

Terms of Reference for

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**NEEDS ASSESSMENT AND DESIGN OF WATER  
QUALITY AND SEDIMENT MONITORING  
NETWORKS**

**(Contract ID No: PPCR/DHM/S/CQS-35)**

**June, 2015**  
Kathmandu, Nepal

## 1. Introduction

This Terms of Reference (ToR) is prepared to acquire the service of a **Consulting Firm** to carry out needs assessment in the field of water quality and river sedimentation, and thereby design monitoring networks associated laboratories, data processing and data management. The scope of work also includes monitoring of water quality and sedimentation in selected lakes and reservoirs.

## 2. Background

Nepal's wetland habitat is created through varied water bodies that range from permanent flowing rivers to seasonal streams, low land ox-bow lakes, high altitude glacial lakes, swamps, marshes, paddy fields, reservoirs and ponds. The ecological diversity of wetland systems is reflected in the great variety of wetlands flora and fauna. These areas provide various products such as livestock grazing, fisheries, recreation and the conservation of biology, fodder and timber and are sites for feeding and breeding for various species of resident and migratory birds. Water is the life thread of all living beings of the globe but increasing water pollution has become a global threat to all life on Earth and is often the cause of great disasters.

Out of 23,705 lives lost to different disasters from 1983 to 2013 in Nepal, epidemics alone were responsible for 11,507 deaths (Disaster Review 2013, Department of Water Induced Disaster Prevention), most of which are water related vector borne diseases. The severity of epidemics can be illustrated by the INSEC record of diarrheal case when the death toll of diarrhea rose to 464 in 18 districts of Mid and Far Western Region during April 30 to September 18, 2009. (<http://www.inseconline.org/>). ICIMOD, a regional organization working for the Hindu Kush-Himalayan region reports that around 16,000 deaths occurring in Nepal every year in an average is linked to poor quality of water (<http://www.icimod.org/?q=64>). Additionally, water quality is also a major factor linked with agriculture productivity, health of livestock and quality of industrial products.

### Water Quality:

The challenge of how to improve water quality by rehabilitation and protection of lakes, streams, reservoirs, wetlands and related surface water bodies is a growing global concern, typified by the recent European Commission Water Framework Directive (EC, 2000). However, surface water pollution risks, particularly in developing nations, remain relatively widespread. A valuable initial step in identifying the nature and extent of water quality impacts linked to pollution is to distinguish their point source (PS) and non-point sources (NPS). PS pollution is commonly linked directly to end-of-pipe releases from industry and municipal wastes. Its control is more direct and quantifiable in many developed countries. Its mitigation has been linked to treatment achieving lower contaminant concentrations before discharge. NPS pollution occurs when contaminants from diverse and widely spread sources

are transported by runoff into rivers, lakes, wetlands, reservoir, ponds, ground water etc. This type of pollution is more difficult to address as there are a large number of sources, for example, varied agricultural areas all of which are using pesticides and nutrients. Today, however, NPS pollution is receiving more attention as its impacts are becoming evident over large areas in lakes, streams and groundwater and can also be linked to the degradation of aquatic freshwater ecosystems.

Thus, the foundation of effective water quality management is reliable water quality monitoring data and analyses. Water quality monitoring is the basis for determining how much the receiving waterbodies have been impacted and can lead to the development of effective means for controlling the pollution.

#### **Sediment Load:**

Soils play an important role in the maintenance of global food supplies and an ever increasingly important role as total population expands. The first 'Global Assessment of Human-Induced Soil degradation (GLASOD)' published in 1990 estimates that 1.97 billion hectares, equivalent to an area of 15% of total land cover, suffered degradation from the mid 1940's up to 1990. Total average global specific total sediment load is estimated to be approximately 140-188 tons km<sup>-2</sup> year<sup>-1</sup>. On a global scale, the loss of 75 billion tons of soil costs the world about US\$400 billion/year (at US\$3/ton of soil for nutrients and US\$2/ton of soil for water), or approximately US\$70/person/year.

Sediment yield in the Himalayas are significant and is considered to be highest in the world. Geologically, the Himalayas are considered to be fairly young in the mountain building process and are still active. This has led to many rock and slope instabilities that are the primary source of sediment for the river system (Source: OSH Research, Nepal, October 2004). The sediment yield of three major rivers of Nepal, the Karnali at Chisapani, Narayani at Narayanghat and Koshi at Chatara is 105 x 10<sup>6</sup> tonnes per year; 176 x 10<sup>6</sup> tonnes per year and 133 x 10<sup>6</sup> tonnes per year respectively (Sharma KP, JalsrotVikasSanstha (JVS)/ Global Water Partnership (GWP) - Nepal; Water: Information and Statistics, 2014)

In recent decades global warming has brought some unprecedented changes in glaciers of Nepal Himalaya and Tibetan part of the Himalaya in China region resulting in GLOF (Glacier Lake Outburst Flood) phenomenon. The impacts of a GLOF event are often devastating in downstream areas as the floods, resulting from the outburst of glacial lakes, usually consist of more sediment than water. Sediment sizes during GLOF events range from small particles to large boulders.

To address these environmental issues, as part of the World Bank funded Building Resilience to Climate Related Hazards (BRCH) project, DHM intends to establish Environmental Monitoring Networks for Basic Water Quality and Sediment Parameters among others.

### **3. BRCH Project**

The objective of the BRCH project is to enhance government capacity to mitigate climate related hazards by improving accuracy and timeliness of weather and flood forecasts and warnings for climate vulnerable communities, as well as developing Agricultural Management Information System (AMIS) services to help farmers mitigate climate related production risks. The project comprises four components:

- A. Institutional strengthening, capacity building and implementation support of DHM;
- B. Modernization of observation networks and forecasting;
- C. Enhancement of the service delivery system of DHM; and
- D. Creation of an agriculture management information system (AMIS).

Component A aims to develop and/or strengthen DHM's legal and regulatory frameworks, improve institutional performance as the main provider of weather, climate and hydrological information for the nation, build capacity of personnel and management, ensure operability of the future networks, and support project implementation. Component B aims to modernize DHM observation networks, communication and ICT systems, improve hydro meteorological numerical prediction systems and refurbish DHM offices and facilities. Similarly, Component C aims to enhance the service delivery system of DHM by creating a public weather service that provides weather and forecasts impact, and information services for climate-vulnerable communities and the key weather dependent sectors. Component D will provide critical and timely agro-climate and weather information as well as agro-advisories to farmers in order to increase productivity and reduce losses from meteorological and hydrological hazards.

A subcomponent of the component A of PPCR project envisages the development of a needs assessment and design for air quality, water quality and sediment monitoring networks; Pilot operation of air quality, water quality, and sediment monitoring networks under the subcomponent of component B expects a modernized environmental monitoring system.

The expected outcomes of the piloting activities are:

- Resource optimization for effective environmental monitoring system;
- Identification of the most effective and reliable sensing/sampling equipment with real time-based communication system for data acquisition facilities;
- Development of a mode of delegating DHM operational and forecasting activities to the regional and basin offices;
- Development of an user-friendly interface as decision support system (DSS) for the acquisition, management and dissemination of data, forecast and early warning information to concerned agencies and individuals including participating communities; and
- Disseminating long-term environmental data for timely evaluation and updating of climate, climatic trends and impacts.

#### **4. Status of Water Quality and Sediment Monitoring System in Nepal**

DHM initiated water quality monitoring program in Kathmandu valley in 1992. The program focused on highly polluted rivers in the Kathmandu valley. Water quality monitoring program was further extended in 1993 to the lakes in Pokhara and to the Narayani River at Narayanghat. Altogether, samples were collected from about 50 sites. The measured in-situ parameters included water temperature, pH, and conductivity and dissolved oxygen. Kit methods were used to collect the sample for chemical oxygen demand, biological oxygen demand, ammonia, nitrate, nitrite, phosphate chloride, iron, aluminum, chromium, cadmium and lead. The sampling frequency was however limited to two to three times a year. The data, however, were not tied to regular hydrometric stations. Some of the methods used were subjective and preliminary. For instance, several inorganic components were identified with visual approach, such as colour matching. The measured data and sampled results from 1992 to 2006 were compiled and published by DHM in 2008 (Water Quality Summary 1992-2006).

Sediment measurement in Nepal started in the late 1960s. Depth-integrated sampling method was used for sampling suspended sediment concentration at about 20 hydrometric stations on regular basis. However due to resource constraint, remoteness of sites, less qualified field staff and complexities of laboratory procedures, the system late in 1990s was simplified to a filtration based procedures with in-situ filtering system. Despite such efforts, the suspended sediment data are not published on regular basis. Bed load measurements are nonexistent.

#### **5. Objective of this Consultancy**

The main objective of this consultancy is to provide recommendations for strengthening the water quality and sediment monitoring network in Nepal and design and prepare tender documents for the "**Monitoring Network for Water Quality and Sediment Monitoring Network.**" This will be based on an assessment of user needs for water quality and sediment monitoring and information, assessment of the existing status of the water quality and sediment monitoring network and key gaps, and a review of international experience. The outputs from the consultancy include the needs assessment: training, capacity building, operational procedures and guidelines, with adequate stakeholders' participation. It will also include preparation of draft specifications and tender documents for observation and laboratory equipment, related ICT and other components needed for operation. The specific objectives are:

- Needs assessment of water quality and sediment monitoring in Nepal;
- Assessment of water quality and sediment transport levels in Nepal;

- Assessment of the existing monitoring network for (i) water quality and (ii) sediment, identification of hotspots/areas where water quality and sediment monitoring networks need to be strengthened;
- Design of a real time modern water quality observation system and sediment monitoring system based on international best practices;
- Preparation of specifications for piloting water quality and sediment observation system under the PPCR project;
- Recommendations for linking the water quality and sediment transport data with the DHM data management systems;
- Institutional analysis, including an initial plan for operation, maintenance, equipment calibration and data management.

## 6. Scope of work

The scope of work under this ToR includes, but is not limited to the following:

### ***Task A. Needs Assessment and Design of Water Quality Monitoring Network and development of tender documents***

Review of international best practices for water quality monitoring. The parameters to be observed are to be as per the WMO Guidelines but not limited to:

1. Basic parameters, e.g. water temperature, pH, conductivity, dissolved oxygen and discharge;
  - Suspended particulate matter, e.g. suspended solids, turbidity and organic matter (Total Organic Carbon - TOC), Biochemical Oxygen Demand - BOD and Chemical Oxygen Demand - COD.
  - Indicators of pollution with oxygen consuming substances e.g. dissolved oxygen, BOD, COD and ammonium.
  - Indicators of pollution with nutrients and eutrophication effects, e.g. nitrogen and phosphorus, and various biological effect variables, e.g. chlorophyll and Secchi-disc transparency.
  - Indicators of retention time in a slow changing water body (lakes, reservoirs, impoundments).
  - Indicators of acidification, e.g. pH, alkalinity, conductivity, sulphate, nitrate, aluminium, phytoplankton and diatom sampling.
  - Indicators for the forecasting of the future eutrophication state of water bodies Specific major ions, e.g. chloride, sulphate, sodium, potassium, calcium and magnesium.
  - Specific minor ions, e.g. arsenic, fluoride.

- Metals, e.g. cadmium, mercury, copper and zinc.
- Organic micro-pollutants, such as pesticides and the numerous chemical substances used in industrial processes, products and households.
- Indicators of radioactivity, e.g. total alpha and beta activity, <sup>137</sup>Cs, <sup>90</sup>Sr.
- Microbiological indicator organisms e.g. total coliforms, fecal coliforms and fecal streptococci bacteria.
- Biological indicators of the ecological quality, e.g. phytoplankton, zooplankton, zoobenthos, fish and macrophytes.

The **Consulting Firm** will recommend parameters to be monitored for each location; methodologies involved and will prepare standard operation procedures for sampling, laboratory analysis, data processing and quality control including integration with the central data base management system;

2. Assessment of user needs for improving water quality monitoring: Identify key users for water quality data and information, purposes for which the data and information/products will be used and procedure for service delivery to the end users;
3. Assess the existing status of the water quality monitoring network and identify key gaps. Highlight priority areas where the water quality monitoring network needs to be strengthened (eg. urban areas, areas with high concentration of industries, major lakes such as Fewa, Rara, Begnas, Mai pokhari, Indrasarovar reservoir (Kulekhani) and so forth);
4. Analyze Institutions and Organizations for water quality monitoring: Identify and assess the existing institutions and organizations involved in water quality monitoring and gaps there of. Present this information in a table;
5. Assess the existing organizational arrangements, roles and mandates for water quality monitoring and service delivery. This should include availability of staff resources and skills needed to undertake water quality monitoring works in Nepal. Also assess training needs of the staff on monitoring, analysis and service delivery;
6. Recommendations: Summarize key findings and recommendations from the above analysis;
7. Design a real time water quality monitoring network, analysis, equipment calibration and decision support system. Present the network in a map;
8. Develop an interactive GIS data base management system;
9. Develop specifications and tender documents for water quality monitoring equipment, laboratory and laboratory equipment and calibration equipment facilities.

10. Develop a training plan with associated costs for water quality monitoring staff and laboratory technicians.

**Task B. Needs Assessment and Design of a Sediment Monitoring Network and development of tender documents**

1. Review the best international practices on sediment monitoring: Sampling procedures, laboratory analysis, data processing and data quality control. Recommend the monitoring parameters in the rivers, lakes and reservoirs;
2. Identify the main users of sediment data and information in the field of hydropower, irrigation, water supply, flood management, etc. Assess user needs for data, products, information and services, purposes for which the data and information/products will be used. Information should be provided in a table for each key user group;
3. Assess the existing status of the sediment monitoring network and identify key gaps. Highlight priority areas where the sediment monitoring network needs to be strengthened based on WMO Guidelines and international best practices and also considering the national requirements. Present this information in a map;
4. Assess the existing organizational arrangements, roles and mandates for sediment monitoring and service delivery. This should include availability of staff resources and skills needed to undertake sediment monitoring work in Nepal. Also assess training needs of the staff on monitoring, analysis and service delivery’
5. Summarize key findings and recommendations from the above analysis;
6. Design sediment monitoring, data processing and dissemination and decision support system: Sampling network, procedures of sample collection, sample handling, sediment laboratory, laboratory analysis, equipment calibration, data processing, data dissemination and decision support system;
7. Develop specification and tender documents with cost estimates for sediment sampling and laboratory equipment;
8. Develop a training plan with associated costs for sediment samplers, monitoring technicians, laboratory staff, data processing technicians and data base management staff.

**Supervision and Quality Assurance**

Project Management Units (PMUs) have been established in each of the two implementing agencies (DHM and MoAD), and include technical, financial, procurement, environment, social, monitoring, and evaluation specialists.

System integrator (SI) is hired for four years to provide service to DHM. The main objective of SI is the development of technical documentation for the implementation of each of the project component and effective technical support for project activities in order to achieve project goals.

All key outputs/deliverables including designs and reports will be subjected to review at

various levels. On technical matters, the **Consulting Firm** will work in close consultation with National Project Director (NPD), PMU, SI, and Project stakeholders.

The **Consulting Firm** can get technical support and guidance from SI as and when required during the period of implementation. In addition the **Consulting Firm** will hold:

- Regular (monthly) consultations with DHM;
- Kick off meeting with key stakeholders (including sector representatives);
- Time to time updates with key stakeholders (including sectors representatives);
- Basin level and field level consultations with local level GOs/NGOs and community representatives ensuring GESI.

## **7. Client's Commitments (Inputs)**

Staff of DHM/PMU will provide basic organizational support to the Consultant. At the request of the Consultant, DHM should provide following documents.

- Information and data related to the project including information on status of observation networks, monitoring/lab equipment, communication, computing resources, and data processing tools;
- Information on the current water quality and sediment monitoring network; type of monitoring systems; responsible agencies tasked with monitoring (and what they monitor); frequency of sampling and reporting; parameters measured; and data available to central and decentralized levels of government as well as reporting requirements for different governmental institutions and the public;
- Project Appraisal Document (PAD), reports of missions and other relevant publications;
- Administrative, financial, legal and regulatory documents in support of activities; and
- Consultant's staff may work in monitoring stations and, if necessary, in any other location in Kathmandu, as per necessity of coordination in relation to the services.

## **8. General Requirements of the consultant/Service provider**

The **Consulting Firm** should have at least 10 years of international working experience in designing, establishing and operating water and sediment monitoring systems and networks. Experience in designing and establishing such networks in developing country contexts as well as experience in Asia and Nepal in particular will have advantage. The service provider should have demonstrated experience in capacity building of local staff charged with operating and maintaining water quality and sediment monitoring systems. Market knowledge of available technology and monitoring equipment (i.e. advantages, disadvantages, limitations, cost considerations, etc.) and knowledge of international best practices, standards and guidelines are essential. The staffing requirements of key personnel for this assignment will include a minimum of the following positions.

### **8.1 International**

- 1. Team Leader (3 Months):** The Team Leader (TL) will have at least 10-years of experience in planning, designing and managing water quality and sediment

transportation monitoring systems relevant to this assignment. S/he shall have the experience for supervising and installing water quality systems in developing countries. Experience working in East Asia or South Asia will be an advantage. TL shall have knowledge in Web-based data portal for managing and disseminating data, and information. TL will also play a role of coordinator in the implementation arrangements of the consultancy. TL is responsible for an overall management including quality assurance, training and capacity building of the staff, finding the institutional gaps, development of laboratory management guidelines and timely delivery of outputs and reports. The team leader shall reside in Nepal for 2 months during the total duration of the project.

**Qualifications:**

- Master's degree in Environmental Engineering/Soil and Water Science and/or Hydrology and/or any related discipline. Relevant PhD degree will be an advantage.
  - Minimum of ten years experience in designing and supervising installation of environmental monitoring networks. Working experience with water quality networks will be an advantage. Working experience in developing country physiographic and socio-economic conditions will be an advantage.
  - Proven experience in designing, developing, and managing projects (including financial management) ensuring alignment with requirements of concerned institutions and development partners.
  - Working knowledge of needs assessments of hydrometry and water quality database management.
  - Working knowledge of water quality and sediment measurement technologies.
  - Knowledge to work with water quality and transport models and GIS will be an advantage.
  - Working knowledge in Human Resources Development.
  - Strong command in computer application and written communication (English).
- 2. Environmental Chemist/Water Quality Expert (2 Months):** The expert will have expertise in water quality and designing, supervising and installing water quality systems in developing countries. The expert will undertake the water quality needs assessment, assess the status of existing network and identify gaps and hotspot areas, design for water quality monitoring and draft specifications for pilot monitoring works. S/he will transfer the knowledge of international best practices in water quality monitoring technology to DHM personnel's and the concerned departments through workshops and seminars in water chemistry and environmental monitoring. The expert shall reside in Nepal for a minimum period of 0.5 month during the total duration of the project.

**Qualification:**

- Minimum M. Sc. in Water Chemistry/ Hydrology and/or other related discipline.
- The Expert will have at least five years' experience in environmental monitoring and environmental modeling and designing and supporting implementation of such systems.

- Experience in statistical analyses, data management and data quality control related to water quality.
  - Proven knowledge to conduct training on water quality monitoring, environmental modeling and computer applications including database management.
- 3. Sedimentologist (4Months):**The expert will have knowledge of monitoring river sedimentation including suspended sediment load and bed load integrating with hydrological monitoring system. The expert will conduct the needs assessment and design of sediment monitoring and draft specifications for needed equipment. S/he will transfer the knowledge of technology to DHM personnel and the concerned departments through training workshops and seminars in sediment sampling, laboratory procedures, and sediment modeling. The Expert shall reside in Nepal for 1.5 months during the total duration of the project

**Qualification:**

- Minimum M. Sc. in Sedimentology/Hydrology/Hydraulic Engineering or related discipline.
- The Expert will have at least fiveyears experience in sediment monitoring and sediment analysis.
- Experience in statistical analyses of model performance and data quality control.
- S/he will have proven knowledge to conduct training on different aspects of river and lake sedimentation.

**8.2 National Experts:**

- 1. Deputy Team Leader, Environmental Monitoring Expert (6 Months):** The expert will support the team leader in making the needs assessment and design of environmental monitoring systems and in overall management of the project. S/he will also support the international experts in collecting necessary background information and carrying out the assessments and in transfer of knowledge to DHM personnel through training workshops and seminars in water chemistry, sedimentology, observation systems, data management and environmental legislation.

**Qualification:**

- Minimum of Master's degree in Environmental Sciences/Environmental Engineering /Water Resources Engineering/Hydrology/ or a related discipline.
- Minimum of two years' experience in managing similar type of projects.
- The expert will have at least 5 years' experience in environmental assessment and sediment monitoring.
- Experience in statistical analyses of model performance and data quality control.
- S/he will have proven knowledge to conduct the training on environmental monitoring, environmental assessment, computer applications, data processing and database management.

- 2. Database Management Expert (1 Month):**The Database Management Expert will make a plan for needed data acquisition and management systems for water quality and sediment monitoring systems and provide recommendations for integrating such data to DHM Central database system using the same communication channel protocols.

**Qualifications:**

- Minimum of M.Sc. in Computer Science/Computer Application/Natural Sciences/Hydrology/Environmental sciences or equivalent.
- Minimum of five years experience in designing, developing, and implementing database management system for environmental monitoring including real time data received through different communication channels. Preferable 10 years experience.

**9. Time Schedule and deliverables**

Key deliverables will include the following

Deliverables from Task A: ***Needs Assessment and Design of Water Quality Monitoring Network and development of tender documents***

S. No.	Tasks/Deliverables	Timeline (from the date of contract signing)
1	Questionnaire for Stakeholders and communities and documented responses	1 month
2	List of key users of water quality data and their needs	2 months
3	Design of water quality monitoring network with identified parameters and data transmission system	3 months
4	Standard Operating Procedures (SOPs)	4 months
5	Design of water quality lab with calibration facilities	4 months
6	Institutional plan and Data management scheme	4 months
7	Training plan	4 months
8	Proposed equipment specification and software	4 months
9	Tender document including cost estimates	5 months
10	Inception Report	2 weeks

## Terms of Reference

### Needs Assessment And Design of Water Quality and Sediment Monitoring Networks

11	Interim (progress) report	3 months
12	Draft Final Report	5 months
13	Final Report	6 months

#### Deliverables from Task B: **Needs Assessment and Design of a Sediment Monitoring Network and development of tender documents**

S. No.	Tasks/deliverables	Timeline (from the date of contract signing)
1	Questionnaire for Stakeholders and communities and documented responses	1 month
2	List of key users of sediment data and their needs	2 months
3	Designed sediment monitoring network with identified parameters and data transmission system	3 months
4	Standard Operating Procedures (SOPs)	4 months
5	Design of sediment lab with calibration facilities	4 months
6	Institutional plan and Data management scheme	4 months
7	Training plan	4 months
8	Proposed equipment specification and software	4 months
9	Tender document including cost estimates	5 months
10	Inception Report	2 weeks
11	Interim (progress) report	3 months
12	Draft Final Report	5 months
13	Final Report	6 months

## 10. Reporting

Reporting requirements shall be as follows: All the reports are to be submitted in 3 hard

copies along with e-copies.

#### **Report No.1 - Inception Report**

The consultant shall submit an Inception Report within 2 weeks from the date of signing the contract. The report will be based on elaborated discussions with DHM, MoSTE, DoEnv, WECS, GOs, I/NGOs, CBOs and other stakeholders. The consultant shall review and verify the content of the tasks and methodologies required. Specifically, the consultant shall review the existing information, identify gaps and make specifications of the surveys necessary for filling information gaps. The consultant will also elaborate on: (i) additional tasks, (ii) work and staffing plans, and (iii) reporting modalities. The report must also clearly specify all risks and issues, which may negatively affect project deadlines and effective execution of project activities.

#### **Report No.2 - Interim (Progress) Report**

The consultant will submit an interim progress report within 3 months. Workshops/consultation with experts, stakeholders including GOs, I/NGOs and civil society.

#### **Report No.3.Draft Final Report**

Draft Final Report will be submitted within 6 months.

#### **Report No.4. Final Report**

Final Report (within 6 months).

### **11. Payment Schedule**

10 percent on signing of contract as advance against a bank guarantee.

40 percent after submission and approval of Interim Progress Report.

40 percent after submission and approval of Draft Final Report.

10 percent after acceptance of the Final Report.

### **12. Selection Procedure and Form of Contract**

The consultants would be selected following Quality and Cost Based Selection (QCBS, Technical 0.8, Financial 0.2) criteria.

### **13. Duration of assignment**

**6months**