Section 5. Draft Terms of Reference

A. BRIEF BACKGROUND:

The construction of a 1.3 km access road in Pasakha, Chhukha Dzongkhag (district), was completed in June 2019 as part of the SASEC Road Connectivity Project. It falls under the Primary National Highway (PNH) standard. The objective is to improve the cross-border movement between Bhutan and neighboring countries. It is financed on cost sharing basis between the Asian Development Bank (ADB) and the Royal Government of Bhutan (RGoB). Department of Roads (DoR) under Ministry of Works and Human Settlement (MoWHS) is the executing and implementing agency.

The scope covers from landslide mitigation works at Bhawanijhora till construction of 122.8m Pre stressed bridge at Bhalujhora. At landslide area, a series of check dams and retaining gabion walls were built to control the flow of debris. A 50 m long multi-cellular culvert with an average height of 5.5 m is built at the downstream. Approximately 3.86 acres of land was developed to establish Allay Land Custom Station (ALCS) on the left and downstream side of the culvert.

However, landslide was triggered at Bhawanijhora, during last monsoon, due to unprecedented heavy rainfall. As a result, debris flow had covered all the as-built structures on both upstream and downstream posing risk to road user and infrastructure at ALCS. The construction of infrastructure with linking road to border side has started.

B. INTRODUCTION

The road section at Bhawanijhora is critical for achieving objectives of the project. Most of the industries in country is located in Pasakha. Thus, many heavy vehicle carrying goods plies over this from across border through Phuentsholing city. The route once connects with border directly, will decrease travel time for the vehicles from across border and at the same time, the traffic flow in the phuentsholing city will be decongested. It is also used as alternative route to travel towards capital city during the monsoon season. Therefore, the road needs to be maintained as all whether use. For this, the landslide should be mitigated.

RGoB and ADB has agreed to use the part of G0400 to carry out consulting service on the detailed study and design of mitigation measures at Bhawanijhora site under the SASEC Road Connectivity project. DoR is the executing and implementing agency.

C. LOCATION

The study area is at Bhawanijhora, Pasakha, Chhukha which is about 11 km from Phuentsholing city. It is located at latitude 26.84°E and longitude 89.43°N.

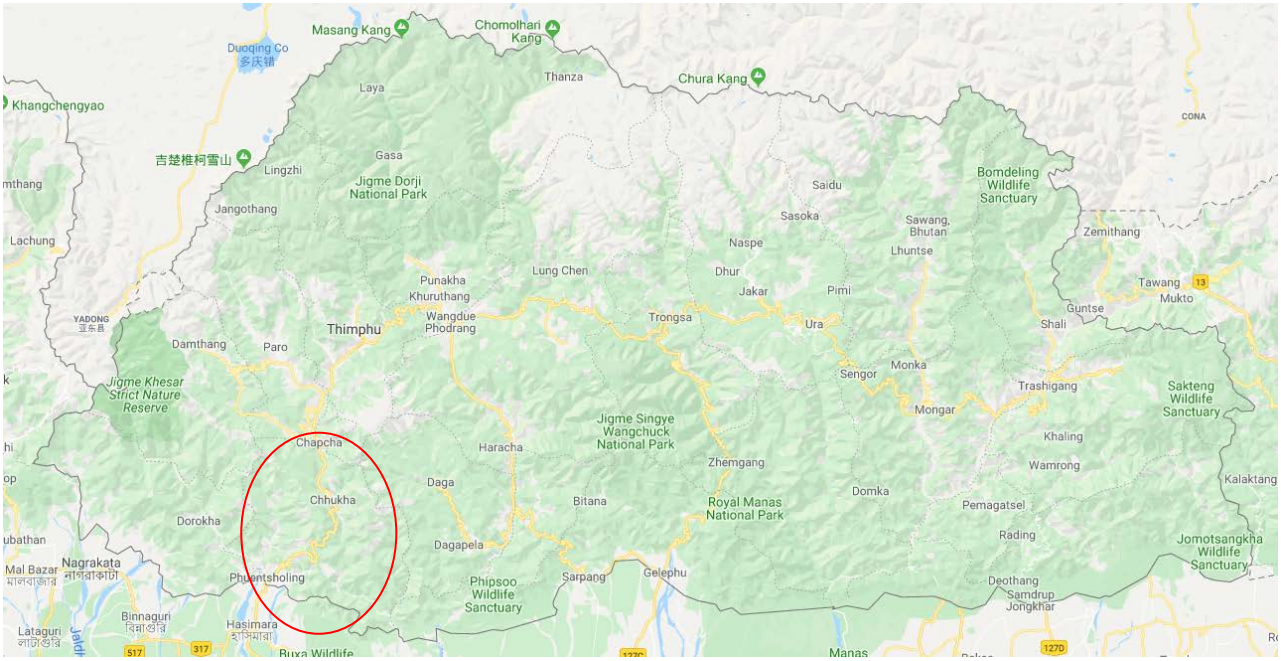


Figure 1 Bhutan Map, Source: https://www.google.com/maps

Figure 2 Chukkha District, Source: Google earth

Figure 3: Bhawanijhora site, Source: Google earth

D. OBJECTIVES

The Project is intended to carry out detailed geotechnical studies and design mitigation/counter measures at Bhawanijhora (landslide area), Pasakha, Chhukha Dzongkhag (District). The design consultant shall prepare detailed design report but **not limited to**:

(i) Preparation of detailed study report and recommendation of three alternative countermeasure structures;
(ii) Designing of countermeasure structures after acceptance by client;
(iii) Preparation of complete set of design report that shall include analysis, detail drawings, technical specifications, bill of quantities (BoQ), rate analysis, cost estimation, Quality Assurance Plan (QAP), schedule and construction methodology;
(iv) Ensuring the required studies and tests are carried out but not limiting to the test specified by the client;
(v) Ensuring the climate change factors are incorporated in the design;
(vi) Ensuring the best international practices are adopted.

E. SCOPE OF WORK

The scope of the service under this assignment is divided into two (2) phases. The detailed study of the landslide area shall be carried in Phase 1 and accordingly, the detailed design work shall be carried out in Phase 2. The consultant's responsibilities will include, but **not limited to** the following:

Phase 1: Detailed study

1. Site Study and Survey Works:

(i) Prospective firms should visit the landslide area to familiarize with the existing site conditions.
(ii) The tentative boundary of the landslide area with test locations are in **Appendix 1** and map showing the existing as-built structure is provided as **Appendix 2**. The overall landslide area at Bhawanijhora is approximately 215 acres but scope of study area is not limited to this boundary.
(iii) Carrying out detailed engineering topographic surveys including cross sections for the study and design purposes. Establish benchmarks and reference beacons as required to prepare detailed engineering design and to enable construction quantities to be calculated with reasonable accuracy.

2. Desk Study:

(iv) The consultancy firm shall carry out detail review and assessment of relevant past studies/reports covering topographical maps, geological maps, land use maps, as-built structure, aerial photographs, satellite imagery and climatological records of the project area. The firm shall consult the relevant stakeholders to obtain the required information of the project area for the purpose of investigation and engineering design of mitigation structures.

3. Geological Investigation:

(v) Identify, assess and prepare instability inventory maps (landslides, erosion, debris flow, scouring, toe erosion, creep, subsidence, rock fall, planar failure, wedge failure, toppling etc.) within the study area and indicate the level of hazard posed by the instabilities. All the instabilities identified within the study area should be mapped on 1:500 scales maps.
(vi) Identify, assess and prepare the material/engineering geological maps for the study areas.
(vii) Identify, assess and mark on map all water bodies (springs, creek, stream both seasonal and perennial, seepages, rivers etc.) that have impacts on the study area.
(viii) Identify and assess the strength of geological materials by conducting necessary field and laboratory tests and analysis.
(ix) Assess the correlations between the instabilities and geology (rock type, soil and deposits), topography (slopes), hydrology (rainfall, seepages, and ground water) and determine the most significant factors that are responsible for causing the instabilities.

4. Geophysical Investigation:

(x) The study shall carry out the geophysical survey using seismic refraction test (SRT) and electrical resistivity test (ERT) to understand the sub surface conditions of the landslide area (ground water table, material types, depth of the sliding plane, overburden thickness etc).
(xi) The consultant shall give on-site training to the engineers from Geotechnical Section of Design Division and Project Management Unit (PMU).

Minimum Requirements	
Number of Tests	**Details**
▪ **4 Profile line** as described below**:** a) Along the slope (A1) 430m b) Across the slope(A2) 500 m c) Along the slope(A3) 500 m d) Across the slope(A4) 490 m *Tentative locations of the resistivity line are shown in **Appendix 1**. The location of resistivity lines can be changed depending on suitable location after field reconnaissance.*	• Prior to collecting resistivity data, field reconnaissance shall be carried out to determine most suitable locations of resistivity lines. • The procedure for carrying out the test, recording and analysis of results and their presentation shall conform to International Standard. • A high-resolution ERT shall be used in all targeted areas to collect resistivity data within a minimum accuracy of 5% of actual depths. • The **spacing** of geophones shall be **5m** and below • Use of **explosives** is not recommended. • Shall maintain record of Location Name, GPS Coordinates and Date of tests carried out.

▪ **2 Profile line** as described below**:** a) Along the slope (B1)450m b) Across the slope(B2) 350 m *Tentative locations of the seismic line are shown in **Appendix 1**. The location of seismic lines can be changed depending on suitable location after field reconnaissance.*	• Prior to collecting seismic data, field reconnaissance shall be carried out to determine most suitable locations of seismic lines. • The procedure for carrying out the test, recording and analysis of results and their presentation shall conform to International Standard. • A high-resolution seismic refraction (SRT) method shall be used in all targeted areas to collect refraction data within a minimum accuracy of 5% of actual depths. • The **spacing** of geophones shall be **5m** and below • Use of **explosives** is not recommended. • Shall maintain record of Location Name, GPS Coordinates and Date of tests carried out.

5. Rotary Core Drilling Investigation:

(xii) The consultancy firm shall carry out the necessary exploratory rotary core drilling works to substantiate results of geophysical investigation.

(xiii) The location of the boreholes shall be marked on the ground as well as on the drawings with coordinates (Easting, Northing & Altitude).

(xiv) Shall carryout visual and tactile examination of each samples, describe material type (soil/rock) and maintain record of depth from the surface, elevation details and photographic records of each sample. Borehole log shall be as per relevant IS Code.

(xv) Standard Penetration Test (SPT) shall be carried out in the boreholes where ever feasible.

(xvi) The cores have to be properly kept in boxes, labeled & handed over to the client for future reference.

Minimum Requirements	
Number of Borehole	**Details**
4 boreholes	• Depth of borehole shall be 15m from the natural ground level. • If the bedrock is determined at shallow depth by SRT, the depth of boring shall be at least 5m depth into in-site rock for confirmation. • Appropriate casing types and sizes shall be used to obtain best core samples. • Shall observe and maintain record of ground water table every day before and after work. • Describe Borehole Test No. / Location ID, Name of Location, GPS Coordinates and Date of Borehole tests.

6. Geotechnical Investigation:

(xvii) Assess and characterize the engineering properties of in-situ soil and rock.

(xviii) Carry out trial pitting minimum of 5 nos of 3 m depth and collect soil samples for laboratory test in order to determine the bulk density, moisture content, grain size distribution, cohesion, angle of internal friction, plasticity indices, permeability etc.

(xix) Conduct soil tests e.g. Gradation test, Atterberg limits, Field Density, Unit weight, moisture content and the Direct Shear Box Tests as per relevant IS or any internationally accepted standards.

(xx) Assess and compute safe bearing capacity for design of appropriate engineering structures based on the finding of in-situ and laboratory tests results conducted on the soil samples.

(xxi) Assess and determine the strength and depth of the soil forming the slope and most likely worst-case ground water and soil moisture conditions.

(xxii) Assess location and extend of weak layers and cavities, if any, below the surface.

(xxiii) Carry out the slope stability analysis for design. The slope stability analysis of soil and rock slopes should include: Depth and configuration of the failures.

(xxiv) Carry out the soil/rock mass classification, geotechnical strength of soil/rock materials and the configuration of soil/rock strata, including basic geological indicators (e.g dip direction/dip) and other features such as fissures, faults, discontinuities in the case of rocks and, density, cohesion and friction angle and other characteristics in the case of soils.

(xxv) Assess worst-case groundwater table, and surface/subsurface soil moisture conditions.

(xxvi) Compute factor of safety for the slope with recommended mitigation action plan.

(xxvii) Assess probable settlement and probable differential settlement of the foundation.

(xxviii) Assess the likely construction difficulties, risks to the slopes, structures, people involved during construction of the structures and chart out the mitigation action plan to nullify the risks.

(xxix) Collect the meteorological and hydrological data of the project area and analyze it prior to design of mitigation structures.

(xxx) Compute the maximum probable discharge based on rainfall-runoff analysis.

(xxxi) Determine the probable floods for various return periods based on flood frequency analysis and design the hydraulic structures based on the maximum probable flood discharge (Minimum 25 years return period).

(xxxii) Assess and determine the extent and depth of scour for the foundation hydraulic structures.

7. Conceptual Design for Counter/Mitigation Measure Structures

(xxxiii) Based on the findings of detailed geotechnical investigation, the consultant shall recommend and submit **three alternative conceptual designs** for countermeasure structures along with probable estimate.

(xxxiv) The proposed countermeasures can be combination of various mitigation techniques as appropriate.

(xxxv) The client shall select most appropriate countermeasure structures recommended by consultant during presentation of midterm progress report.

Phase 2: Detailed design of mitigation measures/counter measures

8. Detailed Design of Counter/Mitigation Measure Structure

(xxxvi) Carrying out the detail design work on the selected option above;

(xxxvii) Preparing standard drawings. The drawings should be done in an appropriate style and the scales suitably fixed so that they are easily readable at site or workshop by naked eye. Except for the general views, the drawings should preferably be made to the scale of 1:50 and for showing minute details to 1:20 / 1:10 / 1:5 where necessary;

(xxxviii) All drawings should be made to paper size – ISO A3;

(xxxix) All drawing dimensions shall be in metric system (i.e. meter, cm and mm);

(xl) Preparing of Bill of Quantity (BoQ). The BoQ should be explicit covering all items of work. It should be as exhaustive as possible to avoid changes, additions, deletions and substitutions during execution and therefore the undesired disputes and claims;

(xli) Preparing rate analysis and cost estimate for all civil works. The cost estimates should be appropriately worked out to indicate the approximate cost of the structures. It should be accompanied by analysis of rates where necessary. The rate analysis and the cost estimate should be treated as highly confidential;

(xlii) Prepare a detailed Technical Specifications for all items of work taking into consideration the relevant Code of Practices and the advancement in technology;

(xliii) Prepare Quality Assurance Plan (QAP) for civil works;

(xliv) Prepare construction methodology and schedule for civil work;

(xlv) In any case if bridge is the chosen counter measure, if its span is longer than 50 meters, the Consultants shall appoint a competent independent third party to do the ‘proof design’. The CVs of proposed proof design Consultants shall be reviewed and approved by the Client after the award of work. The Consultants shall submit a proof design certification from the engineer(s) who has/have carried out the exercise mentioning the particulars such as qualification and experience records of such engineer(s). The design fees for proof design shall be borne by the Consultants.

F. EXPECTED INPUTS

The consulting service for detailed study and design will be provided for 9 (nine) months. The consultant for the service is to be engaged in accordance with Guidelines on The Use of Consultants (2013, as amended to date). The consultants shall engage the following key expert apart from other non-key expert and supporting staff to carry out the service.

A. International Experts:

1) Geotechnical Engineers/Team Leader
2) Geologist

B. National Experts:

3) Structural/Design Engineer/Deputy Team Leader
4) Hydrologist
5) Surveyor
6) Quantity Surveyor

G. QUALIFICATION AND EXPERIENCE

Qualification and experience requirements for Personnel of the Consultant are as suggested below:

A. International Experts

1) **Geotechnical Engineer/Team Leader**

a) Qualification	Minimum: Bachelor's degree in civil engineering or its relevant field Preferable: Master's degree in Geotechnical engineering or its related disciplines.
b) Total Professional Experience	minimum 15 years
c) Project-related Experience	minimum 10 years' experience as a Geotechnical Engineer in the similar project.
d) Overseas/Country Experience	Working experience in Himalayan region.

2) **Geologist**

a) Qualifications	Minimum: Bachelor's degree in civil engineering or Geology. Preferable: Master's degree in geological or relevant field.
b) Total Professional Experience	minimum 15 years
c) Project-related Experience	minimum 10 years' experience as a Geologist in the similar project
d) Overseas/Country Experience	Working experience in Himalayan region

B. National Experts

3) **Structural/Design Engineer/Deputy Team Leader**

a) Qualifications	Minimum: Bachelor's degree in civil engineering. Preferable: Master's degree in structural engineering or its related disciplines.
b) Total Professional Experience	minimum 10 years
c) Project-related Experience	minimum 8 years' experience as Bridge/Structural Design Engineer. He/she should have designed at least 2 nos. of 50 m length bridge in the past.
d) Overseas/Country Experience	Working experience in International Organization.

4) **Hydrologist**

a) Qualification	Minimum: Bachelor's degree in civil engineering Preferable: Master's degree in Hydrology and Watershed Management or its related fields.
b) Total Professional Experience	minimum 10 years
c) Project-related Experience	minimum 8 years' experience as Hydrologist in the similar project

d) Overseas/Country Experience	Working experience in International Organization

5) **Surveyor**

a) Qualification	Minimum: Diploma in civil engineering or Survey Preferable: Degree in Hydrology and Watershed Management or its related fields.
b) Total Professional Experience	minimum 8 years
c) Project-related Experience	minimum 5 years' experience as Surveyor in the similar project
d) Overseas/Country Experience	Working experience in International Organization

6) **Quantity Surveyor**

a) Qualification	Minimum: Diploma in civil engineering Preferable: Degree in civil engineering or its related fields.
b) Total Professional Experience	minimum 8 years
c) Project-related Experience	minimum 5 years' experience as Quantity Surveyor in the similar project
d) Overseas/Country Experience	Working experience in International Organization

H. REPORTS AND DOCUMENTS

The consultant should submit reports and documents as specified below:

Sl. no.	Reports/Documents	No. of copy	Requirement	Distribution address
1	Inception report	3 hard copy and 1 soft copy	● The report shall give initial findings and the work program for the balance of the assignment.	1. Chief Engineer, Construction Division, DoR, Thimphu 2. Project Coordinator, PMU, Phuentsholing 3. Project Manager, PMU, Phuentsholing
2	Midterm progress report/Phase 1 completion report:	3 hard copy and 1 soft copy	1. The report shall cover detailed study on hydrological, geological, geotechnical and mitigation measures; 2. The consultant shall make presentation to the client for review and approval;	1. Chief Engineer, Construction Division, DoR, Thimphu 2. Project Coordinator, PMU, Phuentsholing 3. Project Manager, PMU, Phuentsholing
3	Draft final report	3 hard copy and 1 soft copy	● The report shall cover drawing, schedules, QAP, construction methodology, technical specification, BoQ along with rate analysis and cost estimate; ● The consultant shall make presentation to the client for review and approval;	1. Chief Engineer, Construction Division, DoR, Thimphu 2. Project Coordinator, PMU, Phuentsholing 3. Project Manager, PMU, Phuentsholing
4	Final report	3 hard copy and 1 soft copy	● The report shall cover all comments of the client received during the submission of draft final report; ● The consultant shall make presentation to the client for review and approval.	1. Chief Engineer, Construction Division, DoR, Thimphu 2. Project Coordinator, PMU, Phuentsholing 3. Project Manager, PMU, Phuentsholing

I. SERVICES, FACILITIES AND PROPERTY

The client will provide the consultant with the following services, facilities, and property as listed below:

(i) all available studies, reports, and data relevant to the study area;
(ii) assist the consulting firm to process for visa, work and route permit for foreign experts;
(iii) one (1) pool vehicle for travelling from Phuentsholing to the site, and Thimphu for official purposes.

Any other/additional services, facilities and property required for carrying out service shall be covered from the contract price.

J. COUTERPART PERSONAL

I. Project Management Unit (PMU) is set up in the Phuentsholing, Chhukha Dzongkhag (District) comprises of Project Coordinator, Project Manager and Project Accountant as a representative of the client.
II. The consultant should report to PMU for carrying out the services.

K. DELIVERABLES

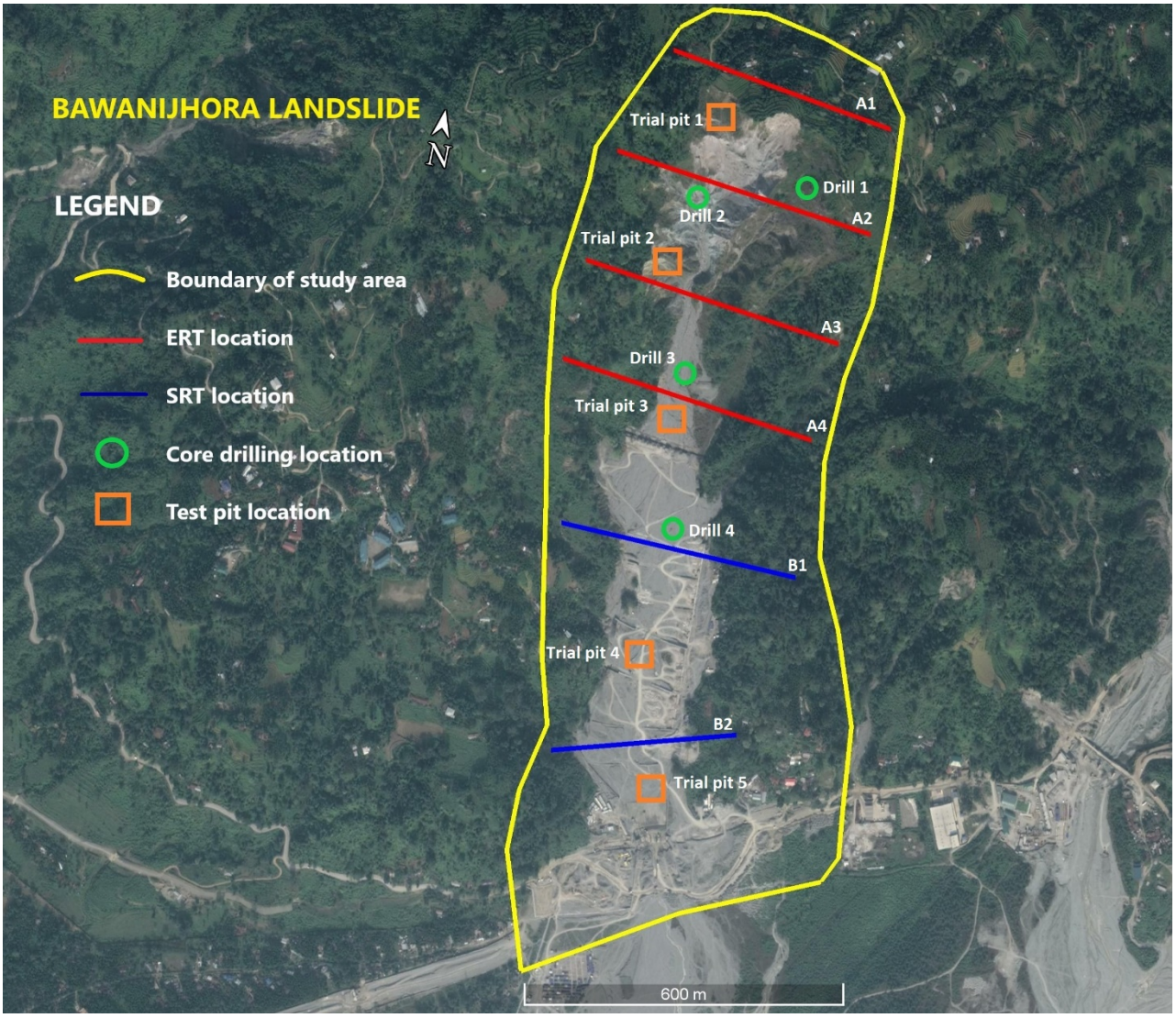
The client shall make payment to the consultant for the following specified deliverables:

Sl. no.	Item	Submission date	Payment
1	Inception report	1 month after the contract effectiveness	10%
2	Midterm progress/Phase 1 completion report	At the end of 5th month from the contract effectiveness	40%
3	Draft final report	15 days prior to end of contract service	30%
4	Final report	Before end of contract period or within 5 days after the end of contract service	20%

Payments by the client are deliverables based. Any deliverables not meeting the required specification/standard will have to be reworked and resubmitted at no additional cost to client. Based on the report and satisfactory performance, payments will be certified by the client.

Appendix 1

LANDSLIDE BOUNDARY AND TEST LOCATION



Appendix 2

AS-BUILT STRUCTURE MAP