TERMS OF REFERENCE FOR CONCEPTION AND INSTALLATION OF BAGMATI RIVER BASIN DECISION SUPPORT SYSTEM, FLOOD FORESCASTING AND EARLY WARNING SYSTEM, WATER QUALITY MONITORING SYSTEM AND PREPARATION OF BAGMATI RIVER BASIN INTGRATED MASTER PLAN

A. BAGMATI RIVER BASIN IMPROVEMENT PROJECT BACKGROUND

1. The proposed Bagmati River Basin Improvement Project (the project) will improve water security and resilience to potential climate change impact in the Bagmati River Basin. It builds on the general public's desire to restore the river environment in the Kathmandu Valley and the Government's efforts to mitigate the impact of water-induced disasters in the middle and lower reaches of the basin. The Project adopts the principles of integrated water resources management (IWRM) and provides Nepal with its first opportunity to apply this policy element since its adoption under the 2005 national water plan.

1. The project will complement the Government of Nepal's (the government) ongoing efforts towards improving the wastewater services in Kathmandu Valley¹ with the overall objective of improving the river water quality in the Bagmati River and achieve bathing water standards at strategic religious sites in the Upper Bagmati providing a safe environment for bathing and religious use of the river at the prominent temple sites at Gokarna and Pashupatinath.

2. The proposed Bagmati River Basin Improvement Project (the project) impact will be increased water security in the BRB. The outcome will be improved river health and flood management. The project is the first attempt in Nepal to apply the concept and principles of IWRM since its adoption under the 2005 National Water Plan.

3. The project focuses on priority issues selected by the basin stakeholders. It will be implemented over a period of 5 years and has the following five outputs:

- (i) Established systems and capacity for integrated and participatory river basin management. Activities include (a) provide legal and institutional strengthening for IWRM and formation of a river basin organization (RBO), (b) mobilize basin stakeholders, (c) build capacity for increasing RBO competence, (d) establish a central water resources information system including a decision support system (DSS) and an operating water quality monitoring (WQ) network, and (e) prepare a 15-year participatory integrated river basin master plan (IRBMP).
- (ii) Improved riverbank environment in urban areas. Activities include (a) remove contaminated riverbed material; (b) construct weirs and provide phytoremediation to enhance the river's self-cleaning capacity; (c) stabilize and beautify the riverbank; (d) mobilize, raise awareness, and build capacity of local government and communities for riverbank management and maintenance; and (e) collaborate with the private sector, which has expressed interest in setting up

¹Kathmandu Valley Wastewater Management Project.ADB Project Number 43524.

recreational businesses along the riverbanks through public–private partnerships or finance maintenance as part of social corporate activities.

- (iii) Increased water availability in the basin during the dry season and watershed conservation. Activities include (a) construct an 861,000 cubic meters (m³) Dhap dam and complete detail design of the 8 million m³Nagmati dam, (b) provide rooftop rainwater harvesting and groundwater recharge, and (c) implement upstream watershed management.
- (iv) Functioning flood forecasting and early warning system for the Bagmati River Basin. Activities include (a) upgrade the existing flood forecasting system,
 (b) install a flood early warning system (FEW), and (c) increase community awareness and build capacity for flood response.
- (v) Efficient project management with effective stakeholder communication. Activities include (a) establish competent project management and project implementation units, (b) undertake timely procurement and disbursement, and (c) implement the project communication strategy and monitoring.

4. The Project Executing Agency is the Ministry of Urban Development (MOUD). The High Powered Committee for Integrated Development for Bagmati Civilization (HPCIDBC) will be the main implementing agency and will establish the project coordination and management unit; and manage outputs 2, 5, and part of 3. The Department of Irrigation will implement the design and construction of dams under output 3 and will establish a project implementation unit in the project coordination and management unit. The Water and Energy Commission Secretariat (WECS) will be the implementing agency for outputs 1 and 4. The Project Coordination and Management Unit (PCMU) will be established in the offices of the(HPCIDBC.

5. The project will be supported by 4 separate consulting packages. These includes (i) 393 persons months of International and national specialists to support the Project Management Design and Supervision (PMDSC) consulting package for overall project management and the implementation of output 2 and 5. PMDSC will also provide support for the RBO formation under output 1, (ii) Detail design of Nagmati dam consulting package approx 250 person months, (iii) RBO support international consultant package totalizing 21 persons months internationals over 3 years to support the RBO formation and policy and legal framework under output 1. and (iv) 148 person month international and national to support DSS system installation , IRBMP preparation FEW and WQ installation under output 1 and 4.

B. OVERVIEW OF THE ASSIGNMENT

6. WECs on behalf of the Government of Nepal is recruiting an international firm(s) (in association with a national firms if necessary) to undertake the followings tasks over a period of 30 months:

- (i) Task 1: Development of the Decision Support System (DSS)
- (ii) Task 2: Flood Forecasting and Early Warning System (FFEWS)
- (iii) Task 3: Water Quality Monitoring System Upgrade
- (iv) Task 4: Integrated River Basin Development Master Plan (IRBDMP)

TASK 1: Development of the Decision Support System (DSS)

1. Objective of the Bagmati DSS

7. The Bagmati DSS will support Integrated Water Resources Management planning and investment decisions in the Bagmati river basin. Its scope includes not only the Bagmati DSS itself, but also the development of core institutional capabilities to assist in the evaluation of alternative development strategies and the identification of investment project at the basin or sub-basin level in future. The DSS should also play a key role in monitoring, managing the impact of any development or water allocations on Bagmati river environment and environmental flow.

8. The basic purpose of the Bagmati DSS is to provide a framework for knowledge sharing, understanding the river system behaviour, designing and evaluating alternative development scenarios, investment projects, and management strategies. The Bagmati DSS should help to *"enhance the capacity to support basin wide communication and information exchange, and identify opportunities for sector cooperative development of the Bagmati water resources"*.

2. The Development Process

9. The Bagmati DSS development process is based on a thorough needs assessment and a subsequent conceptual design of the system. Based on the situation analysis in terms of hydrology, water availability and use patterns, environmental and socio-economic issues a stakeholder's workshop is planned for shared training needs assessment and identification of requirements to the Bagmati DSS.

3. Institutional Context

10. WECS is considered to be the implementing agency for the DSS development. WECS has established an Information Centre that provides updated information on water resources at basin level to stakeholders via its Web-Page. WECS operates and updates their information system on a regular basis.

11. The functional requirements of the DSS will depend on institutional interaction between data collection institutions (DHM for hydrology and meteorology, HPCIDBC presently doing water quality monitoring etc.), and the institutions that will have access to, and use the Bagmati DSS information.

4. Capacity for DSS Development, Operation and Maintenance

12. Being a new concept, the national capacity for DSS design and development is somewhat limited. The design and development of DSS systems for IWRM is carried out by highly specialized international consultants associated to national consultants that may become the future national expertise.

13. Based on developments carried out e.g. for the Nile Basin² and the DSS Planning project³ in India, generic frameworks for IWRM DSS systems are readily available. The

² http://www.nilebasin.org/newsite/index.php?option=com_content&view=section&layout=blog&id=10<emid= 71&lang=en

³ http://hydrology-project.gov.in/dss.htm

development of the DSS for the Bagmati is therefore considered to be based on available technology and generic DSS development systems provided by international consultants.

14. However, it is foreseen that major parts of the adaptation of the DSS framework to the Bagmati Basin will be carried out by national professionals, being trained and supervised by the international consultant.

15. A training programme will be tailor made to enable WECS staff to operate, update and maintain the Bagmati DSS together with the Bagmati River Basin Organization (BRBO) to be formed.

16. Besides, the WECS core staff will be further trained, to be able to roll-out the DSS to other River Basin Organizations in Nepal, and train the BRBO staff in the use of the DSS system for their specific basin planning and management purposes.

5. Scope

17. Based on the existing Information System and expanded to the DSS, WECS expects that the DSS can support them, by providing support to:

- (i) Flood/Drought forecasting (early warning system).
- (ii) Basin planning and management.
- (iii) Techno-economic clearance for projects.
- (iv) Water allocation.
- (v) Regulation.
- (vi) Monitoring and evaluation.
- (vii) Benefit optimization.
- (viii) Conflict Resolution.
- (ix) WRM implementation.
- (x) Co-ordination.
- (xi) Sustainable WR development.
- (xii) Demand/supply projection.
- (xiii) WR Infrastructure Operational policy development.

18. It should be noted that the mandate for Flood Forecasting is with DHM, and considered to remain there. However, the DSS will have functionalities to receive the forecasts for any use of a future Bagmati RBO.

6. Overall Concept for the DSS

a. Interfacing with Existing and Future Models

19. The model system of the Bagmati DSS would provide an open interface to existing and future models being used for the Bagmati river basin can interact, be interfaced and linked dynamically. This would allow for exchange and sharing of data between models at runtime. This modeling interface would be simple and flexible enabling the user to define model interfacing without accessing the source code of the individual model systems.

b. Overall Conceptual Design

20. The Bagmati DSS encapsulates the existing WECS Information system, listing the types of basic information foreseen to be included in the core Data Base.

21. An important feature adding to the present WECS Information System will be the integration of existing and future models, the ability to define planning scenarios, and the facilities for Multi-Criteria-Analyses and optimisation.

c. Training

22. Software related user training including a series of training workshops in conjunction with the installation of the DSS Releases. These trainings are to be held at the location of WECS to be able to directly use the newly installed systems or updates for the training and at the same time subject it to user testing. The training would cover the background, algorithms and use of the software, as well as hands on exercises with relevant test cases to familiarize the core team and selected (RBO) users with the system.

23. The software training to be synchronized with the release of the corresponding user manuals, to be used as course material in the training and to compile user feedback for the improvement of the manuals.

TASK2: Flood Forecasting and Early Warning System (FFEWS)

1. Objective of the Bagmati FFEWS

The overall objective of the component is to equip DHM with a fully operational real time flood forecasting and warning system including an effective community based early warning system for the Bagmati river basin. The FFEWS ultimate objective is to ensure that flood warnings are disseminated 72 hours before flood events (baseline 2013: 24 hours before flood events with low reliability). The consultants will ensure that development in the Bagmati River Basin will be decided in close coordination and collaboration with the World Bank funded Building Resilience to Climate Related Hazards Project.

- 24. The specific objectives and scope of activities include but are not limited to the following:
 - (i) Assess the hydro-meteorological network and data acquisition system required for flood forecasting and early warning in the Bagmati river and its tributaries and to implement priority network and data acquisition improvement activities
 - (ii) Assess the current forecasting capacity and install necessary flood forecasting tools (hydrological and hydraulic models, rainfall forecasting including satellite based rainfall estimates)
 - (iii) Develop hydrological and hydrodynamic models and calibrate with historical data. The model will have a mapping feature to display model results spatially (inundation areas, flood levels etc.). The model will be linked to a real time data acquisition system and other web-based data.
 - (iv) Develop a web based flood forecasting and early warning dissemination system
 - (v) Develop an operational strategy for disseminating flood early warning at the community level
 - (vi) Design and provide necessary trainings and capacity development for sustainable operation of the FFWES at DHM

2. Scope of the work

a. Review of the hydro-meteorological network and data acquisition system and identify network and data acquisition improvement activities

25. A detailed inventory of the hydro-meteorological network, equipment and data acquisition system will be prepared. The existing forecast system has to be reviewed with respect to its on-line data assimilation capacity and coverage. Any additions to the hydrometric network in the Bagmati Basin since the existing forecast system was developed in 2011 will have to be identified. New hydrometric stations have to be included in the data assimilation network as a basis for the updated forecast and warning system. While the development of the existing flood forecast system concentrated on covering especially the most flood prone areas in the lower Bagmati, the present project intends to cover all flood prone areas in the entire Bagmati basin.

b. Review of the current forecasting capacity in DHM and identify necessary flood forecasting tools (models) upgrades

26. The consultant has to acquaint himself with the current weather and hydrological forecasting models and procedures used by the DHM for data acquisition as well as the existing human resources and the computer software and hardware available. While the existing forecast system relies mainly on on-line data from DHMs hydrometric network, numerical weather models and satellite based rainfall forecasts will provide the basis for the flood forecasts. This will require an update of the MIKE11 model currently used as well as upgrade of communication facilities.

c. Procurement of Software and Hardware

27. Based on the inventory of available equipment and the identified need of additional computational capacity and communication facilities specifications for procurement are needed. The selection and installation of the software and hardware will be made in close collaboration with DHM. The PCMU procurement specialist can provide support in the procurement process. Upon procurement the software and hardware will be installed in DHM.

d. Extension of the existing forecast system

28. The coverage of the existing flood forecast model will be extended to generate water levels at key locations and inundation forecasts for all flood prone areas in the Bagmati basin. The river topographic data on which the present flood forecasting model is based should be updated.

29. With the assistance of DHM existing cross section data not included in the existing model shall be obtained, e.g. any data from Department of Irrigation from their Bagmati Irrigation project, from HPCIDBC based on their recent river works in the Bagmati and tributaries in Kathmandu, etc.

30. Additional data needs critical for extension of the flood forecast model shall be identified, specifications to be prepared and procurement of local survey consultant(s) to be done to carry out, e.g. cross section surveys at strategic locations.

31. Based on additional topographic data and river cross section data the existing flood forecasting model will have to be extended, recalibrated and verified based on the DHM hydrometric data from the Bagmati basin.

e. Development and piloting of basin-wide flood forecasting and early warning system

32. The flood forecasting and early warning system will be based on forecasts of catchment rainfall using satellite based rainfall forecasts, numerical weather models and quantitative rainfall forecasts generated by the international and regional resource centers, IMD, RIMES etc.

33. The forecast system will be equipped with facilities for communication and receive of the forecast from RIMES and IMD.

34. The system will provide facilities for preparation of flood risk maps using GIS layers of the Bagmati basin.

f. Assign NGO for Warning Dissemination

35. Prepare detailed Terms of Reference and recruit a local experienced NGO to develop, test and implement effective early warnings to flood prone communities in the Bagmati basin. The testing and implementation of the warning system shall reach at least 10 flood prone communities in the Lower Bagmati.

g. Flood warning dissemination strategy

36. While the dissemination of flood warnings to authorities at district level is relatively easy, reaching the flood prone poor communities with easily understood warnings is not simple. However, relatively successful attempts have been made in Nepal⁴ and neighbouring countries⁵ to establish warning dissemination reaching the rural poor communities.

37. Based on the lessons learned a flood warning dissemination strategy will be developed in close collaboration between the consultant, DHM and the NGO assigned. Based on the experience using mobile phones, this option for warning dissemination should be considered in addition to more traditional methods for warning distribution.

38. Based on the flood warning dissemination strategy the NGO will develop the concept and contents of the flood warning dissemination system to be tested and implemented.

h. Testing and implementing the flood warning dissemination system

39. The testing and implementation of the flood warning dissemination system targets to reach the poor and flood prone communities. However, the testing in the field should also cover that forecasts reach district authorities and disaster management committees and other government agencies.

i. Provision of necessary trainings and capacity development for sustainable operation of FFWES

40. The key to success of the forecasting centre at DHM is the sustainability and the national capacity to maintain and operate the data acquisition, forecasting and early warning system. While annual budgetary provision to meet the cost of the services needs to be sustained, there is a strong need to develop the necessary human resources. Hence, appropriate trainings including specialised courses and exposure visits will be provided to the counterpart staff. On-the-job trainings will be provided by the implementing consulting team.

⁴Banka Bardia Flood Warning programme.<u>http://practicalaction.org/IA15000181NEP-banke-bardia-flood-warning</u>

⁵Consolidation and Strengthening ofFlood Forecasting and Warning Services. Final Report.Vol V – Project Extension. Report to the Bangladesh Water Development Board. DHI. December 2006

41. As DHM and the proposed Bagmati RBO will both be involved in flood disaster risk management in the Bagmati River basin, the forecasting activities need to be established as a joint collaboration between the two. A workable institutional setup will be recommended suitable to meet the objectives of BRBO.

3. The FFEWS

42. Since the Bagmati River basin is relatively small with steep river slopes the lead time of flood forecasting along the Bagmati River mainly depends on lead time of the available weather forecast. Quantitative Precipitation Forecasts can only prove a reliable rainfall forecasts for 1, 2 and 3 days only. Therefore, the lead time of the flood forecasting model of the Bagmati river basin will be limited up to 3 days. The floods are flashy in nature in many parts of the basin, and the travel time of the flood wave from upper Bagmati to the lower part is about 12 hours. The, development of the FFEWS for the Bagmati basin should consider the above factors. The following components are included in the proposed development of FFEWS.

- (i) A Rainfall-runoff model
- (ii) A Hydrodynamic model
- (iii) A Flood forecasting model with data assimilation facilities using real time data
- (iv) A Web based user interface with warning dissemination facilities
- (v) Community based early warning system

4. Capacity Building

a. Capacity for FFEWS Development, Operation and Maintenance

43. The development of the FFEWS for the Bagmati may be based on the MIKE11software which is currently available with DHM and the pilot model of the Bagmati River. However, it is foreseen that the model will be updated to cover the entire basin with additional data of river cross sections, flood plain topography (DEM), structures including embankments. The model will also be updated to incorporate the real-time data (rainfall, water levels). The model will be recalibrated with the latest time series data available before an operation forecasting is implemented by DHM.

44. The operational forecasting for the Bagmati River will be mainstreamed in the forecasting activities of DHM. DHM will however need capacity support both from national and international consultants during the development of the FFEWS. DHM personnel will be trained during the development. It is expected that DHM will require external support for some period before they will be able to take over completely.

45. The training programme described below shall be tailor-made to enable DHM staff to operate, update and maintain the Bagmati FFEWS together with the proposed Bagmati River Basin Organization (BRBO). Besides, the DHM core staff will be further trained, to be able to roll-out the FFWES to other river basins in Nepal.

b. Specialized Training Courses

46. Specialised training courses will be provided in the following topics:

- Concepts of computational hydrology and hydraulics, rainfall-runoff modeling, hydrodynamic modelling, data assimilation and forecasting, flood mapping, GIS, Satellite image processing, data base management and Web updating.
- The consultants will undertake need assessments, prepare training programs identify and recruit training institutes, academia (national and international) from the amount provided under the provisional sums

c. On-the-job training

47. DHM and other related GON staff will be involved in all stages of development and implementation of the forecasting system by consultants.

d. Exposure visits

48. Exposure visits will be conducted for DHM and other related GON staff to observe operational flood forecasting system in other countries and to relevant institutions. The consultants will undertake need assessments, prepare visitprograms identify and recruit institutes, academia, etc (national and international) from the amount provided under the provisional sums for this purpose.

TASK3: Water Quality monitoring system

5. Objective of the Water Quality monitoring system upgrade

49. The overall objective of the component is to provide reliable data and information of the present and future state of the Bagmati River water quality through the upgrading the existing water quality monitoring program carried out by HPCIDCB and its laboratory.

50. The specific objectives and scope of activities include but not be limited to the following:

- (i) Upgrade the existing water quality monitoring program
- (ii) Upgrade the HPCIDBC laboratory with new instrumentation and equipment and safety measures such as improved ventilation.
- (iii) Train staff in carrying out the specified monitoring and water quality sampling program.
- (iv) Laboratory staff trained in analytical procedures and use of new instruments.
- (v) Quality Assurance measures and Quality Control procedures introduced. A QA/QC Manual developed and the staff trained in adherence to the manual procedures in all laboratory activities

6. Scope of the work

- 51. The overall tasks and activities include but are not limited to the following:
 - (i) Review the existing water quality monitoring system, prepare recommendations of improvement and implement these with respect to parameters measured,

frequency, sample positions, need for in-situ measurements, sample handling and preservation.

- (ii) Assess the state of the instrumentation and equipment of the laboratory and if needed update the list prepared by the PPTA of instruments and equipment to be procured.
- (iii) Procure instruments and equipment according to GON and ADB rules, ensure timely delivery according to specifications and install and commission instruments.
- (iv) Train laboratory staff in the analytical procedures of the parameters required in the water quality monitoring system. Ensure safety equipment is used and safety procedures followed.
- (v) Prepare manuals and instructions for the monitoring sampling programme and all aspects of work in the laboratory, including safety procedures.

TASK4:Integrated River Basin Development Master Plan (IRBDMP)

7. Objectives of the Integrated River Basin Development Master Plan

52. The aim of the IRBDMP is to provide GON with a comprehensive development and management plan to guide the rapid rationalisation and improvement of water management in the Bagmati River basin for at least the next 20 years. The Plan will examine each aspect of water management and propose improvement in achievable stages which can be used to obtain essential funding as part of an overall IWRM strategy. The plan will include an update of the 2009 Bagmati action plan (2009-2014) incorporating changes adopted under the Bagmati River Basin Improvement Project and future recommendations for improving river environment improvement and management in the Kathmandu valley.

8. Scope of the work

53. Data collection and consultations will commence during the first year of the BRBIP, and the IRBDMP itself will be compiled during the second year. After approval, the plan will be used to initiate funding for priority activities. The plan will be updated by the RBO, assumed to be established, during the last (fifth) year of the project for use by GON to continue with effective IWRM and the implementation of essential projects in the water sector.

- 54. The plan for the entire Bagmati River basin will include:
 - (i) An overview of GON policy with recommendations for improvement;
 - (ii) Major gaps and issue in water sector
 - (iii) Up-to-date water availability and water use information linked with the DSS;
 - (iv) An up-to-date inventory of current and planned water-related works including their status and condition;
 - (v) A review of Bagmati Action Plan 2009-2014 implementation status and necessary update/modification
 - (vi) Water balance estimation with present scenario, Future scenario (15 years) with business as usual, medium growth and rapid growth scenario.

- (vii) Guiding principle of water sharing among the upper and lower riparian's and federal state
- (viii) Principle for water conflict minimization and conflict resolution
- (ix) Assessment of water quality in the main river and tributaries linked with the DSS in relation to current and planned abstractions and discharges.
- (x) Assessment procurement and administration of additional surveys required to inform the preparation of the plan (resources are available for this purpose under provisional sums)
- (xi) Water sector objective, goals and targets agreed in consultation with stakeholders including GON and civil society;
- (xii) Strategies for IWRM;
- (xiii) Priority activities with plans and programmes
- (xiv) Detailed program of works and other actions by sub-basin;
- (xv) Potential threats
- (xvi) Performance evaluation and monitoring.
- **9**.

C. EXPERTISE REQUIRED FOR CONSULTING SERVICES AND DETAILED TERMS OF REFERENCE

55. A summary of the consultant inputs is listed in the table below. :

	International Specialists	months
	All Tasks	
	Team Leader / Chief Technical Advisor	10
	Task 1: DSS	11
1	DSS Development & Customization Expert	3
2	Process modeling expert incl. water quality	4
3	Database expert	2
4	DSS implementation and training expert	2
	Task 2: FF and FEWS	5
1	FFEWS model expert	3
2	Web based modeling expert	1
3	Community based warning expert	1
	Task 3: Water Quality Monitoring System	8
	Upgrade	
1	Water Quality Monitoring Specialist	4
2	Water Quality Laboratory Expert	4
	Task 4: RBO Support	8
1	IWRM basin planner Specialist	8
	Sub-Total International Specialists	42
	National Specialists	months
	All Tasks	
1	Deputy Team Leader (IWRM River Basin Planner) –see below under task 4	
	Task 1: DSS	34
5	Modeling experts / DSS experts	15

Table 1 : Summary of Consultancy Inputs

6	GIS and database experts	10
7	Implementation and training expert	8
8	Hydrologist	1
	Task 2: FF and FEWS	16
4	National Modeling Expert	8
5	National Warning Dissemination Expert	4
6	Community based warning expert	4
	Task 3: Water Quality Monitoring System	8
	Upgrade	
3	Laboratory Technical Expert	6
4	Monitoring specialist	2
	Task 4: RBO Support	32
2	IWRM Basin planner specialist/ Deputy	30
	Team Leader	
	Unallocated (national)	
f	Unallocated	18
	Sub-Total National Specialists	106
	TOTAL (International + National)	148

ALL TASKS:

56. **Team Leader / Chief Technical Advisor (International, 10 person-months)**. The Team Leader/ Chief Technical Advisor (CTA) will have a Master degree in water resources engineering/Hydrology or similar field with experience in leading teams under similar projects/assignments; with a minimum of 20 years of related professional experience including management of large software development, water resources management, flood forecasting and early warning projects in developing countries.S/he shall have proven experience in software engineering, information technology, hydro-meteorological data collection, processing and management and capacity building of a hydro-meteorological agency in a developing country. S/he will work closely with WECS to develop a Bagmati DSS, and with DHM to develop a Bagmati Flood Forecasting and Early Warning System (FFEWS) and the development of core institutional capabilities to assist in the evaluation of alternative development strategies and the identification of investment project at the basin or sub-basin level in future.S/he will:

As a team leader

- (i) Be responsible for overall direction of the consultant team, coordination of inputs, and management of individual specialists;
- (ii) Ensure timely delivery and quality control of the outputs (with support from the consulting firm Q&C unit)
- (iii) Debrief the WECs, the PCMU, DHM and ADB on the progress of the team.

As a chief technical Advisor

- (iv) Develop a Bagmati DSS based on the use and expansion of the existing Information System that supports:
 - Flood/Drought forecasting (early warning system).
 - Basin planning and management.
 - Techno-economic clearance for projects.

- Water allocation.
- Regulation.
- Monitoring and evaluation.
- Benefit optimization.
- Conflict Resolution.
- IWRM implementation.
- Co-ordination.
- Sustainable WR development.
- Demand/supply projection.
 - Water resources infrastructure Operational Policy Development
- (ii) Prepare and implement a tailor made training program to enable WECS staff to operate, update and maintain the Bagmati DSS together with the Bagmati River Basin Organization (BRBO) to be formed;
- (iii) Assess the hydro-meteorological network and data acquisition system required for flood forecasting and early warning in the Bagmati river and its tributaries and to implement priority network and data acquisition improvement activities
- (iv) Assess the current forecasting capacity and install necessary flood forecasting tools (hydrological and hydraulic models, rainfall forecasting including satellite based rainfall estimates)
- (v) Develop hydrological and hydrodynamic models and calibrate with historical data. The model will have a mapping feature to display model results spatially (inundation areas, flood levels etc.). The model will be linked to a real time data acquisition system and other web-based data.
- (vi) Develop a web based flood forecasting and early warning dissemination system
- (vii) Develop an operational strategy for disseminating flood early warning at the community level
- (viii) Provide necessary trainings and capacity development for sustainable operation of the FFWES at DHM and BRBO
- (ix) Ensure timely delivery of specified reports in a format acceptable to government and the ADB.

TASK 1: Development of the Decision Support System (DSS)

57. **DSS Development & Customization Expert (International, 3 person-months)**. The expert will have a Master's degreein relevant fields, with a minimum of 15 years' experience in application of multi-objective decision making processes. S/he will:

- (i) Work closely with other members of the DSS to develop and setup of the Bagmati DSS;
- Work closely with other members of the DSS team to develop and setup of the Bagmati DSS using multi-objective decision making framework that support riverbasin level decision making;
- (iii) Contribute to the trainings provided to WECS and BRBO staff; and
- (iv) Assist the Team Leader in timely delivery of all outputs and preparation of reports.

58. **Process Modelling Expert incl. water quality (International, 4 person-months)**. The expert will have a Master's degree in natural resources or environmental sciences; with a

minimum of 15 years of working experience in process modeling including water quality for a DSS. S/he will:

- (i) Work closely with other members of the DSS to develop and setup of the Bagmati DSS;
- (ii) Provide specific inputs on developing inventories of environmental assets and aquatic ecosystems, development and applications of environmental indicators, assessing environmental impacts of water resources management and development interventions, and preparing environmental management plans, including water quality monitoring; develop quantitative linkages between alternatives and social and environmental indicators;
- (iii) Contribute to the trainings provided to WECS and BRBO staff; and
- (iv) Assist the Team Leader in timely delivery of all outputs and preparation of reports.

59. **Database Expert (International, 2 person-months)**. The expert will have a Master's degree or higher preferred in computer science, information technology, data management, or database administration; with a minimum of 15 years of working experience in design, development and administration of databases, preferably related to water resources engineering projects. S/he will:

- (i) Work closely with other members of the DSS to develop and setup of the Bagmati DSS;
- (ii) Provide specific inputs on development of database management systems, Geographic Information System (GIS)-basedmodeling applications and simulation/optimization tools;
- (i) Contribute to the trainings provided to WECS and BRBO staff; and
- (ii) Assist the Team Leader in timely delivery of all outputs and preparation of reports.

60. **DSS Implementation and Training Expert (International, 2 person-months)**. The expert will have a Master's level degree or higher preferably in engineering and management or related field with a minimum of 15 years of working experience in designing and implementing training programs related to river basin management and modeling. S/he will:

- Work closely with other members of the DSS on capacity building and trainings to WECS and BRBO staff to manage and use the developed Bagmati DSS for future decision making;
- (ii) Provide specific inputs on training program development and implementation so that the developed DSS is fully operational and managed by WECS staff at the end of the project;; and
- (iii) Assist the Team Leader in timely delivery of all outputs and preparation of reports.

61. **Modelling /DSS Experts (National, 15 person-months).**The expert will have Master's degree in water resources systems/hydrology or closely related fields; a minimum of 10 years of relevant experience in IWRM, hydrological modeling required for a river-basin level DSS. This position may be filled by one or more specialists as per the modeling needs of the DSS. The experts will:

- (i) Work closely with other members of the DSS to develop and setup of the Bagmati DSS;
- Provide specific inputs on water resources assessment, hydrological modeling, river hydraulics, sediment transport, hydrodynamic modeling, flood and drought forecasting, data acquisition and processing, river morphology and soil and water conservation;
- (iii) Contribute to the trainings provided to WECS and BRBO staff; and
- (iv) Assist the Team Leader in timely delivery of all outputs and preparation of reports.

62. **GIS and Database Expert (National, 10 person-months)**. The expert will have a Master's level degree or higher preferred in computer science, information technology, data management, or database administration; with a minimum of 10 years of working experience in design, development and administration of standard database and knowledge of current GIS tools and technologies, preferably related to water resources engineering projects. S/he will:

- (i) Work closely with other members of the DSS and the FEWS to develop and setup of the Bagmati DSS and FEWS;
- (ii) Provide specific inputs on development of database management systems, Geographic Information System (GIS)-basedmodeling applications and simulation/optimization tools;
- (iv) Contribute to the trainings provided to WECS and BRBO staff; and
- (v) Assist the Team Leader in timely delivery of all outputs and preparation of reports.

63. **Implementation and Training Expert (National, 8 person-months)**. The expert will have a Master's level degree or higher preferably in engineering and management or related field with a minimum of 7 years of working experience in designing and implementing training programs related to water resources management and modeling. S/he will:

- (i) Work closely with International Implementation and Training Expert and other members of the DSS on capacity building and trainings to WECS and BRBO staff to manage and use the developed Bagmati DSS for future decision making;
- (ii) Provide specific inputs on training program development and implementation so that the developed DSS is fully operational and managed by WECS staff at the end of the project;; and
- (iii) Assist the Team Leader in timely delivery of all outputs and preparation of reports.

64. **Hydrologist (national, 1 person-month)**. The Hydrologist will have a Master's degree in water resources systems/hydrology or closely related fields; a minimum of 15 years of relevant experience in hydrological modelling required for a river-basin level DSS. S/he will:

- (i) Work closely with other members of the DSS to develop and setup of the Bagmati DSS;
- Provide specific inputs on water resources assessment, hydrological modeling, river hydraulics, sediment transport, hydrodynamic modeling, flood and drought forecasting, data acquisition and processing, river morphology and soil and water conservation;
- (iii) Contribute to the trainings provided to WECS and BRBO staff; and
- (iv) Assist the Team Leader in timely delivery of all outputs and preparation of reports.

TASK 2: Flood Forecasting and Early Warning System (FFEWS)

65. **FFEWS Model Expert (International, 3 person-months).**The expert will have MSc degree in water resources engineering/ hydrology or relevant fields; with a minimum of 15 years of relevant experience in hydrological and hydraulic modelling. S/he will:

- (i) Assess the hydro-meteorological network and data acquisition system required for flood forecasting and early warning in the Bagmati river and its tributaries and to implement priority network and data acquisition improvement activities
- (ii) Assess the current forecasting capacity and install necessary flood forecasting tools (hydrological and hydraulic models, rainfall forecasting including satellite based rainfall estimates)
- (iii) Develop hydrological and hydrodynamic models and calibrate with historical data. The model will have a mapping feature to display model results spatially (inundation areas, flood levels etc.). The model will be linked to a real time data acquisition system and other web-based data;
- (iv) Contribute to on-the-job trainings to enable DHM and BRBO staff to operate, update and maintain the Bagmati FFEWS in particular related to computational hydrology and hydraulics, rainfall-runoff modeling, data assimilation and forecasting, flood mapping, GIS and Satellite image processing; and
- (v) Assist the Team Leader in timely delivery of all outputs and preparation of reports.

66. **Web-based Modelling Expert (International, 1 person-month).** The expert will have MSc degree in computer science, software engineering or closely related fields; with a minimum of 10 years of experience in systems analysis, design and development of web-based modelling systems preferably related to water hydrology/flood/drought forecasting and warning system. S/he will:

- (i) Develop a web based flood forecasting and early warning dissemination system with a user-interface with warning dissemination facilities;
- (ii) Contribute to on-the-job trainings to enable DHM and BRBO staff to operate, update and maintain the Bagmati FFEWS in particular related to database management and Web-updating; and
- (iii) Assist the Team Leader in timely delivery of all outputs and preparation of reports.

67. **Community-based Warning Expert (International, 1 person-month)**. The Expert will have MSc degree in water resources management or rural development or closely related fields; with a minimum of 10 years of experience in community-based flood/drought warning systems. S/he will:

- (i) Develop a community based early flood warning system in close coordination with the modeling experts;
- (ii) Contribute to on-the-job trainings to enable DHM and BRBO staff to operate, update and maintain the Bagmati FFEWS in particular related to dissemination of flood warning to communities; and

(iii) Assist the Team Leader in timely delivery of all outputs and preparation of reports.

68. **National Modelling Expert (National, 8 person-months)**. The expert will have MSc degree in water resources engineering/ hydrology or relevant fields; with a minimum of 10 years of relevant experience in hydrological and hydraulic modelling. S/he will:

- Assist and work closely with other members of the team to develop and setup of the FFEWS;
- (ii) Provide specific inputs to assess the hydro-meteorological network and data acquisition system required for flood forecasting and early warning in the Bagmati river and its tributaries and to implement priority network and data acquisition improvement activities
- (iii) Assess the current forecasting capacity and install necessary flood forecasting tools (hydrological and hydraulic models, rainfall forecasting including satellite based rainfall estimates)
- (iv) Develop hydrological and hydrodynamic models and calibrate with historical data. The model will have a mapping feature to display model results spatially (inundation areas, flood levels etc.). The model will be linked to a real time data acquisition system and other web-based data;
- (v) Contribute to on-the-job trainings to enable DHM and BRBO staff to operate, update and maintain the Bagmati FFEWS in particular related to computational hydrology and hydraulics, rainfall-runoff modeling, data assimilation and forecasting, flood mapping, GIS and Satellite image processing; and
- (vi) Assist the Team Leader and International Modeling Experts in timely delivery of all outputs and preparation of reports.

69. **National Warning Dissemination Expert (National, 4 person-months).** The expert will have MSc degree in water resources engineering or social science or related field with a minimum of 7 years of relevant experience in community based disaster (preferably flood) warning systems. S/he will:

- (i) Assist and work closely with other members of the team to develop community based flood early warning system;
- (ii) Assist the International Community based warning expert to develop a community based early flood warning system in close coordination with the modeling experts;
- (iii) Contribute to on-the-job trainings to enable DHM and BRNO staff to operate, update and maintain the Bagmati FFEWS in particular related to dissemination of flood warning to communities; and
- (iv) Assist the Team Leader and International Experts in timely delivery of all outputs and preparation of reports.

70. **Community-based Flood Warning Expert (national 4 person months)**. The expert will have MSc degree in MSc degree in water resources management or rural development or closely related fields; with a minimum of 10 years of experience in community-based flood/drought warning systems. S/he will:

(i) Develop a community based early flood warning system in close coordination with the international modeling experts;

- (ii) Contribute to on-the-job trainings to enable DHM and BRBO staff to operate, update and maintain the Bagmati FFEWS in particular related to dissemination of flood warning to communities; and
- (iii) Assist the International Expert and Team Leader in timely delivery of all outputs and preparation of reports.

TASK 3: Water Quality monitoring system

71. Water Quality Monitoring Specialist (International, 4 person-months). The specialist will have at least an MSc level education within water resources, water quality, public management, human health, or a closely related field. 15 years of practical international experience in water quality monitoring, river environment and water-related health risks. Practical international experience in the planning, design and implementation of water quality monitoring programmes. Strong interpersonal relationship, experiences in the region preferably and fluent spoken and written English are required. S/he will be the main point of contact in assisting HPCIDBC with implementation of the laboratory upgrade. S/he will report to the PCMU and lead the consultancy. The Water Quality Monitoring Specialist will:

- (i) Be responsible for leading the laboratory upgrade team, coordination and management of the team;
- (ii) Coordinate the planning and implementation of the laboratory upgrade with the leader of the HPCIDBC laboratory;
- (iii) With the assistance of the Procurement Specialist from the PCMU/PMSC arrange for the purchase of instruments etc. for the upgrade of the laboratory, following GON and ADB guidelines.
- (iv) Review the existing monitoring program, methods used for sampling, sampling handling and preservation and make recommendations for any changes, if needed.
- (v) Identify the parameters that should be measured in-situ, and parameters to be measured in the laboratory, and cross-check with the list of instrumentation to be purchased.
- (vi) Update the present monitoring programme and prepare manuals/instructions for the monitoring programme, including safety procedures and train laboratory personnel in implementation.
- (vii) Prepare instruction for maintenance and calibration of material and instruments used during field monitoring, and train the laboratory personnel in implementation of monitoring routines.
- (viii) Prepare guidelines and routines for data registration, quality control, analyses and regular reporting. After review of national water quality standards ensure the analyses of results and reporting refers to national water quality standards.

72. **Water Quality Laboratory Expert (International, 4 person-months)**. The expert will have an MSc level education within analytical chemistry in general, and water analysis in specific. Knowledge about internal quality control and quality assurance activities of analytical work, and experience with organization of laboratory services. 15 years of practical experiences in laboratory activities related to environmental management and control in developing countries. Practical international experience in training of laboratory staffs in developing countries. Strong interpersonal relationship, experiences in the region preferably and fluent spoken and written English are required. The Water Quality Laboratory Expert will:

- (i) Assist the Team leader in project implementation, instrumentation procurement, coordination with laboratory staff and the PCMU.
- (ii) Review the status of the instruments in the laboratory and update the instrumentation list for purchase prepared by the PPTA.
- (iii) With the assistance of the Laboratory Technical Expert and the PCMU procurement Specialist review and identify national dealers and providers of laboratory equipment, and prepare specifications for the instrumentation for procurement.
- (iv) With the assistance of the local laboratory technical expert install and verify the proper functioning of the instruments procured.
- (v) Prepare a detailed training programme for the laboratory staff and implement this, covering sample handling, analytical training following prescribed standards, safety procedures to be followed, analytical data registration, quality assurance, reporting etc.
- (vi) Prepare laboratory manuals covering all aspects of work in the laboratory, including safety procedures.
- (vii) Assist the Team leader in timely delivery of specified reports in a format acceptable to government and the ADB.

73. **Laboratory Technical Expert (National, 6 person-months).** The expert will have a relevant technical education with a demonstrated work experience of at least 5 years in the installation and training in the use of laboratory equipment and instruments. S/he will be the main contact to local dealers and providers of laboratory instruments and equipment. The Laboratory Technical Expert will:

- (i) Assist the Water Quality Laboratory Expert in coordination of the laboratory upgrade with the laboratory staff and the PCMU.
- (ii) Assist the Water Quality Laboratory Expert in the preparation of specifications of instruments and equipment to be purchased.
- (iii) Be responsible for checking the functioning of the instrumentation and equipment procured, and ensure the delivered are in accordance with the specifications.
- (iv) Be responsible for the installation and commissioning of the laboratory instruments,
- (v) Support the Water Quality Laboratory Expert in training of the laboratory staff.

TASK4: Integrated River Basin Development Master Plan (IRBDMP)

74. **IWRM Basin Planner specialist (International, 8 person-months)**. The Specialist will have a degree in water resources engineering/management or related field and a minimum of 10 years of demonstrated work experience in integrated river basin development and management preferably in South Asia. S/he will be responsible to prepare the IRBDMP and to carry out the following:

(i) Review the Bagmati Action Plan (BAP) 2009-2014 and evaluate implementation progress to date, issues and successes including areas that have not been addressed and may need further attention under the IRBDMP.

- (ii) Prepare an outline content of the IRBDMP based on the River Basin profile for the prepared by JWA RETA, the BAP review and other past master plans with equal focus on the Upper, Middle and Lower Bagmati.
- (iii) Review the existing data available and identify essential gaps for the planning process.
- (iv) Prepare a plan for surveys to be carried, terms of reference and implement these in close cooperation with WECs and the PCMU.
- (v) Prepare the Integrated River Basin Development and Management Plan in close cooperation with the WECs and PCMU with consultation and concurrence of the key stakeholders (including GON and civil society); The IRBDMP will address issues and plans for the entire basin in an integrated manner. For the upper Bagmati, the IRBMP will also include a separate updated Bagmati Action Plan that will consider separately issues related to the preservation of the Bagmati river system environment in the Kathmandu valley.
- (vi) In cooperation with WECs and the PCMU carry out extensive consultations with the GON, ADB, key stakeholders obtaining suggestions and concurrence with the contents of the plan.
- (vii) Ensure timely delivery of specified reports in a format acceptable to government and the ADB.

75. **IWRM Basin Planner Specialist/Deputy team leader (National, 32 person-months)**. The Specialist/deputy team leader will have a degree in water resources engineering/ management and minimum of 5 years of demonstrated experience in river basin planning and management. S/he will support the Team Leader in ensuring timely delivery of specified outputs of the assignment. S/he will:

As a deputy team leader

(i) Support the Team Leaderand the team in delivering all envisaged outputs under the assignment, supporting the logistics of the team and in liaising/communication with WECs, DHM and the PCMU and ADB on technical assistance progress.

As IWRM Basin Planner

- (ii) Assist the international IWRM Basin Planner in delivering the expected outputs under task 4
- (iii) Provide organizational and technical support to the development of the Integrated River Basin Development and Management Plan (IRBDM)
- (iv) Lead the organization of the consultation with the key stakeholders (including GON and civil society) that will serve as a Master Plan for Basin side water sector development and management; Ensure all stakeholders are consulted and concur with the proposed IRBMP
- (v) Support survey procurement, supervise implementation and timely delivery of the outputs
- (vi) Coordinate the activities with the GON, ADB, key stakeholders and the BRBIP WECs and the PCMU; and
- (vii) Ensure timely delivery of IRBDMP and updated BAPspecified reports in a format acceptable to government and the ADB.

D. TIME SCHEDULE

Task 1:Development of the Decision Support System (DSS)

76. It is expected that the DSS development and implementation will be completed in 30 months

Task 2: Flood Forecasting and Early Warning System (FFEWS)

77. It is expected that the model development will be completed in six months. However, it is recommended that the operational forecast is implemented for a full flood season after which evaluation and reporting will be done. Including capacity building activities the total project period for this taskis expected to be one year.

Task 3: Water Quality Monitoring System Upgrade

78. It is expected that the instrument and equipment procurement as well as the laboratory upgrade will be completed within nine months.

79. The training activities will cover the period where the laboratory is taking the new instruments and equipment into use, implementing the sample handling and analytical routines and QA/QC procedures. The training is expected to be completed within a 12 month period.

80. The completion of operating manuals, final inspection of laboratory operations and reporting is expected to have a duration of 3 months, with a total task implementation Period of 24 months.

Task 4: Integrated River Basin Development Master Plan (IRBDMP)

81. It is expected that the Integrated River Basin Development Master Plan will be completed in 30 months.

E. REPORTING

82. Reporting requirements shall be as follows:

- (i) Inception Report (After 2 months): As soon as the support consultancy starts, the consultant shall prepare an Inception Report. Based on discussions with GON, WECS, HPCIDBC and the staff who may be allocated for the future RBO secretariat, the consultant shall review and verify the content of the tasks required. Specifically, the consultant shall review the existing information available, identify gaps and make specifications of the surveys necessary for planning purposes. The consultant will also elaborate: (i) other main tasks, (ii) work and staffing plans, and (iii) reporting programme.
- (ii) <u>Half-yearly Reports</u>: Since the inputs are not evenly spaced out over the assignment period of 3 years, it may be appropriate to prepare half-yearly reports summarising progress, and planned work for the next reporting period.
- (iii) <u>Mid-term Report</u>: The Mid-term Report to be provided end 2015 will present the Draft IRBDMP. Depending on comments received the IBRDMP will be updated in early 2016 with revisions presented in the ensuing half-yearly report.

(iv) <u>Final Report</u>: The Final Report will present a summary of all aspects of the consultancy covering RBO formation and parallel and subsequent capacity building and technical training. The report will summarise and discuss the results of specialist aspects together with conclusions, recommendations and lessons learned for future projects of this nature.

83. For each report, four copies in English are to be submitted.(including the executive summary in Nepali). In addition to hard copies, one digital electronic copy shall also be submitted. At the end of the contract, a digital copy of all documents relevant to the project shall be compiled in an orderly manner on a CD and be submitted to WECs, DHM and the PCMU.

84. Policy brief documents both in English and Nepali (Short document).

85. Workshops/consultation with experts, stakeholders including GON and civil society for half yearly report and mid-term report