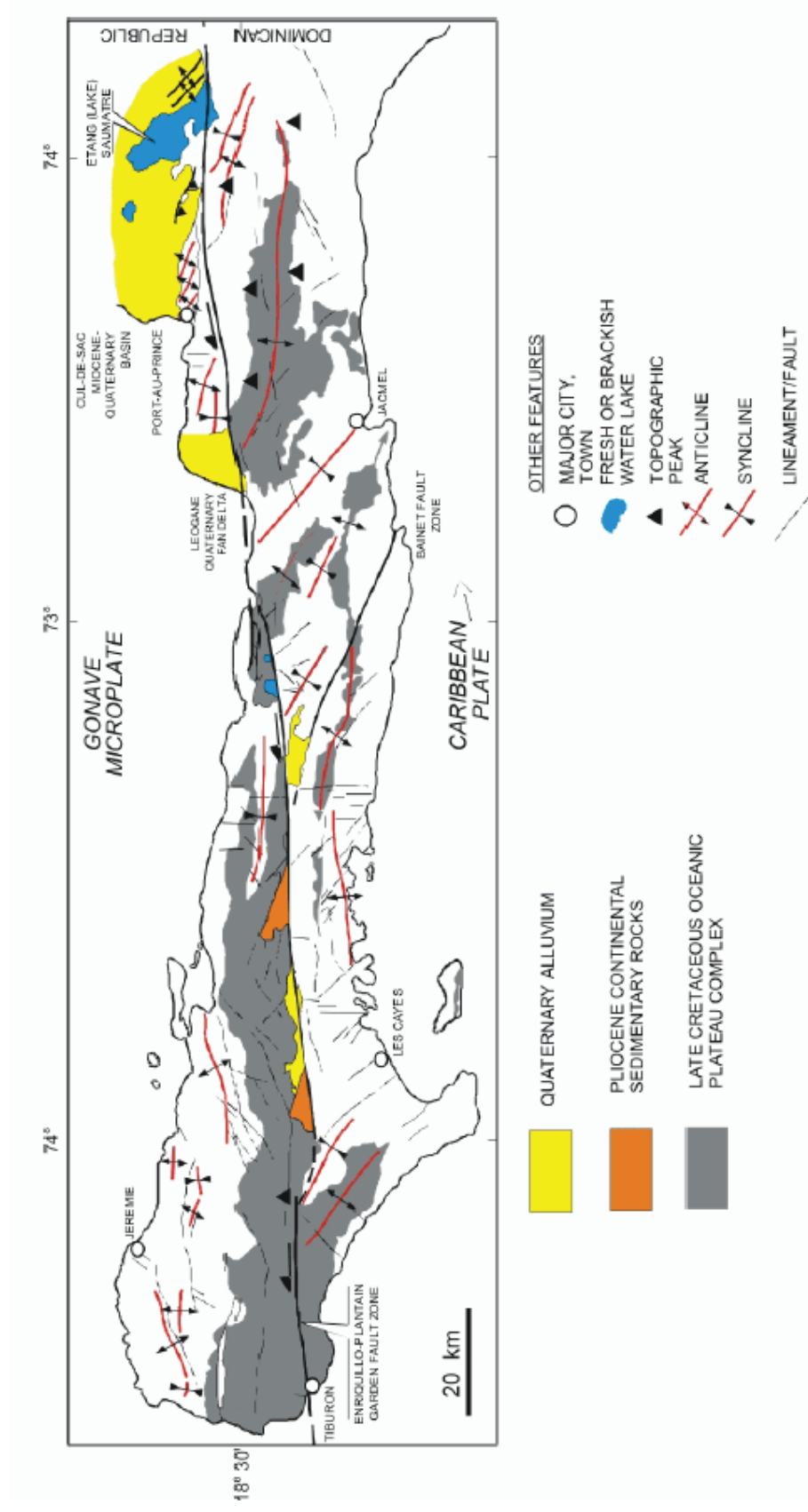


Figure 3 – Details of the Enriquillo Fault in the Southern Peninsula of Haiti (From P Mann)





## 2.2 The January 12<sup>th</sup> earthquake event

The 12<sup>th</sup> January Haiti earthquake occurred on the Enriquillo Fault at 16:53 local time, with the surface location of its epicentre at 18.457 degrees N, 72.533 degrees W which is 25km WSW of Port au Prince. The depth of initiation was 13km and this is considered shallow in tectonic terms.

The fault ruptured for a length of approximately 35km, with approximately 25km west of the epicentre and 10 km east. The resultant energy distribution has not been accurately mapped or modelled, but from the structure and from the noted damage it is clear that the majority of the energy projected west of the epicentre. Hence Leogane, Petit Goave and Grand Goave were subjected to intense shaking whilst Port au Prince was subject to significant but nonetheless much less intense shaking than at the epicentre or further west. Note that the distribution of casualties is therefore more a reflection of urban density and building types than the energy distribution.

## 2.3 Aftershocks

The main event has been followed by a relatively active period of aftershocks. Over 40 aftershocks with a magnitude of 3.0 or more have been detected and the largest most recent shock was a 5.9 registered on January 20<sup>th</sup>. The majority of the aftershocks at present are sourced from the western end of the rupture zone.

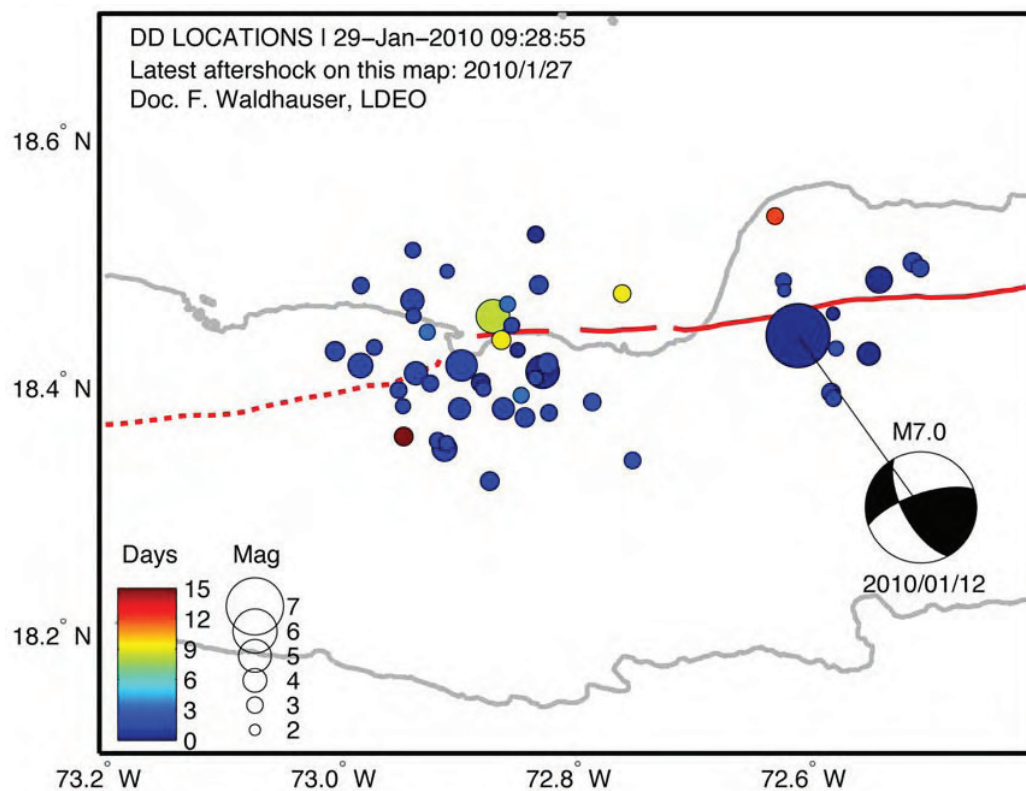


Figure 4 - The January 12<sup>th</sup> earthquake and associated aftershocks

### **3 Social and built environment background**

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#### **3.1 Haitian society in the earthquake impact zone pre January 12<sup>th</sup>**

Approximately 3.0 million people lived in the zone impacted by the earthquake. Over 80% of these people were located in greater Port au Prince, which is an ill-defined but near continuous urban area encompassing the cities and towns of Port-au Prince, Petion Ville, Killick, Carrefour, Cite Soleil, Delmas and Tabarre. The remaining 20% were located in the small towns and countryside in a 40km zone west and southwest of greater Port au Prince: Gressier, Leogane, Grand Goave, Petit Goave, Mirogoane, Jacmel and Marigot. In terms of the livelihood and lifestyles of the affected population the vast majority could be classed as urban dwellers. In terms of socio-economics the area affected includes both the richest area: central Petion Ville and some of the very poorest: Cite Soleil and Killick. Note that key socio-economic figures for Haitian society as a whole are available on the Haiti revised Flash Appeal 2010.

#### **3.2 Built environment pre January 12<sup>th</sup>**

The great majority of buildings in the region are individual units of 1-3 storeys. The predominant building material in the region is masonry bricks within a reinforced concrete frame and poured concrete roof and floor slabs. Other variations include rare older brick buildings with metal roofs and very informal shanties composed of timber, brick, plastic and metal with metal roofs. The city centres of Port-au Prince and Petion Ville have a small number of steel framed concrete clad and full concrete high-rise apartments and commercial structures with the tallest being in the order of 10 stories. Older warehouses are generally brick walled with truss roofs whilst modern warehouses are almost exclusively steel framed and steel/aluminium clad.

The greater Port-au Prince region is a mixture of steep hills and coastal plains and urbanisation is present on virtually all ground types including very unsuitable areas such as on very steep slopes, on infilled marsh and in flood plains. The great majority of the large public buildings were sited in the gently sloping ground of central Port au Prince.

There was and is no definitive count to the number of structures within the impact area. Based on an affected population of 4 million, a typical family unit of 5 or more, extensive communal living and a large number of commercial and government buildings, the number of structures is speculated to be in the order of 500,000. Detailed quantitative assessments of building damage are ongoing.

#### **3.3 January 12<sup>th</sup> damage to the built environment**

Building damage assessments are still ongoing as of March 1<sup>st</sup> however the general extent of the damage can be estimated from early assessment results.

The Haiti government has estimated that 250,000 residences and 30,000 commercial buildings are either badly damaged or destroyed. An on-site engineer (the author) made a first pass ground level estimate of building damage within Port au Prince with the following results. Dependent upon the area

in PaP, approximately 30% of buildings were collapsed or visibly severely damaged with hanging debris and/or shifted walls and floors. Of the remaining 70%, initial building inspections by specialist structural engineers (which generally focused on the better buildings) provided Green (undamaged or lightly damaged) ratings for approximately 50% and either Yellow or Red ratings for the other 50%. This infers that approximately 65% of buildings in PauP are either destroyed or significantly damaged to the extent that repairs may not be practicable. A further percentage (in the order of 10-30%) is slightly damaged and repairable. Within the city, wide variations are visible, with limited damage in Petion Ville and Cite Soleil and major damage in the city centre. There were of course also wide variations in damage based on building design and on size.

Outside of Port-au-Prince the damage varies widely. The hardest hit region from Leogane to Petit-Goave suffered 80% building destruction and almost 100% significant damage.

So in summary, several hundred thousand buildings have been damaged and/or destroyed. This includes many if not most key commercial and government buildings in Port au Prince (Presidential Palace, PaP Cathedral, many Ministry Buildings, Montana and Caribe hotels and several large banks).

**Figure 5 – Destroyed Presidential Palace (Photo Credit Time)**





**Figure 6 – Destroyed informal settlements (Photo Credit Time)**



**Figure 7 – Destroyed townhouses in downtown Port au Prince (Photo Credit Time)**





### **3.4 Casualties, social and economic damage from January 12<sup>th</sup>**

Detailed estimates of casualties and initial social impacts are compiled and updated regularly by the government and the UN. As of February 14<sup>th</sup> the key figures were: Killed 212,069, Wounded 300,000, Missing 361, Displaced 900,000 – 1,200,000 including nearly 500,000 moved to the countryside and regional towns.

### **3.5 The UN in Haiti**

The UN in Haiti on January 12<sup>th</sup> consisted of the UN Mission for Stabilisation in Haiti (MINUSTAH) and over 20 agencies. Total international staff numbers were in the order of 5000 including both national and international staff. The total UN building count is at present not precisely known but anticipated to be in the order of 200. It is important to note that a) the majority of UN buildings are leases, not UN owned and b) many owned building are soft skinned or portable one storey buildings.

The total number of international and national staff residential buildings is as yet unknown but speculated to be in the order of 1000. Virtually all international staff residences are leasehold and many are apartments.

Damage to the UN in Haiti from the earthquake was very significant. As of February 11<sup>th</sup> the key figures were 93 dead, several still unaccounted for and over 100 injured. Several key buildings were destroyed or left unsafe for entry including the UN headquarters (destroyed with major loss of life) and the UNDP-multi agency compound (1 building destroyed, 2 of the 3 other major buildings left unsafe, no major casualties). Of the remaining UN compounds (e.g. UNICEF, WHO, FAO, IOM) all have sustained damage and several are destroyed or left unsafe.

**Figure 8 – UN Headquarters building in Haiti (Photo Credit Time)**



## **4 Post disaster activities and risk management context**

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### **4.1 Introduction**

The first two weeks after the earthquake was a period of frantic emergency response. The major focus areas were on search and rescue, emergency medical treatment and regrouping and mobilisation of relief capacity. In this critical life-saving period large numbers of people took enormous risks to rescue and search for others, supply aid, regroup possessions and restart basic utilities and logistical capacity.

The following month has seen the shut down of search and rescue operations and completion of the first wave of medical treatment. Enormous resources have been mobilised for the relief effort and the number of organisations engaged in the relief effort is estimated by OCHA to be over 900. Large scale relief operations for supply of food, water and shelter are well underway.

At the same time, the population of Haiti has reacted to the disaster in two very positive ways. First of all, the extremely resilient population has rapidly rebounded to the extent possible and normal life has started to reappear in terms of operating businesses, public transport etc. In addition an estimated 500,000 inhabitants of the impacted region have left for other parts of Haiti, generally seeking shelter and assistance with families.

This change in relief and population context is important from a risk management perspective as it marks the commencement of an anticipated long term relief process, which will evolve and hopefully reduce but may still last for two years or more. Recovery is anticipated to take over a decade.

In this context, urgent life-saving risks no longer need to be taken collectively, but are probably only justified for ongoing isolated incidents and associated emergency medical cases. Nonetheless there are still many ongoing hazards linked to the earthquake and introduction of an organised risk management approach may still save lives and avoid needless suffering.

The sections below provide context for the preliminary hazard assessment and solutions proposed in the following chapters.

### **4.2 Ongoing aftershocks and building damage**

A particularly important feature of the post-quake period is the continued aftershocks that have repeatedly been felt across the region since January 12<sup>th</sup>. These aftershocks have had two impacts:

- They have weakened and further damaged buildings already damaged by the January 12<sup>th</sup> event and resulted in isolated collapses and debris falls. In two cases noted by the author a) thin cracks in columns of a 6 storey apartment building barely visible on January 18<sup>th</sup> had expanded dramatically within a week to the extent that structural integrity was compromised and b) previously vertical walls of a warehouse had developed a 5% lean with partial collapses. The most recent reported partial collapse was a supermarket in Port au Prince on February resulting from an 4.0 aftershock.



- They have frightened the population, motivating people to remain outside. This is not a universally positive event as many structurally sound and important buildings such as hospitals have been needlessly evacuated.

**Figure 9 – DASH Delmas 48 Hospital – Sound and undamaged but evacuated (Photo credit EES)**



#### **4.3 Relief programme and shelter sites**

The relief programme is now ongoing at near full scale. Over 900,000 people are being provided safe drinking water each day, food aid has reached 2.3 million and shelter and non-food aid is reaching 19 major sites and many more small sites.

A key issue for interim risk management is the shelter situation. At present plans are underway for moving selected informal camps to organised transitional shelters. The anticipated transitional shelters are one storey buildings with wood or steel frames and so have an inherent low vulnerability to earthquakes.

#### **4.4 Demolition and debris clearance**

Demolition and debris clearance started in the first week as part of road clearance and search and rescue. The scale of activity has escalated with each week however to date most of the activity has been with the national construction company CNE and the private sector. Activity levels are expected to increase radically when the first large scale debris linked aid projects are launched in late February. These projects are of two types: classic demolition and debris transport operations using heavy earthworks machinery and “cash for work” schemes where the focus is on maximising the active labour force. Cash for work entails particular risks associated with building collapse and debris falls.

#### **4.5 Building safety and vulnerability assessments**

Building safety assessments commenced on January 13<sup>th</sup> and have been gradually increasing in scale and formality. Over 10 different volunteer and bilaterally funded assessments teams have visited Port au Prince over a 4 week period and have assessed approximately 400 buildings. Government teams have also formed and started assessments. Early (first week) efforts focused on rapid assessment of life-critical buildings such as hospital space needed for re-occupation as emergency surgical wards and food warehouses. Later efforts spread to UN compounds, houses, apartment buildings, offices, orphanages and other public use facilities. The majority of assessment were based on the US based ATC 20 system (Post earthquake Safety Evaluation of Buildings).

Results varied widely but a typical team result of 107 buildings was 26 marked as Red (Unsafe -No Entry), 23 marked as Yellow (Significant damage, Limited Entry/Restricted Use) and 58 Green (Appears safe).

Building earthquake vulnerability assessments, which are different and more intensive than the ATC20 process have yet to start. An important informal finding from the assessment engineering teams is that the great majority of buildings they inspected would fail many developed country building codes and virtually all formal earthquake codes/vulnerability assessment standards.

**Figure 10 – WFP food warehouse – assessed as Yellow – Restricted Entry (Photo credit EES)**



#### **4.6 Emergency repairs and damage concealment**

To date emergency repairs have been generally limited to temporary works on roads, equipment repairs for utilities and private sector repairs on homes and businesses. Large scale repairs of public sector or UN buildings have yet to commence. The most common type of repairs noted were re-installation of masonry infill walls and walls for security.

An unfortunate and disturbing phenomenon noted by the assessment teams was unsuitable and cosmetic repairs – in some cases extending to concealment of damage. In these worst cases, building owners were infilling cracks and failed beams and columns with cement in an ad hoc manner and then plastering or painting over. This irresponsible behaviour indicates a significant future risk of building collapse in the event of a future earthquake as some apparently unmarked and sound buildings may in fact be seriously weakened underneath a concealing coat of cement, plaster or paint.

A further item of caution was the noted cutting, extraction and re-straightening of reinforcing bars for resale on the open market. Houses built with this weakened material will be more vulnerable to earthquake than those using new reinforcing.

#### **4.7 The UN response in the first 4 weeks**

The UN response in the first 4 weeks was unprecedented as it was both a victim and first responder, with significant resources and expertise already on the ground at the time of the earthquake. As such it conducted many activities in parallel;

- Emergency operations linked to its own losses and also to support the larger international community and the general population (search and rescue, evacuations, medical treatment)
- Helped the government re-establish control and security of emergency and relief operations;
- Coordination of the mobilisation and implementation of the large scale relief effort;
- Commenced planning for early recovery.

With respect to risk management related to natural hazards, the UN focus in the first four weeks was on rapid assessment of aftershock and building collapse risks and broader assessments of damage and other hazards such as landslides. As a precautionary measure, re-entry restrictions were placed on all UN compounds and international staff residences pending the results of ATC 20 type building safety assessments.

As the assessments were completed a gradual process of re-entry and re-use was initiated – for the buildings that passed assessment. Nonetheless due to the occurrence and ongoing risk of aftershocks, as of Feb 11<sup>th</sup> all UN staff were being encouraged to limit building entry and sleep outside or in soft skinned or steel framed buildings.

## **5 The ongoing seismic, geological and building hazards**

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### **5.1 Introduction**

Haiti had a full complement of natural hazards before the January 12<sup>th</sup> earthquake; however the prior focus was on hydro-meteorological hazards (hurricanes and floods). These original hazards remain however the scale, distribution and composition of geological and seismic hazards have been radically altered. In addition the large stock of badly damaged buildings in the quake impact zone now presents its own set of hazards.

There are essentially two types of hazard to be addressed:

- Regional scale hazards, where the exposed/vulnerable population can be in the order of millions.
- Point source hazards, where the exposed vulnerable population is typically in the order of individuals to hundreds.

The following sections list and describe the ongoing regional seismic hazards and also the geological and building hazards (both regional and point source) that apply specifically to the earthquake impacted region.

### **5.2 Regional seismic hazards**

As tragically evidenced on January 12<sup>th</sup>, Haiti is in a seismically active region. Seismic hazards associated with active faults in the region are effectively permanent. The hazards are permanent; however the day to day probability of a serious earthquake continually and gradually evolves over time. Over time stress is built up until the fault suddenly ruptures at a critical point – the epicentre. When an earthquake occurs, the equilibrium is massively disturbed and the risk picture changes – aftershocks continue for months if not years and in some areas the risk of another quake is increased, in other areas it may be decreased.

For the quake impacted region, the short to medium term situation is dependent upon the further behaviour of the Enriquillo Fault and this is addressed in the next sections. For the rest of Haiti there is one important risk to be aware of: the Septentrional Fault. A further regional hazard is tsunamis generated by large marine earthquakes in Haiti or elsewhere in the Caribbean.

### **5.3 Aftershocks on the Enriquillo Fault**

The rupture zone of the Enriquillo fault will continue to produce aftershocks. If it behaves in the general manner of such zones it will produce fewer and fewer aftershocks for a period of months and possibly up to two years at the outside. The US Geological Survey has estimated the risk of aftershocks using a computer model with the following results.



Aftershock magnitude (M)	30 day period	90 day period	One Year Period
M5 or greater	55%	80%	95%
M6 or greater	7%	15%	25%
M7 or greater	1%	2%	3%

(US Geological Survey forecast from February 23<sup>rd</sup> 2010)

So in general these aftershocks are and will be small; however there is a strong possibility of isolated shocks of up to and even greater than M6.0 strength. This strength of shock has the capacity to cause isolated building collapses, cause widespread debris falls and trigger landslides. In summary, aftershocks are considered to be a high probability, regional scale hazard whose impact would be expressed in a number of points rather than across the entire region.

#### 5.4 Triggered earthquakes on the Enriquillo Fault

Triggered earthquakes are simply earthquakes that are linked to prior quakes, principally through the first event bringing the second event forward in time. The cause of the earlier triggering of the second quake is the redistribution of stress caused by the first event.

The risk of triggered earthquakes is important for the Enriquillo Fault due to this redistributed stress affect. The risk is highest immediately east and west of the existing fault rupture zone (See Figure 10).

The US Geological Survey has estimated **the likelihood of a further/triggered earthquake of M7.0 or greater in the Port au Prince region of the Enriquillo Fault as being in the range of 3% for within the next year and 5-15% for within the next 50 years.** This forecast is currently the best possible with existing data. It is also of critical importance for both the short and long term recovery of Haiti.

In the short term, it represents a small but partly avoidable risk of a potentially fatal event. **Simple and generally inexpensive changes in behaviour in the short term (within 12 months) can reduce the exposure of individuals to this risk.**

In the long term the probability of a major event is so high that **for planning purposes it needs to be assumed that it will occur within the lifetime of any permanent building still existing or constructed in the high risk region.**

#### 5.5 Earthquake on the Septentrional Fault

This major fault runs along the northern edge of the Island of Hispaniola and passes very close to the city of Cap Haitian. A large earthquake on this fault in 1842 largely destroyed the city. Accordingly it is a fault capable of very high energy earthquakes and it has not ruptured in this region for nearly 170 years. An earthquake on the Septentrional Fault is overdue, however preliminary stress calculations indicate that the eastern part of the fault, “ the Cibao section”, close to Santiago is under much

greater stress than the western/Cap Haitian region. The day to day and year to year probability of this occurring has not been calculated and this is clearly a priority.

## **5.6 Tsunami**

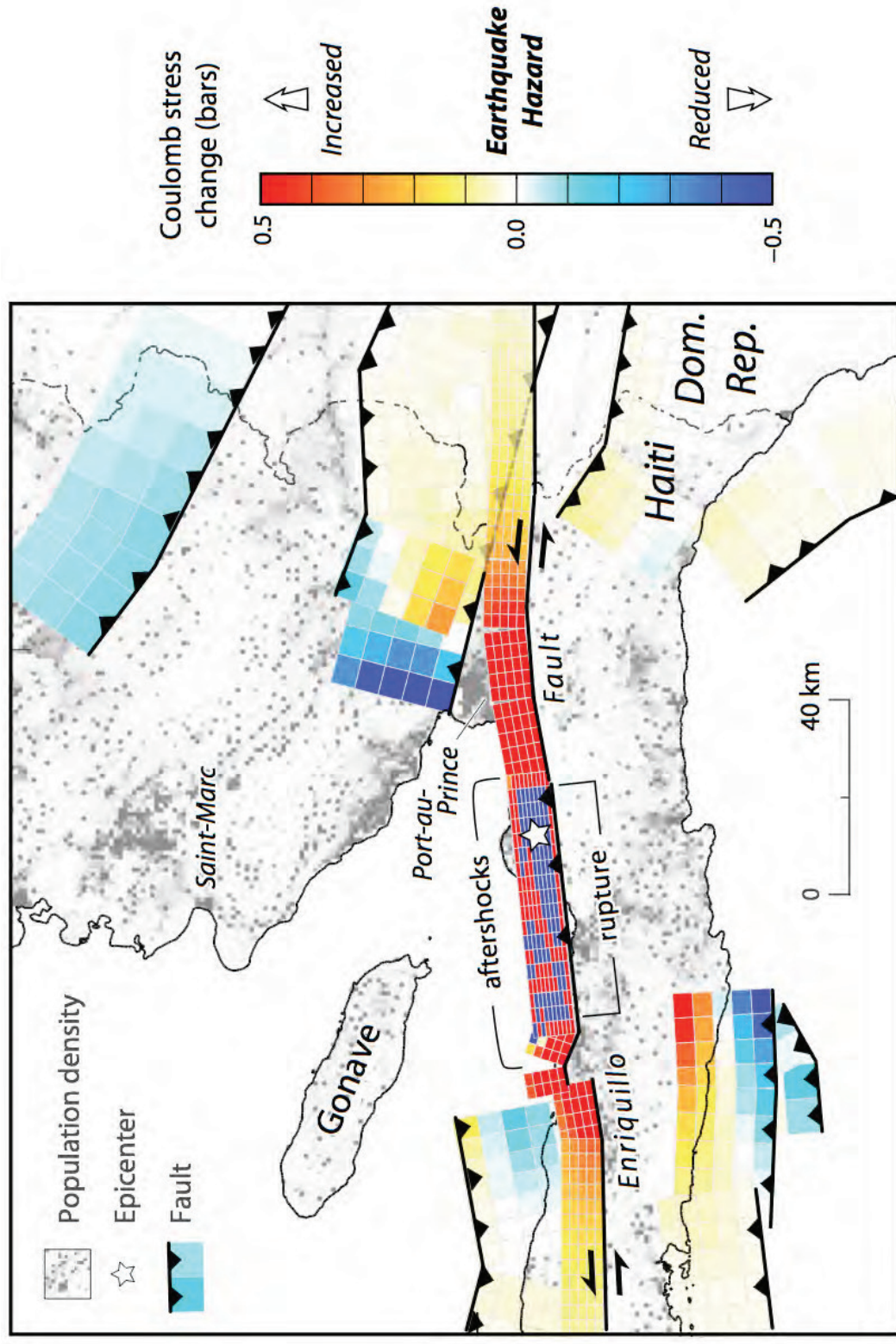
Tsunamis are waves in the sea that are generated by displacement of the seafloor during earthquakes. In addition tsunamis can be caused by underwater landslides also caused by nearby earthquakes. On a large scale tsunamis are normally associated with large earthquakes (7.0 or more) rather than aftershocks. In addition the earthquake must be located close to the sea and only certain types of earthquake generate the type of shocks required to generate a significant tsunami. However large tsunamis when they do occur can be intensely destructive to coastal communities and infrastructure.

Eyewitnesses reported a small tsunami on January 12<sup>th</sup>, that penetrated up to 100m in low lying areas within the Gulf of Gonave but caused no major damage.

At present there is simply insufficient information to assess the risk posed by a tsunami. What is clear is that the trigger event would be the major earthquake as discussed above. Hence tsunamis need to be regarded as a low probability, potential high impact event – however with a current very high level of uncertainty (for both occurrence and impact).

Obtaining better information and a robust assessment of tsunami risk is clearly a priority.

Figure 11 – Stresses changes after the January 12<sup>th</sup> earthquake (from USGS)



## 5.7 Landslides

Landslides are localised slope failures that result in the downhill movement of soil, sediment and rock. They are a point source risk – existing and potential landslide sites can be visibly detected, delineated and behaviour predicted to a certain extent.

Aerial and ground reconnaissance work indicated that many landslides have already occurred in the impacted zone as a result of the earthquake. An important phenomena noted was that in many cases the ground has cracked and failed, but the sliding material has not yet moved far. This is generally due to the dry condition of the ground as a result of the dry season. However the probability of continued and possibly rapid sliding is greatly enhanced by heavy rain which will allow water to drain into the cracks between the stable and unstable sediment. Hence the onset of the rainy season signals a greatly enhanced risk of landslides.

Many of the landslides noted are in rural areas and pose limited risk to life. However there are two areas noted where landslides are confirmed or expected to present significant direct risks to human life:

- Steep, heavily urbanised and informal housing areas in the southern parts of Port au Prince and Petion Ville.
- Steep, heavily urbanised and informal housing areas in the hills south of Carrefour.

There are also two areas noted where landslides present significant risks to major roads;

- An undercutting slope failure on the Ave Pan Americaine between PaP and Petion Ville;
- Multiple and major undercutting slope failures on the Leogane – Jacmel route in the mountainous Morne a Boites region.

Making these landslide sites safe is clearly a priority.

**Figure 12 – Leogane – Jacmel route (Photo credit Southcom)**



## **5.8 Building collapse and debris falls**

Several hundred thousand damaged buildings in the impacted region present a clear hazard of building collapse and debris falls. Collapsing buildings are clearly hazardous however the hazards presented by debris falls are also significant: a single brick falling a single storey has sufficient force to kill or severely injure. These are point source risks – the risk is present at many individual sites.

In the context of the January 12<sup>th</sup> earthquake, further building collapses and debris falls are clearly linked to the risk of aftershocks and triggered earthquakes. However buildings in Haiti do not need earthquakes to be dangerous, as tragically illustrated in the November 2008 school collapse in Port au Prince. The following factors can trigger further collapses and debris falls:

- Time – In some cases, unstable buildings and walls will gradually weaken and drop under their own weight;
- Water – Heavy rain and storm-water can soften foundations and reduce friction, resulting in sudden collapses after rains.
- Vibration – Apart from aftershocks and earthquakes, other sources of vibration include nearby heavy traffic, demolition works or construction works;
- Loading – People entering or walking in or on weakened buildings or using them for storage can trigger further instability.

Building collapse and debris falls are a real and significant risk to thousands of people. Reducing that risk through practical action is clearly a priority.

**Figure 13 - Hanging debris: A simple example of an ongoing building hazard (Photo credit EES)**



## **5.9 Hurricane and flood risk context**

Hurricane and flood risks are overall unaffected by the earthquake. However the vulnerability of the population to hurricanes and floods has been heightened due to the following factors:



- Hundreds of thousands have lost their concrete and brick shelters, their possessions and livelihoods;
- Hundreds of thousands rest in crowded temporary camps, at risk from disease;
- The debris caused by the earthquake may further block urban drainage routes, exposing populations to heightened risks.

A comprehensive multi-hazard risk assessment is a priority given the juxtaposition of the geological, seismic and hydro meteorological hazards and the onset of the 2010 hurricane season.

## **6 Management Plan rationale and context**

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### **6.1 Introduction**

This chapter sets out the rationale and context for an interim response and risk management plan for seismic, geological and building hazards in the period March – December 2010.

The government, the UN and partners have already responded to start to manage the risks outlined above. This work has been undertaken on an ad hoc basis as fragmented elements of the overall relief and very early recovery planning process and was not managed under any form of central plan. Such a plan is needed and will provide the following immediate and lasting benefits:

- It will help avoid needless loss of life from recognised hazards within the relief period;
- It will assist in directing scarce resources towards the most important needs;
- It will inform early decisions on recovery and reconstruction that will have major and long term implications for the country.

It is of course recognised that in addition to seismic, geological and building hazards, Haiti faces many other hazards and issues in the interim period. Hence this interim plan cannot stand alone but is considered to be an important input into the range of ongoing relief and recovery coordination and planning processes.

### **6.2 Prerequisites for planning**

A prerequisite to a valid interim plan are a) knowledge of the hazards, b) scenarios or planning assumption for the interim period of concern and c) an understanding of the implications of the hazards for activities within the interim period d) an understanding of the resources available to implement the plan. To address each of these prerequisites:

- Knowledge of the hazards – current knowledge is summarised in this report. Part of the plan is to fill remaining knowledge gaps;
- Scenarios or planning assumption for the interim period of concern – see below
- An understanding of the implications of the hazards for activities within the interim period – see below
- An understanding of the resources available to implement the plan – The current resources available to the relief and recovery effort are enormous in financial, logistical and technical terms. Over US\$2 billion of relief and recovery programme funding for Haiti is either pledged, in the pipeline or already in the implementation phase. The Haitian government itself has some significant assets and capacity. The issue therefore is not an absolute lack of resources, but directing or redirecting available resources onto the identified needs. In this context a section is included on identified key resource needs for plan implementation.



### **6.3 Planning assumptions**

The planning assumptions for the interim plan are set out below.

#### **Natural environment:**

- The rainy season will commence in April and increase in intensity through to June.
- Aftershocks will continue to occur;
- A major triggered or regional earthquake does not occur – if it does of course this plan is instantly obsolete although many of the risk management principles will remain valid;

#### **Exposed population:**

- The number of people residing in the impacted region and in internally displaced will not change radically in the interim period, although there is expected to be some shift from temporary camps to more organised camps and transitional shelters. Hence the exposed population will stay at approximately 3.0 million.

#### **Relief programme and ongoing economy:**

- The relief programme will continue to grow and operate at full scale for the interim period – and indeed is expected to continue until end of 2010 at least.
- The Haitian economy will continue to rebound and commerce and internal trade will increase in intensity to pre-quake or greater levels.

#### **Recovery and reconstruction planning:**

- A Post Disaster Needs Assessment will start either mid February or early March and will be completed and delivered in April
- High level master-planning for recovery is ongoing and will continue throughout the PDNA process and beyond. The scope of this master planning will include long term urban and land use planning, probably with a focus on a rapid reconstruction process but also on decentralisation and reducing urban congestion in the Port au Prince region.

### **6.4 Implications of the hazards**

The implications of the ongoing hazards on the exposed population, the relief programme, and recovery and reconstruction planning are set out below.

#### **Exposed population**

The exposed population remains very large and their vulnerability to seismic, geological and building hazards has been dramatically increased since the earthquake. The single biggest concern at present is building hazards – either linked to aftershocks or from other sources (see previous chapter).

The scale of displaced ( estimated at 0.9-1.2 million) does not match the scale of building damage: essentially only a fraction of the original 3.0 million inhabitants have left their destroyed or damaged homes and moved to temporary camps or other cities and towns. This infers that the balance (approx. 1.8-2.1 million) continue to live in buildings or camp overnight in open areas before moving back into the houses in daytime.

Given the major disincentives for abandoning their homes (loss of possessions, difficult camp living conditions, insecurity) it is assumed that generally only those with collapsed and massively damaged buildings have moved out. In addition to residences, many businesses have been destroyed; however commercial activity is clearly rebounding and damaged buildings reoccupied.

In summary, approximately two million people are considered to live, work and pass by damaged buildings and so will remain exposed to building hazards ( collapse and debris falls) throughout the interim period. Reducing the vulnerability of these two million people to this clear hazard should be one of the top priorities of the interim plan.

For landslides the exposed population is highly localised and much lower – in the order of hundreds. However the risk to these individuals is very high so reducing their vulnerability through localised intervention is also a priority.

### **Relief programme and ongoing economy**

The relief programme and the ongoing economy are vulnerable to two hazards:

Building hazards and aftershocks – These hazards can slightly hamper and distract the relief programme and ongoing economy. In particular the relief community is also exposed to building hazards and an appropriately balanced risk management plan needs to be put in place so that they can continue to deliver relief in relative safety. Business owners and employees also need to be able to continue to work in relative safety.

Landslide – The top two landslides of concern are on the Ave Pan Americaine between PaP and Petion Ville and the Leogane – Jacmel route in the mountainous Morne a Boites region. The medium to long term closure of either or both of these two major trunk routes due to landslides would have a crippling effect on both the relief effort and the local economy. Hence resolving these two point sources of risk is not a recovery issue – it is a relief issue.

### **Recovery and reconstruction**

The recovery and reconstruction programme will be fundamentally affected by the regional seismic hazards and the triggered earthquake hazard of the Enriquillo fault. In the long term, the probability of a major earthquake event is so high that for planning purposes it needs to be assumed that it will occur within the lifetime of any permanent building still existing or constructed in the high to medium risk region. (Note building lifetimes can run from 25 to well over 100 years dependent on design and maintenance).

Definition of what is a high risk region is work in progress, however preliminary results indicate that at least a 10km band either side of the Enriquillo and Septentrional Faults will fall within a high risk class. Such zoning would cover approximately 15% of the country, the major cities Port au Prince, Cap Haitian, Port de Paix and more than 30 regional towns. The area of medium risk is even less

certain but is expected to cover the entire Southern Peninsula and a 10-20km strip along the northern coastline

In practice, high to medium earthquake risk classifications (usually measured as probabilities of exceeding particular ground forces/accelerations) means that any reconstruction plans in the areas will need to include strong measures to reduce earthquake vulnerability. Such measures are generally expensive, slower to implement than routine reconstruction and may not even be feasible in some instances. For poorer residents with no land tenure in the vulnerable areas it is particularly problematic.

Given the cost and feasibility issues, it may turn out that the most feasible reconstruction scenarios focus on construction away from the fault zones. This in turn would have a radical impact on the future of Port au Prince and the southern peninsula and Cap Haitian.

This is a strategic issue and it cannot be resolved in this interim plan. In addition the anticipated debate needs to be informed by science that is the most up date possible. Seismic data collection and analysis will be ongoing throughout the period March to June and so for the latest information interested parties need to contact the Haiti Seismic Programme team directly ( refer to next chapter).

## **7 Management Plan**

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### **7.1 Goal, Objectives and Scope**

**Title:** Haiti Interim management and response plan for seismic, geological and building hazards.

#### **Goal**

Protect the population of Haiti and international visitors, the economy and the relief effort from ongoing major and life threatening seismic, geological and building hazards.

#### **Objectives**

- Reduce the vulnerability of 3.0 million people to identified life threatening hazards;
- Avoid major disruption to the economy;
- Avoid major disruption to and where possible assist the relief programme;
- Inform and thereby influence the recovery planning process.

#### **Scope**

The planned main activities are:

- Communication and emergency preparedness;
- Landslide assessment and emergency works;
- Building assessments;
- Hazard marking and barricading;
- Emergency demolition;
- Emergency repairs;
- Seismic programme;
- Interim seismic risk zoning;
- Interim building code and permitting scheme;
- Participation in the Post Disaster Needs Assessment and recovery planning process
- Multi-hazard assessment and plan revision

Each of these activities is discussed in turn below and summarised in Table 1.

<b>Activity</b>	<b>Govt focal point(s)</b>	<b>UN focal point(s)</b>	<b>Cost Estimate</b>	<b>Comments</b>
Communication and emergency preparedness	DPC & MTP	UNDP, UNEP, ISDR	200,000	Majority of costs integrated into other budgets
Building assessments ATC 20 & ASCE31	MTP	UNOPS	2,000,000	A pre-requisite for many other elements of the workplan
Landslide assessment and emergency repairs	MTP	UNOPS- Southcom	5,000,000	A time critical issue – delay will result in severe disruption to the relief effort and possible loss of life
Hazard marking and barricading	MTP	UNOPS	200,000	A logical task for MTP to address at an early stage.
Emergency demolition	MTP	UNOPS	5,000,000	Prioritisation is needed to address key risks early and avoid excessive cost to the government
Emergency repairs	MTP	UNOPS	3,000,000	Cost is only for the public sector
Seismic programme	MTP- Bureau of Mines	UNEP, UNESCO, UNDP	2,000,000 ( 12 months)	Year 1 of an urgent but long term programme
Interim building code and permitting system	MTP	UNOPS	800, 000 ( 12 months)	Includes the on-site inspection and inspector capacity building
Participation in the recovery and reconstruction planning processes	MTP & DPC	ISDR, UNEP, UNDP	---	Incorporated into other budgets
Multi hazard assessment	MTP & DPC	ISDR, UNEP, UNDP	--	Incorporated into other budgets
		Total	US\$ 18,800,000	



## **7.2 Communication and emergency preparedness**

The risk messages contained in this report need to be conveyed to the population, the Haitian government and the international community in a form that they can use as a basis for action. The subject is of high relevance and interest to all; what is important is the language and medium used.

Risk communication on seismic, geological and building hazards has already commenced with a press conference in Port au Prince 5<sup>th</sup> February. This event marked the start of an organised communication programme at the national level via bulletins, press briefing and public radio messages. The national media, particularly radio, is considered to be a powerful tool in reducing vulnerability through awareness raising.

Emergency preparedness within the government is the responsibility of the Directorate of Civil Protection (DPC) within the Ministry of Interior. DPC is already preparing for the 2010 hurricane season and with this new information on the geo-hazards will be able to integrate these issues into their plans.

## **7.3 Building assessments**

The ongoing building assessment programme will be greatly expanded and is anticipated to continue well beyond June 2010. For the interim plan the focus will be twofold:

1. Assessing a large number of buildings for damage using the ATC 20 system, to allow re-entry if possible and to develop a worklist for repairs, salvage and demolition. It is anticipated that a joint team of government and international engineers will assess many thousands of building for damage in the four month period.
2. Commencing assessment of intact and slightly damaged buildings for earthquake vulnerability using the ASCE 31 system to start to understand the vulnerability of the remaining building stock and the extent of the reconstruction challenge. This is a time intensive process and so it is anticipated that only a few hundred or less buildings will be fully assessed. Nonetheless the data obtained will be critical for planning any reconstruction effort.

## **7.4 Landslide assessment and emergency works**

The top two landslides of concern on the Ave Pan Americaine between PaP and Petion Ville and the Leogane – Jacmel route in the mountainous Morne a Boites region need to be addressed before the rainy season to avoid the road being cut off for months. This will entail detailed assessment (preliminary assessments have been done), design and implementation of emergency works. These emergency works may include re-routing the Jacmel road as the several of the landslides there are not repairable. The US Army Corp of Engineers has already developed a project for emergency repairs at an estimated cost of over US\$4.0m.

The two most vulnerable urban areas need to be assessed in detail and if serious landslide risks are noted then emergency measures will be needed. It is anticipated that this will entail evacuation any buildings on or below the landslides as such slides are unlikely to be repairable.

### **7.5 Hazard marking and barricading**

Hazard marking and barricading is a quick, economic and effective activity to reduce the vulnerability of the population. The ATC 20 building assessment process includes a form of hazard marking with its Red/Yellow/Green placards. This needs to be extended to marking obviously damaged and semi-collapsed buildings and also paint marking, signposting and if needed barricading these sites to keep people outside of the danger zone.

### **7.6 Emergency demolition**

Emergency demolition is well advanced as of February 19<sup>th</sup> with many dangerous and obstructing buildings have been collapsed and removed as debris. This process needs to continue with a clear focus on buildings that threaten thoroughfares and public sites. There are many deeply unsafe buildings in the private sector that threaten the public space – these also need to be demolished, after a notice period, even if some of them are currently ( unsafely ) in use.

### **7.7 Emergency repairs**

Emergency repairs are designed to make damaged buildings safe for an interim period to allow their continued use or to allow people to pass close to or under the damaged areas. They typically entail the use of scaffolding and props and plank barriers and ad hoc but carefully designed concrete repair work to hold walls in place, reinforce damaged columns and protect people from debris falls. Once emergency repairs are in place, many buildings can be put back into use for the medium term (up to one year) prior to being repaired or demolished (for cost reasons).

### **7.8 Seismic programme**

The Haiti Seismic Programme is a new initiative that commenced on January 30th 2010 and has already delivered substantive technical outputs including key input into this plan. It is convened under the auspices of the UN and is implemented by a taskforce composed of the government of Haiti, the UN and several academic and other government institutions. The medium term workplan is under development but will include organisational development, data collection, analysis, forecasting, warnings, advisory services, communication and education and capacity building.

The programme is designed for a rapid start up but also to run for 10 years or more and to develop into a technically focused partnership between the government of Haiti and 10 or more international partner organisations.

### **7.9 Interim seismic risk zoning**

Interim seismic risk zoning is one element of the Haiti Seismic Programme; however it is also one of the most time critical and immediately useful outputs of the programme. In summary a task team from the programme will model and map the earthquake risks in the vicinity of the Enriquillo Fault. This risk map will allow recovery planning to understand the local implications of the triggered earthquake hazard and is critical input to the proposed interim building code.



### **7.10 Interim building code and permitting scheme**

In the medium term it is anticipated that a detailed seismic and general building code and permitting system will be developed, endorsed by parliament and gazetted into law. This process is not expected to be complete before Q3 2010. An interim building code and permitting scheme is needed to manage the reconstruction activities before the full system is in place. In practical terms this will entail a joint government and specialist team developing an interim set of procedures and issuing them as government bulletins and decrees as appropriate and then moving immediately into enforcement for example via on-site building works inspections by government inspectors and international experts.

### **7.11 Participation in the Post Disaster Needs Assessment and recovery planning process**

The recovery and reconstruction planning process for Haiti is occurring at two levels:

- At the senior/political level the top levels of the government of Haiti, the UN, development banks and 10+ bilaterals are all heavily engaged.
- At the technical a large national and international team is developing a Post Disaster Needs Assessment in March 2010.

This assessment and plan needs to inform and thereby influence the recovery and reconstruction process. In practice this will entail assignment of technical and risk management specialists to the PDNA process and engaging with the senior level via briefings and information bulletins.

### **7.12 Multi-hazard assessment**

This plan covers interim activities for a portion of the major hazards facing Haiti in 2010. The others hazards are hurricane winds and riverine and urban floods.

A completely balanced risk management approach needs to integrate the risks presented by all types of hazard, and this is particularly the case for Haiti in 2010 as it approaches the rainy and hurricane seasons with nearly a million homeless.

Development of an integrated natural hazard assessment is a priority and work which is already in process as of Feb 12<sup>th</sup>. The expected delivery date for the first report and associated workplan is mid March.

### **7.13 Implementation and coordination**

The actions proposed within this plan must be implemented in a coordinated manner. The great majority of actions proposed entail engineering or construction related works so it is proposed that the implementation of the plan is coordinated by the Ministry of Public Works.

The UN agencies, particularly the UN Office for Project Services, the UN Environment Programme and UN Habitat will support the Ministry. Other ministries will be deeply engaged, particularly the Ministry of

Interior through the Directorate Protection Civil. Many other national and international partners will be engaged in this programme.

The proposed actions represent only a very small fraction of the works ongoing and planned for relief, recovery and reconstruction. For example many other demolition activities are required just to service the relief effort by clearing sites for transitional shelters. Again it is the role of the Ministry of Public Works to integrate this programme into the larger relief effort.

#### **7.14 Plan resource needs**

As of 4<sup>th</sup> March this plan was designed and government mandated but only 3% funded. Hence funding is the most critical resource need. Apart from the highly technical seismic programme the majority of resources required can be sourced from the civil engineering and general construction industry. With funding it is anticipated that these resources can be obtained without major problems although delays and cost escalation may occur due to the explosion in demand for engineering and construction resources.

#### **7.15 Next steps**

The next step is securing sufficient funds to enable start-up of the work plan elements that either have not started or need to stop soon due to lack of funds. Once this has occurred then a more detailed work plan needs to be developed.

## **8 Conclusions**

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### **8.1 Key findings**

After the earthquake of January 12<sup>th</sup> over 2 million people are vulnerable to life threatening seismic, geological and building hazards. In addition the implications of the identified hazards are severe for both the relief and recovery programmes. The hazards are highly diverse and are both regional and point source in nature. This vulnerability can and must be reduced. In the case of building hazards, vulnerability can be reduced with a set of practical and commonsense measures. For seismic and geological hazards a more technical approach is required but it is still highly feasible.

### **8.2 Way forward**

A highly focused and prioritised set of interim actions aimed at reducing vulnerability has been developed. At a total cost of less than US\$20 million the actions represent less than 1% of the funds mobilised or requested to date for the relief effort. The immediate priority is funding the plan and then integrating it into the larger programme of work on relief and early recovery and reconstruction. On the governance side, the Government of Haiti should as a priority decide the future institutional structure for the proposed seismic programme.

## **References**

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Maurasse F.M, Survey of the Geology of Haiti, 1982.

Lerner Lam A. et al, Seismological Analysis of the 12 January, 2010 Haiti Earth Quake and its Aftershocks (Ad ho working group, unpublished)

United Nations, Revised Flash Appeal – Haiti Earthquake 2010.

United Nations OCHA – Office For the Coordination of Humanitarian Affairs – Haiti Earthquake Situation Report Nos. 20 – 24.

United States Geological Survey – Earthquake Hazards Program

## **Annexes**

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- I. UN Haiti internal interim risk management strategy**
- II. Interim Guidance to UN International Staff and visitors in Haiti**
- III. Extracts of US FEMA guidance on earthquakes (English Only)**
- III. Haiti Seismic Programme – UN Flash Appeal Project Sheet**

## **I. UN Haiti Interim risk management strategy – for seismic, geological and building hazards**

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### **Introduction**

The UN in Haiti faces many security, safety and health hazards. One subset of the safety related hazards are seismic, geological and building hazards. The other major safety hazards are vehicle and work accidents and weather, i.e. strong winds and floods. This strategy paper addresses only **seismic, geological and building hazards** and as such will be incorporated as appropriate into the larger UN security system in force in Haiti through the normal formal mechanisms such as the UN Security Management Team.

In addition the UN must balance its own internal security management system with the imperative need to implement a large scale relief programme as quickly, efficiently and as safely as possible. In many cases these needs are conflicting so the proposed strategy aims to strike a sensible balance based on identification and management of risks.

The UN interim strategy for risk reduction is straightforward and has three main elements:

**1. Funding and implementation of the joint government and UN plan:** This plan is designed to reduce the vulnerability of all parties residing and working in Haiti and avoid damage to the relief effort – hence its implementation has many benefits for all and needs to be considered an integral part of the relief effort;

**2. Issuing non-binding guidance to UN staff and international visitors to Haiti.** This basic guidance (see Annexes II and III) is educational material designed to enable individuals and in particular visitors to Haiti to reduce their own vulnerability through improved awareness of the seismic, geological and building hazards present in Haiti at this time. Note that as per the plan above, over time Creole material and different distribution mechanisms (e.g. radio) will be used to help ensure appropriate guidance reaches the entire Haitian population.

**3. Developing and enforcing internal regulations for application to MINUSTAH and UN Agencies.** Each UN organisation has responsibility for the safety of its own staff and working areas. It is up to each organisation, either individually or collectively via the UN Security Management Team, to develop and enforce their own safety regulations.

Note for humanitarian reasons, the UN will definitely continue to work in the high risk zones as this is where the bulk of the affected population and the government is still based. Risk reduction during the working day and nights will be achieved through a combination of communications/ guidance, selected interventions and application of new interim security regulations. It is however expected that the UN will act over time to sharply reduce the numbers of international staff who are allowed to reside in vulnerable buildings in the high risk zone as this can be implemented without affecting its performance



in delivering assistance to the government and population of Haiti. The UN is reviewing its strategy for reducing the vulnerability of its national staff living in the high risk zones.

## **II. Interim Guidance to UN International Staff and visitors in Haiti on seismic, geological and building hazards**

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### **Introduction**

Safety is your own responsibility. This guidance is designed to help you make decisions regarding your own safety on an informed basis. As the situation in Haiti is changing rapidly, this guidance is considered valid for the period March – June 2010 only.

### **Detailed information**

Detailed information on the seismic, geological and building hazards present in Haiti is available in the report: Preliminary Seismic, Geological and Building Hazard Risk Assessment and Management Work Plan February 2010 and associated references. In addition individuals are encouraged to read the detailed background information available on earthquake preparedness and survival on sites such as USA FEMA (see below and Annex III).

### **The hazards**

The natural hazards of key concern to individuals at present in Haiti are:

- Aftershocks – these will be less frequent but will continue until at least the end of 2010;
- Building hazards – collapses and debris falls;
- Strong winds ( not covered further in this guide);
- Floods ( not covered further in this guide);

The hazards of lower probability but severe potential impact are:

- Major earthquakes
- Tsunamis associated with major earthquakes

Landslides are a rare but locally very important hazard.

### **Behaviour which can reduce your vulnerability to these hazards**

The behaviour which will reduce your vulnerability to these hazards:

**General and Local Awareness and signposting** Once you are aware of the general hazards in Haiti, you can act to become and stay aware of hazards present in your immediate surrounding and along your travel routes. Look for the warning signs and building damage assessment placards – If already inspected to a relevant standard (ATC 20 or similar) buildings will have a posted note on the entrance: Green for undamaged/apparently safe for entry, Yellow for Restricted Entry and Red for Unsafe. If it does not have a posting, then it is unlikely to have been assessed.

Over time it is expected that landslide hazards will also be signposted with site specific advice.

**Planning to reduce short term vulnerability** Your own choices on places to work, socialise and sleep dictate your vulnerability. This is particularly the situation with damaged buildings – If you have any choice whatsoever do not work, socialise or sleep in damaged buildings. One sensible alternative to sleeping in damaged or vulnerable buildings is to restrict entry and use tented accommodation.

**Take extra care during the aftershock period.** Aftershocks are not a risk – they are a certainty. Aftershocks are still being detected every week. Extra care needs to be taken in the first months.

**Prepare yourself, your household and workplace for earthquake – before, during and after.** Detailed guidance on this subject is available online at US FEMA (tailored for American audiences but still relevant).

### **Residents - Planning to reduce long term vulnerability**

People who reside or work in the vicinity of the major active faults and the associated risk zones will be much more vulnerable (i.e. exposed over time to higher levels of risk due to the extended time of exposure) than visitors to the risk of earthquake. There are several valid ways to reduce this long term vulnerability.

- **Respect the building damage notifications.** It is expected that many damaged buildings will remain in place for months to years. Look for and respect the Green, Yellow and Red signposting.
- **Understand the long term risk zoning for earthquakes.** At present the interim UN risk zoning is a high rating within a 5km band either side of the Enriquillo Fault surface trace and a medium risk zoning within 20km. Note that a major earthquake can impact buildings 30km or more from its epicentre. The UN risk zoning is not a legal or government endorsed standard. This interim zoning may be replaced by a government endorsed and more scientifically based seismic micro-zoning maps for all of the country.
- **Understand the vulnerability of your existing key buildings** (homes and workplaces) through securing an expert assessment using the ASCE 31 or similar system and then changing buildings or locations if you wish to reduce your personal or your teams' vulnerability. Note that determining the vulnerability of buildings to earthquakes is an expert task. Vulnerability is determined by shape, height, design features, materials used, quality of construction, topography and geology. Initial indications from UN managed building assessments conducted in January and February are

that very few buildings, damaged or undamaged, would be classed as highly earthquake resistant – in fact the majority are considered highly vulnerable.

- **Work, socialise and sleep in buildings of certified earthquake resistance or of inherently low risk** such as steel framed portable buildings and warehouses – thereby avoiding the need for ad hoc assessments or zoning requirements.
- **Minimise the time spent in any uncertified building in the most vulnerable areas close to the active faults.** This can be achieved for example by scheduling meetings outside of the high risk zones or in certified or inherently low vulnerability buildings.

### **III. Extracts of US FEMA Guidance on Earthquakes**

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[http://www.fema.gov/hazard/earthquake/eq\\_before.shtm](http://www.fema.gov/hazard/earthquake/eq_before.shtm)

#### **Fast Facts about Earthquakes**

- Earthquakes strike suddenly, violently, and without warning at any time of the year and at any time of the day or night.
- Smaller earthquakes often follow the main shock.
- An earthquake is caused by the breaking and shifting of rock beneath the Earth's surface. Ground shaking from earthquakes can collapse buildings and bridges; disrupt gas, electric, and phone service; and sometimes trigger landslides, avalanches, flash floods, fires, and huge, destructive ocean waves (tsunamis).
- Most earthquake-related injuries result from collapsing walls, flying glass, and falling objects.
- Several thousand shocks of varying sizes occur annually in the United States, and 70 to 75 damaging earthquakes occur throughout the world each year. All 50 states and all U.S. territories are vulnerable to earthquakes. Where earthquakes have occurred in the past, they will happen again.
- California experiences the most frequent damaging earthquakes; however, Alaska experiences the greatest number of large earthquakes—most located in uninhabited areas.
- Earthquakes occur most frequently west of the Rocky Mountains, although historically the most violent earthquakes have occurred in the central United States.
- The largest earthquakes felt in the United States were along the New Madrid Fault in Missouri, where a 3-month-long series of quakes from 1811 to 1812 included three quakes larger than a magnitude of 8 on the Richter Scale. These earthquakes were felt over the entire eastern United States (over 2 million square miles), with Missouri, Tennessee, Kentucky, Indiana, Illinois, Ohio, Alabama, Arkansas, and Mississippi experiencing the strongest ground shaking.
- The Richter Scale, developed by Charles F. Richter in 1935, is a logarithmic measurement of the amount of energy released by an earthquake. Earthquakes with a magnitude of at least 4.5 are strong enough to be recorded by sensitive seismographs all over the world.
- It is estimated that a major earthquake in a highly populated area of the United States could cause as much as \$200 billion in losses.

#### **Know Your Earthquake Terms**

Familiarize yourself with these terms to help identify an earthquake hazard:



**Aftershock**

An earthquake of similar or lesser intensity that follows the main earthquake.

**Earthquake**

A sudden slipping or movement of a portion of the earth's crust, accompanied and followed by a series of vibrations.

**Epicenter**

The place on the earth's surface directly above the point on the fault where the earthquake rupture began. Once fault slippage begins, it expands along the fault during the earthquake and can extend hundreds of miles before stopping.

**Fault**

The fracture across which displacement has occurred during an earthquake. The slippage may range from less than an inch to more than 10 yards in a severe earthquake.

**Magnitude**

The amount of energy released during an earthquake, which is computed from the amplitude of the seismic waves. A magnitude of 7.0 on the Richter Scale indicates an extremely strong earthquake. Each whole number on the scale represents an increase of about 30 times more energy released than the previous whole number represents. Therefore, an earthquake measuring 6.0 is about 30 times more powerful than one measuring 5.0.

**Seismic Waves**

Vibrations that travel outward from the earthquake fault at speeds of several miles per second. Although fault slippage directly under a structure can cause considerable damage, the vibrations of seismic waves cause most of the destruction during earthquakes.

**What to Do Before an Earthquake**

Earthquakes strike suddenly, violently and without warning. Identifying potential hazards ahead of time and advance planning can reduce the dangers of serious injury or loss of life from an earthquake. Repairing deep plaster cracks in ceilings and foundations, anchoring overhead lighting fixtures to the ceiling, and following local seismic building standards, will help reduce the impact of earthquakes.

**Six Ways to Plan Ahead****1. Check for Hazards in the Home**

- Fasten shelves securely to walls.
- Place large or heavy objects on lower shelves.
- Store breakable items such as bottled foods, glass, and china in low, closed cabinets with latches.
- Hang heavy items such as pictures and mirrors away from beds, couches, and anywhere people sit.
- Brace overhead light fixtures.

- Repair defective electrical wiring and leaky gas connections. These are potential fire risks.
- Secure a water heater by strapping it to the wall studs and bolting it to the floor.
- Repair any deep cracks in ceilings or foundations. Get expert advice if there are signs of structural defects.
- Store weed killers, pesticides, and flammable products securely in closed cabinets with latches and on bottom shelves.

## **2. Identify Safe Places Indoors and Outdoors**

- Under sturdy furniture such as a heavy desk or table.
- Against an inside wall.
- Away from where glass could shatter around windows, mirrors, pictures, or where heavy bookcases or other heavy furniture could fall over.
- In the open, away from buildings, trees, telephone and electrical lines, overpasses, or elevated expressways.

## **3. Educate Yourself and Family Members**

- Contact your local emergency management office or American Red Cross chapter for more information on earthquakes. Also read the "How-To Series" for information on how to protect your property from earthquakes.
- Teach children how and when to call 9-1-1, police, or fire department and which radio station to tune to for emergency information.
- Teach all family members how and when to turn off gas, electricity, and water.

## **4. Have Disaster Supplies on Hand**

- Flashlight and extra batteries.
- Portable battery-operated radio and extra batteries.
- First aid kit and manual.
- Emergency food and water.
- Nonelectric can opener.
- Essential medicines.
- Cash and credit cards.
- Sturdy shoes.

## **5. Develop an Emergency Communication Plan**

- In case family members are separated from one another during an earthquake (a real possibility during the day when adults are at work and children are at school), develop a plan for reuniting after the disaster.
- Ask an out-of-state relative or friend to serve as the "family contact." After a disaster, it's often easier to call long distance. Make sure everyone in the family knows the name, address, and phone number of the contact person.

## **6. Help Your Community Get Ready**

- Publish a special section in your local newspaper with emergency information on earthquakes. Localize the information by printing the phone numbers of local emergency services offices, the American Red Cross, and hospitals.
- Conduct a week-long series on locating hazards in the home.
- Work with local emergency services and American Red Cross officials to prepare special reports for people with mobility impairments on what to do during an earthquake.
- Provide tips on conducting earthquake drills in the home.
- Interview representatives of the gas, electric, and water companies about shutting off utilities.
- Work together in your community to apply your knowledge to building codes, retrofitting programs, hazard hunts, and neighborhood and family emergency plans.

## **What to Do During an Earthquake**

Stay as safe as possible during an earthquake. Be aware that some earthquakes are actually foreshocks and a larger earthquake might occur. Minimize your movements to a few steps to a nearby safe place and stay indoors until the shaking has stopped and you are sure exiting is safe.

### **If indoors**

- **DROP** to the ground; take **COVER** by getting under a sturdy table or other piece of furniture; and **HOLD ON** on until the shaking stops. If there isn't a table or desk near you, cover your face and head with your arms and crouch in an inside corner of the building.
- Stay away from glass, windows, outside doors and walls, and anything that could fall, such as lighting fixtures or furniture.
- Stay in bed if you are there when the earthquake strikes. Hold on and protect your head with a pillow, unless you are under a heavy light fixture that could fall. In that case, move to the nearest safe place.
- Use a doorway for shelter only if it is in close proximity to you and if you know it is a strongly supported, loadbearing doorway.
- Stay inside until shaking stops and it is safe to go outside. Research has shown that most injuries occur when people inside buildings attempt to move to a different location inside the building or try to leave.

- Be aware that the electricity may go out or the sprinkler systems or fire alarms may turn on.
- DO NOT use the elevators.

**If outdoors**

- Stay there.
- Move away from buildings, streetlights, and utility wires.
- Once in the open, stay there until the shaking stops. The greatest danger exists directly outside buildings, at exits, and alongside exterior walls. Many of the 120 fatalities from the 1933 Long Beach earthquake occurred when people ran outside of buildings only to be killed by falling debris from collapsing walls. Ground movement during an earthquake is seldom the direct cause of death or injury. Most earthquake-related casualties result from collapsing walls, flying glass, and falling objects.

**If in a moving vehicle**

- Stop as quickly as safety permits and stay in the vehicle. Avoid stopping near or under buildings, trees, overpasses, and utility wires.
- Proceed cautiously once the earthquake has stopped. Avoid roads, bridges, or ramps that might have been damaged by the earthquake.

**If trapped under debris**

- Do not light a match.
- Do not move about or kick up dust.
- Cover your mouth with a handkerchief or clothing.
- Tap on a pipe or wall so rescuers can locate you. Use a whistle if one is available. Shout only as a last resort. Shouting can cause you to inhale dangerous amounts of dust.

**What to Do After an Earthquake**

- Expect aftershocks.** These secondary shockwaves are usually less violent than the main quake but can be strong enough to do additional damage to weakened structures and can occur in the first hours, days, weeks, or even months after the quake.
- Listen to a battery-operated radio or television.** Listen for the latest emergency information.
- Use the telephone only for emergency calls.**
- Open cabinets cautiously.** Beware of objects that can fall off shelves.
- Stay away from damaged areas.** Stay away unless your assistance has been specifically requested by police, fire, or relief organizations. Return home only when authorities say it is safe.

•**Be aware of possible tsunamis if you live in coastal areas.** These are also known as seismic sea waves (mistakenly called "tidal waves"). When local authorities issue a tsunami warning, assume that a series of dangerous waves is on the way. Stay away from the beach.

•**Help injured or trapped persons.** Remember to help your neighbors who may require special assistance such as infants, the elderly, and people with disabilities. Give first aid where appropriate. Do not move seriously injured persons unless they are in immediate danger of further injury. Call for help.

•**Clean up spilled medicines, bleaches, gasoline or other flammable liquids immediately.** Leave the area if you smell gas or fumes from other chemicals.

•**Inspect the entire length of chimneys for damage.** Unnoticed damage could lead to a fire.

•**Inspect utilities.**

- **Check for gas leaks.** If you smell gas or hear blowing or hissing noise, open a window and quickly leave the building. Turn off the gas at the outside main valve if you can and call the gas company from a neighbor's home. If you turn off the gas for any reason, it must be turned back on by a professional.

- **Look for electrical system damage.** If you see sparks or broken or frayed wires, or if you smell hot insulation, turn off the electricity at the main fuse box or circuit breaker. If you have to step in water to get to the fuse box or circuit breaker, call an electrician first for advice.

- **Check for sewage and water lines damage.** If you suspect sewage lines are damaged, avoid using the toilets and call a plumber. If water pipes are damaged, contact the water company and avoid using water from the tap. You can obtain safe water by melting ice cubes.

## **IV. Haiti Seismic Programme – UN Flash Appeal Project Sheet**

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### **Haiti Flash Appeal 2010 UNITED NATIONS ENVIRONMENT PROGRAMME (UNEP)**

**Project Title:** Haiti Seismic Programme    **Project Code:** HTI 10/ER/31874/R

**Sector/Cluster:** EARLY RECOVERY

**Goal:** To reduce the vulnerability of the population through the provision of technically sound analyses, advice and capacity building in the field of seismology.

**Objectives:** The objectives of the programme are:

- **Analysis**    To develop a detailed understanding of the active fault architecture and long term behaviour of these faults; to understand the Jan 12th 2010 event and the subsequent and ongoing behaviour of the fault system and associated plates and plate boundaries;
- **Forecasting**    To provide the best available probabilistic forecast of the likelihood, location and severity of future earthquake events;
- **Warning** – To evaluate and provide timely warning of periods of elevated risk; to improve the effectiveness of how warning is communicated.
- **Advice**    To provide strategic advice on the management of earthquake risks in the relief and recovery programme and in the longer term.
- **Capacity building**    To establish a local seismic monitoring network and build local technical capacity to ensure the benefits obtained are sustained in the long term and are shared in the international geo science arena.
- **Link with regional programmes**    To coordinate and integrate with other hazard observation programmes in the northern Caribbean.
- **Multi hazard integration** – to incorporate new information on seismic risk into existing frameworks for risk reduction concerning floods, soil erosion and landslides.
- **Regional integration** – The Haiti risks are acute and the knowledge gaps extreme, but the risks and capacity needs are regional in scope, and the programme will ensure adequate integration into relevant regional initiatives.

**Beneficiaries** Total: 2000000 Current population highly vulnerable to ongoing seismic events

**Implementing Partners:** Haiti Bureau of Mines, Columbia University, Purdue University, 5+ other universities

**Project Duration:** Jan 2010 - Dec 2010    **Current Funds Requested:** \$2,000,000.00

### **Needs**

The January 12th 2010 earthquake came as a tragic surprise. However, to the extent that earthquakes are predictable, this one was. The earthquake occurred on a well known fault and was in line with assessments made by scientists as recently as 2008. Nonetheless the country had no seismic monitoring equipment and no coherent process of earthquake awareness raising. The scientific research work done was intermittent and underfunded. There was also no history of earthquakes in living memory. As a result the complete absence of a risk reduction culture strongly contributed to over a hundred thousand deaths.



Since then, the earthquake risk for Port au Prince has actually risen. The risk is present on 2 fronts. Aftershocks are a real hazard for the next months to up to two years. There is a strong probability of what is classed as a 6.0 UTS aftershock which would weaken already damaged buildings and result in further building collapses. In addition the realignment of stress in the earth crust after the earthquake has actually increased the risk of a new major earthquake on the Enriquillo Fault in 2 critical areas. Whilst these triggered earthquakes have a low probability, if they occurred they would have a devastating impact on the Port au Prince region.

Worldwide many densely populated regions face an earthquake risk of 7.0 UTS or even higher. What is exceptional about Port au Prince and the southern peninsula is the extreme vulnerability of its 4 million population. This vulnerability arises from multiple factors:

- Building quality is uniformly low and earthquake vulnerable due to a preference for concrete and masonry brick structures, many of which are built on steep slopes with limited foundations.;
- The earthquake has damaged approximately 80% of these already unsuitable buildings and it will take years to fully repair or demolish and rebuild.
- The earthquake has reduced the resilience of the millions of people impacted which are now homeless and at risk from communicable diseases and food insecurity;
- At least 2 million people live in dense urban areas within 5km of the main fault zone;
- The limited depth of knowledge of the region and the complicated pattern of post Jan 12th seismic behaviour results in a current high degree of uncertainty for earthquake risk forecasting.

The general needs arising from this situation can be divided into 3 groups:

**1) Science foundation:** Earthquake risk assessment and management for situations as complex as this need to be based upon solid science. That translates to adequate data collection and in depth time investments by a team of international and national scientists and engineers.

**2) Communication and education:** The technical findings need to be translated into messages that the population and decision makers can understand and use as a basis for action. A communications and awareness raising programme will need to include an education component, both to raise awareness and to teach basic skills for example for earthquake survival.

**3) Capacity building:** Capacity building for Haitian organisations and individuals needs to be integrated into all activities and also needs a stand alone investment. The long term goal should be an autonomous national institution that both delivers a national seismic programme but also is self financing and sustainable. In the context of the urgent humanitarian response the focus will be on ensuring Haitian national engagement at all times and leadership wherever possible.

**Identified urgent needs** in the context of the humanitarian response are as follows:

- Rapid data collection as a prerequisite to risk assessment;
- Earthquake risk awareness raising regarding aftershocks;
- Earthquake risk zoning to assist planning of transitional shelters and recovery;
- Development and coordination of the Haiti seismic taskforce –moving from an ad hoc volunteer structure to a stable professional organisation capable of delivering services for at least 1 year.

## **Activities**

The proposed activities are structured as a programme. For the purposes of the CAP, only the first year of the programme is presented in detail. The year 1 Work Plan activities include:

- Organisational development: Building of a Haiti Seismic taskforce composed of the government, international agencies and academia to develop and deliver the seismic programme and provide long term continuity;
- Data collection:The collection of data from existing sensors and the deployment of new sensors to collect data on the behaviour of the fault system – thereby improving the forecasting;
- Analysis:Analysis of historical and recent data to develop a detailed model of the fault system, the recent earthquake events and its ongoing behaviour;
- Forecasting:Use of the analysis and best available seismic forecasting techniques and models to provide forecasts of the likelihood, location and severity of aftershocks and potential earthquake events;
- Warning:Assessment and provision of timely and targeted warnings direct to decision makers and emergency management authorities of periods of elevated risk of earthquakes.
- Advisory services: Provision of strategic advice through high level and technical briefings and technical reports focused on the management of earthquake risks in the relief and recovery programme.
- Communication and education: Developing and delivering awareness raising and educational material in French, Creole and English.
- Capacity building: Provision of equipment, training and advisory services to build the national capacity for seismic monitoring and analysis.

The outputs linked to these activities are anticipated to include:

- Installed monitoring stations and associated generated data
- A dedicated Haiti seismic information portal
- A series of briefings and practical advices notes for the Haitian population
- A series of briefing for decision makers
- Substantive technical reports – both self standing and as part of larger multi hazard disaster risk assessments. Initial use of the reports will be as input to the Post Disaster Needs Assessment;
- Training courses for Haitian organisations and individuals.

The team that will deliver the programme is labelled the Haiti Seismic Taskforce, an initiative which was launched on Jan 28th. It currently consists of 2 government ministries ( Bureau of Mines Min Public Work and Directorate Protection Civil Min Interior, UNEP and multiple technical and academic institutes in the USA, France, Canada and Japan ( with more joining). At present over 30 scientists are engaged including staff from the US Geological Survey. Virtually all of the scientist previously engaged in work on Haiti have been invited and are now part of the taskforce. Logistical support on the ground is being provided by the UN and the US Army Corp of Engineers.

Note that several teams of scientist have already visited Haiti or are still in the field. One of the early objectives of the programme is to mobilise a senior scientist to Haiti on a longer term basis to support the government and coordinate the technical efforts at the national level. International coordination on technical issues is currently undertaken by staff from the Earth Institute, Columbia University New

York and from Purdue University, Illinois. UNEP is coordinating UN, managerial, political and risk communication issues and working closely with the UN leadership in Haiti.

Advisory services and risk communication have already started with extensive briefings provided to national and international decision makers in Haiti and elsewhere. In addition a Haitian led and internationally supported press conference on the 5th February was an important first step in an organised public risk communication programme.

**Outcomes**

The anticipated RBM outcomes of the Year 1 Workplan are:

- Awareness raised and vulnerability reduced for the 2,000,000 or more continuing to live in the aftershock risk zone;
- The relief effort is provided with the information required to manage the identified risks linked to its operations – such as establishment of transitional settlements;
- The recovery programme is provided with the information required to enable long term recovery planning;
- Commencement of a long term earthquake vulnerability reduction programme;
- Commencement of improved local capacity in the field of seismic risk management.

In summation, the programme will progress some way to reducing the acute and long term vulnerability of nearly 3 million people who are already facing one major crisis and need to be protected to the extent possible from yet another.