World Hydrological Cycle Observing System Guidelines

World Meteorological Organization

Weather • Climate • Water

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EDITORIAL NOTE

METEOTERM, the WMO terminology database, may be consulted at: http://www.wmo.int/pages/prog/lsp/meteoterm_wmo_en.html. Acronyms may also be found at: http://www.wmo.int/pages/themes/acronyms/index_en.html.

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The first version of the WHYCOS Guidelines (WMO, 2005) was a collaborative effort of a number of individuals, groups and institutions, without whose input, support and hard work, they would not have been produced.

This second version was requested by the WHYCOS International Advisory Group (WIAG), which saw a need to review and revise the Guidelines based on more recent experiences with WHYCOS and its implementation. Three experts contributed to these revisions. Firstly, Paul Pilon, is a former member of the WMO Commission for Hydrology (CHy) and its Advisory Working Group and was co-lead of the recent review of the WHYCOS programme (WMO, 2011(a)). The other two experts contributed to the first version and made significant contributions to the revisions. They were Stefan van Biljon, formerly with the Department of Water Affairs of South Africa, with experience in a range of HYCOS Projects, and Datius Rutashobya, former president of CHy. Thanks are also due to the other members of WIAG and CHy for providing comments on various drafts.

ACRONYMS AND ABBREVIATIONS

CSD	Commission on Sustainable Development (United Nations)
CHy	Commission for Hydrology (WMO)
EA	Executing Agency
EUMETSAT	European Organisation for Exploitation of Meteorological Satellites
FRIEND	Flow Regimes from International Experimental and Network Data
GFCS	Global Framework for Climate Services
Cg	Congress (WMO)
GEWEX	Global Energy and Water Cycle Experiment
GOES	Geostationary Operational Environmental Satellite
GSM	Global System for Mobile Communications (formerly Groupe Spécial Mobile)
GTS	Global Telecommunication System (WMO)
HIS	Hydrological Information System
HWRP	Hydrology and Water Resources Programme (WMO)
HYCOS	Hydrological Cycle Observing System
IA	Implementing Agency
ICSU	International Council for Science
IGAD	Intergovernmental Authority on Development
IPCC	Intergovernmental Panel on Climate Change (WMO–UNEP)
ISO	International Standards Organization
IWRM	integrated water resources management
METEOSAT	Geostationary Meteorological Satellites
NHS	National Hydrological Service (WMO)
NMS	National Meteorological Service (WMO)
OECD	Organization for Economic Cooperation and Development
PMU	Project Management Unit
PSC	Project Steering Committee
QA/QC	quality assessment/quality control
QMF	Quality Management Framework
QMS	Quality Management System
RPC	Regional Project Centre
SADC	Southern African Development Corporation
SQL	Structured Query Language
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
USGS	United States Geological Survey
WCG	WHYCOS Coordination Group
WHYCOS	World Hydrological Cycle Observing System
WIAG	WHYCOS International Advisory Group
WIGOS	WMO Integrated Global Observations System
WIS	WMO Information System
WMO	World Meteorological Organization
WWAP	World Water Assessment Programme (UNESCO)

FOREWORD

Integrated water resources management (IWRM) calls for an informed participation of different stakeholders concerned with the sustainable development and use of water resources. Timely, accurate and comprehensive information about the state and distribution of water resources underpins sound decision-making and forms the basis for effective water resources management. In its Chapter 18, Agenda 21, the blueprint for sustainable development adopted in Rio de Janeiro in 1992, recognizes that the monitoring and assessment of water resources, in terms of both quantity and quality, require adequate meteorological, hydrological and other related data. The Plan of Implementation of the World Summit on Sustainable Development, adopted 10 years later in Johannesburg, included the development of IWRM and water efficiency plans, as well as programmes for mitigating the effects of extreme water-related events. It also recognized the need to support developing countries and countries with economies in transition in their efforts to monitor and assess the quantity and quality of water resources, including through the establishment or further development of national monitoring networks, and to improve water resources management and scientific understanding of the water cycle through cooperation in joint observation and research. In 2012, the UN General Assembly, through Resolution 66/288 – The future we want – further recognized the need to support developing countries in their efforts to collect environmental data. The capabilities for collecting data, producing information and exchanging them are also recognized as the basis of the successful monitoring of water-related targets defined in the framework of Sustainable Development Goals.

At the basin and regional levels, information on components of the water cycle contributes substantially to various aspects of sustainable development. Such information supports poverty alleviation, enhanced flood forecasting and drought prediction, increased agricultural development and productivity, as well as improved land-management practices, fisheries management, energy production and human and ecosystem health.

Regrettably, the capability to collect and manage information related to water resources within countries remains inadequate in many parts of the world. This situation often arises from a lack of adequate financial support, while data-collection networks would require significant and continued investments from national governments to be maintained and strengthened. As a consequence, hydrological networks have been deteriorating and the ability of many National Hydrological Services (NHSs) to provide critically needed data, products and services is declining. The end result is an inability to manage water resources efficiently and effectively.

In order to increase focus and attention on the importance of water-cycle data and information to sustainable development, the World Meteorological Organization (WMO) in 1993 launched the World Hydrological Cycle Observing System (WHYCOS) to help overcome obstacles that hinder the effective collection of water cycle data and information. WHYCOS, an umbrella programme of WMO, is a combined effort of participating countries, regional and basin institutions, international agencies and donors. WHYCOS provides a unique opportunity and tool for the protection, use and management of water resources in a sustainable manner.

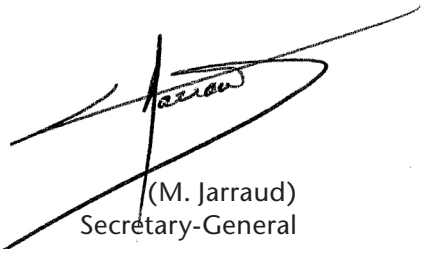
WHYCOS is a global concept, comprising a number of independent regional or basin-wide Hydrological Cycle Observing System (HYCOS) components. At the local level within a country, HYCOS brings together various agencies to work on delivering enhanced data and information products, such as the production and delivery of flood forecasts and warnings. An important complementary activity is the building of closer ties to communities and groups whose primary mandate benefits from access to the enhanced data, products and services, thereby achieving increased positive societal impacts. This contributes to increasing the capacities of institutions and communities to work more closely together.

In the light of experiences gained from the implementation of regional HYCOS projects since the inception of WHYCOS, the WHYCOS International Advisory Group (WIAG) was set up to oversee its coordination, provide policy guidance and advise on its future development. It has called for a common, yet flexible, approach to the development and implementation of HYCOS components.

The Guidelines presented herein are therefore aimed at ensuring that each project remains consistent with the WHYCOS vision, objectives and principles, while responding to local and regional needs, realities and changing situations.

Consistency across the various HYCOS components remains one key important objective, as it is aligned with quality-management processes. WHYCOS assists NHSs in embracing Quality Management Systems (QMSs) to more effectively and efficiently direct and control processes to achieve a more consistent quality of data, products and services. Fundamental to this is the use of agreed standards and recommended practices and procedures as adopted by WMO and its Members, which are reflected in the Quality Management Framework – Hydrology.

It is my hope that this new edition of the Guidelines will help in improving the development, implementation and long-term sustainability of individual HYCOS components and of the WHYCOS programme as a whole.



(M. Jarraud)
Secretary-General

1. INTRODUCTION

Water is one of the most highly valued natural resources. It exerts an enormous influence on a nation's economy and almost every aspect of societal development is closely linked to its utilization. It is critically needed for both environmental conservation and economic development and, as such, should be managed through an integrated approach to reflect land use, water availability and waste management. With due attention to all the uses of water in nature and society, as well as the evident linkages between upstream land and water use on downstream water availability and quality, the most evident unit of integration should be the catchment or river basin.

When the amount of freshwater available for human use and ecological needs is calculated, what counts is not the total sum of global freshwater resources, but the rate at which freshwater resources are renewed or replenished by the global hydrological cycle and how they are harnessed and sustained. There is an enormous disparity between the huge volume of saltwater and the tiny fraction of freshwater. Some 97.5% of the total volume of the world's water is estimated to exist in the oceans and only 2.5% as freshwater. Nearly 70% of this freshwater is considered to occur in the ice sheets and glaciers in the Antarctic, Greenland and mountainous areas, while a little more than 30% is estimated to be stored as groundwater in the world's aquifers (see Figure 1). In order to assess the level of water availability, adequate meteorological, hydrological and other related data are needed to assess the amount of water that is available within a basin. This requires a better understanding of the water cycle, by which water evaporates from oceans, other water bodies and land areas, accumulates as water vapour in clouds, is transported by wind and returns to oceans and other water bodies and land areas as rain and snow, to become surface runoff or groundwater.

Given the uneven temporal and spatial distribution of water resources globally and the growing evidence of impacts of climate change thereon, water scarcity is becoming recognized as a growing global problem with strong regional connotations. At the same time, escalating losses arising from flooding have led to widespread loss of life and property with disruption to local development, the economy and the environment. This underscores the absolute importance of enhancing our knowledge of the state and distribution of water resources at various space- and timescales – which can only be understood within the context of the dynamics of the water cycle.

According to the World Water Development Report (WWAP, 2003), the rapid growth of its population has been one of the most visible and dramatic changes in the world over the last 100 years, impacting various aspects of water resource use. Water is a renewable resource, but only renewable within limits, and the extent to which increasing demands can be met is finite. Moreover, any growth in population is further compounded as patterns of water use change to

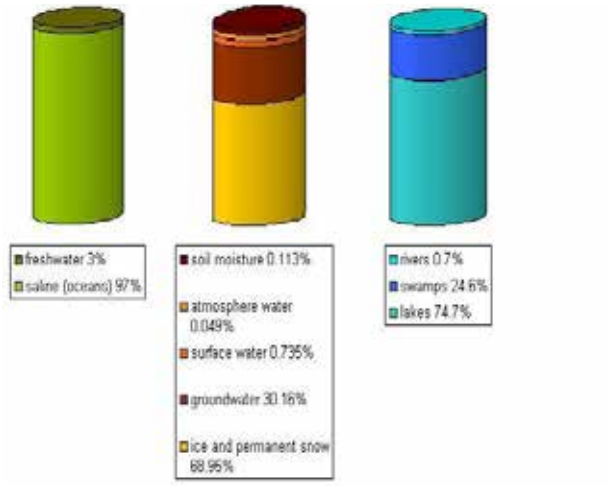


Figure 1. Distribution of water on Earth

Source: adapted from United States Geological Survey (USGS)

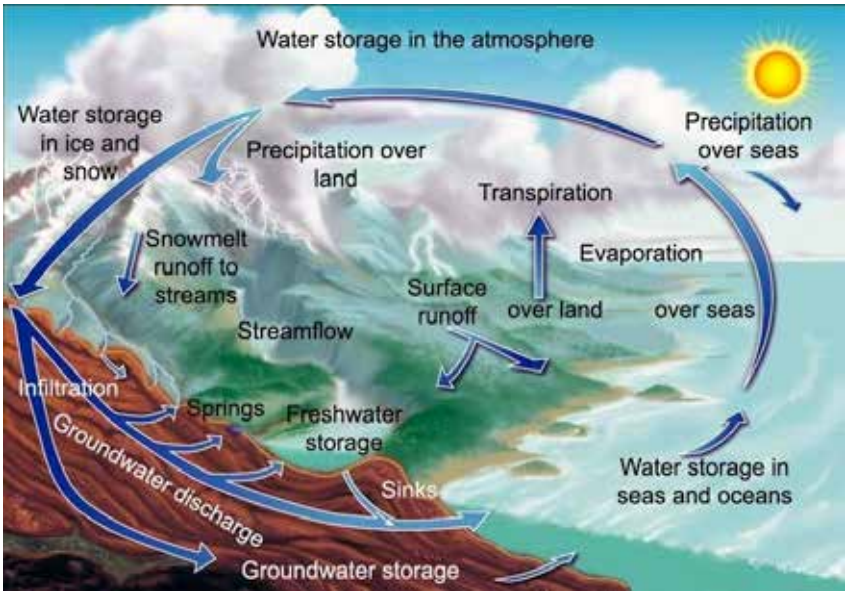


Figure 2. The hydrological cycle

Source: USGS

reflect increases in industrialization and irrigation. This trend of increasing demand for water can also increase the possibility of conflicts arising among different users and countries sharing transboundary basins.

A second major driver of increased pressure on water resources is climate variability and change. The global climate-change scenario has the potential to impact the availability of water resources significantly in both time and space. Climate variability and change are increasingly affecting the water resources of most countries. Higher temperatures and resulting decreases, increases or shifts in precipitation patterns predicted by the Intergovernmental Panel on Climate Change (IPCC) for certain parts of the world are not only likely to lead to decreased water availability in some areas but also result in the deterioration of, and alterations to, ecosystems (Bates et al., 2008; IPCC, 2012). When combined with land degradation, this has serious negative implications, not only on the availability, but also the usability of water resources.

Flooding, which has caused increased loss of life and property in many parts of the world, also causes widespread destruction of crops, infrastructure and economic assets. Furthermore, it can result in the release of toxic chemicals and pollutants to the local environment that can affect the well-being of populations, economic development, heritage and overall prosperity. Drought and desertification are also threatening human survival in many regions. In addition to human suffering, the landscape is being transformed, with the unfortunate consequence of human activities being less sustainable in some regions.

Under these circumstances, the planning and decision-making of all water-related issues must achieve new levels of sophistication. Cooperation at the regional, transboundary river-basin and global levels must be improved above all else in the field of data and information gathering, product development and dissemination. Such cooperation is imperative if global, regional and local communities are to reduce and mitigate the impacts of natural disasters such as floods and droughts, as well as the long-term negative effects of climate variability and change.

WHYCOS is a vehicle that allows the strengthening of the capabilities of NHSs, resulting in much needed enhancements in the reliability and availability of data and information products. Through WHYCOS, NHSs will continue to embrace QMSs to direct and control services more effectively and efficiently in order to achieve a more consistent quality of data and products. Fundamental to this is the use of agreed standards and recommended practices and procedures as adopted by WMO and its Members, which are reflected in the Quality Management

Box 1. Climate change and water resources

"Observational records and climate projections provide abundant evidence that freshwater resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences on human societies and ecosystems…

Many semi-arid and arid areas (the Mediterranean Basin, western USA, southern Africa and north-eastern Brazil) are particularly exposed to the impacts of climate change and are projected to suffer a decrease of water resources due to climate change (*high confidence*)...

The frequency of heavy precipitation events (or proportion of total rainfall from heavy falls) will be *very likely* to increase over most areas during the 21st century, with consequences for the risk of rain-generated floods. At the same time, the proportion of land surface in extreme drought at any one time is projected to increase (*likely*), in addition to a tendency for drying in continental interiors during summer, especially in the sub-tropics, low and mid-latitudes." (Bates et al., 2008, p. 3)

"… while it is not currently possible to reliably project specific changes at the catchment scale, there is *high confidence* that changes in climate have the potential to seriously affect water management systems". (IPCC, 2012, p. 16)

Framework – Hydrology[1]. Timely access to reliable data and information products form the basis for making informed, wise decisions regarding the management of our most valuable resource – water.

2. BACKGROUND

Confronted with "a worsening of poverty … and the continuing deterioration of the ecosystem on which we depend for our well-being", the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992, produced Agenda 21 (United Nations, 1993) as a blueprint for the future. This far-reaching document made the important linkages between poverty alleviation and sustainable development, recognizing the importance of building national capacities and calling for requisite international, financial and technical support.

The chapter on freshwater (Chapter 18) of Agenda 21 recognized that knowledge of the hydrological cycle, in terms of quantity and quality, forms the essential basis for effective water resources management. It also recognized the multisectoral nature of water resources development and highlighted uses of water resources for water supply and sanitation, agriculture, industry, urban development, hydropower generation, inland fisheries, transportation, recreation, low- and flatland management, and other activities. It underscored the need for water-conservation and protection measures, as well as giving priority to flood-prevention and control measures and drought prediction. These aspects were also complemented by activities on promoting sustainable land-use planning and management, particularly with regard to promoting human-settlement planning and management in disaster-prone areas.

Since UNCED and its Agenda 21, there has been a growing need for more accurate and reliable data and information on the distribution and availability of water resources, yet NHSs are less able than ever to meet the challenges. As a result of a basic lack of hydrological data and information, sustainable land-use planning in disaster-prone areas and the provision of flood forecasts and warnings to avert loss of life and reduce loss of property have not been fully realized. Numerous water resources development schemes cannot be designed optimally,

[1] For more information pertaining to the Quality Management Framework – Hydrology, see http://www.wmo.int/pages/prog/hwrp/qmf-h/index.php.

thereby reducing potential benefits to society, the economy and the environment. There is a need to reverse the trend in the decline of monitoring networks, the absence of computer-based archives, and a general lack of qualified staff, which result from cuts in funding to NHSs. This unfortunate situation is true for many countries and is not limited to developing countries; it also affects several countries with economies in transition and developed countries.

In addition to the need to have hydrological data and information available for local to national water-management, infrastructure design and flood protection, regional and global efforts also depend on such data and information and can lead to significant benefits on the local to national scales. For example, the work of the international scientific community on research into the global hydrological cycle and into climate variability and change (IPCC, 2012) can provide invaluable insights as to how the hydrological regime is changing, with potentially far-reaching implications on future local water availability and its management. In addition, regional datasets have been assembled under the auspices of the Flow Regimes from International Experimental and Network Data (FRIEND) project, implemented by the United Nations Educational, Scientific and Cultural Organization (UNESCO), with extensive efforts being devoted to improving knowledge of the impacts of climate variability and land-use change on the hydrological regime (UNESCO, 2006).

To address these problems, WMO, with the support of the World Bank, launched the World Hydrological Cycle Observing System (WHYCOS) in 1993 as a worldwide network of key hydrological stations linked with an associated quality-controlled database. It consists of a number of regional or basin-wide initiatives known as HYCOS components. The intention is to build HYCOS components through the implementation of one or more HYCOS projects following standards and recommended practices and procedures as adopted by WMO and its Members, tailored to meet the needs of the participating countries.

The support of WMO to hydrological programmes, including WHYCOS, is entrenched in several decisions by its governing bodies, the latest of which is reflected in two resolutions adopted at Sixteenth World Meteorological Congress (2011), namely Resolution 12 (Cg-XVI) – Hydrology and Water Resources Programme and Resolution 14 (Cg-XVI) – World Hydrological Observing System. Annex 1 contains the text of these resolutions. Moreover, Thirteenth World Meteorological Congress (1999) adopted Resolution 25 (Cg-XIII) – Exchange of hydrological data and products. This resolution is of fundamental importance in promoting the free and unrestricted exchange of hydrological data and products. Annex 2 contains the text of this resolution.

With two decades of experience having been gained through international collaboration in the implementation of the regional HYCOS projects and the recent publication of a comprehensive review of WHYCOS (WMO, 2011(a)), there is a need in a new edition of the Guidelines to reflect the evolution of the WHYCOS concept, ensuring that each project remains consistent with the vision, objectives and principles of WHYCOS, while responding to local needs and constraints. Such activities are warranted to strengthen the programme and its derived outcomes and enhance societal benefits, through institutional, organizational and human resources capacity development. The intent is to allow a more holistic strengthening of the capabilities of NHSs and regional organizations to improve the effectiveness of aid in building capacity and achieving desired results consistent with national priorities. This approach has been reflected through the Paris Declaration on Aid Effectiveness (OECD, 2005) and the Accra Agenda for Action (OECD, 2008).

This second version of the Guidelines is intended to help develop and improve the implementation and long-term sustainability of future HYCOS projects. The Guidelines aim to enable the development and implementation of projects adapted to local realities and changing situations, while pursuing overall WHYCOS objectives and principles. The Guidelines are designed to serve as a framework for initiating and implementing HYCOS projects.

These Guidelines are intended to assist those who are currently, or might soon become, interested in developing HYCOS components. The target audience includes, but is not limited to,

Box 2. Agenda 21 (excerpt from Chapter 18) (United Nations, 1993)

Protection of the quality and supply of freshwater resourses: Application of integrated approches to the development, management and use of water resources

18.1. Freshwater resources are an essential component of the Earth's hydrosphere and an indispensable part of all terrestrial ecosystems. The freshwater environment is characterized by the hydrological cycle, including floods and droughts, which in some regions have become more extreme and dramatic in their consequences. Global climate change and atmospheric pollution could also have an impact on freshwater resources and their availability and, through sea-level rise, threaten low-lying coastal areas and small island ecosystems.

18.2. Water is needed in all aspects of life. The general objective is to make certain that adequate supplies of water of good quality are maintained for the entire population of this planet, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors of water-related diseases. Innovative technologies, including the improvement of indigenous technologies, are needed to fully utilize limited water resources and to safeguard those resources against pollution.

18.3. The widespread scarcity, gradual destruction and aggravated pollution of freshwater resources in many world regions, along with the progressive encroachment of incompatible activities, demand integrated water resources planning and management. Such integration must cover all types of interrelated freshwater bodies, including both surface water and groundwater, and duly consider water quantity and quality aspects. The multisectoral nature of water resources development in the context of socioeconomic development must be recognized, as well as the multi-interest utilization of water resources for water supply and sanitation, agriculture, industry, urban development, hydropower generation, inland fisheries, transportation, recreation, low and flat lands management and other activities. Rational water utilization schemes for the development of surface and underground water supply sources and other potential sources have to be supported by concurrent water conservation and wastage minimization measures. Priority, however, must be accorded to flood prevention and control measures, as well as sedimentation control, where required.

18.4. Transboundary water resources and their use are of great importance to riparian States. In this connection, cooperation among those States may be desirable in conformity with existing agreements and/or other relevant arrangements, taking into account the interests of all riparian States concerned.

18.5. The following programme areas are proposed for the freshwater sector:
(a) Integrated water resources development and management;
(b) Water resources assessment;
(c) Protection of water resources, water quality and aquatic ecosystems;
(d) Drinking-water supply and sanitation;
(e) Water and sustainable urban development;
(f) Water for sustainable food production and rural development;
(g) Impacts of climate change on water resources.

policy- and decision-makers, the NHSs of participating countries, donors, transboundary river-/lake-basin organizations, local basin councils and commissions, scientific communities and other relevant international organizations and programmes. Also targeted are those that may find themselves in charge of preparing new projects or evaluating their performance.

In this revision of the first version of the Guidelines (WMO, 2005), we have made an effort to clarify the governance and management structure of HYCOS components and the vision, principles and objectives that help guide the development and implementation of the unfolding projects. Consistency with the vision, principles and objectives and the application of standards and recommended practices and procedures across the various components remain key to ensuring the usability and reliability of the data and products. This underscores the importance of adopting a quality-management approach that is built on agreed standards and guiding principles, which is achieved through the WMO Quality Management Framework – Hydrology.

3. WORLD HYDROLOGICAL CYCLE OBSERVING SYSTEM

WHYCOS is a framework programme, consisting of HYCOS components at the regional and/or transboundary basin scale. As a bottom-up approach, from country to basin or regional scale, HYCOS components focus primarily on strengthening the technical, human and institutional capacities of NHSs through regional and basin-wide projects. They support the NHSs to better fulfill their responsibilities by improving the availability, accuracy and dissemination of water resources data, information and products through the development and implementation of appropriate national water resources information systems. These projects will also promote regional and international cooperation in the sharing of hydrological data, information and products and their use in water resources management, thereby facilitating sustainable socioeconomic development and environmental conservation and protection.

3.1 The initial concept of WHYCOS

The WHYCOS concept was a response to the absence of reliable and accessible data and products in real- or near-real time on freshwater resources in many parts of the world, particularly in developing countries. WHYCOS was originally conceived as a WMO programme with the ultimate objective of promoting and facilitating the collection, exchange and dissemination of water-related data, using modern technologies, thereby allowing access to data for use in a number of possible global hydrological studies. A number of regional HYCOS components were proposed to form collectively the building blocks comprising the programme, through which data on hydrological and meteorological variables would be captured and transmitted in real or near-real time via satellite to regional databases established within a HYCOS project. The WMO Global Telecommunication System (GTS) was perceived as the medium for data transmission. This approach embraced advanced technologies and their broad implementation. The intention was also to ensure that the shared data were consistent with, and conformed to, the standards and recommended practices and procedures outlined in the *Technical Regulations*, Volume III: *Hydrology* (WMO, 2006) and the *Guide to Hydrological Practices* (WMO, 2008; 2009).

3.2 Evolving concept of WHYCOS

Since the inception of WHYCOS, a number of factors became evident, requiring the review and evaluation of the WHYCOS programme (see Annex 1 – Resolution 14 (Cg-XVI)). Experience garnered from the implementation of HYCOS projects, the results of dialogue with a number of

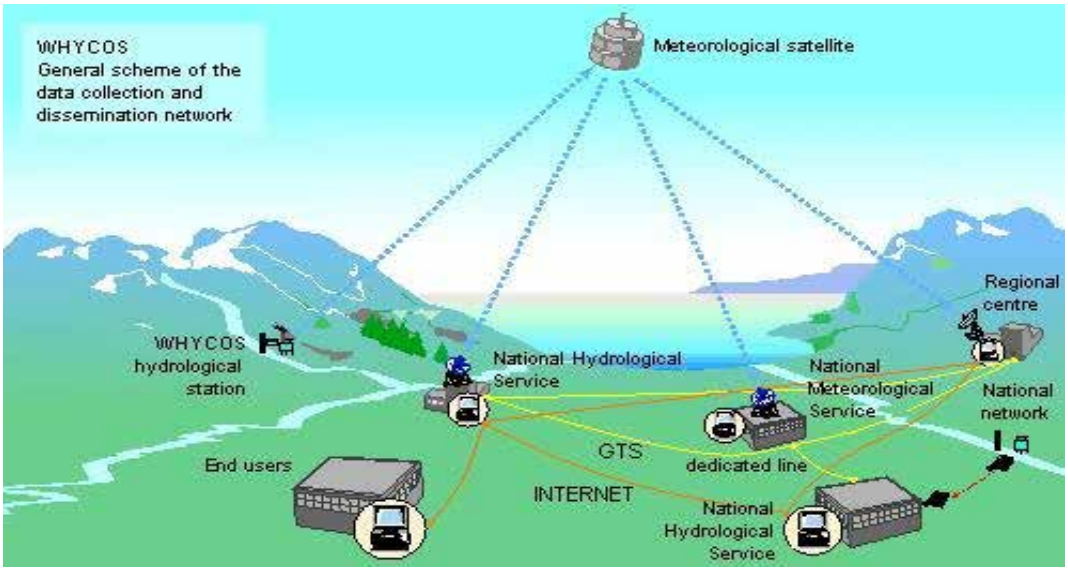


Figure 3. WHYCOS data-flow scheme

Members and donors and recognition of the advances in science and technology over the last few decades all contributed to the need to adjust the WHYCOS programme (WMO, 2011(a)). No longer was WHYCOS seen primarily as a means of providing global science programmes with a wealth of hydrological data, but rather as a vehicle to strengthen technical, human and institutional capacities of the NHSs of Members in hydrological data collection and in the development and dissemination of information products. While promoting regional cooperation in the sharing of hydrological data and the management of shared waters, WHYCOS was also seen as needing to provide a stronger emphasis on building linkages with other groups requiring hydrological products, thereby resulting in increased socioeconomic benefits and positive societal impacts, such as reducing loss of life and property from flooding and increased food and energy production. No longer was WHYCOS seen as having one high-end technological solution but rather as a mechanism employing the most appropriate technologies to meet the needs of Members and being economically sustainable and supported over the longer term by them. All of this remains true to the intent of ensuring the conformity of hydrological data and products with the standards and recommended practices and procedures of WMO (WMO, 2006; 2008; 2009) and the international exchange of hydrological data and products (see Annex 2 – Resolution 25 (Cg-XIII)).

3.2.1 *Exchange of hydrological data and products*

Resolution 25 (Cg-XIII) reflected the need of Members and organizations to have access to hydrological data and products for a variety of uses. The WHYCOS programme further reinforces this exchange of hydrological data and products as outlined in the resolution, and further requires Members participating in a HYCOS project to share such data and products with all other participating Members. Participating Members are also required to comply with the provisions of Resolution 25 (Cg-XIII). The intent of these requirements is to build upon the existing practices of exchanging hydrological data and products. Such an exchange is beneficial for transboundary water resources management and the provision of services in support of the protection of life and property and the well-being of all peoples. In addition, such exchanges are important in sustaining programmes and projects of international organizations related to hydrology and water resources research at the national, basin, regional and global levels. One example of the valorization of such data that are exchanged is in the area of climate-change research. It is known that climate change will have an impact on the availability and distribution of water resources, both temporally and spatially, with potentially far-reaching implications for society, the economy and the environment. Increasing local knowledge of the impacts will increase the ability of society to adapt to the changing conditions. In essence, studies carried out

Figure 4. Field training for NHS staff – Volta-HYCOS

at the regional and global levels can provide valuable insights and benefits for managing water resources at the national and local levels.

3.2.2 *Capacity-building*

Capacity-building forms an important pillar of the new concept of WHYCOS. The intent is to strengthen technical, human and institutional capacities of the NHSs in Members in hydrological data collection and the development and dissemination of data and information products. People remain the most important valuable resource in implementing a HYCOS project. Training allows the upgrading of skills in new technologies and techniques and increased knowledge of new practices and procedures. Training is too frequently viewed as being provided solely through training courses, without effort being placed on mentoring and on-the-job training to complement the knowledge and skills gained through the more formal classroom approach. Frequently, the variety of training courses presented and the number of participants is reported as part of an evaluation of a HYCOS project. The perception is that the larger the variety of training courses and the higher the number of participants, the more successful is the training.

Unfortunately, the capacity of trainees to apply their new skills in their day-to-day work and to transfer them to their colleagues is often limited. Training should be combined with hands-on applications to gain sufficient work-related experience. Many NHSs have a limited number of qualified staff to train and recruitment of new staff is not sufficient to replace the retiring ones, thus compounding the difficulties.

How can a HYCOS project strive to better build the capacity of staff than what has been achieved thus far? The answer lies in the careful selection of trainees and preparation of a curriculum, practical field and office applications of lessons learned and broad exposure to problems and mentoring programmes as part of wider career development within the NHS. Efforts need also to be focused on creating a local expertise resource that can be called upon for assistance when specific problems arise. On-the-job training can, at times, be achieved through temporary secondment to any unit, where the type of work is performed at an appropriate level of quality. Examples of different areas requiring knowledge and skill development are: gauging site selection and building of new stations; data capture, validation and archiving; streamflow gauging, including calibration and verification of rating curves; maintenance of gauging sites, including sediment flushing and controls; removal and servicing of field equipment; hydrological modelling; and development and dissemination of flood forecasts and warnings.

Once the trainees have received training, had the necessary exposure in a practical field and office setting and demonstrated that the subject matter has been fully understood and can be successfully put into practice by them, they can be said to have been successfully trained. At this point, they are potential candidates to be trainers and mentors of other staff. Temporary secondments or assignments should be considered as a means of exposing individuals to a broader variety of conditions than they would otherwise have been. Such opportunities to hone skills should not be limited to a particular HYCOS project, but should be looked upon as a long-term endeavour in developing the capabilities of the human resource. Development and retention of appropriately qualified staff should be a high priority.

3.2.3 *Technology*

Sustainability of any investment in technology is highly dependent on having the appropriately trained staff and financial resources to undertake site visits, provide maintenance and purchase and install replacements. This underscores the importance of having the requisite financial resources to achieve long-term sustainability of investments made by donors and Members after completion of the HYCOS project. The NHSs of Members must be in a financial position that allows staff to continue to visit sites, take measurements and maintain and replace all technologies required to allow the proper functioning of the monitoring system.

Figure 5. Staff gauges

Source: Niger Basin Authority

Based on the experience gained from implemented projects, the long-term sustainability of HYCOS project achievements remains a challenge. In many cases, the cost of maintaining and replacing equipment can be prohibitively expensive compared to the meagre budgets of NHSs. This has contributed to increased attention on defining what the primary needs are for data and how best to meet them using the most affordable yet reliable technologies. Many NHSs continue

Figure 6. Hydrometric station built to withstand a large range of water levels

Source: Environment Canada

to use human observers who can provide observations to a central location using landline and cellular phone networks. Should there be a need for higher temporal resolution data than can be provided by human observers, the adoption of modern technologies is appropriate. Should there be no requirement for real- or near-real-time acquisition, data loggers could be employed, while maintaining human observers as a back-up. When real- or near-real-time data are required, various modes of communication can be considered to transfer the data. In essence, the approach to designing the data-collection and transmission system should be flexible for achieving the overall needs for data from the site, while at the same time considering what is affordable to the NHS over the long term.

Unfortunately for some HYCOS projects, automated and unattended stations have typically experienced a high degree of vandalism and theft. This has hindered, to varying degrees, the successful implementation of new technologies. The continued use of human observers has proved successful in allowing the continued flow of data, as observers provide an increased degree of security to a site, depending on its location. NHSs and basin authorities are also urged to involve local communities and their elected officials near HYCOS stations by informing them of the benefit of the installations. Where social measures taken to safeguard equipment prove ineffective, physical measures to protect the integrity of installations may be undertaken. Unfortunately, a physical "hardening" of HYCOS installations involves additional costs, which would need to be weighed against the value to be placed on acquiring the data. There may be occasions when the additional expenditure and efforts are necessary, such as for stations required for the provision of flood forecasts and warnings, particularly when there is potential for loss of life or significant damage to property.

Recent advances over the last few decades in a variety of technologies have greatly influenced monitoring and dissemination practices. Advances in communication technologies, such as cellular networks and the Internet, and their ubiquitous presence in society, provide an opportunity for change. Furthermore, information technology is blossoming with potential new approaches under development. To take advantage of such advances, WMO is developing the WMO Information System (WIS) as its strategy for managing and distributing weather, water and climate information in the 21st century. WIS is being designed to meet the requirements for the routine collection and automated dissemination of observed data and products, as well as data discovery, access and retrieval services for all weather, climate, water and related data. At the same time, hydrological communities are experimenting with new approaches to discovering, assessing and retrieving hydrological data, using, for example, WaterML2.0 (see WMO, 2012, Resolution 3 (CHy-14)). As technology is advancing rapidly in this area, the design of HYCOS projects will have to remain flexible to allow taking advantage of new and emerging technologies and what they offer in capabilities.

It has been observed that various HYCOS projects have devoted significant resources and time to the procurement and installation of new field equipment, as well as the upgrading of databases and information systems. It has also been observed that additional efforts are required to ensure the proper development of rating curves, which requires several streamflow measurements to be taken over as broad a range as possible of flow conditions. It is well understood that such curves can be developed only by judiciously seizing opportunities to obtain measurements suitable for enhancing the definition of the curve. Such curves can only be developed over time in accordance with the conditions that arise at the site. Nature does not always cooperate in a timely fashion that allows the capture of measurements over a broad range of flows. For example, if a long-term drought is in progress, measurements can be taken to define the low end of the rating curve. Values tending to represent average or very high flows will, however, have to await the arrival of such conditions, which might not occur for some time. Diligence and perseverance applied to such efforts are directly linked to ensuring the quality of the data produced by the observing system.

3.2.4 *Quality Management Framework – Hydrology*

Reliable hydrological data and information products are key inputs to the sound and wise management of water resources. Particularly within the context of IWRM, where decisions

are increasingly being made in coordination with relevant stakeholders, it is imperative that accurate data and information products are accessible in a timely manner to facilitate informed decision-making. The value of such data and information increases when they are provided by organizations that have established, and adhere to, quality-management principles.

To accomplish their mission and achieve their strategic direction, NHSs must ensure that the core activities of hydrological data acquisition and delivery of products and services are performed efficiently and effectively. It is also beneficial to have quality-management procedures in place so that assurances can be provided that the stated data quality is being attained. The implementation of quality-management systems will also assist NHSs in the application of good management practices and ultimately enhance confidence in the quality of their data, products and services. This can enhance the reputation of the NHS among clients, users and stakeholders and possibly raise awareness of the need for financial and human resources to manage and operate the NHS.

Accordingly, it is most desirable that the NHS and each organization involved in the provision of hydrological data, products and services within a country or a basin establish a management system to support the continuous improvement process of all monitoring and information-delivery activities. Quality management is a process for ensuring that all the activities necessary to design, develop and deliver data, products or services are conducted effectively and efficiently. It typically involves one or more of the following elements: quality planning, quality control, quality assurance and quality improvement. Thus, it focuses not only on product and service quality, but also on the means to achieve it. By using quality assurance and control of functions as well as of products, it is possible to achieve more consistent quality. Although quality control and quality assurance have long been familiar tools within National Meteorological and Hydrological Services for ensuring data accuracy and consistency, the broader concept of a QMS, which also incorporates quality planning and quality improvement, may be less familiar and less widely used.

In order to advance the adoption and use of such concepts within NHSs, CHy, at its 13th session in 2008, adopted the Quality Management Framework – Hydrology. It provides an overall strategy, advice, guidance and tools for NHSs to attain efficiency, quality and effectiveness in their functioning and encourages NHSs to design and implement QMSs. These would be based on the WMO Quality Management Framework (QMF) and the principles of the International Standards Organization or other relevant quality-management standards, as appropriate to their situations. CHy has also been preparing and publishing guidelines for implementing a QMS in NHSs. In recognition of the importance placed on the reliability of hydrological data and information products and the need to ensure that the core activities of hydrological data acquisition and the delivery of services and products are performed efficiently and effectively, the WHYCOS programme is embracing quality management and will be careful to ensure that standardized and recommended practices and procedures are being applied within HYCOS projects.[2]

3.3 WHYCOS management perspectives

3.3.1 *Vision of WHYCOS*

WHYCOS is a unique tool to attain, through regional cooperation and the strengthening of capacities, quality-assured surface- and groundwater data and products to generate knowledge of water for its sustainable management, poverty alleviation, prevention of loss of life and property during extreme hydrological events and protection of the environment.

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[2] For more information pertaining to the Quality Management Framework – Hydrology, see http://www.wmo.int/pages/prog/hwrp/qmf-h/index.php.

3.3.2 *Mission of WHYCOS*

To strengthen the technical and institutional capacities of NHSs to:

- Design, install, maintain and operate surface- and groundwater monitoring networks;
- Deliver quality-assured data, products and services to a variety of users based on agreed standards and quality-management procedures to be employed for a variety of needs, such as water resources assessment, provision of flood forecasting and warnings and the design, planning and management of infrastructure and IWRM in general.

3.3.3 *Objectives of WHYCOS*

The main objectives of WHYCOS, which are provided in Resolution 14 (Cg-XVI) (Annex 1), are:

(1) Strengthening technical, human and institutional capacities of NHSs of Members in hydrological data collection and management and in the development and dissemination of information products;

(2) Promoting regional and international cooperation in the sharing of hydrological data and the management of shared water resources;

(3) Adaptation to the impacts of climate variability and change.

3.3.4 *WHYCOS principles*

WHYCOS is based on, and espouses, the following principles:

1. The HYCOS project must:

- Welcome WMO in its oversight role;
- Emanate from a request for regional cooperation from an appreciable percentage of countries within the region or from countries comprising a significant portion (more than three-quarters of countries or basin area) of a particular basin or group of basins;
- Complement and supplement the existing national hydrological data collection, processing and product-preparation capacities;
- Allow participating NHSs to actively participate in its governance and implementation;
- Be sustainable over the long term from its onset;
- Provide hydrological data, metadata and information products in compliance with WIS;
- Have a focus on one or more of the following areas:
    - Hydrological data rescue;
    - Hydrological data collection;
    - Hydrological data processing;
    - Hydrological data transmission and distribution;
    - Hydrological product or services development.

2. An individual participating NHS of a Member must:

- Be actively involved in the governance of the HYCOS project and be responsible for, and committed to, national implementation thereof;
- Exchange hydrological data and information products freely and unrestrictedly in a timely manner with all other participating countries in a project;
- Comply with Resolution 25 (Cg-XIII) – Exchanging hydrological data and products;
- Provide hydrological data, metadata and information products in compliance with WIS;
- Ensure its long-term commitment to the sustainability of the HYCOS component; and
- Adopt and implement standards and recommended practices and procedures as per the WMO Technical Regulations for all relevant activities associated with the project.

3. WMO must:

- Ensure compliance of activities of the project and participating countries with the WHYCOS vision, principles and objectives; and
- Ensure judicious use by the project of human and financial resources.

4. The donor must:

- Be flexible, so as to take into account the amount of time required to allow proper implementation of the project; and
- Transfer ownership of any capital items purchased for the project to NHSs and/or other parties involved with its implementation, such as a regional basin organization.

3.4 Hydrological Cycle Observing System components

WHYCOS is being developed in the form of regional or shared-basin components referred to as HYCOS components, each of which meets the priorities expressed by the NHSs and users of their data and information products. The strength of the WHYCOS programme is attained through its HYCOS components truly meeting the requirements of the local communities without proposing unaffordable solutions. Viable solutions should incorporate flexibility, thereby making use of different technologies and mechanisms to meet various user requirements.

The successful HYCOS component will collect and make easily available hydrological data and products needed by a variety of users, such as planners, decision-makers, scientists and the public. In addition, for specific sites, it will provide hydrological data and information products in real or near-real time when required for the early warning and mitigation of impacts of water-related natural disasters or for other uses where timeliness of delivery is imperative. The overall requirements of each HYCOS component will be specified in detail and will be typically associated with one or more of the following purposes:

- To support regional institutions and NHSs in discharging their relevant regional and national responsibilities in support of:
  - IWRM;
  - Water resources assessment;
  - Flood forecasting and warning;

Figure 7. Intergovernmental Authority on Development (IGAD)-HYCOS climate monitoring site in Rwanda

- Adaptation to climate change.

- To strengthen the capacity of regional institutions and NHSs to undertake core activities of hydrological data acquisition and delivery of information products in an efficient and effective manner;

- To supplement existing hydrological observing programmes, especially in terms of observing networks and data-management practices;

- To improve the quality of hydrological and related data and information products by adopting international standards and recommended practices and procedures;

- To support the development, implementation and maintenance of appropriate modernized regional and national databases;

- To support greater efficiency in the acquisition and dissemination of water-related information and the development of regional and national water resources information systems by encouraging and facilitating cooperation among countries sharing the same water resources;

- To serve global scientific interests in terms of characterizing and attributing hydrological variability, detecting climate change and developing the ability to predict impacts of climate change, thereby helping to develop a sustainable national adaptation strategy for water resources management;

- Provide improved knowledge of the status and trends of the availability of freshwater resources on the local to regional to global scales as a basis for setting priorities and planning international action and providing advisories to governments;

- Strengthen cooperation between NHSs and National Meteorological Services (NMSs), which are key players in providing relevant information in the field of sustainable water resources management and the provision of early forecasts and warnings of water-related hazards through sharing physical, financial and human resources and integration of the information for increased efficiency and effectiveness.

Associated HYCOS components

A number of networks or projects exist or are being developed which focus on obtaining hydrological data and/or information products at the initiative of national or regional institutions or transboundary basin authorities without the involvement of WMO. Those responsible for such networks or projects wishing to receive the designation of "associated HYCOS component" can do so by applying to WMO. The network or project will be evaluated by WMO to ensure that it meets the vision, mission, principles and objectives of WHYCOS, as outlined in previous sections of these Guidelines, and adopt and adhere to WMO recommended standards and practices.

4. DEVELOPMENT PROCESS OF HYCOS COMPONENTS

4.1 Project stages

A number of preliminary activities are necessary for the successful development, implementation and long-term sustainability of a HYCOS component. Such a project has usually been developed in stages involving the WMO Secretariat, participating countries, a regional institution or river-basin authority and donors. However, the stages depicted here are intended to provide a logical flow from the initial concept to implementation to post-project maintenance. As a particular project emerges, the flow, as well as the stages themselves, may be dynamically adapted and modified to meet specific needs and circumstances. A general structure, which is intended to be flexible and comprises some proposed stages, is described below. The stages include:

- Project initiation stage;
- Project implementation stage;
- Post-project maintenance stage.

WMO will provide at least partial financial support and oversight for the initiation stage to ensure the preparation of a concrete proposal that is appealing to donors and assists in seeking funds from donors for the project implementation to the post-project maintenance stages. WMO will also be undertaking evaluations of the project and a post-project assessment, which are further covered under the aegis of WMO (section 6.2). It is expected that national and/or regional resources will replace external funding within the project upon its completion, thereby ensuring the long-term sustainability of the investments made during the project.

It has been observed that at the "stated completion date" of some HYCOS projects (that is, by the end of the donors' support), additional efforts were identified to complete the original or it had been determined that the attainment of additional goals would be beneficial. When developing the concept of a new HYCOS project, it may be beneficial to consider approaching the overall attainment of goals or objectives through a phased implementation. The adoption of phases can be particularly beneficial, as they allow a progressive development of capacity and information products over time. Donors may also choose to provide funding to fine-tune the requirements of new phases based on accomplishments achieved in the initial phases.

4.1.1 *Project initiation stage*

The formal request

Recognizing the need for increased cooperation in water resources management or strengthening hydrological services and having consulted with NHSs within the area, a regional institution or river-basin authority can make a request for the development of a HYCOS component under the umbrella of WHYCOS. The request must have the support of at least

three-quarters of the countries sharing the basin or of countries within whose jurisdiction more than three-quarters of the basin area falls. As a minimum, at least two countries must participate in the project. The regional institution or river-basin authority should convey its intentions and those of the countries concerned to the WMO Secretariat through an official, written request. Should no formal regional institution or river-basin authority exist, the NHSs of the countries sharing a basin or an area can approach the WMO Secretariat individually or as a group. The WMO Secretariat will then investigate the feasibility of the project as a basin- or regionally based HYCOS.

The project proposal – a brief project concept document

Having received the written formal request and depending on the circumstances, efforts are undertaken to define the project and seek its funding from donors. If expressed donor interest to provide funding is yet to be secured, the first step would be to prepare a brief project concept document. This is normally funded by the WMO Secretariat as an activity under its Hydrology and Water Resources Programme. This document provides a succinct overview of the project and comprises a formal expression of intent of the countries to work together and develop jointly a HYCOS component under the aegis of the WHYCOS programme. It is essentially based on preliminary consultations and discussions between the WMO Secretariat and the requesting regional institution or river-basin authority.

This brief project concept document is sometimes seen as a precursor to developing a more detailed project proposal. The intent of the brief project document is to provide sufficient details concerning the project to warrant the interest of a donor. Once a donor shows interest and is willing to provide some funds for the project, more intensive activities can commence, usually in the form of developing the more detailed project proposal. Based on input from user groups, the participating countries and the regional institution or river-basin authority and in-depth consultations and analysis of the issues, it describes the project elements to address them. It is intended to provide sufficient information for donors to consider more fully the attributes of the project for significant funding.

The detailed project proposal

The detailed project proposal should describe the issues that the project would be designed to address; identify and elaborate on specific objectives that the project would attain and how; and identify the future status, given the successful completion of the project. The document should also indicate how the project activities would attain or contribute to societal outcomes and impacts that might occur, given the achievements of the project. For example, it would describe

Box 3. Project proposals

Based on experience gained from HYCOS projects that have already been implemented, the following observations are of relevance for a project proposal.

- It may be desirable and more productive to approach overall project implementation through a number of phased efforts.
- An initial short-term phase of approximately 12–24 months may be beneficial to establish the Project Management Unit (PMU), recruit staff and initiate core activities, such as identifiying potential modelling platforms and model capabilities, designing the network, preparing tender documentation and undertaking the tendering process.
- It is beneficial to establish the PMU with delegated authority at the start of a new HYCOS project. This provides the structure, leadership and capacity to commence implementation activities.
- The distances involved and size of implementation area will greatly influence the human and financial resources required for the project, as well as the duration of project implementation.

Box 3. Project proposals (*continued*)

- The inclusion of a sufficient number of experienced staff within the Regional Project Centre (RPC) is vital to the success of the project and the longevity of the results. Such expertise is essential for technical assistance and trouble-shooting, as well as training NHSs staff in how to select sites; install equipment; operate and maintain equipment and sites; conduct river surveys; calibrate and validate stage-discharge or rating curves; apply corrections to the curves; install, operate and maintain the regional database, national databases and project website; apply hydrological models and approaches to develop hydrological information products and implement quality assessment/quality control (QA/QC) practices.

- It is important not to underestimate the complexity and time required to build strong relations with users; design and implement information products such as a flood forecast and warning system or a regional water resources information system; account for administrative problems (custom clearance of imported goods, secondment of staff, etc.) and design and implement an effective and sustainable network and its associated operations, including a regional database, national databases and the implementation of Hydrological Information Systems (HISs) in each participating NHS.

- Emphasis should be placed on ensuring the promulgation of standards and recommended practices and procedures in the design and implementation of all aspects of the project. This would, for example, have the result that care and attention would be focused on taking streamflow measurements to calibrate and validate the rating curve, as unreliable estimates of discharge severely compromise the ability to provide early warning of flooding and severely hamper water resources assessment and management.

- Classroom or distance learning should be combined with on-the-job training under the guidance of experienced mentors.

- The status of aquifers should be monitored through records of groundwater levels and abstraction from production boreholes to determine trends possibly caused by water-use practices and climate change. Such monitoring can provide information to support decision-making on the feasibility of implementing groundwater recharge or modifying water-use practices.

- A clear commitment in writing is required between NHSs and the Implementing Agency (IA) and the RPC to cover the ongoing costs of data communications, such as mobile telephony or satellite, and licence fees on software, such as national databases or HISs, and other maintenance fees.

how the data collected and disseminated would be used by specialized groups to reduce the loss of life and property through floodplain delineation, the issuance of flood forecasts and warnings, emergency preparedness and disaster-mitigation planning.

The document should also contain the general agreement of the NHSs of the interested participating countries to agree to uphold the principles of WHYCOS (section 3.3.4). Given the human and financial resource implications, as well as the requirement to work cooperatively at the international level, the preliminary agreement should be endorsed at the requisite, senior decision-making level within each country and the regional institution or river-basin authority. Annex 3 provides an example of such an agreement.

To help develop the detailed project proposal, the participating countries are expected to:

- Provide input in the form of the status of the existing technical, human and institutional capacities, identifying gaps therein;

- State the desired purposes, issues to be resolved and expected needs of the countries with respect to the project; and

- Prioritize the capacity-development requirements.

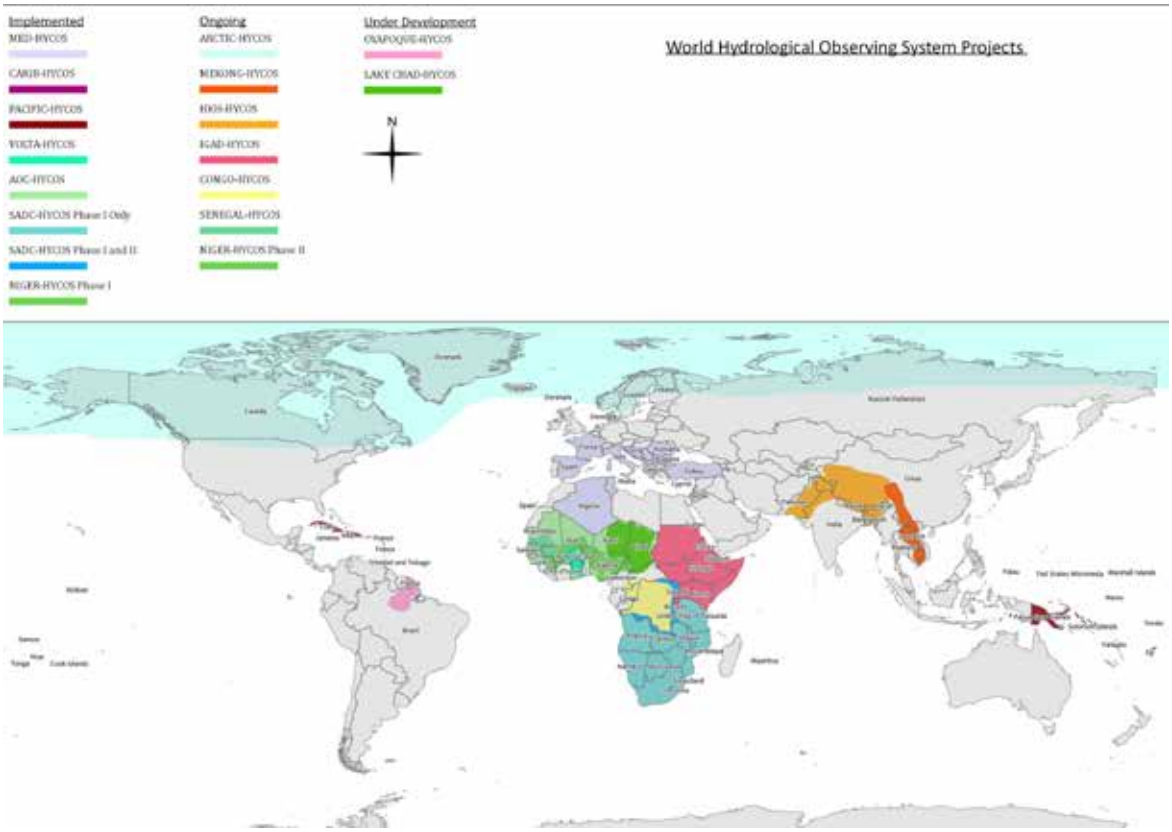

Figure 8. WHYCOS components worldwide (2014)

The project proposal should:

- Define the commitments required from all relevant stakeholders to implement the project;
- Contain an assessment of the status and ability of each of the participating NHSs in terms of its human and financial resources to undertake responsibilities for project implementation and for the long-term sustainability of investments made through the project and into the post-project maintenance stage;
- Propose any ameliorating measures that are needed to increase the ability of the parties to successfully implement the project and to ensure long-term sustainability;
- Contain the preliminary agreement among the participating countries committing themselves to the project and to upholding the principles of WHYCOS;
- Identify ongoing related projects in the region and potential linkages with the HYCOS component to prevent duplication and to enable collaboration and synergy;
- Specify the proposed activities and expected results;
- Identify the financial and human resource contributions or inputs to be made by the countries themselves, as well as those expected from external sources for implementation of the project and the post-project stage to ensure long-term sustainability of investments;
- Identify the potential users, outside NHSs, of the planned information products;
- Identify and analyse potential risks to successful implementation of the project.

The successful completion of the project initiation stage is the identification of a donor or donors who are willing to support the implementation of the HYCOS project.

4.1.2 ***Project implementation stage***

At this stage, a governance and management structure will need to be created. This will reflect the various levels of management required to undertake the project and will be based on administrative and financial arrangements and agreements of the parties. These aspects are covered in Chapter 6 – Governance and financial arrangements of HYCOS projects.

The detailed implementation plan

Once a donor(s) has (have) been identified and indicates its (their) support for the specific HYCOS, the next step involves the development of a detailed implementation plan. The preparation of this document is based on a continuing dialogue with all the participating agencies and stakeholders with the intention of adding further details to the project plan, allowing for coordinated project implementation. The format of such a document and the design of the implementation plan should also consider the requirements of the donor(s), which, in turn, should be aware of the inherent complexity of the task.

While preparing the detailed implementation plan, it should be remembered that it is being developed primarily as a vehicle for promoting appropriate, robust and affordable technology and the capacity to sustain it, and should be able to create national ownership, the requirements of which have to be clearly identified and officially endorsed. During this process, the WMO Secretariat will work with all contributing agencies to identify the institutional and human resource capacity-building and training needs of the countries and recommend training and other capacity-development activities to ensure the long-term sustainability of the project. The plan will also cover all the technical and administrative details, as well as office and field activities, such as the network to be strengthened; the sites to be equipped and the type of equipment to be installed; the acquisition of national HISs and associated training; and the development and

Figure 9. Winter discharge measurement

Source: Environment Canada

implementation of hydrological products and their dissemination. It will include a detailed budget and workplan and will reflect the contributions of all parties to various aspects of the work.

Office and field implementation

This aspect of implementation basically comprises taking the necessary steps to execute the detailed implementation plan. It will likely be highly focused on strengthening technical, human and institutional capacities, both in the office and in the field. Activities could be, but would not be limited to, rationalizing the existing hydrological network; training (classroom and on-the-job); procurement of equipment and software systems; field site preparation and installation of new stations; refurbishing existing stations; establishing a regional database and information system; and developing hydrological products. Typically, NHSs will be fully responsible for all office and fieldwork activities in their country and all matters related to the production of reliable data and products. They will provide human and financial support (travel and labour-related costs) for site preparation; the installation of new stations; the refurbishment of existing stations; performing flow measurements over a range of conditions to calibrate or update rating curves; and other logistic support, as required. They will also provide staff and office support for the implementation of national software systems associated with hydrometric and other hydrological data production and the issuance of hydrological information products. They will also be responsible for the organization of national training events, workshops and seminars.

Office and field implementation will be facilitated, coordinated and managed by the project governance structure. The donor(s) is (are) expected to cover all financial costs during implementation, including those associated with managing and executing the project. The WMO Secretariat will provide oversight and undertake regular monitoring of progress, perform a mid-term evaluation (to be submitted to the governance structure of the project and donor(s)) and, if called upon, will develop and undertake training and other capacity-building activities. A detailed governance and management structure for the project implementation stage is described in Chapter 6. The WMO Secretariat, with the support of the project management, should prepare a final evaluation report at the conclusion of the project. This report should also document the lessons learned, contain a sustainability plan and detail how to improve and adopt best practices in subsequent HYCOS projects.

4.1.3 ***Post-project maintenance stage***

Once the project has been completed, attention turns to the post-project maintenance stage. Depending on the circumstances and the remaining needs of countries, the regional institution or river-basin authority, the countries and the donor(s) may decide to continue their involvement through the initiation of an additional phase to the original HYCOS project. At times, the amount of capacity-building and the complexities of the institutional change, adoption of new technologies and development of human skills may best be accomplished through a phased approach. This allows the development of capacities and the strengthening of NHSs to be achieved over a more realistic timeline. The overall process for each additional stage may be similar as for a new project, but with one cascading after the other. Each additional phase should be able to adjust the project documents to reflect accomplishments of the earlier phase and any course corrections required due to a variety of reasons, such as changing technologies and user needs. A donor may evaluate its interest at each phase of the development of the HYCOS component and additional donors may express interest in funding one versus another phase. When a second or further phase appears to be necessary, the risk of losing the achievements of the earlier phase, if the time interval between the two is too wide, should be taken into account.

Should a new phase of the overall project not be required or agreed upon by all parties, the project enters the post-project maintenance stage. During this stage, the participating countries will maintain the network infrastructure and continue the activities under the project with the

regional institution or river-basin authority to ensure its long-term sustainability. This would include continued involvement of, and support for, an RPC.

The developed project plan and the subsequent detailed project implementation plan should have reflected the agreement and identified the resources as to how the regional water resources information system, national HISs and associated infrastructure are to be funded, located and operated, following completion of the project. In addition, it is expected that hydrological data and information products will continue to flow to interested users. Through its continuous association with the NHSs, the WMO Secretariat will continue to provide assistance and support to the countries, within internal budgetary constraints.

In addition to the project evaluation conducted at the end of project implementation, a post-project evaluation should also be carried out two to three years after completion of the project. This should review and comment on the status of achievements attained through the project and any concerns that might be apparent regarding long-term sustainability.

5. IMPLEMENTATION OF HYCOS PROJECTS

The following paragraphs provide broad guidelines for project implementation. A somewhat detailed discussion is provided for some specific examples with the intent of providing guidance for success. Much of the material is based on the experience garnered from HYCOS projects that have already been implemented under the WHYCOS programme.

As indicated in section 3.3.4, a HYCOS project can focus on a variety of hydrological activities, ranging from hydrological data rescue to hydrological product and services development. While providing general guidance, this chapter will primarily provide guidance on the activities of a HYCOS project, generally consisting of the following categories:

- Improvement of national and regional hydrometric networks;
- Establishment of a data-collection and transmission system;
- Development and implementation of a regional water resources information system;
- Development and implementation of national HISs;
- Capacity-building;

Box 4. WHYCOS criteria for station selection

New stations

- The site is readily accessible for the installation and operation of a data-collection platform (DCP).
- Facilities for telemetry or satellite relay can be made available, if required.
- The catchment or basin is in a pristine state.
- Where feasible, the site has all the characteristics required for a sound and robust rating curve and stage and discharge measurement.

Old stations

- A long historical record should be available.
- A stable rating curve should be available.
- Time series should be homogeneous and stationary (the contrary might indicate major water consumption or a faulty discharge rating table).
- Access should be easy.
- Data collected should, as far as possible, reflect a hydrological and climatic regime that is not too diverse.

- Support for regional institutions and NHSs in activities related to water resources assessment, IWRM, flood forecasting and warning and adaptation to climate change.

5.1 Improvement of national and regional hydrometric networks

It must be kept in mind that WHYCOS does not replace existing hydrological observing programmes, but is intended to complement and supplement ongoing national efforts. WHYCOS is intended as a catalyst in promoting the adoption of quality-management procedures. It also introduces, as appropriate, new equipment, techniques and information technology. It provides an opportunity to develop and implement technologies and upgrade skills for a suite of hydrological information products, such as flood forecasts and warnings, which are dealt with, in part, in section 5.4. In improving the hydrometric network, preference is generally given to the rehabilitation and upgrading of existing stations, in association with the rescue of their historical data, with new stations established only when and where necessary.

An analysis of the existing networks should be conducted in accordance with the standards, procedures and practices documented in the *Technical Regulations*, Volume III: *Hydrology* (WMO, 2006) and the *Guide to Hydrological Practices*, Volume I (WMO, 2008). The existing networks in the participating countries should also be evaluated for any deficiencies in relation to the overall purposes or needs for data, such as the provision of flood forecasts and warnings, water resources assessment and reservoir management. Based on these evaluations, and keeping in mind the overall purposes and objectives of the project, the hydrological sites to be included in the project network should be identified and designed. To ensure the long-term sustainability of the system, it is recommended that the design also considers long-term affordability. NHSs, with the previously agreed-upon assistance of the regional institution or river-basin authority, must be in a position, after completion of project implementation, to maintain, repair and replace all equipment associated with the acquisition, processing, transmission and dissemination of data. Hence, all available equipment and means of providing the required-quality data to users should be considered for each station as requirements on timeliness of data, for example, can vary greatly, according to needs. Sensitizing decision- and policymakers as to the benefits of water-related data collection should be part of the project implementation.

5.1.1 *Site selection for new stations*

Selecting the location of the site of a particular station should follow the standards and recommended practices and procedures as documented in the *Technical Regulations*, Volume III: *Hydrology* (WMO, 2006), the *Guide to Hydrological Practices*, Volume I (WMO, 2008) and the *Manual on Stream Gauging* (WMO, 2010). Network design considers user needs for the data and should provide insight as to the general location of the data-collection sites. For each site, local information is used to select the most suitable location for instrumentation and to obtain satisfactory data. In the case of discharge, the site should be suitable for the technique to be used for its estimation. For example, the site should have characteristics that allow the establishment of a sound and robust rating curve and accurate stage and discharge measurements. Modifications to the site may be necessary to improve the quality of the data: clearing of vegetation and control stabilization and improvement, for example.

Once a site has been selected and instrumentation installed, the station should be operated and maintained to established standards. In general, this involves the execution of an adequate schedule of visits to the site to perform inspection and maintenance to ensure continuity and reliability of data. Visits should include checking measurements and calibrations to ensure that data of the required accuracy are being obtained.

5.1.2 *Upgrading existing stations*

An assessment of the needs for hydrological data may indicate that timely access to data is of critical importance – in the issuance of flood forecasts and warnings, for example. This may

necessitate upgrading or modernizing some existing specific and important stations to allow the acquisition and transmission of data in a timely manner to meet the needs as identified in the HYCOS project. In other instances, where access to the data in real time is not a requirement, the use of human observers may prove sufficient to meet the needs. However, if data are required to define the hydrograph on a highly responsive stream, necessitating several observations a day, then upgrading the station to include a data-logger may be appropriate. Expert judgment is required in the overall design of networks and the selection of approaches to be taken for the collection of data to meet the intended purposes of the data from each site, while maintaining an affordable network over the long term.

5.1.3 ***Instrumentation***

Elements to be monitored

Each HYCOS hydrological station should be designed to meet the requirements for data as documented in the detailed project proposal and the detailed implementation plan. As provided for in the *Technical Regulations* (WMO, 2006), hydrological stations can be categorized as being a hydrometric station, climatological station for hydrological purposes, a groundwater station or a hydrological station for specific purposes.

At a hydrometric station, observations can be made of some or all of the following elements:

- River, lake or reservoir stage;
- Streamflow;
- Sediment transport and/or deposition;
- Temperature and other physical properties of the water of a river, lake or reservoir;

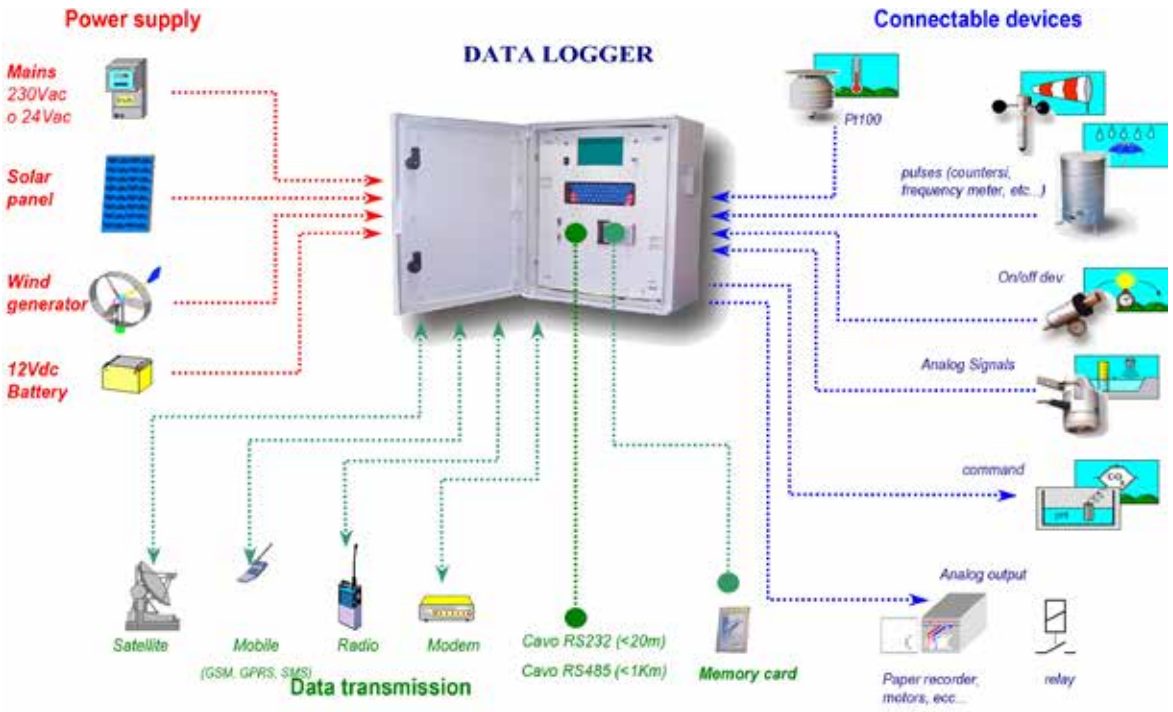

Figure 10. Data-logger schematic diagram

Source: Siap+Micros

- Characteristics and extent of ice cover on rivers, lakes and reservoirs;
- Chemical and biological properties of the water of a river, lake or reservoir.

At a climatological station for hydrological purposes, observations can be made of one or more elements necessary for the quantitative estimation of the atmospheric phases of the hydrological cycle. A few examples are:

- Precipitation (amount, time of occurrence, intensity);
- Air temperature (for operational purposes: air temperature could also be measured inside the instrumentation hut or enclosure);
- Air humidity;
- Evaporation (measured with evaporation pan);
- Solar radiation.

At groundwater stations, observations can be made of one or more of the following elements:

- Water level;
- Temperature and other physical properties of the water;
- Chemical properties;
- Rate and volume of abstraction or recharge.

At hydrological stations for specific purposes, observations can be made of those elements that are appropriate for the purposes of the station and may include some of the elements listed above. The elements to be observed will depend to a large extent on the purpose of the gauging site for the country and/or basin.

Detailed specifications for the types of stations and elements to be monitored will depend on the user requirements for the data as documented in the detailed project proposal and detailed implementation plan. Specific instruments would be identified, based on the elements selected. The approaches taken to obtain the observations and the requirements for specific instrumentation at each particular site occurs after the network design has been completed.

Data-collection platforms

Initial HYCOS projects tended to be based on relatively high-end technologies such as DCPs, typically using satellite transmission of data.[3] This approach has since evolved to allow consideration of a suite of possible approaches from manual observing systems to the use of DCPs. The exact approach at a particular site will depend on various factors, leading to installing or using the most fit-for-purpose instruments and approaches and with consideration being given to long-term sustainability of the investment and its overall affordability.

The main advantages of a DCP system as compared to other more basic solutions are:

- Flexibility in the timing and frequency of data acquisition to better reflect the dynamics of each element measured;

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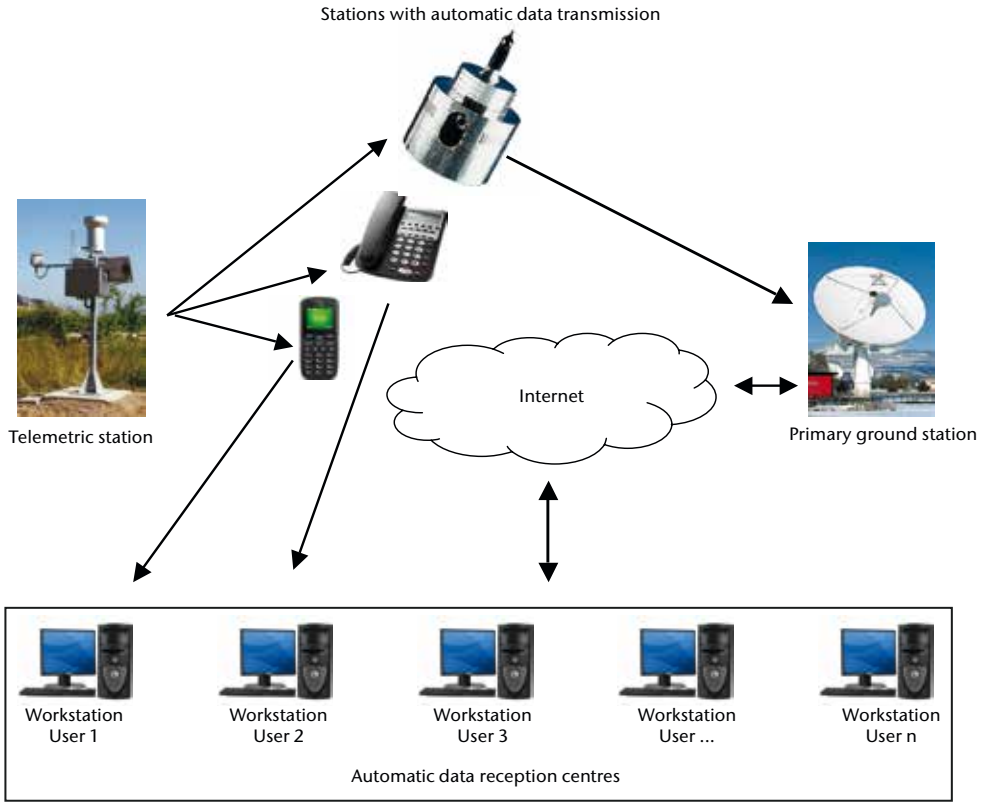
[3] Data-collection platform (DCP) is used herein to describe an integrated data acquisition and telemetry instrument capable of processing data inputs from various sources, while telemetry infers the transmission of data by wire, radio or satellite.

- Availability of unverified data in real to near-real time;
- Direct transfer of the digital data into electronic databases; and
- Immediate notification of data transmission failure allowing corrective action to be taken.

When deploying DCPs, the data so acquired should be compatible with WIS – and specifically the GTS – as regards frequency and format. When DCPs employing satellite transmission are used within a HYCOS project, the WMO Secretariat shall ensure the free transmission of data from the satellite operator and the exact transmission time of each DCP will also be assigned. The rapid growth worldwide of mobile-phone networks in recent decades and the availability of good-quality coverage, even in remote areas, makes the use of mobile-phone technology a viable, alternative technological option.

Appropriate technology

Successful and sustainable HYCOS implementation requires the use of appropriate observational approaches and appropriate technology for a particular site. The instruments to be installed should be standard, simple, maintainable at a reasonable cost and appropriate for their intended functions, with a high level of demonstrated reliability and robustness. Variations in climatological conditions and technological and infrastructure facilities available in the participating countries must be given due consideration while selecting the project equipment. An important impact on design might arise should vandalism and/or theft be experienced or is of concern. In such cases, alternative approaches to monitoring may be required and it might not



INFORMATION DISSEMINATION SCHEME
INTERNATIONAL WATER RESOURCES INFORMATION SYSTEM
Each user workstation (Nation) includes a software package that acquires and decodes the e-mails from the remote stations and updates automatically the RDBMS – the relational database management system (RDBMs). Each workstation can also receive data through fixed or mobile-phone transmission

Figure 11. Regional water resources information system

Source: Siap+Micros

be feasible to meet the needs of users without incurring significant additional costs for reinforcing or guarding facilities.

Threats to the performance of instrumentation may be caused by instrument failure; extreme environmental conditions (temperature, humidity), natural hazards such as floods and lightning; theft or vandalism. It must be realized that instrumentation is fragile and errors in installation or electrical coupling beyond tolerable limits may result in equipment failure. The gauge shelter should be located at an elevation sufficient to protect against high water levels. Care should also be taken not to locate it on erodible shorelines or where debris might impact its integrity. When modern electronic equipment is deployed in areas susceptible to lightning strikes, lightning protection should also be included in the design.

The possibility of theft and vandalism may impact the selection of the location of stations, the approach to monitoring (for example, manual versus automated acquisition) and the cost of instruments to be deployed. The most successful protective measure to combat theft and vandalism is to employ a local observer to watch over the station and who also takes staff-gauge readings at regular intervals as a crosscheck. Such observations are useful as a quality check and to adjust data acquired electronically at the site. Avoiding use of automated data acquisition and telemetry systems and maintaining human observers may well have distinct advantages, particularly from an affordability perspective, but may not allow sufficiently timely and frequent observations required for some purposes. It may also be difficult to employ human observers in very remote locations and timely communication of observations would be dependent on the availability of modern communication infrastructure in the area. Although, at times, human observations may not be the most desired approach, it is by far more acceptable than more technologically driven vandalized systems with repeated loss of equipment, resulting in complete failures of data acquisition.

It is, therefore, recommended that, in the detailed project proposal and the detailed implementation plan, consideration be given to selecting the most appropriate approach to monitoring for each site. This would reflect the purposes for which the data are to be used, the possibility of vandalism and theft, and the overall affordability beyond completion of the project for maintenance and replacement of instruments when required. Older or basic technologies should not be discarded out of hand, but should be carefully considered within the possible mix of human–machine observing systems that can be deployed within the HYCOS project. Although a mix of differing approaches and technologies may be more difficult to implement, it is possible to use such a "mix" to obtain greater sustainability and increase the reliability of acquiring data when they may be most needed.

5.2 Data collection and transmission system

HYCOS stations should transmit data in real or near-real time if the primary purpose for collecting the data so dictates and should therefore be equipped with an appropriate telemetry system. The transmission of data in real or near-real time is a prerequisite for the provision of flood warnings and early warning of accidental pollution events, as well as facilitating management activities associated with them. Another significant advantage provided by the use of telemetry is the remote monitoring of the status of the condition of the instruments and the DCPs at the site, thus allowing targeted visits to repair faulty equipment in a timely manner. This practice decreases the loss of data and increases the reliability of the observing system.

The system should be selected to best meet user needs and to cope with the local conditions and available infrastructure. Furthermore, capital and ongoing costs associated with the acquisition, maintenance and running of the transmission system should always be a consideration. Various technologies exist that allow reliable and timely transmission of data: these include landline telephone, mobile-phone network, radio transmission and satellite. Each may have its advantages and disadvantages, based on local conditions and costs, which should be carefully considered before proposing possible solutions. Again, the entire network need not rely on one mode of telemetry; a mix of technologies might prove to be the most effective and efficient vehicle for the transmission of real- or near-real-time data for the project.

It is important to note that data transmission from the field to a national data centre need not necessarily be in real time. For certain normal operational purposes, such as engineering design and assessing general water availability in a region, near-real-time data may suffice. In such cases, where timely delivery is not imperative, various options for transmission can be considered. This need might well be met by using the services of an observer. Human observations may be transmitted to the national data centre, using one of a variety of technologies. Such options include mailing in hardcopy form (while maintaining a copy at the site); using the Internet to upload the data; using a landline or mobile telephone to enter the data into an automated response system; or verbally. Such a basic system, if considered appropriate for users' needs, should be considered for incorporation into a HYCOS. The main disadvantage of such a system is the longer delay between making the observation and having it available for use by others. Ancillary advantages of such a basic system are the creation of jobs, reliability of the human observer and protection against vandalism and theft. Moreover, the human observer can also provide first-hand knowledge of the events that are unfolding at the location. A few disadvantages are risks arising from the human element (sickness, error in taking an observation). Should a major flood occur, there is also the possibility that the observer may give a higher priority to other matters, thereby neglecting to carry out the observations.

Use of older communication technology, such as a land-based radio system, should also be explored. Such a radio system is restricted in terms of transmission range, but repeater stations may be used to overcome this restriction. A number of local observers may report to a central node, where all the information can be integrated and further transmitted via various other telemetry approaches to a regional or national centre. The main disadvantage of such a system is the increased number of nodes within the data chain and the associated increase in the possibility of its failure. It is possible that, after closer analysis, "mixed technology" solutions, such as the use of cellular or radio-transmission systems, in conjunction with the Internet, may provide adequate, yet cost-effective, solutions.

An in-depth analysis and investigation of circumstances in each country should be undertaken to consider policies regarding the employment of local observers; the availability of supporting technologies, such as landlines, mobile-telephony-based data-transmission systems in remote places, etc. It should be conducted when preparing the detailed project implementation plan: the most cost-effective yet reliable solution should be considered for adoption.

5.3 Quality management and data and products

As mentioned in section 3.2, increased emphasis is being placed by WMO and NHSs on activities related to ensuring the reliability of data, products and services. The development and adoption of QMSs have become a standard business practice that has been embraced and adopted by many NHSs. To help ensure the reliability of data and information products, such efforts put in place practices that formalize and standardize procedures from data collection to processing to extensive data checking to the provision of flood forecasts and warnings. A number of quality assurance activities are typically taken to help ensure the overall quality of the data. Such activities encompass training, identification and use of best practices, recording errors and malfunctions, recording corrective actions taken, checking and other quality-control steps, and independent audits of the entire operation. The *Guide to Hydrological Practices*, Volume I (WMO, 2008) recommends that, subject to the availability of resources, NHSs should adopt a quality-management programme. Such investments have been made in all these areas by many organizations to ensure the production of reliable hydrological data and information products, as they are key inputs to the sound and wise management of water resources and initiating responses to pending floods or droughts.

The strengthening of technical, human and institutional capacities of NHSs in hydrological data collection and the development and dissemination of information products should be based on activities within the context of a QMS. In so doing, formalized procedures should be adopted that address the quality control that involves all business procedures, including the process of checking and validating the data and the quality of the information products. At the various steps from collection to dissemination, data should undergo a number of checks to determine

their accuracy and accuracy. This allows making corrections to data and rating curves to reflect site conditions – weed growth, for example – based on check measurements. With the adoption of new developments in technology, it is more important than ever that data-processing and quality-control systems are well organized and understood by those involved. This allows appropriate application and tracking of all changes made, resulting in final approved data for archival and dissemination. With the advent of near- and real-time data and because of their inherent nature, only preliminary automated checking of such data can take place, prior to their being handed over to the user or for use in hydrological information products such as flood forecasts and warnings (WMO, 2011(b)). Hence, users unfamiliar with the data-production chain should be made aware of the preliminary or provisional state of such data.

5.4 Development and implementation of a regional water resources information system

The establishment of a regional water resources information system and its regional database is an important activity for most HYCOS projects. The various activities of such an information system should be reflected in the detailed project proposal. Some typical aspects of establishing and operating an information system include:

- Identification and establishment of national data centres;
- Establishment of regional and national databases and information systems;
- Agreement on, and preparation of, information products;
- Agreement on data and information-exchange policy among participating countries; and
- Dissemination of data and information products.

5.4.1 *National database at the National Hydrological Service or river-basin authority*

Each country is expected to undertake primary and secondary processing procedures and validation procedures to ensure the highest possible standard of all the data before they are given to users (WMO, 2008). T*echnical Regulations*, Volume III: *Hydrology* (WMO, 2006), the *Guide to Hydrological Practices*, Volume I (WMO, 2008) and the *Manual on Flood Forecasting and Warning* (WMO, 2011(b)) provide the recommended practices and procedures to be taken. These include periodic inspection of stations to ensure the correct functioning of installed equipment, calibration/recalibration of measuring instruments, measurement of gauge data to check for and record any changes to levels (appropriate for hydrometric and groundwater stations) and the taking of discharge measurements to ascertain the stability of the rating curve.

The national database and processing system, sometimes referred to as a Hydrological Information System, should have the technical functionality to acquire, archive, modify and compute discharge and disseminate data, as well as products. It must allow the tracking of all checks and changes to data that may have occurred as part of the quality-control procedures. The core of the system is typically a hydrometric workstation which allows experts to verify with rigour the stability of a rating curve and provide adjustments to it over time, thereby influencing the accuracy of the data for archival and distribution.

A HYCOS project presents a unique opportunity to make advances in database and processing technologies explicitly designed for use by hydrometric and hydrological programmes. When electronic databases do not exist within an NHS, or are in the process of being developed by the NHS, assistance should be provided either for upgrading or for replacing the databases and processing system as part of the project. The possibility of using a standard database and data-processing system for the various NHSs participating in the HYCOS project should be explored due to economies of scale and availability of a tried-and-tested appropriate database and processing system for national use. This also allows synergy within the regional or basin

community regarding technical support and advances within the system over time. In the case where an NHS may already have in place a database and processing system and there is no advantage to moving to the commonly agreed-upon system, efforts should then be undertaken to make the existing system interoperable with the common system. This is recommended to allow for the seamless moving of data and metadata within the overall system.

A number of hydrological databases and processing systems are available from vendors all over the world. Many have been adopted by NHSs and their functionality has increased over time, but also tends to vary from system to system. Some systems possess handy utilities such as easy capture of digitized data from charts, graphical displays of raw and validated data, multiple linear regression software for filling in gaps within time series from adjacent gauging stations and calibration software embedded within the database. Some have very specialized approaches for calibrating and validating the rating curve. WMO is making freely available the Database Management System (Meteorology, Climatology and Hydrology (MCH)) open-source software, providing all basic features required by a database-management system for dealing with hydrometeoclimatic data.

While it is relatively easy to create a Microsoft Access or SQL database (or other similar types of database, using other software), it becomes much more difficult to integrate software of the aforementioned types with a commercial database, debugging the software and validating the product. Systems are available that can be up and running immediately and populated and used after training. The greatest asset provided by using some commercially available systems is the additional functionality they provide that is required by the NHS. One aspect not to overlook is the need of the database and processing system to maintain all data and metadata of the NHS and not be restricted to just those data and metadata collected under the HYCOS data. In essence, the HYCOS project provides the NHSs with an ability to migrate to what is considered a more sufficient and reliable system. Maximized benefits are attained by having each NHS adopt a standard system within its operations.

It is recommended that the needs of the NHSs and/or the regional organization or basin authority be determined. This should be captured as a list of requirements and features to be possessed by the HIS, thereby making it suitable, for example, for acquiring, processing, archiving and disseminating hydrological data and for developing some hydrological information products (see Annex 4 for a sample list of requirements and functionality and Annex 5 for some examples of hydrological data and information products). Available software for possible procurement may then be evaluated against pre-established functionalities that reflect the requirements of the NHSs. An evaluation of the features of each system is then required for procurement purposes.

It is highly recommended that sufficient support also be given by the vendor for:

- Long-term maintenance of the system, including operating system upgrades and improvements and upgrades to the database and processing system;
- Hands-on support by the vendor for legacy data migration from other digital systems to the new one;
- Introductory training followed by in-depth training of responsible staff on the operation and maintenance of the system; and
- Development of additional functionality as required by the NHSs.

For this purpose, the national data centres of the participating NHSs should be equipped with appropriate computing equipment, an e-mail system and an Internet connection with adequate bandwidth in order to ensure a swift and reliable channel for receipt and exchange of data and products during the implementation of the project and afterwards. As stressed previously, each NHS is responsible for undertaking the primary and secondary processing and validation procedures of data collected within its country under the HYCOS project. The NHS should regularly update rating curves and all relevant metadata for its stations in the HYCOS network.

Functionality to undertake these activities should be an important consideration in evaluating available systems. The most appropriate software meeting or surpassing the agreed-upon requirements should be identified and acquired for use within each NHS.

Additional equipment, such as routers, modems and dedicated data receivers, may be required for computer networking. Depending on the requirements, the system may need to link to the GTS or cellular or landline phone networks or radio-transmission system. Each participating NHS must be provided with the necessary equipment and receive relevant training for its operation and maintenance. Training in using and adapting such systems for the local environment should also be encouraged. Suitable training is required to allow NHSs to take full advantage of the capability of the system.

5.4.2 *Regional database*

Usually within a HYCOS project, an organization such as a regional institution or river-basin authority may be involved in the overall distribution of data and information products with the NHS through the RPC. This is especially important when participating NHSs have limited capabilities and tools for the proper handling and archiving of data. If national capabilities are sufficient, an alternative option for sharing regional data may be explored. A regional database may be designed and created essentially for the storage and distribution of data related to the climatological, hydrological and other water-related information. The source of such data are the participating NHSs, which act as nodes within the overall system. Each NHS is usually connected and provides data to the regional database. To guard against accidents and malicious virus attacks, a mirror image of each country's database will be maintained in the regional database system. This allows for an additional level of data security, which is considered wise, given the intrinsic value of the data to the country. Information and products that are transboundary in nature may be provided using the regional database and the regional water resources information system. Their development may form part of the HYCOS project proposal and as such, all parties may be benefiting directly from them.

The detailed project proposal and the detailed project implementation plan should indicate the data-transmission system to be selected and the model describing the flow of data from countries to the regional database and/or vice versa. In some cases, the regional database may be designated the central node or hub for receiving all raw data directly from the observational network. The data would then be redistributed to the appropriate national data centre for suitable quality control and processing. Once this is done, they would be so identified and stored within the national database and would also be retransmitted to the regional database.

The regional database should use the most appropriate technology available at the time, such as Web-based application software, to enable the creation of a dynamic website. The NHSs participating in the project and the RPC hosting the regional database would be using agreed-upon data exchange formats and protocols to ensure a smooth functioning transference of data. Automatic routines should be developed to facilitate the exchange of data with existing databases, which may have different formats. Interoperability with existing databases developed under other HYCOS components should also be taken into account in the database design.

5.4.3 *Preparation of hydrological information products*

Based on the expressed need as identified in the detailed project proposal and the detailed project implementation plan, national and basin-wide/regional products may be developed to support local sustainable socioeconomic development; provide sound information for the sharing of water in transboundary river basins; and issue timely forecasts and warnings of water-related hazards. As mentioned previously, such hydrological information and products should be identified within the project initiation stage. Based on needs, various types of information and products could result from the implementation of the HYCOS project. These could include regular information on the current availability of water resources, seasonal forecasts, drought prediction, statistical analysis of hydrometeorological data for engineering

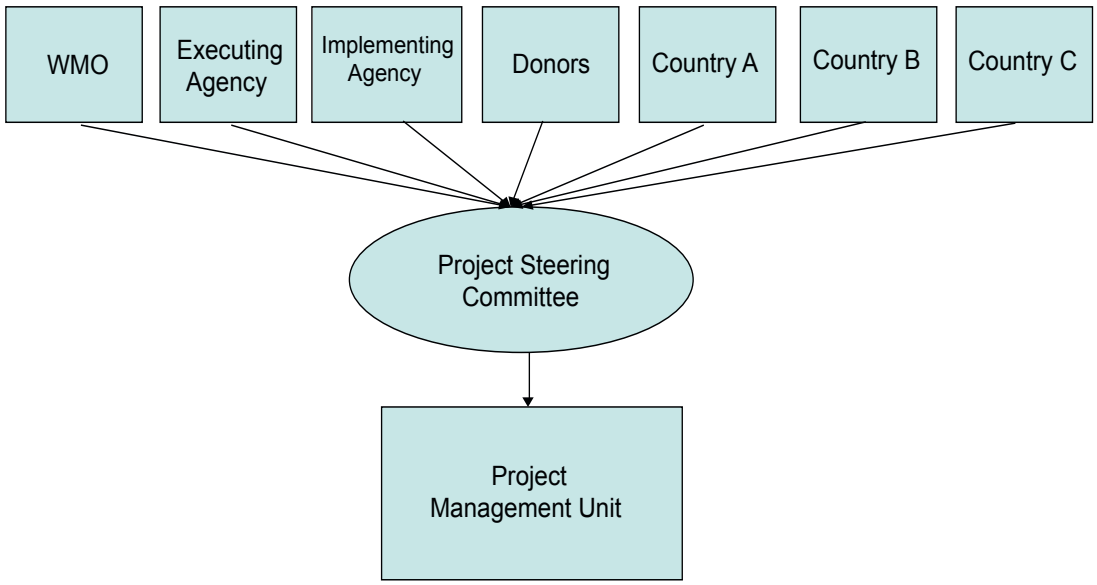


Figure 12. Project-management structure

design, reservoir management, floodplain mapping, spatial distribution of hydrological variables for use by other parties, and so on. Such information and products have the advantage of contributing directly to societal benefits, such as reducing the loss of life and property from flooding and increased agricultural production or hydropower generation. Such a system provides the public and private sectors, as well as the general public, with improved information and knowledge on the current and future state of the river, from which untold benefits may be derived. Such knowledge of the dynamics within a transboundary river has the advantage of improving awareness, understanding and cooperation among jurisdictions.

A comprehensive list of data and information product needs should be carefully assessed when the detailed project proposal is being developed. Important, agreed-upon elements should be included in the detailed project implementation plan. All product-development activities should be undertaken in close consultation with the end users, and their value and effectiveness continually evaluated, using appropriate feedback systems.

5.4.4 *Dissemination of data and information products*

The IWRM concept, now widely adopted to help attain sustainable development, requires a complete flow of data and information products across various jurisdictional boundaries within a country and within the transboundary basin. To ensure this seamless flow, the available tools provided by information technology in the form of the World Wide Web should be used effectively. The development of a website should be one of the activities of each HYCOS project to facilitate the exchange of data and information products among the various participating countries and among various users within each country. The data and information products to be placed on the Internet should be decided during development of the detailed project proposal and the detailed project implementation plan, in consultation with the countries and their identified major user groups and organizations. This mechanism of dissemination also facilitates the broad sharing of data and information products regionally and globally for a variety of potential uses as enshrined in Resolution 25 (Cg-XIII) (see Annex 2).

The Web design should permit easy access to data and information products, both in text and graphic formats. The tools developed for this purpose in other HYCOS projects could provide some insights for possible specific development within the new HYCOS project. Each HYCOS project should also be aware of experiences and lessons learned from the various other HYCOS projects through dialogue with the WMO Secretariat and the WHYCOS portal maintained by WMO.

6. GOVERNANCE AND FINANCIAL ARRANGEMENTS OF HYCOS PROJECTS

Each HYCOS component is developed to meet specific regional and national needs and calls for contributions by participating countries, donors, and organizations. The governance structure should be tailored to address regional or transboundary river-basin and national conditions and needs. To facilitate cooperation and coordination, it is essential to establish a governing structure for the project that:

- Plans, organizes, coordinates, motivates and controls resources;
- Monitors and evaluates progress and takes corrective action;
- Provides guidance wherever and whenever necessary;
- Considers all participating organizations and groups in the decision-making process;
- Promotes transparent financial and administrative practices; and
- Ensures accountability.

A general management structure is described below, recognizing that a specific HYCOS project might adopt it or develop its own structure to facilitate project implementation. This is particularly true for the selection process of project staff and the administrative actions for their recruitment. To facilitate this process, the roles and responsibilities of various entities are provided.

6.1 Donors

The donors provide funding that allows the creation of an enabling environment within which a HYCOS project can be implemented according to agreed-upon criteria. The donors have the right to participate fully in all project-related meetings and are invited to participate as members of any bodies created for project management. The donors normally set requirements for financial audits, which are customarily undertaken in collaboration with the WMO Secretariat. Typically, regular progress reports on the status of project implementation, measured against annual workplans, are required by donors. Donors should also be aware of the complexities of the implementation of field activities and therefore set achievable time targets for project implementation.

6.2 World Meteorological Organization

The WMO Secretariat provides oversight and facilitates the implementation of the project and, if required, will provide technical and scientific back-up. As custodian of the WHYCOS programme, the WMO Secretariat will provide guidance to all involved with the implementation of the project, ensuring that advantage is taken of lessons learned from the implementation of other HYCOS projects and benefits from other ongoing or planned ones. Moreover, the WMO Secretariat is prepared to mediate whenever differences of opinion arise that may negatively influence project implementation and progress. As such, the WMO Secretariat will be invited to participate in any bodies created for project management.

The role and responsibilities of the WMO Secretariat are to:

- Provide oversight of the project;
- Participate actively in any project management body;
- Ensure compliance of the project with WHYCOS principles;

- Assist in bringing together countries and/or a regional institution or a river-basin authority for the development of a HYCOS project;
- Assist in seeking project funding;
- Facilitate project implementation;
- Support implementation by advising on technical standards and QMF/QMS practices;
- Provide technical back-up;
- Provide advice and guidance on specification, preparation and evaluation of tenders for equipment and services;
- Provide advice on the organization of training courses and provide relevant material;
- Provide the link with the meteorological community (NMS and EUMETSAT) to facilitate the use of (a) geostationary meteorological satellite(s) and exchange of data through the GTS and Internet;
- Coordinate the implementation and standards of different HYCOS projects and components through WIAG;
- Mediate to solve differences of opinion that may have a negative impact on the project;
- Lead a mid-term and final evaluation of the implemented project and conduct an evaluation approximately three years following its completion.

6.3 Executing Agency

The Executing Agency (EA) is an organization that has the authority to receive funds from donors and has the lead responsibility to execute the overall project as outlined in a general agreement with participating Members, donors and the WMO Secretariat. The EA may be a regional institution or a river-basin authority and, on occasion, has been the WMO Secretariat when no other regional entity could be identified. The EA is responsible for implementing the detailed project proposal. It will undertake discussions and negotiations with donors and has the authority to sign project-funding agreements on behalf of Members. It will ensure that Members are invited to fully participate in project management and the undertaking of activities and will coordinate their contributions. It will be a member of any project management body.

The role and responsibilities of the EA are to:

- Seek project funding, negotiate with the donors and sign the funding agreement on behalf of the Members;
- Negotiate, facilitate and coordinate participation and contributions from participating Members;
- Implement the agreed-upon detailed project implementation plan with all participating entities, according to approved project documents;
- Initiate and participate in project-management activities;
- Develop an agreement with an organization to undertake implementation of the project as IA (see section 6.5), if required;
- Delegate full project specific authority to the IA for implementing the project, if required;
- Be financially accountable to donors.

6.4 Participating countries

The participating countries will have a number of responsibilities for project implementation. They and/or the river-basin authority have by implication already committed themselves to providing hydrological data and products generated under the project and, whenever possible, historical data. The participating countries will also be responsible for field site preparation, operation and maintenance of instrumentation, calibration of equipment, developing rating curves and undertaking quality-management practices. It remains imperative, however, for the representatives of each participating country to obtain ministerial/high-level level approval for its implementation activities within the regional or river-basin HYCOS project. Therefore, memorandums of understanding between participating countries or the regional institution or river-basin authority and the EA are required in order to guarantee that national cooperation will be forthcoming in all activities as envisaged in the project documents, thereby securing commitments to both the spirit of WHYCOS and the financial and human resources required to make the project a success. The aforementioned provision of data and products, as well as the release and support of NHS staff to participate in project activities, are key responsibilities of participating countries. In addition, participating countries will have agreed to provisions to safeguard the long-term sustainability of investments, allowing the accrual of benefits from the project well into the future. All such contributions are required to make a HYCOS project successful.

The role and responsibilities of the participating countries are to:

- Provide appropriately qualified staff to participate in project activities (office and field activities, training, etc.);
- Support missions by staff undertaking activities associated with the project;
- Manage any impediments to successful project implementation (land access, customs clearance, etc.);
- Carry out site preparation, installation, maintenance and operations and other identified work as per the project documents;
- Undertake discharge measurements and associated surveying to ensure successful calibration of gauging stations and levelling of instruments to a known datum;
- Perform ongoing, routine activities related to the provision of quality-controlled data within the project and following its completion;
- Disseminate validated data and products to users and for archiving on the regional database;
- Provide metadata, including measurement data, rating curves and tables and other pertinent information on project gauging stations for inclusion in the regional database;

Box 5. Executing Agency and Implementing Agency

An example of where there were both an EA and an IA is SADC-HYCOS. The EA was the Southern African Development Community (SADC). Its activities were organized in several major programmes, among which was the programme on infrastructure and services, with water as one of its prominent fields of intervention. A HYCOS project was launched in the SADC region to support SADC efforts for the development of water resources. The Department of Water Affairs and Forestry of South Africa assisted by being the IA and hosted the PMU).

The Niger-HYCOS project can be used to illustrate the opposite case: the Niger River Basin Authority was the EA and as such undertook the implementation of the project.

Figure 13. River gauging site with weir – Carib-HYCOS

- Provide progress and status reports as requested by the project management body;
- Provide information about the project to national interests and the public;
- Make optimum efforts to retain experienced staff and use training, secondment and mentoring to build capacity;
- Undertake awareness-building at the national and community levels;
- Provide validated, long hydrological time series data of non-HYCOS stations to the regional database and the Global Runoff Data Centre for studies of climate change and other studies of a regional and/or international nature.

6.5 Implementing Agency and Project Management Unit

The EA may choose to engage another agency or organization to undertake the implementation of the project when there is not a specialized operational unit within its structure capable of ensuring the implementation of project activities. The organization leading the implementation of the project on behalf of the EA and participating countries is termed the Implementing Agency (IA).

The PMU is the focal point of most activities concerning the project within the IA. The term Regional Project Centre (RPC) is also used to denote a "centre of excellence" associated with the HYCOS project. The RPC can include the PMU and may incorporate other elements related to the provision of infrastructure by the IA in support of the project. It has been stressed that, after completion of the project, the role of the RPC is instrumental in ensuring the continued success of the project.

As previously mentioned, the design of the project structure is intended to be flexible to allow it to reflect local needs and conditions.

The IA and its PMU must have demonstrated technical and project-management capabilities and be widely accepted by the participating countries, regional institution or river-basin authority, donors and stakeholders. The IA may also have dedicated infrastructure to receive, process, store

and disseminate data from a variety of sources (for example, telemetered data and human observers). The IA may host the regional database, the regional water resources information system and the HYCOS project website, as well as contributing substantially to the PMU.

The roles and responsibilities of the IA are to:

- Delegate full specific project authority to the Project Manager, for the purposes of managing the PMU;
- Keep in close contact with the EA, participating countries, donors and WMO Secretariat on a variety of issues to facilitate timely implementation of the project;
- Provide facilities to house the PMU within the RPC and to provide the necessary infrastructure to make the data receiving system operable, regional water resources information system, regional database, etc.;
- Provide infrastructure support to acquire and process project data, maintain and update the regional database and develop and maintain the regional water resources information system and the project website;
- Provide the human resources and financial and administrative assistance required to manage implementation of the project;
- Provide administrative and secretarial support to the PMU (including recruitment of staff);
- Provide facilities and logistical support to the PMU (premises, telephone, electricity supply, Internet connection, IT support, etc.);
- Coordinate with other water-related projects in the region or basin.

The PMU is established and hosted by the IA to execute tasks identified in the detailed project proposal. Some of the first activities usually include staffing of some key positions to allow commencement of work and the development of the detailed implementation plan and its associated workplan. The role of such a group is crucial for the success of a HYCOS project, as it has the prime responsibility for day-to-day project implementation. The PMU should invariably be located in an existing regional institution, river-basin authority or national institution selected on the basis of the terms of reference as agreed to by the participating countries.

The IA shall, among others, make available office and warehouse space, telecommunications (telephones, Internet access and fax machines) and other logistical support, as required. The role of the IA is crucial to the success of the project as it provides the institutional and administrative capacity to develop and foster the PMU and to support its efforts in implementing the project. Upon completion of the project, the IA may also have a continuing role in maintaining and updating the regional database and the regional water resources information system. Such aspects should be reflected in the project documents, as they contribute significantly to the long-term sustainability of the project.

The PMU may be a separate entity or group within the IA and may be staffed through assignments, secondments, international exchanges, contract positions or whatever human resource and financial approaches are suitable for the host institution. However, the existence of the PMU is usually restricted to the duration of the project as its main function is to manage and coordinate project activities implemented in and by the participating countries. As previously mentioned, some functions of the PMU may be devolved upon completion of the project to other groups to allow the functionality attained through the project to continue. Funding of this requirement should be considered when project inception is being discussed by the participating countries, the regional institution or river-basin authority, the WMO Secretariat and donors.

The role and responsibilities of the PMU are to:

- Obtain, coordinate and manage funding received from the EA, using the financial and administrative rules and procedures of the IA;
- Prepare a draft detailed project implementation plan for consideration by the project management body, termed the Project Steering Committee (PSC) (see section 6.6);
- Manage the overall implementation of the project;
- Provide financial and administrative control and reporting on the project;
- Manage the provision of services, service contracts and the procurement of materials and equipment under the individual project activities subject to IA procedures and donor modalities;
- Foster regional technical and scientific cooperation;
- Provide a forum for exchange of expertise and knowledge;
- Coordinate the project activities with other water-related projects in the region;
- Act as a focal point to coordinate the installation of field and information technology equipment in participating countries and provision of technical support and training;
- Act as a focal point to coordinate the project activities implemented in and by the participating countries;
- Report on the progress of the project in a standard format to the PSC, noting that separate reporting of progress may be desired by various participating agencies and organizations (for example, the EA, WMO Secretariat, donors);
- Provide secretarial support for organizing meetings of the PSC and preparation of meeting reports.

It is to be noted that the above-mentioned roles and responsibilities of the IA would be ascribed to the EA in the event that it directly implements the project. An agreement must be reached between the donor(s) and the agency undertaking implementation regarding financial procedures and accountability to ensure that the requirements of both parties are met.

6.6 Project Steering Committee

HYCOS projects usually have a PSC that represents the highest executive authority. It is formed to make executive decisions on project direction, activities, initiatives and implementation. The group is called the PSC owing to the responsibility of steering or directing the overall implementation of the project.

The PSC provides the top-level governance and administration of the project, while also providing clear direction to the Project Manager and the PMU and may also focus on the formulation of strategies and approaches for achieving the project's key results. It should also pay close attention to creating and strengthening linkages with the broader user community, thereby increasing the value of the data and products generated through the implementation of the project.

The PSC consists of all heads of NHSs participating in the project, representatives of the EA, the IA (should one exist), donor(s), the WMO Secretariat, and the Project Manager. The PSC should deal with matters as they arise via e-mail or teleconferencing to save costs and time, thereby arriving at decisions and providing guidance in a timely fashion. The PSC should meet at least

once a year and when matters cannot be effectively handled by the aforementioned communication technologies. Members are responsible for informing their parent organizations on activities pertaining to the project, thereby keeping everyone informed on progress and the importance of the project. The PSC is responsible for enforcing discipline and is empowered to suspend and request replacement of a representative from an agency or a Member should incidents of a negative nature influence or retard project implementation or progress.

Should a meeting be convened, the PMU normally provides secretarial support. The PSC may be chaired by the representative of the EA or the chairperson may be selected by the membership.

The role and responsibilities of the PSC are to:

- Develop strategies and approaches to facilitate implementation of the project plan;
- Review, revise and approve the project implementation plan and its associated workplan;
- Evaluate progress by Members against self-determined implementation workplan milestones;
- Evaluate progress of the PMU against workplan milestones;
- Review, evaluate and take corrective action on an ongoing basis on the project implementation process;
- Develop and oversee implementation of mechanisms to strengthen project ownership by Members;
- Identify actions and negotiate with entities to further the goal of long-term project sustainability;
- Identify regional bodies and other interest groups for possible collaboration under the project;
- Ensure the policies identified by the PSC are upheld at project implementation level;

Figure 14. Water management – spillway for a reservoir

Source: Eric Hervo

- Mediate conflicts or disagreements among participating countries/parties;
- Review, revise and approve any changes to the project document, the project implementation plan, the workplan and budget; and
- Provide a communication channel with regional bodies and other users.

6.7 Financial arrangements

Data and information related to water are essentially a public good. This is more so in the context of the new IWRM paradigm, in which all stakeholders, including the general public, are expected to participate. As such, basic hydrological data collection should be, and is generally seen as, providing a public service and is largely funded through public finances. In recent years, however, the move towards a market economy has blurred this concept and public funding for maintaining basic hydrological data is on the decline in many countries. The WHYCOS programme is an attempt to reverse this trend by providing initial support for an improvement of the existing network, capacity-building and forging stronger linkages with users, thereby demonstrating the attainment of societal benefits. The long-term responsibility for the sustainability of the network and provisions of products, however, remains with national governments. This section describes the financial arrangements envisaged for the development, execution, management and sustainability of the HYCOS components.

WHYCOS is one of the major programmes designed to address these issues. It is a project undertaken under the Basic Systems in Hydrology subprogramme of the HWRP of WMO. Since the magnitude of the problem being addressed through this project is vast, it cannot be handled through the regular budgetary resources of WMO. Support from international and bilateral funding agencies is required to allow benefits to be attained through implementation of the WHYCOS programme.

6.7.1 *World Meteorological Organization*

As described earlier, the project cycle starts with interested countries making a request to WMO for the development of a HYCOS project. WMO assists the interested countries or regional institutions making the request in the initial stages of the project by undertaking negotiations and other related activities from its regular budget. After receiving a commitment from the countries to comply with the WHYCOS Guidelines and a memorandum of understanding to cooperate to develop the project, WMO prepares a brief project concept document for submission to potential donors. The cost of these activities is met by WMO, which also undertakes to assist the countries and the regional institutions in seeking funds for the project implementation stage.

WMO will provide oversight of the project implementation stage to ensure that the project is implemented in accordance with the WHYCOS vision, principles and objectives. In its oversight role, WMO acts as a catalyst in bringing countries and interested entities together, contributes to the preparation of the project documents and undertakes periodic evaluations. The activities undertaken by the WMO Secretariat in performing its functions in the project implementation stage are financed through project funds. The cost of the activities reflect the person-months of staff and/or consultants expected to be spent on the provision of oversight and technical support, as well as travel and travel-related expenditure. Such costs are subject to overhead charges, according to the WMO financial rules.

6.7.2 *Donors*

It is important that potential donors are involved early in the process from project initiation to implementation to the post-project maintenance stage. This may require additional efforts

Box 6. African ministerial commitments on implementation and partnerships for achieving the water and sanitation targets

Too many preventable diseases and deaths and economic losses are caused by floods, droughts, pollution and other water-related hazards. Droughts, floods and storms are becoming more common and severe in Africa. The human and environmental costs of weather, climate and water related disasters have increased dramatically over the past 40 years. Equilibrium shifts are impacting the resilience of ecosystems, affecting water availability and creating increased water stress in many regions. Hydrological and meteorological data and information are essential for fundamental basis of IWRM.

- To increase our funding to the institutions responsible for the maintenance and operation of the hydrological and meteorological networks in Africa and to enlist, for this purpose, the support of development cooperation partners and financial institutions.

- To foster data and information exchange as a baseline requirement to ensure improved early warning and forecast, especially in trans-boundary basins.

- To support the expansion of the World Hydrological Cycle Observing System (WHYCOS) and other networking mechanisms to cover all regions and river/lake basins in Africa.

Pan African Implementation and Partnership Conference on Water
(Addis Ababa, Ethiopia, December 2003)

(a)

(b)

Figure 15. Water use: (a) hydroelectric power generation; (b) irrigation

Source: Diana Garcia/Shutterstock)

for all involved, but helps to ensure that aid is achieving the intended results. Within this process, it has been recommended that countries and donors adopt the Paris Declaration on Aid Effectiveness (OECD, 2005) when working with WMO on implementing the WHYCOS concept through the HYCOS project. It is envisaged that doing so would greatly assist the effectiveness of the project and its potential for achieving the desired outcomes (WMO, 2011(a)).

As a result, it is expected that there will be increased flexibility to better reflect the amount of time that might be required to properly implement components. It is also expected that donors will ensure that the financial aspects of the project comply with their administrative requirements.

The role of donors in HYCOS projects is to:

- Provide financial support to the project;
- Provide financial guidance to the various entities involved;
- Ensure that EA/IA expenditures and tendering procedures are carried out according to the financial agreements signed by the parties.

By definition, a HYCOS project generally covers large areas and activities involving a number of countries and its implementation may continue over a period of several years. Thus, the cost of the project implementation stage is substantial and may not fall within the interest zone of a single donor. In such a case, it would be necessary to pool resources from different donors through different channels (international, regional, bilateral). This also means that it might sometimes be preferable to limit the size and scope of a specific HYCOS project or approach the overall design through separate phases. As the number of funding sources increases, however, a number of constraints and problems arise, notably in the financing aspects of the different donors, such as the application of different administrative rules on the eligibility of some countries to receive grants, tendering procedures, timing and type of audits, etc. Moreover, for the sound evaluation of the cost-effectiveness of their contribution, some donors prefer to fund an identified stand-alone project rather than contributing in a non-differentiated manner to the support of a larger project. In such a situation, the donor is encouraged to fund specific activities of the project through WMO. In such cases, the project should adopt WMO's financial regulations and procedures.

6.7.3 *National Hydrological Services*

NHSs should have a substantial involvement from the inception of the project and will have assured that the activities of the project are aligned with national priorities. NHSs will undertake the implementation process at the national level. They will carry out all the site preparation, maintenance and installation activities inside the country and provide logistic support for project implementation. The cost of these activities should be covered by NHSs as national contributions to the project, unless otherwise specified in the project proposal. They will contribute, coordinate activities and cooperate to ensure successful implementation. They will also run and maintain national aspects after donor support ends to ensure project sustainability. This commitment is well reflected in the declaration below.

6.8 **Project sustainability**

The HYCOS project is seen as a vehicle to strengthen technical, human and institutional capacities of NHSs of Members in hydrological data collection and in the development and dissemination of information products. A project is successful through a combination of conditions or factors being attained and the continuation of efforts beyond project completion to allow the continuation of benefits to accrue.

The conditions and factors that lead to success include:

- Recognizing the magnitude of the problems that are being tackled by the project, realizing that long-term commitments and continued efforts are required to correct systemic programme weaknesses;

- Having a regional institution or river-basin authority that will be the project champion and will work closely with participating countries on attaining project goals and desired outcomes well into the future;

- Designing the project to truly meet the requirements of the local communities to attain affordable solutions for the participating countries and the regional institution or river-basin authority after completion of the project;

- Participating countries taking national ownership of their networks and developing and maintaining the capabilities to operate and maintain them;

- Valorizing data collected through their use, such as in flood-risk management and disaster-risk reduction, including the provision of flood forecasts and warnings.

6.8.1 ***Commitment***

The long-term commitment of participating countries is required to support their NHSs in its day-to-day activities, such as data collection, operation and maintenance of the network, quality control and primary processing of data, database updating, preparation of products and dissemination of data and information products. Such support should be persistent and tied to the performance of the NHSs in providing reliable, quality-assured data and information products for a multitude of users. At the onset of the project, memorandums of understanding should be developed, indicating the strong support of the participating country to the success of the HYCOS project.

The regional institution or river-basin authority must also be committed in the long term to assist the NHSs. This commitment should be demonstrated through the establishment of an RPC, usually comprising hydrological and other expertise, as required. Based on the HYCOS project design, the RPC may provide regional information and products at the national level and could greatly assist in capacity development, including training of NHS staff. Regional information and products could include the status (storage and use) and trends of water resources along international waterways, seasonal forecasts, flood forecasts and guidance, drought outlooks, status of accidental pollution spills, etc.

Preliminary meetings with information users and decision- and policymakers (Ministry of Finance, Prime Minister's office, etc.) should be used to raise awareness of the benefits of the project and the continuous collection of hydrological data and dissemination of water-related information.

6.8.2 ***Affordability***

It is important to choose solutions that are affordable over the long term. In some cases, relatively expensive modern technology has been acquired without forethought of the ability of the NHS to maintain or replace the equipment from its budget during the post-project maintenance stage. This is exacerbated when in situ modern equipment is vandalized or stolen, thereby raising concern about the ability of the individual NHS to afford replacements or even continue deploying equipment. Depending on the circumstances, it may be more affordable and more desirable to maintain human observers rather than modern technology. It may be useful to retain them even when new technology is deployed for redundancy, should the modern equipment be vandalized, stolen or broken, and to provide check readings for quality-control purposes.

Care should also be taken to ensure that the instruments and technology for HYCOS components are selected to withstand local, adverse extreme-weather conditions. Efforts should be made to ensure consistency of instruments and technologies of the HYCOS project with those already being used in the country, unless they are obsolete or outdated. This will enable countries to obtain spare parts and keep expertise available for the functioning and maintenance of the instruments and equipment under the project in the long term. At the time of developing the project document or before deciding the detailed specifications of the instruments and equipment, an overview of the available hydrometeorological equipment and technology being used by the countries should be considered, including the facilities, expertise and infrastructure available for its maintenance.

6.8.3 *Capacity-building*

The main objectives of the WHYCOS programme (section 3.3.3) can be described simply as "capacity-building". Capacity-building should be designed to help the NHSs and Members achieve their development goals and measurable and sustainable results. To do so requires understanding the issues or obstacles that are inhibiting the people, communities and governments from achieving their goals and to put in place a series of actions that are designed to achieve sought-after but elusive success.

The design of the HYCOS project is intended to be flexible so as to allow its associated efforts to meet local and regional needs. It has also been developed to strengthen the technical, human, institutional and operational capacities of Members' NHSs in hydrological data collection and management and in the development and dissemination of information products. Much attention needs to be given to both aspects (data collection and development/dissemination of information products), as it is through their combined attainment that success is achieved. This underscores the importance of valorizing the collected data, which, through their repeated use, address a number of needs, such as the planning and design of infrastructure in the floodplain, delivery of flood forecasts and warnings, emergency preparedness, drought prediction, fisheries management, irrigation, etc.

For a HYCOS project to be successful, the capacity-building effort must also be successful. It should focus on reinforcing specific, targeted capabilities of NHSs in technical fields that contribute to the long-term sustainability of the project results. Given that these should be striving to achieve positive societal impacts, such as reducing the risk of loss of life and property damage from floods, the project needs to build linkages with local communities, the media and external organizations that have a primary mandate to attain the societal benefits, for example, national disaster-management organizations.

HYCOS projects usually have a strong element of training in their design, typically targeting the staff of the participating NHSs. The scope of training topics can be broad, as well as highly specialized, with the curriculum being designed to achieve the desired project results. For example, should the project include the issuance of flood-warning products, managers need to fully understand and recognize the range of user requirements so that the flood-warning products, data and information can be tailored to meet their needs. Training should be provided to end users as to what the information means and how it can be used to benefit their operations (WMO, 2011(b)). Training may be viewed broadly to include user groups, such as local communities, so that they are aware of what the flood warnings mean and what actions to take.

Training may be provided on a variety of topics, which include:

- Installation, commissioning, operation, maintenance and trouble-shooting of hydrometric and hydrological equipment and sites;
- Use of WIS and GTS (if applicable);
- Management and use of HISs;

Figure 16. Staff downloading data using a portable computer

Source: French Institute for Development Research

- Data-quality control and assurance procedures;
- Development and issuance of flood forecasts and warnings;
- Development and issuance of water-availability forecasts and drought prediction;
- Establishing understanding of forecasts and warnings by users;
- Preparing and marketing hydrological data and information products for water resources management, etc.; and
- Broad dissemination of data and information products for a variety of uses, including local, national and global hydrological studies related to climate change.

Priority areas for capacity building are given in Box 7.

It is highly recommended that training programmes be designed to increase local capacity. Part of the training programme should be on-the-job practical experience and mentoring after completion of classroom training or distance learning. Assignment of staff to allow growth of expertise in different areas and to obtain on-the-job experience in the training topic should be considered. After assignment or secondment has been completed, the individual, on return to the NHS, should apply his/her knowledge and skills to further the training programme within his/her own NHS. The sought-after expertise should be acquired by trainees in participating countries and/or basin authorities. Practical application after training is necessary to retain knowledge and build personal competencies. All employees should be trained according to the needs of their position to ensure appropriate implementation of standards and recommended practices and procedures under various circumstances and conditions. Trainees should be selected to ensure they have appropriate backgrounds, with selection being based on needs. When human observers are involved in the observing activities, they should receive adequate

Box 7. Priority areas in training for capacity-building

Priority areas in training for capacity-building are divided into three categories: core activities, tools and applications and management.

1. Core activities
- Design and evaluation of hydrological networks
- Hydrological instruments: maintenance, upkeep and calibration
- Standard data-collection methodologies (including water-quality monitoring)
- Streamgauging
- Installation, operation and maintenance of stations
- Safety measures in hydrometry
- Data management (processing, storage, retrieval and dissemination)
- Quality management

2. Tools
- Water resources information systems
- Hydrological information systems
- Hydrological modelling
- Hydrological forecasting systems
- Flood-forecasting techniques
- Remote-sensing

3. Applications and management
- Water resources assessment
- Flood forecasts and warnings
- Integrated water resources management
- Extreme event analysis and design flood estimation
- Environmental issues (impact assessment and ecological flow requirements)
- Irrigation and agricultural drainage
- Management of hydrological services
- Evaluation of national capabilities
- Project development and management
- Reservoir management

Figure 17. The WHYCOS website

training to perform their expected duties. Adequate resources shall also be made available to pay their allowances.

7. POLICY AND COORDINATION

7.1 Data exchange and dissemination

In implementing a HYCOS project, it is understood that that countries are the owners of their data, metadata and information products and are responsible for the control thereof in accordance with national regulations. It is also understood that countries are responsible for ensuring that quality-management procedures have been followed, leading to validated, reliable data and information products. It is an absolute priority, therefore, that all countries participating in a HYCOS project are able to send and receive data and information products. All countries must have in place the technology and appropriately trained staff to undertake appropriate checks to ensure the quality of data and information products transmitted by the network.

In order to develop and maintain a regional framework for cooperation, the hydrological data and products emanating from the HYCOS project shall be shared among the participating countries in a timely manner in a free and unrestricted fashion, in accordance with the WHYCOS principles (section 3.3.4). Furthermore, all participating countries shall comply with Resolution 25 (Cg-XIII) – Exchange of hydrological data and products (see Annex 2). Moreover, countries are encouraged to contribute data and information to global data centres, such as the Global Runoff Data Centre, the Global Precipitation Climatology Centre and the Global Environmental Monitoring System for Water, not only from the stations established under the HYCOS projects, but also from additional national hydrological stations. Such data are valuable for establishing patterns in trends or changes that are occurring at the continental to regional and national levels, developing hydrological products, building models to estimate the frequency of occurrence of hydrological extremes on ungauged basins, and to support climate-change modelling, as well as climate-adaptation studies. These datasets will enable scientists and engineers to undertake studies that benefit society. Whenever data are used, the source – the NHS – is to be acknowledged.

During the project initiation stage, participating countries will usually undertake an agreement (see Annex 3) to share and ensure access to hydrological data and information products. This agreement should address: (a) the real- and near-real-time hydrological data collected by the project; (b) hydrological data collected by the project from sites not equipped with transmission systems; (c) hydrological data collected from non-HYCOS project sites; and (d) the corresponding historical data and metadata collected for the sites identified in (a), (b) and (c).

An example of data-exchange policy developed in a shared international basin is given in Annex 6 (Policy on the Exchange of Hydrological and Meteorological Data and Information in the Sava River Basin).

7.2 WHYCOS coordination mechanism

To support and ensure successful implementation of the WHYCOS programme, it is recognized that its activities need to be adequately coordinated and an appropriate mechanism established therefor. The mechanism consists of two components, namely the WHYCOS Coordination Group (WCG) and WIAG. These are described below.

7.2.1 *WHYCOS Coordination Group*

WCG serves as an internal WMO coordination mechanism to ensure that the inputs of the various departments within the WMO Secretariat are linked to the WHYCOS programme and the

individual HYCOS projects. While the overall responsibility for the development and implementation of the WHYCOS programme resides with the Climate and Water Department, WCG has been established to help address overall policy aspects related to WHYCOS, as well as to help ensure the coherence of WHYCOS activities with other WMO programmes and projects. WCG meets once or twice a year, depending on needs.

The WCG members are the Secretary-General, Deputy Secretary-General, Assistant Secretary-General, all Directors of the technical departments contributing to WHYCOS, and the Director of Resource Management, who acts as secretary. Directors of the Regional Offices can also participate, as appropriate. WCG meetings that address overall policy aspects related to WHYCOS are chaired by the Secretary-General, while those concerning implementation issues are chaired by the Deputy Secretary-General. The WCG establishes a task team for each HYCOS project to assist with guiding project development and implementation.

The terms of reference of WCG are to:

- Ensure coordination of technical, scientific, legal and resource mobilization and policy aspects of the implementation of specific HYCOS components, including preparation of agreements;
- Establish cost-recovery mechanisms for those HYCOS components in which WMO plays an oversight role; and
- Ensure coherence with other WMO programmes and projects.

7.2.2 *WHYCOS International Advisory Group*

WIAG serves as an external coordination mechanism to ensure worldwide operational linkage among the various HYCOS components and to coordinate all technical aspects of the programme. It provides overall guidance for establishing a common conceptual basis and ensures consistency of practices and results. Annex II to Resolution 4 (CHy-14) (WMO, 2012) provides the specific terms of reference. It states that WIAG shall:

(1) Consider and advise WMO on the concept, objectives, expected benefits/costs and future development of WHYCOS;

(2) Review and assess the status of WHYCOS, and the progress towards its objectives, and propose strategies for any necessary remedial action;

(3) Review the relationship of WHYCOS with other relevant international programmes, particularly from the point of view of coordination and avoidance of overlap and duplication, and propose any necessary actions;

(4) Identify and evaluate constraints on, and potential risks to, the future implementation and sustainability of WHYCOS, and propose strategies to minimize those risks. Risks include, inter alia, those of a financial, technical, operational and institutional/political nature;

(5) Consider and propose plans for the effective promotion and dissemination of the achievements of WHYCOS;

(6) Consider and propose ways and means of engaging with donors in all project stages, especially for the future sustainability and appropriate expansion of WHYCOS;

(7) Review and advise on the terms of reference and composition of WIAG.

WIAG is composed of the president of CHy (chairperson); one representative from each operational HYCOS project; one representative from each active technical partner and donor; and one representative of the Advisory Working Group of CHy or appointed CHy expert. Other persons may be invited from time to time to participate as observers, including regional

hydrological advisors; representatives of prospective donors; representatives of perspective HYCOSs; representatives of prospective technical partners and other relevant international programmes and regional groupings; and representatives of other relevant WMO programmes.

In addition, observers may be invited by WIAG to participate in certain meetings, depending on the agenda, such as representatives of chairpersons of the Regional Associations' Working Groups on Planning and Implementation of the WMO World Weather Watch Programme; relevant regional groupings, for example the Southern African Development Community (SADC) and IGAD; other donors; other related global programmes, such as the Global Runoff Data Centre, the Global Environmental Monitoring System for Water, the Global Climate Observing System and Flow Regimes from International Experiments and Network Data; international scientific and professional associations (for example, the International Association of Hydrological Sciences and the International Commission of Irrigation and Drainage); and other users. WIAG meets every one to two years, with the Director of the WMO Hydrology and Water Resources Branch acting as secretary.

7.3 Collaborating institutions

A collaborating institution is designated by WMO Secretariat on the basis of certain criteria to form part of an international collaborative network carrying out activities in support of the Organization's programmes at various levels. A department or laboratory within an institution undertaking research, development, managing operational programmes or training activities may be designated as a collaborating institution. A collaborating institution plays an essential role in helping the Organization in implementing its work and programme priorities, in close coordination with the WMO Hydrology and Water Resources Branch, and assists in developing and strengthening the institutional capacity of countries and regions.

7.3.1 *Criteria for a collaborating institution*

A collaborating institution should possess some of the following characteristics:

- Engagement in water-related activities;
- Excellence in the field of hydrology and/or water resources;
- Experience in WMO activities;
- Good facilities for training and research;
- Ability to generate and raise funds;
- Good links with potential donors.

7.3.2 *Tasks of a collaborating institution*

Within the WHYCOS context, a collaborating institution may carry out the following functions:

- Assists in preparing draft HYCOS project proposals;
- Assists with project implementation through the introduction and monitoring of standard operating procedures and capacity-building;
- Assists with the identification and development of hydrological products to meet specific national and regional needs;
- Assists in technology transfer among HYCOS projects;

- Assists in mobilizing funds in support of the programme; and
- Assists WMO in undertaking specialized studies, such as hydrological cycle changes induced by climate change.

8. PROJECT MONITORING AND EVALUATION

Monitoring and evaluation are essential management functions that are interactive and mutually supportive. Monitoring and systematic reporting on progress must be undertaken for all projects.

8.1 Project monitoring

Participating countries will be required to supply and report on all raw data and the importation of validated data into the national and regional databases. These statistics should allow an assessment of the success of: data acquisition; data processing, including quality checks; and transfer of data for all hydrological elements (see section 5.1.3). The latter should allow assessment of the transfer of data by Members to other participants in the HYCOS project and the broader community. Progress as regards the creation and use of hydrological products and feedback received for the user communities, as well as the extent to which the project website is used should be reported, among others. These reports should be circulated by e-mail to all members of the PSC prior to meetings for discussion. They are also required by the Project Manager to assess ongoing achievement of milestones and target any corrective measures, such as additional assistance, with participating Members.

The Project Manager will report on progress, through use of e-mail or other agreed-upon means, to all members of the PSC. The frequency of such reports will be as directed by the PSC. One such report may be delivered at the PSC meetings, if timing is appropriate. The timing of PSC meetings should take into account required reporting cycles when determining meeting dates. The report should focus on achievements, successes and failures in implementation, against the implementation schedule and relevant workplans (milestones) and should assess and highlight performance. Attention should be paid to problems, detailing why they are occurring, and suggested actions that should be or are being taken and by whom, to overcome them. Reports will also contain detailed financial information as required to assess expenditure, assist financial planning and facilitate requesting project funds from the donor(s). Any major implementation deviation should be reported, with justification, to the PSC.

It will be the prerogative of the donor(s) to decide if and when implementation and achievements are evaluated. Project monitoring should, however, include a mid-term evaluation and, where necessary, a redefinition of targets and a review of the strategy for achieving overall targets and objectives.

Monitoring and evaluation reports should be submitted to the PSC for review. Such reports could contain recommendations in respect of changes to strategies, targets or objectives and would be considered for modification and possible adoption by the PSC.

8.2 Post-project evaluation

The WHYCOS programme includes the undertaking of two post-project evaluations to help assess overall achievements, performance and the sustainability of activities. One is to be undertaken upon completion of the project, while another is to be undertaken approximately three years after the first. The requirement for the two post-project evaluations should be reflected in the project proposal, keeping in mind any requirements of the donor(s) associated with the project, as they may have requirements for similar reviews. Coordination of such reviews is recommended.

Post-project evaluation is a tool to allow the assessment of the success of the project. The first post-project evaluation should address various questions, such as: "Did the project accomplish what it set out to do?"; "If it did not, why not, and what remains to be done?"; "Are there any follow-up activities that should be undertaken?"; and "Are there any lessons learned that should be shared with other projects?". The first report captures and documents key project metrics after project completion for the purpose of comparing and validating attainment of the initial objectives, explaining significant deviations and providing guidance for future activities or additional phases for the project. It could also record the satisfaction of participating Members, the regional institution or river-basin authority and users with the project and include what it has been able to attain. The first evaluation is also intended to assess the effectiveness of the processes and methods used in the project for the purpose of capitalizing on successes and ongoing continuous improvement.

The second evaluation is undertaken to confirm the status of the achievements of the project, which is an assessment of the sustainability of the investments made. Such an evaluation would assess activities, approaches and capacities from pre-project to close of project to the final evaluation. This evaluation may well highlight the need for further activities and corrective measures, specifying what they might be, and why they would be required.

WMO, in collaboration with the donor(s) and EA, which may be a regional institution or a river-basin authority, should appoint (an) independent expert(s) for post-project evaluation. The evaluations should also focus on the success of knowledge transfer and technology, an assessment of the continuation of the project for a further phase and if there remains a need for a PMU and RPC. The cost of such evaluations should be included in the project budget.

REFERENCES

Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof (Eds.), 2008: *Climate Change and Water*, Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp.

Frigon, M., A. Bouchard and B. Pessah, 2010: *Hydrological Information System (HIS) Requirements and Inter-Comparison of Commercially Available Systems*, Hydrology and Water Resources Branch, WMO, Geneva, 62 pp.

IPCC (Intergovernmental Panel on Climate Change), 2012: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (C.B. Field, V. Barros, T.F. Stocker, D.Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (Eds.)). Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 582 pp.

OECD (Organisation for Economic Co-operation and Development), 2005: *The Paris Declaration on Aid Effectiveness*. http://www.oecd.org/dataoecd/11/41/34428351.pdf

———, 2008: *The Accra Agenda for Action*. www.oecd.org/dataoecd/11/41/34428351.pdf

United Nations, 1993: *Agenda 21*, United Nations Conference on Environment and Development (UNCED), Earth Summit, Rio de Janeiro, Brazil, 3–14 June 1992, 300 pp. http://sustainabledevelopment.un.org/content/documents/Agenda21.pdf

UNESCO (United Nations Education, Scientific and Cultural Organization, 2006: *FRIEND – A Global Perspective 2002–2006*. (E. Servat and S. Demuth (Eds.)). IHP-HWRP, Koblenz, Germany.

WMO (World Meteorological Organization), 2000: *Establishment of a Global Hydrological Observation Network for Climate*, WMO/TD-No.1047, Geneva.

———, 2005: *WHYCOS Guidelines – Hydrological Information Systems for Integrated Water Resources Management*, WMO/TD-No. 1282, Geneva.

———, 2006: *Technical Regulations*, Volume III: *Hydrology*, WMO-No. 49, Geneva.

———, 2008: *Guide to Hydrological Practices*, Volume I: *Hydrology – From Measurement to Hydrological Information*, WMO-No. 168, sixth edition, Geneva.

———, 2009: *Guide to Hydrological Practices*, Volume II: *Management of Water Resources and Application of Hydrological Practices*, WMO-No. 168, sixth edition, Geneva.

———, 2010: *Manual on Stream Gauging*, Volume I: *Fieldwork* and Volume II: *Computation of Discharge*, WMO-No. 1044, Geneva.

———, 2011(a): *Comprehensive Review of the World Hydrological Cycle Observing System*, Geneva.

———, 2011(b): *Manual on Flood Forecasting and Warning*, WMO-No. 1072, Geneva.

———, 2012: *Commission for Hydrology (CHy) – Fourteenth session: Abridged final report resolutions and recommendations*, Geneva, 6–14 November, WMO-No. 1105, Geneva.

World Water Assessment Programme (WWAP), 2003: *World Water Development Report 1: Water for People, Water for Life*, UNESCO, Paris.

ANNEX 1. RELEVANT RESOLUTIONS OF SIXTEENTH WORLD METEOROLOGICAL CONGRESS

Resolution 12 (Cg-XVI)

HYDROLOGY AND WATER RESOURCES PROGRAMME

THE CONGRESS,

Noting:

(1) Resolution 20 (Cg-XV) – Hydrology and Water Resources Programme,

(2) Resolution 7 (CHy-XIII) – Work Programme and Structure of the Commission for Hydrology,

(3) Recommendation 1 (CHy-XIII) – WMO Strategic Plan 2012–2015 and Monitoring and Evaluation of the Hydrology and Water Resources Programme,

(4) Resolution 5 (EC-LXI) – Report of the thirteenth session of the Commission for Hydrology,

(5) The WMO Strategic Plan,

(6) The report of the president of the Commission for Hydrology to Sixteenth Congress,

(7) The report of the High-level Taskforce on the Global Framework for Climate Services, Climate Knowledge for Action: *A Global Framework for Climate Services – Empowering the Most Vulnerable* (WMO-No. 1065), discussed by Sixteenth Congress under agenda item 11.1,

(8) Resolution 25 (Cg-XIII) – Exchange of hydrological data and products,

Considering the need to develop ways to bridge the gap between the climate information being developed by the scientific community on the one hand, and the service providers and the users in the water sector, on the other hand, with a special emphasis on efforts to adapt to global change, and that water resources assessment is an indispensable prerequisite for a sound operational basis for such endeavours,

Urges Permanent Representatives to appoint Hydrological Advisers, duly giving consideration to the fact that hydrological activities are undertaken by various institutions within the countries;

Endorses the WMO Strategy on Education and Training in Hydrology and Water Resources (Annex 1 to Resolution 5 (CHy-XIII) – Capacity-building in hydrology and water resources);

Decides to adopt the Hydrology and Water Resources Programme (HWRP) for the period 2012–2015 as described in Annex II to the Report of the Sixteenth World Meteorological Congress;

Requests the Executive Council and Secretary-General to take all the necessary actions:

(1) To arrange for the implementation of the Hydrology and Water Resources Programme and to assist the Commission for Hydrology and all bodies concerned in its implementation, in accordance with **Decides** above;

(2) To ensure that WMO continues playing an active role in UN-Water, the inter-agency coordination mechanism of the United Nations system on water-related issues;

(3) To continue to provide support to regional activities of the Hydrology and Water Resources Programme;

(4) To support the cooperation between HWRP and other governmental and non-governmental organizations;

(5) To reaffirm Resolution 25 (Cg-XIII) as an essential cornerstone in the efforts to seamlessly address climate and water issues from scientific research to policy development and operational implementation;

Requests the president of the Commission for Hydrology:

(1) To promote cross-technical commission and cross-programme cooperation in areas of concern to the Commission;

(2) To encourage and support active collaboration between the Commission and the regional associations, in particular their groups related to hydrology and/or water resources management;

(3) To fully engage with the governance and implementation of the Global Framework for Climate Services (GFCS);

(4) To ensure that the Commission takes an active part in facilitating the active role of National Hydrological Services and National Meteorological Services in the user interface component of the GFCS, to promote the development and delivery of user-oriented climate information and prediction services meeting the needs of climate variability and change adaptation in the water sector;

(5) To seek to further improve the coordination of the Hydrology and Water Resources Programme with the International Hydrological Programme of the United Nations Educational, Scientific and Cultural Organization and to collaborate with other UN-Water agencies in areas of common interest;

Requests the regional associations to take into account, while deciding on the structure of their subsidiary bodies, the benefits of regional Working Groups on Hydrology as a platform for hydrologists within a Region to discuss matters of common concern;

Urges Member States to comply with Resolution 25 (Cg-XIII) and thus to jointly address the challenges societies face with regard to climate change and the consequences of global changes;

Invites Members to participate in, and contribute to, technical cooperation activities in hydrology and water resources also by contributing to the Hydrology and Water Resources Trust Fund in support of water-related activities.

_____

Note: This resolution replaces Resolution 20 (Cg-XV), which is no longer in force.

Resolution 14 (Cg-XVI)

WORLD HYDROLOGICAL CYCLE OBSERVING SYSTEM

THE CONGRESS,

Noting:

(1) Resolution 20 (Cg-XII) – World Hydrological Cycle Observing System (WHYCOS),

(2) Resolution 25 (Cg-XIII) – Exchange of hydrological data and products,

Appreciating:

(1) The continuing potential benefits of enhanced exchange of hydrological data and information within shared river basins and aquifers,

(2) The successful implementation of the WHYCOS programme through eight regional Hydrological Cycle Observing System (HYCOS) components that have been implemented or are presently under implementation,

(3) The financial support of around CHF 23 million provided by the Governments of the Netherlands, France and Finland, the European Commission, and the African Water Facility for the implementation of the regional HYCOS components in the last financial period,

(4) The continued interest of these partners in continuing their support,

(5) The positive impacts of implemented HYCOS components on the strengthening of technical and institutional capacities of National Hydrological Services (NHSs) in a number of countries, including improved international cooperation in transboundary and international rivers basins,

Considering:

(1) That WHYCOS is one of the basic responses by WMO to the recommendation of the United Nations Commission on Sustainable Development to strengthen efforts towards a comprehensive assessment of freshwater resources,

(2) That WHYCOS makes a significant contribution to water resources assessment on global, regional and national scales, supports the assessment of the impacts of climate variability and change on water resources, and assists in identifying appropriate mitigation and adaptation measures under the changing climate,

(3) The continuing need for strengthening the capabilities of NHSs in hydrological and hydrometeorological data collection and management and in the development and dissemination of information products, particularly in developing countries,

(4) The contribution that WHYCOS can make to the strengthening of these capabilities,

(5) That WHYCOS provides a vehicle for implementation of the Quality Management Framework-Hydrology through applying best practices in measurements, enhanced quality of observations and development of water resources information systems,

(6) That WHYCOS can provide essential data to several programmes, such as the Global Climate Observing System, the Global Terrestrial Observing System, the Global Ocean Observing System and the Global Terrestrial Network - Hydrology,

(7 That WHYCOS, as a strong contributor to the WMO Integrated Global Observing System (WIGOS), will benefit from the development and implementation of WIGOS and the WMO Information System (WIS),

Reaffirms the importance of WHYCOS as a priority activity within the WMO Hydrology and Water Resources Programme, with the main objectives of:

(1) Strengthening technical, human and institutional capacities of NHSs of Member States in hydrological data collection and management and in the development and dissemination of information products;

(2) Promoting regional and international cooperation in the sharing of hydrological data and the management of shared water resources;

(3) Adaptation to the impacts of climate variability and change;

Also reaffirms the ownership by WMO of WHYCOS and its HYCOS components and the central role of the Secretariat as a provider of technical and scientific support with a view to ensuring the

achievement of the programme goals, consistency among components, and the transfer of data, tools and expertise;

Invites Members and national and international aid agencies:

(1) To continue and broaden their financial support for the implementation of ongoing and planned HYCOS components;

(2) To coordinate the implementation of regional components with the WMO Secretariat in order to maximize benefits from collaboration with, and transfer of tools and products from, other projects;

(3) To encourage other countries in the Regions to, where relevant, join a HYCOS component;

Urges Members and regional institutions involved in the implementation of HYCOS components:

(1) To actively support the project implementation, by, inter alia, making available the required staff for field activities and training courses, ensuring timely implementation of project activities at the national level (including customs clearance and installation of equipment), and performing quality control and validation of data collected within the framework of the project;

(2) To ensure the long-term sustainability of project outcomes through the provision of adequate human and financial support for their continuing operation;

Requests the Secretary-General:

(1) To carry out an independent external evaluation of the WHYCOS programme, as a follow-up to the one carried out in 2005;

(2) To review the mandate, composition and functioning mechanism of the WHYCOS International Advisory Group, to enable it to better respond to the new challenges facing the WHYCOS programme, by focusing in particular on:

   (a) Reviewing and assessing the concept, objectives and progress towards them, expected benefits/costs, and future development of WHYCOS, and proposing strategies for any necessary remedial action to address possible shortcomings;

   (b) Ensuring the efficient relationship of WHYCOS with other relevant initiatives and international programmes, especially its integration with WIGOS and WIS;

   (c) Coordinating the implementation of the various HYCOS components and WMO inputs with stakeholders, especially national and regional partners and donors;

(3) To invite other international organizations to cooperate with WMO to contribute to WHYCOS implementation, and to make use of its products;

(4) To provide all possible support to WHYCOS development from available resources and to seek additional resources for this purpose from external sources;

Requests the president of the Commission for Hydrology to ensure that the Commission provides WHYCOS with the technical advice that it requires.

_____

Note: This resolution replaces Resolution 20 (Cg-XII), which is no longer in force.

ANNEX 2. RESOLUTION 25 (Cg-XIII) — EXCHANGE OF HYDROLOGICAL DATA AND PRODUCTS

THE CONGRESS,

Noting:

(1) Resolution 40 (Cg-XII) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities,

(2) The inclusion of dedicated observations of the climate system, including hydrological phenomena, as one of the four main thrusts of The Climate Agenda, which was endorsed by Twelfth Congress,

(3) That Technical Regulation [D.1.1] 8.3.1(k), states that, in general, the routine functions of National Hydrological Services (NHSs) should include, inter alia, "making the data accessible to users, when, where and in the form they require" and that the Technical Regulations also contain a consolidated list of data and product requirements to support all WMO Programmes,

(4) That the nineteenth Special Session of the United Nations General Assembly agreed, in its overall review and appraisal of the implementation of Agenda 21, that there is an urgent need to "...foster regional and international cooperation for information dissemination and exchange through cooperative approaches among United Nations institutions, …" (A/RES/S-19/2, paragraph 34(f)),

(5) That the fifty-first session of the United Nations General Assembly adopted, by resolution 51/229, the Convention on the Law of the Non-navigational Uses of International Watercourses, Article 9 of which provides for "regular exchange of data and information",

(6) That the Intergovernmental Council of the International Hydrological Programme of the United Nations Educational, Scientific and Cultural Organization (UNESCO) adopted at its twelfth session Resolution XII-4 which dealt with the exchange of hydrological data and information needed for research at the regional and international levels,

Considering:

(1) The significance attached by the International Conference on Water and the Environment (ICWE) (Dublin, 1992) to extending the knowledge base on water and enhancing the capacity of water sector specialists to implement all aspects of integrated water resources management,

(2) The call of world leaders at the United Nations Conference on Environment and Development (UNCED)(Rio de Janeiro, 1992) for a significant strengthening of, and capacity building in, water resources assessment, for increasing global commitment to exchange scientific data and analyses and for promoting access to strengthened systematic observations,

(3) That the United Nations Commission on Sustainable Development (CSD) in its Decision 6/1 "Strategic Approaches to Freshwater Management" has strongly encouraged States to promote the exchange and dissemination of water-related data and information, and has recognized "the need for periodic assessments … for a global picture of the state of freshwater resources and potential problems",

(4) The call by the nineteenth Special Session of the United Nations General Assembly "for the highest priority to be given to the serious freshwater problems facing many regions, especially in the developing world" and the "urgent need … to strengthen the capability of Governments and international institutions to collect and manage information … and

environmental data, in order to facilitate the integrated assessment and management of water resources",

(5) The requirements for full, open and prompt exchange of hydrological data and products in support of various international conventions, such as the Convention on Biological Diversity, the United Nations Framework Convention on Climate Change, and the Convention to Combat Desertification,

(6) The requirement for the global exchange of hydrological information in support of scientific investigations of world importance such as those on global change and the global hydrological cycle, and as a contribution to relevant programmes and projects of WMO, other United Nations agencies, the International Council for Science (ICSU) and other organizations of equivalent status,

(7) The opportunities for more efficient management of water resources and the need for cooperation in mitigating water-related hazards in transboundary river basins and their water bodies which depend on the international exchange of hydrological data and information,

(8) The increasing recognition through scientific and technical endeavours, such as the Global Energy and Water Cycle Experiment (GEWEX), of the importance of hydrological data and products in improving the understanding of meteorological processes and subsequently the accuracy of meteorological products,

Recognizing:

(1) The responsibility of Members and their NHSs to provide for the security and well-being of the people of their countries, through mitigation of water-related hazards and sustainable management of water resources,

(2) The potential benefits of enhanced exchange of hydrological data and information within shared river basins and aquifers, based on agreements between the Members concerned,

(3) The continuing need for strengthening the capabilities of NHSs, particularly in developing countries,(4) The right of Governments to choose the manner by which, and the extent to which, they make hydrological data and products available domestically and internationally,

(5) The right of Governments also to choose the extent to which they make available internationally data which are vital to national defence and security. Nevertheless, Members shall cooperate in good faith with other Members with a view to providing as much data as possible under the circumstances,

(6) The requirement by some Members that their NHSs earn revenue from users, and/or adopt commercial practices in managing their businesses,

(7) The long-established provision of some hydrological products and services on a commercial basis and in a competitive environment, and the impacts, both positive and negative, associated with such arrangements,

Adopts a stand of committing to broadening and enhancing, whenever possible, the free and unrestricted1 international exchange2 of hydrological data and products, in consonance with the requirements for WMO's scientific and technical programmes;

Further adopts the following practice on the international exchange of hydrological information:

(1) Members shall provide on a free and unrestricted basis those hydrological data and products which are necessary for the provision of services in support of the protection of life and property and for the well-being of all peoples;

(2) Members should also provide additional hydrological data and products, where available, which are required to sustain programmes and projects of WMO, other United Nations agencies, ICSU and other organizations of equivalent status, related to operational hydrology and water resources research at the global, regional and national levels and, furthermore, to assist other Members in the provision of hydrological services in their countries;

(3) Members should provide to the research and education communities, for their non-commercial activities, free and unrestricted access to all hydrological data and products exchanged under the auspices of WMO;

(4) Respecting (2) and (3) above, Members may place conditions on the reexport3, for commercial purposes, of these hydrological data and products, outside the receiving country or group of countries forming a single economic group;

(5) Members should make known to all Members, through the WMO Secretariat, those hydrological data and products which have such conditions as in (4) above;

(6) Members should make their best efforts to ensure that the conditions placed by the originator on the additional hydrological data and products are made known to initial and subsequent recipients;

(7) Members shall ensure that the exchange of hydrological data and products under this resolution is consistent with the application of Resolution 40 (Cg-XII) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities;

Urges Members, in respect of the operational and scientific use of hydrological data and products, to:

(1) Make their best efforts to implement the practice on the international exchange of hydrological data and products, as described in **FURTHER ADOPTS** (1) to (7);

(2) Assist other Members, to the extent possible, and as agreed upon, in developing their capacity to implement the practice described in **FURTHER ADOPTS** (1) to (7);

Requests the Executive Council to:

(1) Invite the Commission for Hydrology to provide advice and assistance on technical aspects of the implementation of the practice on the international exchange of hydrological data and products;

(2) Keep the implementation of this resolution under review and report to Fourteenth Congress;

Decides to review the implementation of this resolution at Fourteenth Congress.

ANNEX 3. EXAMPLE OF AN AGREEMENT BETWEEN EACH PARTICIPATING COUNTRY AND THE PROJECT REGIONAL CENTRE

INTRODUCTION

1. The _____ HYCOS project aims at the development and implementation of _____ for the _____ basin/region. The ultimate goal of the project is _____. To achieve this, the project will _____.

COOPERATION AND COLLABORATION

2. The _____, referred to hereinafter as "_____", and the _____ representing the Project Regional Centre, referred to hereinafter as "_____", agree that with a view to facilitating the implementation of the _____ HYCOS project, they will act in close cooperation with each other and consult each other regularly with regard to matters related to the implementation of the project. The _____ and the _____ also recognize and comply with the WHYCOS Guidelines, its vision, principles, objectives, and approaches for development, implementation and governance of the project.

TASKS AND RESPONSIBILITIES

3. The __(NHS)_____ undertakes to:

(a) Nominate the representative of its country to the Project Steering Committee;

(b) Identify a focal point in the country to devote his/her time to collaborate with the Project Regional Centre for the office and field activities of the project in the country;

(c) Coordinate the activities related to the project among various national agencies and end-users involved in the implementation of the project within the defined scope of the project and as modified from time to time by the Project Steering Committee;

(d) Identify the information products required by various stakeholders as deliverables from the project within its defined scope.

4. The _____ recognizes its responsibilities to undertake the implementation of the office and field activities related to the project, in particular its responsibility to:

(a) Undertake administrative approvals and arrangements for the import of equipment and services and construction activities in relation to the implementation of the components of the project;

(b) Provide all relevant information for setting up the regional and national databases, including the website;

(c) Carry out the civil works for the preparation of sites and installation of the equipment.

5. The _____ recognizes the responsibilities assigned to the Project Regional Centre for the implementation of the project as laid down in paragraph 7 below. In particular, it recognizes the mandate of the Project Regional Centre to ensure that the data obtained in the course of the project are quality controlled and reliable. In this regard, the _____ undertakes to validate the data collected in the country. It also undertakes

to comply with and adopt the common standards and recommended practices and procedures of WMO.

6. The _____ also recognizes the importance of making hydrological data and information products accessible. The _____ will exchange hydrological data and information products freely and unrestricted in a timely manner with all other participating countries in the project and the Project Regional Centre and will fully comply with WMO Resolution 25 (Cg-XIII) – Exchange of hydrological data and products. Accordingly, the _____ and the Regional Centre will ensure together that data and information products related to the __(transboundary river basin)____ in general and the project in particular are properly archived on the regional and national databases through the project procedures.

7. The Project Regional Centre recognizes its responsibility for implementation of the activities planned under the project, and, in particular, its responsibility to:

(a) Act as focal point for coordinating the project activities carried out in, and by, participating countries;

(b) Provide countries with the support and advice needed to successfully establish the network of data collection sites and technologies associated therein;

(c) Manage the redistribution of data to participating countries that do not have direct access to satellite transmission systems or other advanced forms of telemetry;

(d) Develop, manage and update the regional database, taking into account tools already developed under other HYCOS projects;

(e) Develop the regional water resources information system including hydrological information products adapted to countries' needs and appropriate means for delivering them to end-users;

(f) Develop, manage and update the project's website;

(g) Carry out all the activities ascribed to the Project Regional Centre as specified in the project documents, such as training seminars and advice on how to manage the DCP network and other technologies;

(h) Encourage regional cooperation in water resources assessment and other applications as identified in the project documents;

(i) Act as a forum for sharing expertise and skills.

WORKING ARRANGEMENTS AND FINANCING

8. Appropriate arrangements shall be made from time to time for the implementation of office and field activities in the country.

9. The ___(NHS)_____ will receive financial support from the project budget as identified in the project document to ensure timely and successful implementation of the project activities in the country.

10. This agreement shall come into force upon its signature by both parties.

_____

ANNEX 4. HIGH-LEVEL REQUIREMENTS OF A NATIONAL HYDROLOGICAL INFORMATION SYSTEM

FUNCTIONALITY ASSOCIATED WITH DATA PRODUCTION

A. DATA ENTRY

- Includes a data-acquisition module that can access stations by modem, satellite and through the Internet (time series).
- Includes the capacity to apply automated QA/QC procedures to data gathered in real time (minimum ability to flag data).
- Allows manual data entry into the system (discrete, discharge measurements, levelling).
- Integrates multiple data types required for the hydrometric data production process (water, air, sediment, station health, etc.) – continuous and discrete.
- Integrates multiple environmental data types such as groundwater and water quality – continuous and discrete.

B. STATION INFORMATION AND METADATA

- Allows for the input and manipulation of metadata (station information) associated with hydrometric sites and equipment.
- Allows for the input and manipulation of metadata (station information) associated with groundwater and water-quality sites and equipment.
- Be able to manage and keep track of the history of all modifications to data and metadata (station information).

C. COMPUTATION

- Enables the application of corrections (shift, gauge, time and sensor reset, disregard, override).
- Includes functionality for the development and application of the rating curve.
- Includes the capacity to add more model types to deal with situations without stable controls (hydraulic, hydrological, etc.).
- Integrates methodologies for the estimation of missing data.
- Includes the capacity for the manual application of QA/QC procedures to data generated/corrected by users (minimum ability to flag data).
- Has a computation module to generate discharge and other parameters both manually and automatically.
- Has the capability to implement an approval procedure.

D. OUTPUT AND DISSEMINATION

- Has the ability to generate various outputs (daily means, hourlies, monthly, etc.) for example, product generator functions (automated reports).
- Has the ability for real-time data dissemination on the Web.

SYSTEM-WIDE SOFTWARE FUNCTIONALITY

- Makes use of intuitive graphical user interfaces in all its modules (data acquisition, rating-curve development, graphics for visual comparison and manipulation of data).
- Be adaptable to plug into other data/metadata structures and to make use of their functionality in this respect (middleware, etc.) (read/write data from multiple database structures).
- Includes an alert capacity to manage information related to events that occur in the system (for example, a failure needs to be signified to a technologist).
- Allows for different user-level privileges and approval privileges.
- Provides the ability to ingest historical data (legacy system).
- Allows for data archival.

ARCHITECTURE and Operating System

- Functions under the most recent versions of Windows (8, 7, Vista, XP, etc.).
- Portable and scalable to allow for its implementation on a portable PC and its operation in stand-alone mode in the field.
- Be adaptable for use in a network environment where data are replicated over multiple nodes (multiple users at multiple sites who can all access the same information).
- Be based on well-known/supported relational database management system.
- Language supported, as required: French (F), English (E), Spanish (S), other (O).

Source: adapted from Frigon et al., 2010.

ANNEX 5. HYDROLOGICAL DATA AND PRODUCTS FROM HYCOS PROJECTS

Among the outputs of the implementation of HYCOS projects are hydrological data and information products. These can be in the form of data or result from the processing and analysis of the data and related information collected from HYCOS stations or other sources. The table below lists some possible data and information products.

Hydrological product	*Description*
Mean annual precipitation	A map of the average annual precipitation that can be produced based on the observed time series of precipitation for a certain period (~30 years). Such maps can be used for planning and designing development projects.
Daily precipitation	Variability of precipitation in time and space is a useful input for modelling catchment response and for assessing possible options for meeting various water needs.
Heavy convective storm data	Heavy rainfall can result from the upward movement of moist airmasses and is termed a convective storm. Such storms can also produce hail, lightning and strong winds and might result in the formation of what is termed a supercell, which might last for several hours. These form the most powerful of thunderstorms and can result in flash floods.
Annual maximum n-hour precipitation	The highest amount of precipitation recorded for various time intervals, usually from 5 minutes to 24 or 48 hours within the year. Such data are used to undertake rainfall intensity-duration-frequency analysis, which is used in designing drainage structures for small catchments.
Duration of dry spells	Periods without, or with little, precipitation. They are of interest especially because of their effect on hydrology and water management, agriculture, forestry and tourism.
Mean annual potential evapotranspiration	Potential evapotranspiration is the quantity of water capable of being transferred from the soil to the atmosphere by evaporation and plant transpiration when well supplied with water. It is useful in water-balance calculations and assessment of irrigation needs.
Natural characteristics of rivers	Important in determining stable river sections for locating hydrological stations or other engineering structures and their impacts on river behaviour. They are also important in measuring discharge, developing (unit) hydrographs in ungauged catchments, etc.
Minimum and maximum daily records	Useful in designing drainage structures, reservoir regulation, hydrological modelling and several other applications (temperature, discharge, etc.)
Minimum and maximum annual records (precipitation, runoff, etc.)	Smallest and highest values of annual series of precipitation, runoff, etc. Useful in assessing storage requirements for meeting needs.
Daily maximum instantaneous discharge	Typically used for infrastructure design.
Design floods	Discharge values derived from a frequency analysis and correspond to a given return period. Important for solving many problems in water resources management and design.
Rating curves	Show the relationship between stage and discharge in a river section. Useful tools in calculating discharge from water-level data in a river and can be used to determine hydraulic characteristics of the river reaches in the vicinity of the section.

Hydrological product	*Description*
Mean annual depth of runoff	Mean annual depth of runoff is a major component of the water balance. It is an important variable for hydropower production, water supply studies, etc.
Annual or seasonal n-day low flow time series	Records of the lowest discharge that has occurred over a rolling window of n-days for a particular time period, such as the growing season. Useful for water supply studies and ecosystem analysis.
Mean annual fluctuations of table	Determined on the basis of regular monitoring of groundwater levels. They allow conclusions to be made on groundwater recharge based upon precipitation and exchange processes between groundwater and surface water.
Long-term trends of groundwater the levels determining	Long-term trends of groundwater levels are useful in assessing sustainable use of groundwater. Also useful in baseflow and low flows in perennial rivers.
Water balance	The accounting of inflow and outflow of water within a basin for a given period of time (usually one year). It is used in water-management planning and is useful in assessing the availability of water for meeting demands. It is also useful for understanding the relative magnitude of the components of the hydrological cycle.
Water quality	Water-quality monitoring is conducted to determine the suitability of the water for various purposes, and to detect negative developments at an early stage. Information about its quality is the basis for evaluating existing or potential uses of water.
Hydrological forecasts	Predictions of discharge and water levels in a river/stream based on precipitation and streamflow inputs monitored and reported on a real-time basis and can be made from various hydrological data obtained from HYCOS stations. Important for issuing warnings of impending hydrological events, such as floods and droughts, and for a number of uses, including reservoir regulation and irrigation.
Flood forecasting and warning	Hydrological forecasts of events that are likely to cause inundations beyond the normal stream limits. Warnings are important in alerting society to a pending flood, saving lives and reducing property damage.

ANNEX 6. EXAMPLE OF INTERNATIONALLY AGREED POLICY ON THE EXCHANGE OF HYDROLOGICAL AND METEOROLOGICAL DATA AND INFORMATION: THE CASE OF THE INTERNATIONAL SAVA RIVER BASIN COMMISSION

Policy on the Exchange of Hydrological and Meteorological Data and Information in the Sava River Basin (*Courtesy of the International Sava River Basin Commission*)

The Signatories to this Policy (hereinafter: *Signatories*),

Recognising the vital importance of trans-boundary co-operation on hydrometeorological data and information for the sustainable management of the Sava River Basin;

Referring to the Framework Agreement on the Sava River Basin of 3 December 2002;

Taking into account the significant progress made in relation to the sharing of hydrological and meteorological data and information since the formation of the International Sava River Basin Commission;

have agreed as follows:

1. Definitions

1.1 In this Policy, unless otherwise stated, all terms are defined in accordance with the *WMO/UNESCO International Glossary of Hydrology* (WMO-No. 385, 3rd Edition, 2012).

1.2 The terms below shall have the following meanings:

"Data"	Output resulting from the measurement or observation of variables.
"Information"	Result of analysing or integrating data.
"Sava River Basin"	The geographical area determined by the watershed limits of the Sava River and its tributaries, which comprises surface and ground waters, flowing into a common terminus.
"The States"	States whose territories include part of the Sava River Basin.
"The Commission"	International Sava River Basin Commission.
"Data Provider"	Any organisation listed in Annex A which provides data or information for exchange under this policy.
"Data Receiver"	Any organisation listed in Annex A which receives data or information exchanged under this policy.
"Redistribution"	Dissemination by a Data Receiver of data or information exchanged under this Policy to a third party. Including the sale and free dissemination, either physically or electronically, of data and information.

2. Context

2.1 Exchange of hydrological (and meteorological) data and information within the Sava River Basin is vital for the sustainable management of water resources and mitigation of water-related hazards.

2.2 Through Resolution 25 (Cg-XIII) — Exchange of Hydrological Data and Products, and Resolution 40 (Cg XII) — Policy and Practice for the Exchange of Meteorological and Related Data and Products, the World Meteorological Organization encourages its Members to provide on a free and unrestricted basis[4] those hydrological data and products which are necessary for the provision of services in support of the protection of life and property and for the well-being

[4] "Free and unrestricted" means non-discriminatory and without charge. "Without charge", in the context of this resolution means at no more than the cost of reproduction and delivery, without charge for the data and the product themselves.

of all peoples. Resolution 25 recognises the right of Governments to choose the manner by which, and the extent to which, they make hydrological data and products available domestically and internationally.

2.3 Under Articles 9 and 12 of the Convention on Cooperation for the Protection and Sustainable use of the Danube River (Danube River Protection Convention), the Contracting Parties have agreed to the exchange of data related to the Danube River Basin and cooperation in the field of monitoring and assessment.

2.4 As agreed in Article 4 of the Framework Agreement on the Sava River Basin (hereinafter: the FASRB), the Parties to that Agreement shall, on a regular basis, exchange information on the water regime of the Sava River Basin, the regime of navigation, legislation, organisational structures, and administrative and technical practices.

2.5 To date, different data management procedures and data accessibility issues within the Sava River Basin have resulted in problems affecting the implementation of the FASRB.

2.6 The States' current legal statutes regarding the collection and exchange of hydrological (and meteorological) data and information differ however; international cooperation on this matter within the Sava River Basin provides benefits to all States and their hydrometeorological institutions. In this regard, the Signatories will, within the constraints of their States' legal statutes, comply with the principles and practices detailed in this Policy.

2.7 Through the regular exchange of data and information as outlined in this Policy, the S*ignatories* will – both individually and through the Commission – take steps toward the improved water management in the Sava River Basin.

3. Objectives of the Policy

3.1 This Policy provides the technical and conceptual principles required to promote data exchange and interoperability within the Sava River Basin. By establishing this Policy, the Commission ensure the freedom to access and disseminate hydrological (and meteorological) data and information for the purpose of sustainable transboundary water management in the Sava River Basin.

3.2 This Policy is intended to provide a framework within which *Signatories* will exchange data and information. While it outlines a minimum level of data and information exchange (Annex C), this is not to be seen as all-inclusive and Signatories agree to work (both bilaterally and through the Commission) to further develop other data and information exchange.

4. Organisations covered by the Policy

4.1 The organisations which may provide (Data Providers) or receive (Data Receiver) data or information under this Policy are listed in Annex A. This list should comprise all current *Signatories*, the Commission and any other organisation mutually agreed by all current *Signatories* and approved by the Commission.

5. Data covered by the Policy

5.1. This Policy covers all data or information listed in Annex B which are collected by the Signatories at monitoring sites in geographical locations covered by Clause 6.

5.2 All data and information listed in Annex B which are currently collected or held by the *Signatories* are included. The Policy recognises that some *Signatories* do not currently collect or hold all of the data and information listed in Annex B. Where data is not currently collected the relevant *Signatory* will consider whether extension of current monitoring (and/or data processing) programmes would be possible in order to supply such data and/or information in future.

5.3 The Commission will maintain and publish a listing of the *Signatories* within each State responsible for the collection and management of the data and information covered by this Policy. The listing will include an indication of whether data is collected/held by a *Signatory* and, where it is stored and details of a current named contact (or contacts) responsible for its collection and management. Each *Signatory* will review this list annually and provide the Commission with updated information as required.

6. Monitoring locations covered by the Policy

6.1 The monitoring locations covered by this policy should normally include all observation stations within the Sava River Basin. Additional observation stations in the surrounding geographical area may be included where the data or information is to be used in the management of the Sava River Basin.

6.2 It is recognised that in some cases, exchange of data or information may be limited by controls on the dissemination of observations from certain locations or other limiting factors. Where possible, *Signatories* will make efforts to minimise such exclusions of monitoring locations so as to maximise the data and information available for the management of the Sava River Basin.

6.3 The Commission will maintain a listing of all locations within the Sava River Basin (and the surrounding area) where data or information listed covered by this Policy is monitored or held by the *Signatories*. All *Signatories* will provide this metadata to the Commission and ensure that it is reviewed, and where necessary updated, annually. The metadata to be included will be agreed between the *Signatories* and the Commission.

7. Data to be exchanged

7.1 The principles and procedures contained within this Policy may be used to exchange any data and information covered by Clause 5. *Signatories* agree to make any such data or information available to all other *Signatories* (and the Commission) where possible.

7.2 The Policy specifies a minimum level of data and information exchange in Annex C. Exchange of the data and information outlined in Annex C is deemed essential for the effective management of the Sava River Basin. Where *Signatories* currently collect or hold any of the data and information listed in Annex C they agree to the regular exchange of this in accordance with procedures and timetables outlined therein.

7.3 Where organisations are exchanging data or information under this Policy other than specified under Annex C, they are expected to mutually agree the contents between themselves in accordance with Clauses 8-17.

8. Exchange routes

8.1 This Policy covers the transfer of data or information from one Data Provider to one or more Data Receiver.

8.2 The Commission may develop an on-line data portal to facilitate the exchange of data and information between the *Signatories*.

8.3 *Signatories* may only exchange data or information under this Policy which has been collected by their own organisation (unless covered by Clause 8.2).

9. Exchange procedures

9.1 The normal procedure for exchange of data or information (other than under Annex C) is for the organisation requiring data to lodge a request for an individual or repeated exchange, in writing, with the relevant Data Provider. Requests should be addressed to the relevant named contact point (see Clause 5.3).

9.2 Requests should precisely and unambiguously define what data or information is required and by when, including details of the parameter, time period, reporting interval and monitoring station required.

9.3 The intended use of the data or information should be defined in the request and if the supplied data or information is subsequently to be used for other purposes than expressed, new permission should be sought from the Data Provider.

9.4 *Signatories* will respond to all requests within 15 days of receiving a written request for data or information, providing details on when and how the data or information will be provided or otherwise outlining the reasons why it cannot be provided.

10. Timetable for provision

10.1 Where organisations are exchanging data or information (other than under Annex C), the Data Provider is expected to supply this within a maximum of 30 days of receiving a written request. This deadline may be extended to 60 days for information which requires significant processing prior to exchange.

10.2 Where repeated exchanges are established, or (near) real-time data is required, the Data Provider and Data Receiver should agree a timetable for regular delivery.

11. Format and transfer method

Data and information should be transferred in a format mutually agreed between the Data Provider and Data Receiver. It is expected that this will be by electronic transfer in most cases.

12. Metadata

12.1. Appropriate metadata should be provided with any data or information exchanged under this Policy, in particular detailing the measurement method and describing the quality and reliability of the data.

12.2. The metadata to be provided should be mutually agreed between the Data Provider and Data Receiver and should include, but not be limited to, the information specified in *WMO Technical Regulations*[5].

13. Data quality and measurement standard

13.1 Through the use of quality control procedures, Data Providers agree to make efforts to maintain and improve the quality and consistency of data and information being transferred under this Policy.

13.2 Where data and information is exchanged that has not undergone full quality control and is considered to be provisional, the Data Provider will inform the Data Receiver at the point of transfer.

13.3 Appropriate use of data and information exchanged under this Policy is the responsibility of the Data Receiver. The Data Provider accepts no liability for any loss or damage, cost or claims arising directly or indirectly from their use.

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[5] For example: for hydrological observing stations, where applicable, this should include information specified in *WMO Technical Regulation*, Volume III, Section D.1.1.5.

14. Storage

14.1 Data Receivers may store data or information provided under this Policy for future use but, in discussion with the Data Provider, efforts should be made to regularly update these records where they may have changed (for example, as a result of further quality control).

15. Use and redistribution

15.1 Data or information exchanged under this policy may be used by the Data Receivers in connection with any activities which aid the management of the Sava River Basin.

15.2 Data Receivers (other than the Commission) may not redistribute data or information exchanged under this Policy to any third party without the prior agreement or consent of the Data Provider.

15.3 The Commission may publish data or information exchanged under this Policy in its publications (for example: Hydrological Yearbooks; Hydrological Studies; River Basin Management/Flood Protection/Sediment Management Plans). The Commission may also redistribute data and information publically via its online web-portal for navigational use and other uses covered by the FASRB.

16. Ownership and acknowledgment

16.1 The provision of data or information under this Policy confers only a right for the Data Receiver to use it as detailed in Clause 15. Ownership of the data or information will not be transferred.

16.2 In any publications, reports or products arising from use of the data or information, the Data Receiver undertakes to acknowledge the Data Provider as the source.

17. Charging

17.1 Data and information exchanged under Annex C is done so freely and without charge. When exchanging other data and information under this Policy, Data Providers and Data Receivers should agree any charges between themselves.

17.2 It is expected that most data will be exchanged free of charge and handling charges will only be levied where data requires significant manual processing prior to exchange. In all cases charges should be limited to reproduction and delivery costs only. All data and information for research or educational use should be provided free of charge.

17.3 *Signatories* agree to develop and maintain clear policies on any charges which will apply to data or information transferred under this Policy (other than under Annex C) and make this information available to all other *Signatories* (and the Commission) on request.

18. Future harmonization of data and information

The main providers of hydrological (and meteorological) data and information for the management of the Sava River Basin are the States' hydrometeorological institutions. While recognising current differences in the collection and management of hydrological (and meteorological) data by these organisations, historically similar legislation and practice mean that similar datasets exist across the Sava River Basin. The *Signatories* agree to work together, through the Commission, to further standardise the collection and management of the data and information covered by the Policy. It is expected that this will include, where possible, harmonisation of data measurement methods, units of observation, transfer formats and metadata.

19. Disputes

19.1 If a dispute arises between two or more *Signatories* about the interpretation or implementation of this Policy, they shall seek a solution by negotiation.

19.2 If the concerned *Signatories* are unable to resolve the dispute through negotiation, the matter should be referred to the Commission.

20. Entry into force

This Policy will enter into force upon agreement by the Commission and be concluded for an indefinite period of time.

21. Changes to the Policy

21.1 Changes to this Policy, other than to the Annexes, must be agreed by the Commission.

21.2 The Commission will amend Annex A in light of new or withdrawing *Signatories*, and other required changes. The Commission will inform all *Signatories* of any changes to Annex A within one calendar month.

21.3 Annexes B and C will be reviewed, and where necessary amended, by the Commission upon proposal of the Expert Group for Hydrological and Meteorological Issues (established by the Commission) at least once every 2 years to ensure they reflect current Sava River Basin management needs. The Commission will inform all *Signatories* of any changes to these Annexes within one calendar month.

22. New signatories

The *Signatories* to this Policy should normally include, but are not limited to, the States' national hydrometeorological institutions — or equivalent organisation responsible for the collection and/or management and distribution of a States' national hydrological (and meteorological) data or information. Additional organisations which operate in one (or more) of the States, in connection with the management of the Sava River Basin, may become a *Signatory* to the Policy at the invitation of the Commission.

23. Termination and withdrawal

23.1 This Policy may be terminated by mutual agreement of all *Signatories*.

23.2 Any *Signatory* to this Policy may withdraw from this Policy by giving at least 90 days written notice to the Commission, who shall communicate it to all other Signatories without delay.

24. Other

24.1 The Policy does not affect arrangements for the exchange of data and information between the *Signatories* provided for in other bilateral or multilateral agreements.

24.2 The Annexes to this Policy shall constitute an integral part thereof. The Annexes are as follows:

Annex A: Organisations Covered by the Policy

Annex B: Data Types Covered by the Policy

Annex C: Minimum Level of Agreed Data Exchange

25. Depositary

The Commission shall be the depositary of this Policy.

Annex A Organisations covered by the Policy

A.1 International Sava River Basin Commission (ISRBC).

A.2 *Signatory* organisations:

State	*Name of organisation*	*Abbreviation*
Bosnia and Herzegovina	Federal Hydrometeorological Service	FHMZFBIH
	Sava River Watershed Agency	AVPSAVA
	Public Institution of Waters of Republic of Srpska	
	Republic Hydro-Meteorological Service of Republic of Srpska	RHMZRS
Montenegro	Hydrometeorological and Seismological Service of Montenegro	ZHMS
Republic of Croatia	Meteorological and Hydrological Service of Croatia	DHMZ
	Croatian Waters	
Republic of Serbia	Republic Hydrometeorological Service of Serbia	RHMZ
	Agency for Environmental Protection	
Republic of Slovenia	Slovenian Environment Agency	ARSO

A.3 Other organisations:

State	*Name of organisation*	*Abbreviation*

Annex B Data types covered by the Policy

B.1 List of data and information types covered by the Policy:

Parameter	*Temporal Resolution (Statistic[1])*	*Units*
River, Lake or Reservoir Level/Stage	Daily (Mean) Hourly	cm
River Discharge	Daily (Mean) Hourly	m3 s^{-1}
Water Temperature	Daily (Mean)	°C
Suspended Sediment Discharge	Daily (Mean)	kg s^{-1}
Groundwater Level	Daily	
Every 5/10th Day	cm	
Ice Condition	Daily	% of river cross section or text description
Precipitation	Annual (Total) Monthly (Total) Daily (Total) 6/12 Hourly (Total) Hourly (Total)	mm
Air Temperature	Daily (Mean) Hourly	°C
Relative Humidity	Daily Hourly	%
Wind (Speed and Direction)	Daily Hourly	m/s
Snow Depth	Daily	cm
Evaporation	Daily (Total)	mm
Solar Radiation	Daily	J m^{-2}
Sunshine	Daily (Total)	Hours
Atmospheric Pressure	Daily	hPa

[1] Where a statistic is not defined for a particular temporal resolution (for example: Mean for Daily River Discharge) this implies an instantaneous measurement of the parameter.

Annex C Minimum level of agreed data exchange

C.1 Purpose

C.1.1 This Annex outlines a minimum level of agreed data and information exchange to be concluded under this Policy.

C.2 General

C.2.1 *Signatories* will make the data and information outlined in this Annex available without charge to all other organisations covered by the Policy for the management of the Sava River Basin.

C.2.2 Unless otherwise specified, data and information exchanged under this Annex is done so in line with the principles and procedures outlined in the Policy.

C.2.3 All data and information listed in this Annex shall be in compliance with Clause 5.1.

C.2.4 The data and information detailed in Section C.3 of this Annex includes, but is not limited to, all data published by the Commission in the Hydrological Yearbooks of the Sava River Basin.

C.3 Data to be exchanged

C.3.1 All data and information outlined in the following table, which are currently collected or held by the *Signatories* for the monitoring locations specified in C.4, will be exchanged:

Parameter		*Temporal Resolution (Statistic)*	*Units*
P1	Water Stage	Daily (Mean)	cm
P2	River Discharge	Daily (Mean)	$m^3 s^{-1}$
P3	Water Temperature	Daily (Mean)	°C
P4	Suspended Sediment Discharge	Daily (Mean)	$kg s^{-1}$
P5	Precipitation	Daily (Total)	mm
P6	Air Temperature	Daily (Mean)	°C
P7	Water Stage	Current Stage	cm
P8	River Discharge	Current Discharge	$m^3 s^{-1}$
P9	Water Temperature	Current Temperature	°C

C.4 Monitoring stations included

C.4.1 Full period of record, data and information from the monitoring stations in the following table will be exchanged:

State	*Monitoring Lociation*	*Parameter*									*Data Provider*
		P1	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*	*P8*	*P9*	
BA-Fed	Una at Martin Brod	✓	✓	✓							AVPSAVA
BA-Fed	Una at Kralje	✓	✓					✓			AVPSAVA
BA-Fed	Una at Otoka	✓	✓								AVPSAVA
BA-Fed	Unac at Rmanj Manastir	✓	✓					✓			AVPSAVA
BA-Fed	Sana at Kljuc	✓	✓								AVPSAVA
BA-Fed	Sana at Sanski Most	✓	✓	✓				✓			AVPSAVA
BA-Fed	Vrbas at Daljan	✓	✓	✓							AVPSAVA
BA-Fed	Vrbas at Kozluk Jajce	✓	✓	✓							AVPSAVA
BA-Fed	Bosna at Reljevo	✓	✓								FHMZFBIH

State	Monitoring Location	Parameter									Data Provider
		P1	P2	P3	P4	P5	P6	P7	P8	P9	
BA-Fed	Bosna at Raspotočje	✓	✓	✓							AVPSAVA
BA-Fed	Bosna at Zavidovići	✓	✓	✓							AVPSAVA
BA-Fed	Bosna at Maglaj	✓	✓	✓							AVPSAVA
BA-Fed	Željeznica at Ilidža	✓	✓	✓							AVPSAVA
BA-Fed	Miljacka at Sarajevo	✓									FHMZFBIH
BA-Fed	Lašva at Merdani	✓	✓								AVPSAVA
BA-Fed	Krivaja at Olovo	✓	✓								AVPSAVA
BA-Fed	Krivaja at Zavidovići	✓	✓								AVPSAVA
BA-Fed	Usora at Kaloševići	✓	✓	✓							AVPSAVA
BA-Fed	Drina at Goražde	✓	✓	✓				✓			AVPSAVA
BA-Fed	Vrbas at Gornji Vakuf							✓			AVPSAVA
BA-Fed	Spreča at Strašanj							✓			AVPSAVA
BA-Fed	Spreča at Karanovac							✓			AVPSAVA
BA-Fed	Tinja at Srebrenik							✓			AVPSAVA
BA-Fed	Drvar					✓	✓				FHMZFBIH
BA-Fed	Sanski Most					✓	✓				FHMZFBIH
BA-Fed	Lušci Palanka					✓	✓				FHMZFBIH
BA-Fed	Biha					✓	✓				FHMZFBIH
BA-Fed	Bugojno					✓	✓				FHMZFBIH
BA-Fed	Jajce					✓	✓				FHMZFBIH
BA-Fed	Bjelašnica					✓	✓				FHMZFBIH
BA-Fed	Sarajevo-Bjelave					✓	✓				FHMZFBIH
BA-Fed	Olovo					✓	✓				FHMZFBIH
BA-Fed	Zenica					✓	✓				FHMZFBIH
BA-Fed	Tuzla					✓	✓				FHMZFBIH
BA-Fed	Gradačac					✓	✓				FHMZFBIH
BA-RS	Sava at Gradiška	✓									RHMZRS
BA-RS	Sava at Srbac	✓						✓			RHMZRS
BA-RS	Una at Novi Grad – upstream	✓		✓							RHMZRS
BA-RS	Una at Novi Grad – downstream	✓	✓	✓							RHMZRS
BA-RS	Sana at Prijedor	✓	✓	✓							RHMZRS
BA-RS	Sana at Donji Ribnik	✓									RHMZRS
BA-RS	Vrbas at Banja Luka	✓	✓								RHMZRS
BA-RS	Vrbas at Delibašino Selo	✓	✓	✓							RHMZRS
BA-RS	Bosna at Doboj	✓	✓	✓							RHMZRS
BA-RS	Vrbanja at Vrbanja	✓	✓								RHMZRS
BA-RS	Drina at Foča – downstream	✓									RHMZRS
BA-RS	Novi Grad					✓	✓				RHMZRS
BA-RS	Prijedor					✓	✓				RHMZRS
BA-RS	Banja Luka					✓	✓				RHMZRS
BA-RS	Gradiška					✓	✓				RHMZRS
BA-RS	Srbac					✓	✓				RHMZRS
BA-RS	Doboj					✓	✓				RHMZRS
BA-RS	Bijeljina					✓	✓				RHMZRS
BA-RS	Drinić					✓	✓				RHMZRS

State	Monitoring Location	Parameter									Data Provider
		P1	P2	P3	P4	P5	P6	P7	P8	P9	
BA-RS	Ribnik					✓	✓				RHMZRS
BA-RS	Mrkonjić Grad					✓	✓				RHMZRS
BA-RS	Šipovo					✓	✓				RHMZRS
BA-RS	Sokolac					✓	✓				RHMZRS
BA-RS	Han Pijesak					✓	✓				RHMZRS
BA-RS	Višegrad					✓	✓				RHMZRS
BA-RS	Foča					✓	✓				RHMZRS
BA-RS	Čemerno					✓	✓				RHMZRS
HR	Sava at Jesenice 2	✓	✓					✓			DHMZ
HR	Sava at Podsused/Ž	✓	✓		✓			✓			DHMZ
HR	Sava at Zagreb	✓	✓	✓				✓			DHMZ
HR	Sava at Rugvica	✓	✓					✓			DHMZ
HR	Sava at Crnac	✓	✓	✓				✓			DHMZ
HR	Sava at Jasenovac	✓	✓		✓			✓			DHMZ
HR	Sava at St.Gradiška	✓	✓					✓			DHMZ
HR	Sava at Mačkovac	✓	✓					✓			DHMZ
HR	Sava at Davor	✓	✓					✓			DHMZ
HR	Sava at Sl.Kobaš	✓	✓					✓			DHMZ
HR	Sava at Sl.Brod	✓	✓	✓	✓			✓			DHMZ
HR	Sava at Sl.Šamac	✓						✓			DHMZ
HR	Sava at Županja	✓	✓					✓			DHMZ
HR	Sutla at Zelenjak	✓	✓	✓							DHMZ
HR	Krapina at Kupljenovo	✓	✓		✓						DHMZ
HR	Kupa at Brodarci	✓	✓								DHMZ
HR	Kupa at Karlovac	✓									DHMZ
HR	Kupa at J.Kiselica	✓	✓								DHMZ
HR	Kupa at Farkašić	✓	✓								DHMZ
HR	Una at Kostajnica	✓	✓								DHMZ
HR	Una at Dubica	✓	✓								DHMZ
HR	Orljava at Pleternica	✓	✓								DHMZ
HR	Krapina					✓	✓				DHMZ
HR	Križevci					✓	✓				DHMZ
HR	Zagreb Grič					✓	✓				DHMZ
HR	Puntijarka					✓	✓				DHMZ
HR	Parg					✓	✓				DHMZ
HR	Karlovac					✓	✓				DHMZ
HR	Ogulin					✓	✓				DHMZ
HR	Sisak					✓	✓				DHMZ
HR	Daruvar					✓	✓				DHMZ
HR	Sl.Brod					✓	✓				DHMZ
HR	Gradište (Žup.)					✓	✓				DHMZ
ME	Lim at Bijelo Polje	✓	✓								ZHMS
ME	Tara at Trebaljevo	✓	✓								ZHMS
ME	Kolasin					✓	✓				ZHMS
ME	Bijelo Polje					✓	✓				ZHMS
ME	Berane					✓	✓				ZHMS

State	Monitoring Location	Parameter									Data Provider
		P1	P2	P3	P4	P5	P6	P7	P8	P9	
RS	Sava at Jamena	✓	✓	✓				✓	✓		RHMZ
RS	Sava at S.Mitrovica	✓	✓	✓				✓	✓		RHMZ
RS	Sava at Šabac	✓		✓							RHMZ
RS	Sava at Beljin	✓									RHMZ
RS	Sava at Beograd	✓		✓				✓			RHMZ
RS	Drina at Bajina Bašta	✓	✓	✓				✓	✓		RHMZ
RS	Drina at Radalj	✓	✓					✓	✓		RHMZ
RS	Lim at Brodarevo	✓	✓					✓			RHMZ
RS	Lim at Prijepolje	✓	✓	✓				✓	✓		RHMZ
RS	Lim at Priboj	✓	✓								RHMZ
RS	Vapa at Čedovo	✓	✓								RHMZ
RS	Jadar at Lešnica	✓	✓					✓	✓		RHMZ
RS	Bosut at Batrovci	✓									RHMZ
RS	Kolubara at Valjevo	✓	✓					✓	✓		RHMZ
RS	Kolubara at Slovac	✓	✓					✓	✓		RHMZ
RS	Kolubara at Draževac	✓	✓					✓	✓		RHMZ
RS	Ljig at Bogovađa	✓	✓					✓	✓		RHMZ
RS	Ćemanov Most at Tamnava	✓	✓					✓	✓		RHMZ
RS	Beograd-Vračar					✓	✓				RHMZ
RS	Loznica					✓	✓				RHMZ
RS	Sjenica					✓	✓				RHMZ
RS	Sremska Mitrovica					✓	✓				RHMZ
RS	Valjevo					✓	✓				RHMZ
RS	Zlatibor					✓	✓				RHMZ
SI	Sava at Radovljica I	✓	✓	✓				✓	✓	✓	ARSO
SI	Sava at Šentjakob	✓	✓	✓				✓	✓	✓	ARSO
SI	Sava at Litija I	✓	✓	✓							ARSO
SI	Sava at Čatež	✓	✓	✓							ARSO
SI	Sora at Suha	✓	✓	✓	✓			✓	✓	✓	ARSO
SI	Sotla at Rakovec	✓	✓								ARSO
SI	Kolpa at Metlika	✓	✓	✓							ARSO
SI	Ljubljanica at Moste I	✓	✓	✓				✓	✓	✓	ARSO
SI	Savinja at Nazarje	✓	✓	✓				✓	✓	✓	ARSO
SI	Savinja at Veliko Širje I	✓	✓	✓	✓			✓	✓	✓	ARSO
SI	Krka at Podbočje	✓	✓	✓				✓	✓	✓	ARSO
SI	Sava at Medno							✓	✓	✓	ARSO
SI	Sava at Hrastnik							✓	✓	✓	ARSO
SI	Sava at Jesenice na Dolenjskem							✓	✓	✓	ARSO
SI	Savinja at Letuš							✓	✓	✓	ARSO
SI	Savinja at Medlog							✓	✓	✓	ARSO
SI	Savinja at Laško							✓	✓	✓	ARSO
SI	Ljubljana-Bežigrad					✓	✓				ARSO
SI	Novo mesto					✓	✓				ARSO
SI	Celje					✓	✓				ARSO
SI	Krvavec					✓	✓				ARSO

State	*Monitoring Location*	*Parameter*									*Data Provider*
		P1	*P2*	*P3*	*P4*	*P5*	*P6*	*P7*	*P8*	*P9*	
SI	Lesce					✓	✓				ARSO

C.5 Timetable for provision

C.5.1 Signatories will make the data and information available in accordance with the schedule outlined in the following table:

Parameter	*Frequency of exchange*	*Maximum delay between end period of observation and data/ information being available to other Signatories*
P1	Annual	Within 1 year of the end of the calendar year of observation.
P2	Annual	Within 2 years of the end of the calendar year of observation.
P3	Annual	Within 1 year of the end of the calendar year of observation.
P4	Annual	Within 1 year of the end of the calendar year of observation.
P5	Annual	Within 1 year of the end of the calendar year of observation.
P6	Annual	Within 1 year of the end of the calendar year of observation.
P7	Constant	Near real-time transfer of more recent observation.
P8	Constant	Near real-time transfer of more recent observation.
P9	Constant	Near real-time transfer of more recent observation.

C.6 Format of data

C.6.1 Data and information outlined in this Annex will be made available electronically in a format to be agreed by the Commission's Expert Group for Hydrological and Meteorological Issues by June 2015.

C.7 Transfer method

C.7.1 The *Signatories* will make the data and information outlined in this Annex available via on-line transfer or arrange transfer by email.

C.8 Metadata

C.8.1 Appropriate metadata should be provided with data and information exchanged under this Annex, in accordance with Clause 12.1. The metadata to be provided will be agreed by the Commission's Expert Group for Hydrological and Meteorological Issues by June 2015.

For more information, please contact:

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