GLOBAL FLASH FLOOD GUIDANCE SYSTEM

South America

IMPLEMENTATION REQUIREMENTS

Global Flash Flood Guidance System
Implementation Requirements

June 2016

Document Purpose

This document provides guidance to project participants, in particular National Meteorological and Hydrological Services (NMHSs) on minimum requirements with respect to professional capabilities, availability of data and information as well as computational and communication infrastructure to implement a **Flash Flood Guidance System (FFGS)**. In addition, the document provides information of the functions of the Regional Centres and NMHSs leading to the delivery of flash flood guidance products on regional and national levels.

These requirements reflect a system that provides timely and useful data and information based on robust communication infrastructure in a form that is consistent with the operations in place in many of the National Meteorological and Hydrological Services (NMHSs) throughout the world. Of primary importance is to establish a system that becomes part of NMHS operations and is used as the primary tool by these services for providing flash flood alerts/warnings to the appropriate agencies and/or the public.

Overview of the FFGS

The primary purpose of the FFGS is to provide real-time informational guidance products pertaining to the threat of potential small-scale flash flooding. The system is designed to address the reduction in devastation caused by flash floods in terms of reductions in the loss of life, suffering and property damage. The system provides the necessary products to support the development of warnings for flash floods from rainfall events through the use of remote sensing-based rainfall estimates (primarily satellite).

The system outputs are made available to forecasters as a diagnostic tool to analyze weather-related events that can initiate flash floods (e.g., heavy rainfall, rainfall on saturated soils) and then to make a rapid evaluation of the potential for a flash flood at a location. The system empowers users with readily accessible observed data and products and other information to produce flash flood warnings over small flash flood prone basins. The system is designed to allow the addition of experience with local conditions, incorporate other data and information (e.g., Numerical Weather Prediction output) and any last minute local observations (e.g., non-traditional gauge data), to assess the threat of a local flash flood. Generally, evaluations of the threat of flash flooding are done over hourly to six-hourly time scales for basins from 100 - 150 km^2 in size.

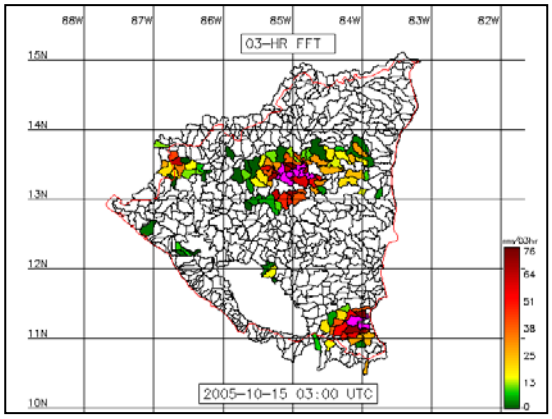
Important technical elements of the Flash Flood Guidance and Warning System are the development and use of a bias-corrected satellite precipitation estimate field, high-resolution numerical weather prediction model outputs (where available), and physically-based hydrological modelling to determine **Flash Flood Guidance** and **Flash Flood Threat**. These system elements can now be applied anywhere in the world. Real-time estimates of high resolution precipitation data from satellite are now routinely available globally (and can be further enhanced with locally available radar estimates of precipitation). Global digital terrain elevation databases and geographic information systems may be used to delineate small basins and their stream network topology anywhere in the world. In addition, there are global soil and land cover spatial databases available to support the development of physically-based soil moisture accounting models. The real-time satellite precipitation estimates needed to drive the regional

systems on a global scale (using global data provided by NOAA and the WMO) will be developed first followed by the development of specialized products.

The system then provides information on rainfall and hydrologic response, the two important factors in determining the potential for a flash flood. The system is based on the concept of **Flash Flood Guidance** and **Flash Flood Threat.** Both indices provide the user with the information needed to evaluate the potential for a flash flood, including assessing the uncertainty associated with the data.

The flash flood guidance approach to developing flash flood warnings rests on the comparison in real time of observed or forecast rainfall volume of a given duration and over a given catchment to a characteristic volume of rainfall for that duration and catchment that generates bank full flow conditions at the catchment outlet. **Flash Flood Guidance** (FFG) is that characteristic rainfall volume for the given duration over the small catchment that generates bank full flow conditions at the catchment outlet. FFG is updated in time based on current soil water deficit (as determined by antecedent soil moisture conditions), rainfall, evaporation, and groundwater losses. If the observed or forecast rainfall volume exceeds the FFG of the same duration, this excess is termed the **Flash Flood Threat** and flooding at or near the catchment outlet may be likely.

Flash Flood Threat



Global Flash Flood Guidance System Program Background

The purpose of the Global FFGS (GFFGS) program is the development and implementation of regional flash flood guidance and early warning systems. The approach entails development of infrastructure on a global scale to then support the development and implementation of regional flash flood guidance projects comprising of technology, training, protocols and procedures components to address the issues of mitigating the impacts of flash floods.

Regional flash flood guidance and early warning systems are designed based on operational regional programs in Central America, Southeast Asia, Central Asia, South East Europe, South Asia, Black Sea Middle East and Southern Africa. The project approach is to provide a tool for each country within a specified region to access the

data and information needed to develop alerts and warnings for flash floods. The main objective of this project is, therefore, to contribute towards reducing the vulnerability of people around the world to hydrometeorological hazards, specifically flash floods, by developing and implementing flash flood guidance systems to strengthen regional capacity to develop timely and accurate flash flood warnings.

The data and information part of the requirements also provides guidance with respect to the selection of areas/basins on national level that can be covered with a flash flood guidance system based on the availability of critical data and information.

Implementation of this program is in concert with the World Meteorological Organization's Flood Forecasting initiative guided by the Hydrology and Water Resources Branch of the Climate and Water Department of WMO. In the context of this initiative, the World Meteorological Congress has endorsed the implementation of a Flood Forecasting Initiative. A goal of this initiative is to develop and implement programs that encourage hydrologists and meteorologists to work together towards the improvement of operational flood forecasting services.

The GFFGS program is being accomplished under the Memorandum of Understanding (MoU) noted below[1].

The system design is such that it allows for efficient global data ingest and support of regional cooperation among NMHSs. The system design is characterized by distributed operations and functions on global, regional and national levels. Centres of computation and product dissemination will support the operational functions of the NMHSs through the timely provision of data, ancillary information, software, hardware and training. A schematic of the global-regional-national system is shown in Figure 1.

The interface with global information is the link to real-time global satellite precipitation estimates and to global in situ observations through the regional centre.

All requisite real-time data (global, regional, and local) are ingested at servers located at the Regional Centres where the FFG software is installed. Graphical and text products are then provided to the participating countries through a secure internet connection.

It is necessary to designate a focal institution (most probably an NMHS or an existing Regional Centre with proven scientific and technical capabilities) and with existing communications and infrastructure capabilities to support a Regional FFGS centre. Key proposed operational Regional Centre responsibilities are identified in Appendix A.

[1]MoU "Establishing a Cooperative Initiative among the World Meteorological Organization, Hydrologic Research Centres, U.S. National Oceanic and Atmospheric Administration/National Weather Service and the U.S. Agency for International Development/ Office of U.S. Foreign Disaster Assistance for the Flash Flood Guidance System with Global Coverage Project"

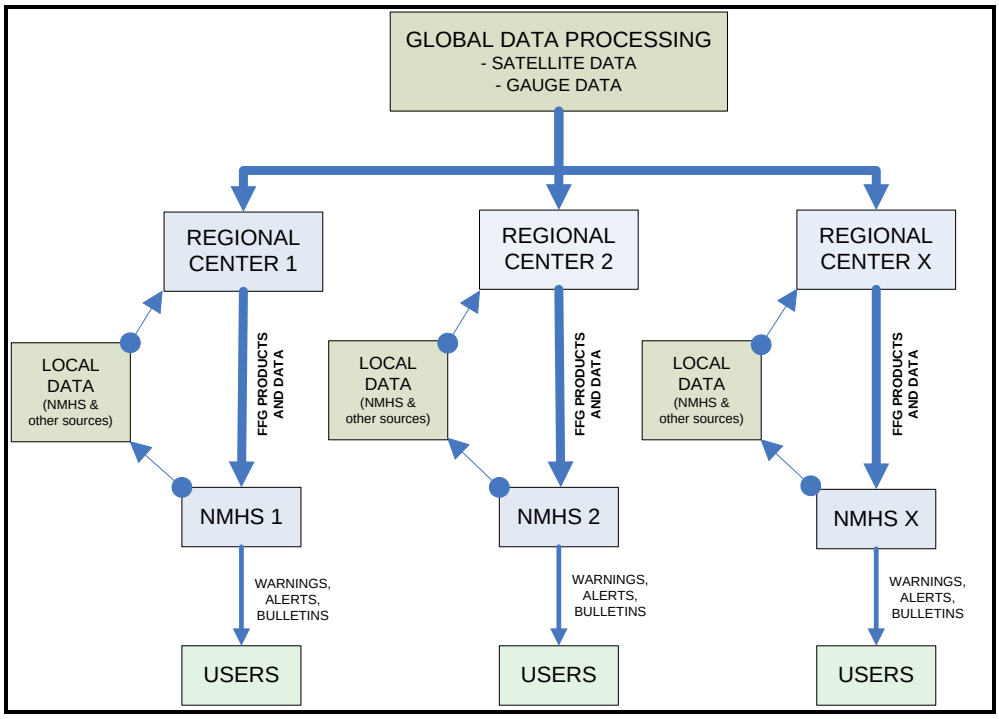


Figure 1. GFFG System Schematic – Global Implementation

NMHS functions pertaining to the use of the flash flood guidance and warning system include:

- Develop country hydrometeorological analysis using the system products and information and other local products and information;
- Develop country adaptations of the flash flood guidance and precipitation nowcasts on the basis of within-country most-recent data and information;
- Develop local flash flood watches and warnings as required;
- Provide data and information to the Regional Centres (based on regional agreements);
- Monitor system performance (availability and effectiveness) and feedback to the Regional Centres; and,
- Communicate with user agencies for effective disaster risk reduction.

Resources of country NMHSs will determine the actual configuration and type of software used in each case, given the provision of within-country basic software and communication links to Regional Centres facilities.

It is expected that the products available from the Regional Centres will be adequate to support a range of desk top computer-based processing capabilities at the NMHSs, from using simple spreadsheet software to those computational facilities that support

interactive graphical generation of products (much like the capability of the Regional Centres). This provision will allow the NMHSs of participating countries to develop near real-time flash flood guidance and warnings.

Data and Information Requirements

To ensure that the FFGS provides the highest quality data and information to forecasters, various historical and real-time hydrometeorological data and other information are required in order to develop, implement and operate the flash flood guidance systems. Historical data and information are needed for the development of the system and calibration of the models. Real-time data are needed for system operations. Terrain and other spatial-database information are used to delineate the small catchments for which flash flood guidance will be computed, to calibrate the models and to operationalize the flash flood guidance information.

It cannot be emphasized enough that quality data and information are needed to provide the optimum system for use by forecasters for the development of flash flood warnings.

Data and information needs are detailed in Appendix B. Appendix C is a survey of automatic rain gauges and weather stations. This information is important to fully understand the current status of these systems.

Resource Requirements

Personnel

The system is designed to be used operationally and jointly by meteorologists and hydrologists. The following expertise is recommended at the Regional Centres and country levels for the primary users, mainly the system operators.

Recommended Minimal Available Expertise

Area of Expertise	Regional Centres	Country NMHS
Have a meteorological or hydrologic technical background	Both meteorological and hydrologic expertise	Either meteorological or hydrologic expertise
Have experience in operational quantitative weather or hydrologic forecasting specific to the region or country	Priority	Priority
Have experience in weather-related hazard emergency management operations	Priority	Priority
Have experience in or knowledge of quantitative analysis of satellite-based rainfall estimates	Priority	Preferred

Area of Expertise	Regional Centres	Country NMHS
IT capability for server system administration, network connectivity, and product availability	Priority	Preferred

Both the Regional Centres and the country NMHS should operate on a round-the-clock basis either continuously year-round or at the minimum during seasons with significant flash flood risk.

Computers and Communications

Servers using the LINUX operating system will be provided for the Regional Centres through the project. The country NMHS requires a current-generation PC and an internet connection with periphery devices in order to access products from the internet. The Regional Centres will need hi-speed internet service and, potentially, access to GTS/WIS.

Training Program

During the course of the FFG System implementation for the region, training will be provided to forecasters on the scientific basis and operations of the system. The training program is a five step blended learning model - known as the Flash Flood Hydrometeorologist Training (FFHT) Program (Figure 2). The five step program includes:

1. Introductory regional workshop.

2. eLearning program to support system operations, product interpretation, system validation, including the use, management, and interpretation of output from the system, and the development of protocols to alert response agencies and the public of an impending or existing threat. For each completed course learners earn an HRC Course Certification, once they have completed the core curriculum they are eligible for Step Three.

3. Advanced Operations and Interactive Simulator Training at the Hydrologic Research Center to assist with reviewing and assessing the operating versions of the system. Included is the Interactive Simulator training to provide the user with the skill to interpret and validate skill using real flash flood events. Upon successful completion of the Advanced Operations Training each learner earns an HRC Advanced Training Operations Certification; once they have completed this step they are eligible for Step Four.

4. Regional Operations Training Workshop – where HRC trainers in combination with Trained Regional Trainers present regional operations workshop. Upon successful completion of this stage of training Regional Trainers earn a WMO Certification as FFG trainers.

5. Regional Operation Sustainability Workshop led by WMO certified trainers acts as refresher training in operations, overview of data requirements, system verification and user validation

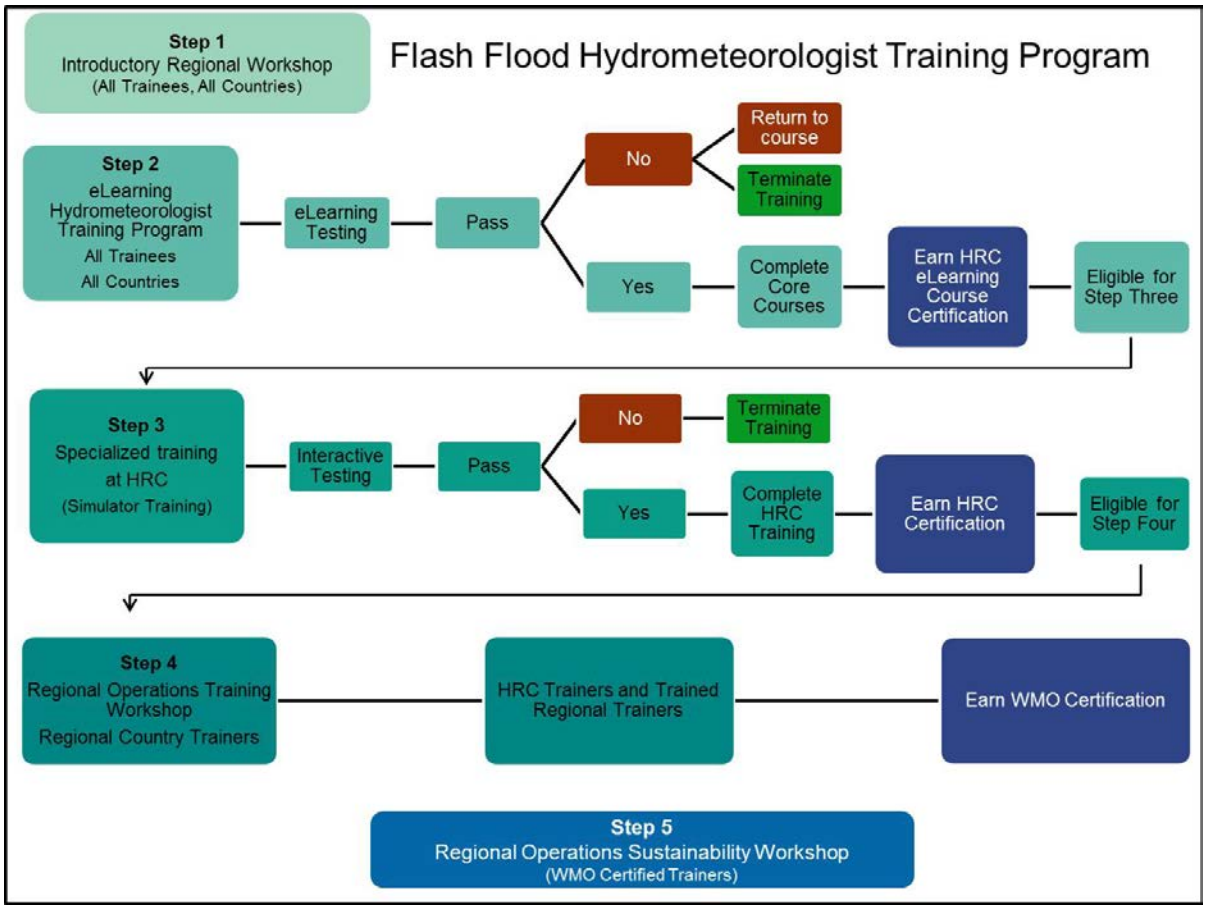


Figure 2. Illustrating five steps of the Flash Flood Hydrometeorologist Training Program

Appendix A

Regional Centre Roles and Responsibilities

System Development

The Centre has the responsibility to assist with tasks during the regional FFGS development and implementation. These responsibilities include:

- The Centre will be the focal point for the collection of the required spatial and historic hydrometeorological data needed for system development from the countries.

- The Centre will assist the FFGS developer in coordinating country-specific reviews of various products created and data sets used during system development.

System Operations Responsibilities

In meeting its responsibility to maintain the base node of the FFGS system, the Centre will have the following roles, responsibilities, and operations to the extent possible and reasonable:

- The Centre will develop and maintain a local database of contributed, real-time input products from participating NMHS agencies and make available those products to the automated acquisition processes of the FFGS Server. This will require that the Centre work with the countries to develop a set format of the data to be transferred to the Centre for use in developing this real-time database that feeds the FFGS.

- The Centre will provide access via the internet (as primary) to all FFGS products to all key participating agencies from the countries in the in the region in real-time.

- Centre forecasters will work directly with the country forecasters in evaluating and applying the FFGS products and will provide critical hydrometeorological expertise when required.

- When appropriate, the Centre will be available for the briefings and discussions needed to properly evaluate flash flood potential using the FFGS tool. The Centre forecasters will work with the country forecasters to ensure that they understand the weather forecasts and to provide consistency, including evaluating and interpreting the applicability of current and forecast precipitation events.

- The Centre will evaluate the FFGS products from a regional perspective and will communicate this perspective to the countries as appropriate. The Centre will ensure consistency of FFGS products throughout the region.

- The Centre will provide regional and national validation of system results and will advise the countries of the presence of noted biases in system outputs.

- Where appropriate, the Centre will coordinate the issuance of flash flood watches and warnings (as applicable) in a consistent format using the FFGS tool as well as incorporating other information and tools available.

- The Centre will support routine training/workshops on system operations, product interpretation and development, product verification, etc. to country forecasters.

- The Centre will coordinate with the FFGS global data processing Centre or its equivalent in matters of data flow and communications or for conveying information regarding potential improvements that will affect the region products.

Centre System Management/Maintenance Roles and Responsibilities

The Centre will maintain and operate the Regional Linux server which computes and disseminates regional and country FFGS products (text and/or images). A server using the LINUX operating system will be provided for the Regional Centre through the project.

Even though the FFGS servers are designed to be fully automated, there will always remain a critical need for ongoing observation and quality control of its processing tasks and data products. This requires expertise from two basic categories: systems administration and operational quality control of the data products. Skills in both areas of expertise are needed to properly monitor and confirm the overall performance of the system. This can be fully achieved only through the cooperative efforts of both IT Staff and Forecasters. In fulfilling its system maintenance responsibilities, the Centre needs to perform the following activities.

- Maintain Network Connectivity and Data Availability – This relates primarily to the systems administration efforts of IT staff. Of concern are potential problems related to internet and/or GTS service availability, adequate communications throughput to ensure timely data downloads and access by the NMHSs, network cabling, switches, or any one of numerous hardware and security issues related to the servers themselves. The assessment and correction of potential problems relating to any of these areas requires specific technical skill and an understanding of the systems and technologies involved.

- Product Quality Control – This relates to the function of the forecasters at the Centre. Their expertise in hydrology and meteorology is required to properly understand the relative quality of the FFGS input and output products at any given time. Accordingly, Centre forecasters must perform quality control procedures on the data and outputs and determine whether or not any perceived problems are the result of a parametric shortcoming, a failure in one of the FFGS models, or if it might relate to the quality or availability of the real-time input data that drives the system.

- Operational Process Monitoring – In order to successfully fulfill the specific responsibilities of IT staff and forecasters identified above, both groups must engage in a necessarily cooperative effort of routine and systematic review of system processing activity. This involves regular inspection of system image products, data products, status indicators and log files as a means to confirm the

proper operation and health of the system while maintaining a keen familiarity with the status quo in order to immediately recognize any deviation from it.

Training Responsibilities

The Centre will be directly involved in the various training programs during implementation and operations. Training programs can involve both Centre staff and country staff. Regional representatives will be equipped to play a fundamental part in the training of country staff, especially during system operations. The primary purpose of training is for Centre representatives to familiarize themselves and develop a level of competency in the FFGS system basics (physical principle, components, operation, and validations), product interpretation and use, and collaboration for prediction and warning. Particular emphasis for the Centre will be placed on validation, operations, trouble shooting and maintenance, data management, communications, realistic scenarios, and preparedness for unusual circumstances or errors. The Centre may offer opportunities for NMHS personnel to serve at the Centre for hands-on training and to support the Centre operations.

Centre Personnel Recommendations

Staff that supports the operations of the Centre should possess the following qualifications to the extent possible.

Staff

The following expertise is recommended for the staff supporting the Centre.

Area of Expertise	Regional Centre
Have a meteorological or hydrologic technical background	Both meteorological and hydrologic expertise
Have experience in operational quantitative weather or hydrologic forecasting specific to the region or country	Priority
Have experience in weather-related hazard emergency management operations	Priority
Have experience in or knowledge of quantitative analysis of satellite-based rainfall estimates	Priority
IT capability for server system administration, network connectivity, and product availability	Priority

Focal Point

It is recommended that the Centre maintain a focal point for all operations and activities. This focal point should meet the following qualifications and responsibilities:

Qualifications

The qualifications for the Centre Focal Point are recommended to be as follows:

- Have good knowledge and background in operational meteorology and hydrology in the Central Asia region;

- Have appropriate experience in providing technical training in hydrometeorology; and,

- Have undergone advanced training in the theory and operations of the FFG system from the system developer and implementer.

Responsibilities

The responsibilities for the Centre Focal Point are recommended to be as follows:

- Assist the system developer in the collection of required regional spatial and hydrometeorological data needed for system development;

- Be directly involved in the various training programs provided by the Global FFG Program partners during FFG system implementation and operations;

- Provide regional and national validation of FFG System results (with and without forecaster adjustments) to the countries; and, on the basis of such regular feedback, coordinate with the Global Data Processing Centre for potential improvement and to review system products;

- Submit a detailed report annually based on:
    - Number of major events of flash flooding in the region
    - Deaths/property losses estimates for those events
    - Performance of the regional FFG
    - Operations information (percent of hours of system downtime and percent of hours with lack of remotely-sensed and in-situ rain gauge data); and,

- When needed, arrange and possibly visit a country's forecasting operations to provide training if the operations of the regional FFG is not at its optimum in that country (based on outputs from the annual report and country feedback).

Operation Schedule

Both the Regional Centre and the country NMHS should operate on a round-the-clock basis either continuously year-round or at the minimum during seasons with significant flash flood risk.

Summary

In summary, key Regional Centre responsibilities are:

- Disseminate real-time country graphical products from the FFGS for the NMHSs in the region;

- Collect available real-time meteorological data for ingest to the FFGS for the development of regional products;

- Support regional flash flood operations by:
    - Provide routine regional hydrometeorological analysis,
    - Provide daily guidance discussion to NMHSs from a regional perspective,
    - Provide regional flash flood hazard information,
    - Provide regional validation of products and formulation of plans for improvements, and
    - Provide communications for system analyses to NMHSs of the region.

- Provide communications of regional system modifications necessary to developers;

- Collect spatial and historical hydrometeorological data needed for system development;

- Develop a historical archive of the system products;

- Support regional training of NMHS representatives; and,

- Provide routine maintenance and IT support for the FFGS server.

Appendix B

Data and Information Requirements

For each area or basins where flash flood guidance will be provided, various historical, real-time and state variable data and information are needed for the development and operation of the flash flood guidance system. As much of the following data and information as possible should be collected and/or made available from each country within the region. Note that the following items represent the optimum data and information requirements; system development and operations designs will consider which data are available for use.

Logistical Data (Metadata)

- Longitude and latitude coordinates (in decimal degrees) and elevation (in meters) of all sensors providing real time data and historical data, type of data, units of measurement and sensor.

- Longitude and latitude coordinates (in decimal degrees) of dams and reservoirs

- Evaluation of basin delineation: initial delineations based on hydrologic processing of the SRTM (90-m) resolution digital elevation data and hydrographic information from the Digital Chart of the World

    - Evaluation of the delineation results with local knowledge and expertise is required for final quality assurance
    - Delineation maps may be provided in GIS format; shapefiles are preferred.

Spatial Digital Data or Maps (for areas of interest)

- Digitized stream network data

- Digitized country catchment boundaries data

- Land-use and land-cover data

- Soils data to include soil texture or FAO soil classification or soil properties data, and depth of upper soil and sub-soil

- Local stream cross-sectional survey data for natural streams draining 10-2000km^2, including any reports of regional relationships between channel cross-sectional characteristics and catchment characteristics

- GIS map of bedrock and alluvial channels

- Population distribution data

Reports

- Flood Frequency Analysis (regional and local)
- Flash Flood Occurrence (regional and local)
- Stream geometry studies for small streams
- Climatological precipitation and flood studies

Historical Data

- Precipitation data (hourly, daily, monthly, climatology)
- Air temperature data (hourly, daily, monthly, climatology)
- Pan evaporation data (daily, monthly, climatology)
- Soil moisture data for top 1 meter of soil (weekly, monthly, climatology)
- Streamflow discharge data for local streams with drainage areas less than 2000 km^2 (hourly, daily, monthly, climatology)
- Spring discharge data
- Stream stage data (hourly, daily, monthly, climatology) and associated stage-discharge curves (rating curves), also for local streams
- Radiation data for computation of potential evapotranspiration (daily, monthly, climatology)
- Wind, humidity data for computation of potential evapotranspiration (daily, monthly, climatology)
- Historical radar data, once radars become operational, and satellite data
- Groundwater recharge rates, channel transmission losses, and groundwater level data for surficial aquifer
- Snow water equivalent data

Real Time Data

- Surface precipitation and weather data (hourly or 6hourly) (**important**)
- River stage + rating curves, or discharge data (hourly, 6hourly or daily)
- Snow water equivalent or depth (daily or weekly data)

Appendix C

Real-Time Data Specifications and Information

Please provide the following information for each real-time rain gauge and automatic weather station:

- Location of the station as latitude and longitude in decimal degrees and elevation in meters.

- Deployment status – e.g., in place and operational, in place but not yet operational, planned for installation. If known, please specify the start date of operation.

- Current operational status (for all in-place stations) – e.g., fully operational, operating but intermittent, operating but erroneous or unreliable, offline for maintenance/repair, etc. Current status should be provided for each sensor of multi-sensor stations. Any additional information relating to problematic stations/sensors will be helpful.

- Method of data transmission – e.g. Internet, satellite, telephone landline, telephone cellular, telephone SMS, telephone fax, microwave radio, HF/VHF radio (voice or data), etc.

- Period of observation (data recording resolution, per sensor) – This is the duration of time over which data is accumulated or averaged, as provided, e.g., 15-minute, 1-hourly, 6-hourly, 12-hourly, daily. For any instantaneous measurements, such as temperature, please indicate the interval between recordings.

- Frequency of data transmission/collection (on what interval is the data received by the responsible agency?) – e.g. randomly, 5-minute, 15-minute, 1-hourly, 3-hourly, daily or manual data logger collection.

- Survey information:

    - What is the functionality and adequacy of the data-reception and storage systems in the country?

    - What preventive maintenance, calibration or repair needs to be performed on the gauges/stations? What is the typical schedule for routine, operational maintenance of gauges/stations?

    - What is the perceived level of institutional support for the agencies responsible for monitoring?

    - How can real-time data from the currently operating rain gauges and weather stations be accessed for use by the FFGS?