Eurowaternet Quantity

Technical guidelines for implementation

Authors:
C. Marcuello and M. Menéndez (Cedex)

Country contributions:
M. Menéndez (Cedex)
T. Estrela (Júcar River Authority, MMA)
T. J. Marsh and K. Thomas (CEH)
A. Lázár and A. Kiss (VITUKI Consult Rt.)
J. Bøgestrand (NERI)

ETC/WTR Manager:
T. J. Lack

EEA Project Managers:
Peter Kristensen and Niels Thyssen

European Environment Agency

Layout: Brandenborg a/s

A great deal of additional information on the European Union is available on the Internet.
It can be accessed through the Europa server (http://europa.eu.int)

ISBN: 92-9167-627-6

European Environment Agency
Kongens Nytorv 6
DK-1050 Copenhagen K
Tel. (45) 33 36 71 00
Fax (45) 33 36 71 99
E-mail: eea@eea.eu.int
Internet: http://www.eea.eu.int

Contents

The country contributions (pilot tests) are published separately on the ETC Water web page, URL: http://eea.eionet.eu.int:8980/Members/irc/eionet-circle/water/library?l=/eurowaternet_guidelines&vm=detailed&sb=Title

Preface

The European Environment Agency (EEA) aims to support sustainable development and to help achieve significant and measurable improvement in Europe's environment, through the provision of timely, targeted, relevant and reliable information to policy-making agents and the public.

The two main objectives of EEA in carrying out this mandate are:

- to assist the Community and EEA member countries to identify, frame, prepare and implement sound and effective environmental policy measures and legislation, and to monitor, evaluate and assess actual and expected progress in the implementation and results of such measures;

- to establish and coordinate the European environment information and observation network (Eionet) based on an information infrastructure for collection, analysis, assessment and management of data shared with European Commission services, EEA member countries and international organisations, agreements and conventions (EEA, 2002a).

The products developed by the EEA are based on trend analyses in 'State of the environment' reports, monitoring progress under separate EU legislation and international conventions, and more recently the development of indicators to support reporting on progress with EU environmental policy, sectoral integration and, in the future, sustainable development. In particular, the EEA is moving towards an agreed core set of policy-relevant indicators to regularise its reporting activities over the next five to 10 years. The core set of indicators should be based on Eionet priority data-flow process, which will be further extended to underpin the implementation of the core set (EEA, 2002b).

The European Topic Centre on Water (ETC/WTR) has designed and tested an information and monitoring network, called Eurowaternet. This network aims to provide the European Environment Agency with information that it needs to meet the requirements of its customers including the European Commission, other policy makers, national regulatory bodies and the general public. Information is required on:

- the status and trends assessments of Europe's water resources, quality and quantity; and

- how the state relates and responds to pressures on the environment (cause-effect relationships).

Eurowaternet Quantity is one component of Eurowaternet. It has been designed with the aim of filling the gaps in the water quantity aspects within the Eionet data-flow process and to provide the EEA with comparable and reliable information on the quantitative aspects of freshwater resources. The data arising through Eurowaternet are used to compile indicator fact sheets upon which the EEA reports are based, and fact sheet production will include the data provided by Eurowaternet Quantity. Eurowaternet is currently based on the monitoring networks that already exist in EEA member countries and makes no additional demands for new data gathering.

1. Background

Much of the work developed by the EEA in relation to water quantity has been based on existing aggregated data from countries, and water quantity data from a particular country is often used without having detailed knowledge of the methodology used by the country which provided the data. Very often there are differences between the approaches used for the computation of water quantity in different countries, which make comparability a difficult task.

Sometimes the estimation of the river runoff internally generated in a basin or country is calculated assuming that a non-altered regime exists, that is, that which would exist in the absence of human modifications. In other cases, river runoff is computed as the difference between precipitation and evapotranspiration, based on the equation for the (long-term) water balance of a territory. Moreover, in both cases, the calculations are usually carried out with the aid of mathematical models and the differences in estimating river runoff by the two methods can be significant. An added uncertainty is the aggregation in space and time of the hydrological data.

Spatial aggregations depend on the number of stations used and the data quality of the measurements. Spatial precipitation is usually estimated from raingauges, but their number can vary from year to year, affecting particularly the estimations in higher altitudes. In addition, the spatial aggregations depend on the methods used for the interpolation of point data, which can vary from simple interpolation algorithms to more complex geostatistical techniques.

Thus, a systematic assessment of the quantity of the freshwater resources that are available for use, both now and under future conditions, would help to overcome those differences. Many of the aforementioned differences could be counterbalanced by a suitable technical evaluation of the data supplied. However, in spite of the different initiatives taken by institutions such as Unesco (with the International Hydrological Programme) or the World Meteorological Organisation (with the Operational Hydrological Programme), no organisation has yet carried out this function on a European scale. Eurostat has launched the most recent initiative for compilation of methodologies and existing networks. The EEA's Eurowaternet Quantity proposed in this report, provides a methodology for station selection that guarantees comparable data on precipitation and river runoff across the EEA member countries.

For inland water quantity, there are two broad categories of monitoring networks:

- statutory and operational monitoring arising from national or international obligations or designed to provide information for the business and operational needs of the regulators, suppliers and users of water;
- surveillance monitoring designed to characterise and make assessments of the status of water resources, including physicochemical and ecological quality elements.

Though in practice there may be considerable overlap between these two categories of network at some sites, the classification is based on measurements taken to ensure legal compliance or efficient use of freshwater resources. In addition, the measurements help to inform policy making, assist planning decisions and increase basic knowledge.

The EEA requires information from a sound surveillance network, but this network should be flexible enough to be able to quantify pressures and impacts and to give answers to specific policy responses or mitigation measures. Eurowaternet Quantity has been designed to give this information.

Finally, the EEA has undertaken a major task involving the definition of a core set of water indicators, many of them developed from the comparable information provided from river, lake, groundwater, transitional, coastal and marine water monitoring stations included in Eurowaternet. Eurowaternet Quantity will provide the information related to freshwater resources and water availability across the EEA countries, with the main aim to fill the gap in the water quantity aspects within the Eionet data-flow process and to provide the EEA with comparable and reliable information on the quantitative aspects of freshwater resources.

2. Definition of Eurowaternet Quantity

Eurowaternet is the monitoring network from which the EEA obtains the information on water resources (quality and quantity) it needs to answer questions raised by its clients. Questions may relate to statements on general status (of rivers, lakes and ground waters, transitional, coastal and marine waters) or specific issues (such as water stress, nutrient status, hazardous substances and sustainable fisheries at a European level (EEA, 1998).

Hence Eurowaternet Quantity is the component of the network by which the EEA obtains information on water quantity and can answer questions on the general status of river runoff or specific issues (such as water stress (the balance between availability and use), identification of droughts and floods, and the effect of climate change on water resources).

The network is designed to give a representative assessment of the quantity of freshwater resources across the EEA region and within member countries. The use of the same criteria for selecting raingauges and gauging stations in countries will ensure that valid comparisons will be obtained when estimating the internal flow and precipitation inside a country.

Eurowaternet Quantity has three main components, based on a selection of raingauge and flow-gauging stations:

- precipitation;
- natural internal flow, which is based on discharges in undisturbed catchments;
- actual outflow, which is based on discharges at the mouth of the large or representative rivers.

Station selection is based on the existing networks in countries and helps to overcome the differences in freshwater resources estimation that arise from:

- the lack of one single definition for water quantity aspects;
- different ways of taking measurements;
- different methodologies for assessment;
- different spatial and time scales for interpolation;
- the use of information that has not been validated.

EEA member countries are asked to provide temporally aggregated data on precipitation and discharges from selected stations. It will also be useful if supportive information on gauging or raingauge sites and basin characteristics is provided. For the assessment of annual freshwater resources and precipitation, mean annual data will be requested. For the development of hydromorphological elements, such as the identification of river regimes, low and high flows, long-term trends in altered and non-altered basins, some statistics should be provided. The statistics should be percentile or extreme values with a confidence of 90 % descriptive of annual variations of the river flow.

In conclusion, Eurowaternet Quantity is a network based on a common methodology for station selection from existing networks, where each type of station is selected for a particular goal and to answer specified policy questions. In these respects, it is quite different from European networks providing precipitation and river discharge data. To this end, several international networks have been established, mainly worldwide, in order to provide the scientific community and stakeholders with hydroclimatic data that is relevant and valuable to deepen the knowledge of the hydrological cycle and its implications for human development. The following section overviews the most important existing international climate and hydrological networks or databases and makes judgements about the suitability of the data for EEA purposes.

3. Existing climatological and hydrological networks at European level: the added value of Eurowaternet Quantity

The World Meteorological Organisation (WMO) and the International Hydrological Programme (IHP) of Unesco are organisations that have established initiatives for hydro-climatological data collection worldwide. FAO/Aquastat and Eurostat also have data compilations on water resources from many countries. Despite both types of initiatives (that is, monitoring networks and compilations of synthesised data) having many advantages, they do not fully provide the information that the EEA requires for meeting its particular purposes.

Climate data (precipitation)
Precipitation is observed at a large number of stations by the national meteorological services, as part of the climate variables recorded. A subset of those records is exchanged in compliance with international agreements. The WMO leads the most recognised network worldwide for climate. One of the most prominent activities that WMO has been undertaking under different programmes is the development of climate databases. Climate data are routinely published by WMO, in the *World weather records bulletins*, which contain monthly and annual means or totals for each year of a decade, and the corresponding decadal (10-year) averages of pressure, temperature and precipitation. The bulletins have been published in regional volumes since the 1920s, the latest being the five volumes for the decade 1981–90 published in 1999. The Global Precipitation Climatology Centre (GPCC), at the German National Meteorological Service (DWD), has produced these records since 1989.

To date, the GPCC has collected monthly precipitation data from about 40 000 stations worldwide from around 150 countries. The data collection of GPCC is primarily based on direct contacts. The delivery and processing of the large amount of data causes serious delays in the database updating and analysis (WMO, 2000b). The GPCC point data are available in the annual bulletins. A total of 63 stations over 36 countries in Europe and the Middle East, i.e. WMO Regional Association VI, have reported data for the last annual regional bulletins (WMO, 1999 and WMO, 2000a). GPCC also provides gridded datasets as contributors to the Global Precipitation Climatology Project (Huffman et al., 1997), which was established in 1986 with the initial goal of providing mean monthly precipitation data on a 2.5° grid. The project currently has developed gridded products at 2.5° and 1.0° from point data as well as for combined point and satellite data, on a monthly and annual basis, up to February 2003. The image format for the mean interannual precipitation based on observed records is shown in Figure 3.1.

The Climatic Research Unit (CRU) and Tyndall Centre (TC) for Climate Change Research, of the University of East Anglia in UK, have compiled datasets of climatic variables, which include precipitation time series. This huge compilation has been developed through direct contacts with the national meteorological agencies and with additional information from WMO. The data were acquired through the free and unrestricted exchange of meteorological and related data, resulting in a total of 27 075 precipitation stations worldwide. The available products developed by CRU and TC are gridded datasets at 5° and 10' resolution. In particular, the TYN_CY_1.1 dataset is the spatial aggregation at country level of the climatic variables included in the CRU_TS_2.0 grids, which include monthly precipitation at 0.5° worldwide ranging from 1901 to 2000 ([1]) (Mitchell et al., 2002, Mitchell et al., in prep.).

The global climate observing system (GCOS) was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users. It is co-sponsored by the WMO, the

(1) The CRU_TS_1.2 have the precipitation datasets at 10' resolution for Europe.

Intergovernmental Oceanographic Commission (IOC) of Unesco, the United Nations Environment Programme (UNEP) and the International Council of Scientific Unions (ICSU). GCOS is intended to be a long-term, user-driven operational system capable of providing the comprehensive observations required for monitoring the climate system, for detecting and attributing climate change, for assessing the impacts of climate variability and change, and for supporting research toward improved understanding, modelling and prediction of the climate system. It addresses the total climate system including physical, chemical and biological properties, and atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes. In response to requirements from the climatological community, the GCOS program developed the GCOS surface network (GSN) which consists of 989 meteorological surface reporting stations from 50 Member States of the WMO (NOAA, 2001). GSN stations are expected to disseminate the information they provide via the global telecommunication system of the WMO on a global scale. The list of GSN stations operated by WMO RA-VI countries consists of 122 high-quality climatological stations (Rösner et al., 2000). NOAA's National Climatic Data Center (NCDC) operates a climate database that currently contains GSN data from 387 stations worldwide, of which 36 are in the RA VI countries. The latest updates were of 1999 data.

In comparison to point data, gridded datasets are more easily accessible from public sites. At present, CRU gridded products may be freely used for non-commercial scientific and educational purposes, provided that the datasets are correctly referenced. On the contrary, CRU is not able to release the station data, but is able to provide information on the number of stations within a grid-box. As for the GPCC point data and the GSN point data in the NCDC database, the information they provide requires some downloading and processing time, either from the bulletins or from the database. The data is not very timely.

An additional drawback of the currently available products is the density of the network on which the grids have been developed and the spatial resolution of the interpolations. The GPCC products are at 1° resolution. This resolution is quite coarse, particularly when trying to identify high precipitation at mountainous sites, which are neither reflected in the gridded result nor in the network. In contrast, Eurowaternet Quantity provides reasonably good resolution at all altitudes (Figure 3.2). The greatest effort in terms of spatial resolution has been carried out by CRU, which has developed 10' datasets, up to the year 2000, based on their own database. The number of stations included in GPCC or GSN is very low for making any aggregation at country level. The usefulness of this information is more directed towards surveillance of long-term trends in precipitation.

Each country that contributes climate information to a programme is responsible for the data quality of the provided information, in particular for the point data. Although there are procedures in place to develop common data quality protocols for precipitation, the type of quality control to which the data have been subjected varies from country to country. As regards the quality of gridded datasets, the metadata of the stations on which interpolations have been based should be reported to allow comparability checks.

Inside Europe, Eurostat compiles annual information on precipitation through the joint Eurostat/OECD questionnaire (JQ). The information that countries provide is the mean annual precipitation inside the country, which is available from the New Cronos database. Countries use their own methodology for estimating precipitation, but the database does not hold information on how the areal estimation has been done nor the number of stations used by each country. A new methodology has been recently adopted in agreement with the EEA and Eurostat in order to make data comparability easier (see Section 5 for more details).

Table 3.1 illustrates the differences of the results for mean annual precipitation in countries obtained from some of the mentioned international initiatives.

The added value of Eurowaternet Quantity is that it establishes an operational database derived from selected stations (raingauges), which allows estimating the mean areal precipitation in a particular area, that is, a country, according to a proposed, standardised methodology. Its widespread use will eliminate the variability seen in Table 3.1.

Figure 3.1 Precipitation normals 61/90. Analysis 1° mean precipitation for calendar year in mm/month. Data source: GPCC

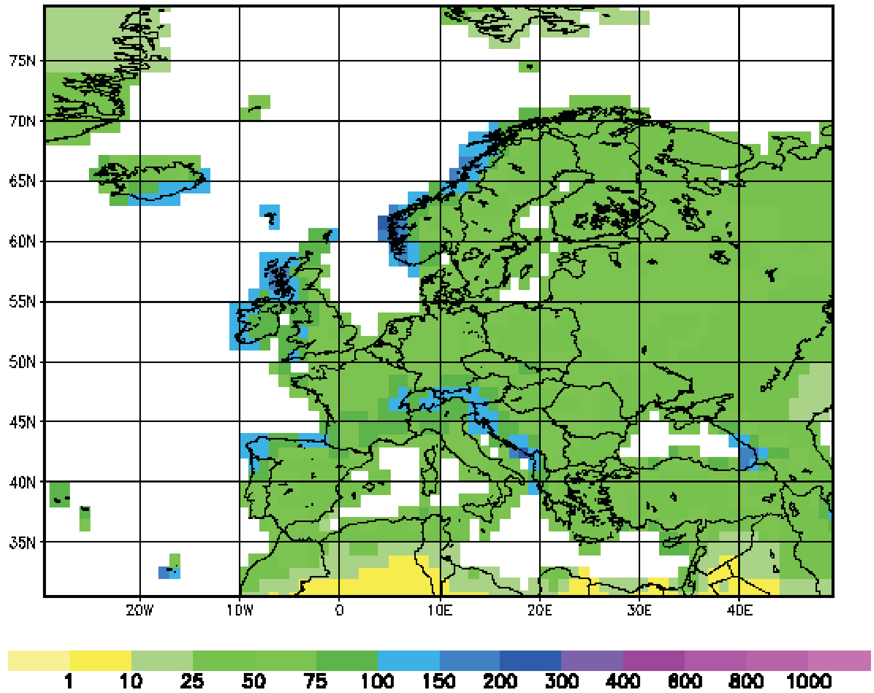
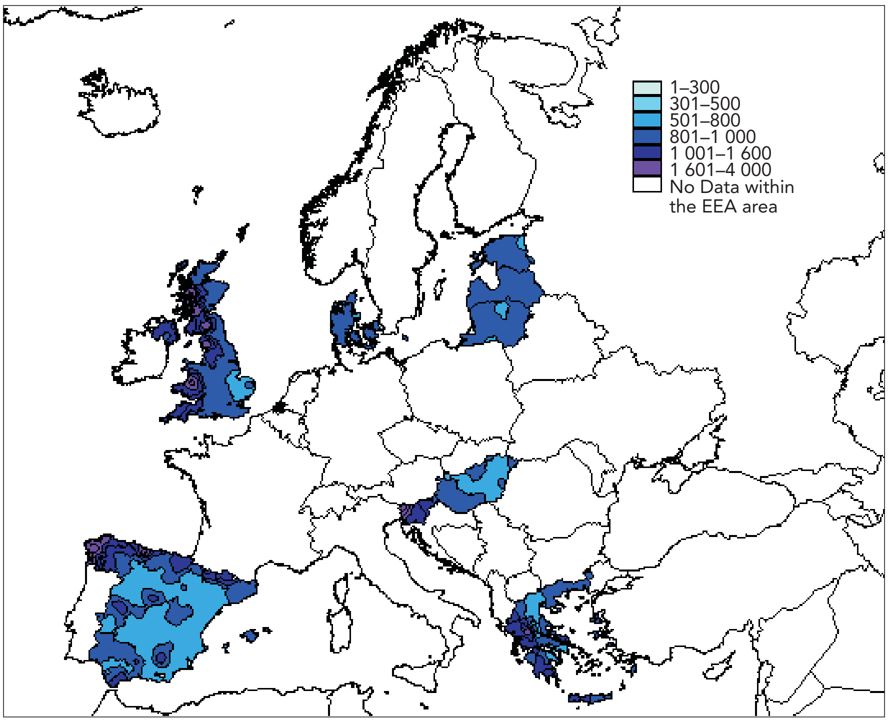


Figure 3.2 Mean precipitation 90/99 from Eurowaternet Quantity



Hydrological data (river discharges)
The primary sources for hydrological data and information are the national hydrological services, which also provide data for contributing to international initiatives. The three most outstanding international hydrological networks are: the Global Runoff Data Centre (GRDC), the flow regime for international experimental and network data (Friend) and the world hydrological cycle observing system (Whycos). The GRDC and Whycos are supported by the WMO, whilst Friend is a Unesco/IHP initiative.

Table 3.1 **Mean precipitation by country from various sources (mm/year)**

Country name	ISO Code	TYN61_90	GPCC61_90	TYN70_99	PEUROST70_99	EWNetPilot
Austria	AT	1 110	1 216	1 108		
Belgium	BE	847	756	838	871	
Cyprus	CY	498		478	316	
Czech Republic	CZ	677	635	665	691	
Denmark	DK	703	850	699	959	716
Estonia	EE	626	590	640	92	675
Finland	FI	536	684	542	4 645	
France	FR	867	924	870	918	
Germany	DE	700	708	692	786	n.d.
Greece	GR	652	308	633		841
Hungary	HU	589	454	588	648	623
Iceland	IS	978	853	1 005		
Ireland	IE	1 118	914	1 152		
Italy	IT	832	801	829	1 020	
Latvia	LV	641	793	666	744	682
Lithuania	LT	656	601	675	589	671
Luxembourg	LU	934		920	802	
Malta	MT	383		387	641	
Netherlands	NL	778	943	771	796	
Norway	NO	1 120	1 024	1 135		
Poland	PL	600	626	599	658	
Portugal	PT	855	1 033	830	946	
Romania	RO	637	315	643	663	
Slovakia	SK	824	463	814	792	
Slovenia	SI	1 162	401	1 150	1 090	1 363
Spain	ES	636	545	613	696	675
Sweden	SE	624	744	634	689	
Switzerland	CH	1 537	1 855	1 547	1 499	
United Kingdom	GB	1 220	1 079	1 246	1 201	1 123

TYN61_90 and TYN70_99: Mean annual precipitation from the TYN_CY_1.1 dataset (Mitchell et al., 2002) for the period 1961-1990 and 1970-1999 respectively.
GPCC61_90: GPCC aggregation for countries for the period 1961–90.
PEUROS70_99: Mean precipitation from Eurostat for the period 1970–99.
EWNetPilot: Result of applying the methodology proposed in Eurowaternet Quantity pilot testing studies.
n.d. indicates no data delivered for precipitation network testing but only for internal flow network testing.

The Friend project was initiated in 1985 in Europe within IHP-III on the premise that improvements could be made if hydrologists were to exchange data and experiences with their counterparts in neighbouring countries. To date, two out of the eight regional Friend projects have been established in Europe, that is, northern Europe and the Alpine and Mediterranean region (AMHY). The scientific aspects of the Friend project include studies into: low flows, floods, variability of regimes, rainfall/runoff modelling, processes of stream-flow generation, sediment transport, snow and glacier melt and climate and land-use impacts (Unesco, 2001). The northern European Friend project was started in 1985 and the completion of its first phase in 1989 led to the establishment of the European water archive (EWA). The EWA comprises two distinct elements: a relational database management system based on Oracle, which stores time series of river flow data, catchment characteristics and derived flow statistics; and a geographical information system, which stores spatially referenced data as ArcInfo coverages. For regional analysis, both time series and spatial data elements are routinely used in conjunction with each other (CEH, 2002). EWA holds a total number of 5 248 stations of 29 countries, with an average length of 30 years. The last update was in 1999. EWA is located at the Centre for Ecology and Hydrology in UK and its data is subject to the UK Natural Environment Research Council (NERC) data policy. EWA had a considerable expansion, after the first Friend report in 1997, following the completion of two projects. The first was the establishment of a European Data Centre for the NIS countries in St Petersburg, and the second was the EU ARIDE (assessment of the regional impact of droughts in Europe) project. At present, it seems that the archive needs additional support in order to be updated.

The GRDC collects and maintains a river discharge dataset worldwide. The database has been operated by the Federal Institute of Hydrology in Koblenz, Germany, since 1988. Countries submit daily and monthly river discharges at gauging stations with additional information on the catchment properties. The guiding criteria for including stations in the database are: stations at rivers representative of the hydrological regime, or are economically important in a region; stations having a large catchment area or large mean annual discharge; stations at undisturbed catchments and stations with long records. GRDC has developed a catalogue tool, which allows free access to users to look up the summary statistics of the stations, such as the number of stations in each region, the coordinates, the catchment area, the type of information provided, that is, monthly or daily, the percentage of missing values, the mean annual discharge, the year of start and last update of data. For example, in the EEA area plus Balkans, there are a total of 698 stations in 33 countries. Although the database is continuously updated, in the EEA countries plus Balkans the average for the start year of monthly discharges is 1955, and for the last is 1988, with a rate of 4 % of missing values. For daily data, the last year is 1993 on average, with a rate of 2 % of missing values. Data availability is subjected to the GRDC's data dissemination policy. The current situation is that data submission and thus database updating does not seem to be working on a timely basis.

Whycos is a WMO global programme that is structured into regional components. Its aim is to improve countries' capacity to supply reliable water-related data to resource planners, decision-makers, scientists and the general public. Of the European areas covered by Whycos, only the Mediterranean basin, that is, MED-HYCOS, has been implemented, while the Baltic, Black Sea and Danube basins are at different stages of development (Whycos, 2002). The major output of the MED-HYCOS project has been the development of the Mediterranean hydrological information system (MHIS), which includes information on the station location, hydrological regime, length of the time series, quality and quantity of the information available and information about water resources availability in countries. The database holds information on 94 stations, of which 87 belong to the EEA area plus Balkans, which are weekly or monthly updated, and the main areas of interest are the collection/transmission of (near) real-time data, technology transfer and Internet-oriented outputs. A tool for Internet data retrieval and display has been developed, which allows free access to users to data in tabular, graphic and cartographic form, since it is provided with a basic GIS interface.

Both the Friend and GRDC databases contain data from small and undisturbed catchments. The monitoring of discharges at these non-altered basins allows the evaluation of natural hydrological conditions and helps to identify, detect and evaluate the effects of climate change, in contrast to the altered regimes of the largest basins. This type of station can form a reference network. According to the WMO's definition, a reference (climatological) station 'provides the data intended for the purpose of determining climatic trends. This requires long periods (not less than 30 years) of homogeneous records, where human-influenced environmental changes have been and/or are expected to remain at a minimum. Ideally the records should be of sufficient length to enable the identification of secular (over time) changes of climate'. Though this definition applies to climatological stations, it can also apply to streamflow monitoring. In order to have insight of the effects of climate change from reference hydrometric stations, they need to be operated for long periods over representative and widespread areas and provide accurate data according to established data quality indexes. Eurowaternet Quantity provides the basis for the establishment and operation of a reference-type hydrometric network that will be able to estimate internal flow in areas (countries) and evaluate trends in natural discharges.

Gridded runoff datasets often require the use of water balance models (WBMs) for their

Table 3.2 **Internal flow by country from various sources (Mm^3/year)**

COUNTRY	ISO Code	UNH/GRDC	FAO/Aquastat	Eurostat	EWNPilot
Albania	AL	24 102	26 900		
Austria	AT	50 849	55 000	55 000	
Belgium	BE	11 477	12 000	12 400	
Bosnia and Herzegovina	BA	41 095	35 500		
Bulgaria	BG	22 390	21 000		
Croatia	HR	31 370	37 700		
Denmark	DK	20 505	6 000	6 115	11 980 ([1])
Estonia	EE	31 424	12 710	12 044	n.d.
Finland	FI	179 564	107 000	107 000	
France	FR	195 975	178 500	180 231	
Germany	DE	141 531	107 000	111 000	86 867
Greece	GR	34 814	58 000	60 000	n.d.
Hungary	HU	6 272	6 000	6 000	6 045
Iceland	IS	132 044	170 000	170 000	
Ireland	IE	67 822	49 000	49 000	
Italy	IT	144 606	182 500	167 000	
Latvia	LV	25 930	16 740	18 444	17 265
Lithuania	LT	24 204	15 560	15 510	15 669
Luxembourg	LU	680	13 000	905.1	
Netherlands	NL	8 977	11 000	8 480	
Norway	NO	414 684	382 000	358 671	
Poland	PL	76 403	53 600	54 800	
Portugal	PT	37 497	38 000	38 593	
Romania	RO	38 287	42 300	39 415	
Slovakia	SK	18 940	12 600	13 074	
Slovenia	SI	23 283	18 670	7 406	16 226
Spain	ES	114 285	111 200	111 133	105 184
Sweden	SE	219 390	171 000	170 000	
Switzerland	CH	47 753	40 400	40 150	
United Kingdom	GB	181 346	145 000	157 886	n.d.
Yugoslavia	YU	32 525	44 000		

([1]) Based on country data of 12 092 Mm^3/year.
EWNetPilot: Result of applying the methodology proposed in this report.
n.d. indicates no data delivered for internal flow network testing but only for precipitation network testing.

development. WBMs need climate data such as precipitation, air temperature, vapour pressure, wind speed, etc. as inputs, and streamflow is used as a calibration or validation variable. The errors involved in observed precipitation and in river discharge measurement considerably limit the accuracy of the estimates based on climate variables (Fekete et al., 2000; WMO, 2000b). There are several models at a global scale that have developed runoff fields based on the USGS DEM at 30' resolution. Some recently published examples are the WGHM developed at Kassel University (Döll et al., 2003) and the UNH/GRDC composite runoff fields (Fekete et al., 2000). The GRDC has also published a raster-based model for Europe at that same spatial resolution (GRDC, 2000).

The global terrestrial observing system (GTOS) was established in 1996 by FAO, ICSU, UNEP, Unesco and WMO. Its main activity is to help direct users towards sources of terrestrial data. GTOS, GCOS and the WMO hydrology and water resources programme are developing a global terrestrial network on hydrology (GTN-H), which should provide users with timely access to global hydrological data and metadata and promote and facilitate free and unrestricted exchange of data and products within the existing framework. However, it seems that there is only one component of this developing network for river discharge — the GRDC.

FAO compiles worldwide data on total renewable resources by country, which are stored in the Aquastat information system on water and agriculture. The Aquastat programme has been in operation since 1993, with the main purpose to 'select systematically the most reliable information on water resources and water uses in countries and to make it available in a standard format to users …' (FAO, 2003). The data compilation follows a set of rules for carrying out a water balance at national scale, by taking account of the internal and external flow and the external groundwater. However, there is not a common methodology for the estimation of each component. Data are available in two online databases: the water and agricultural data and the national institutions dealing with water and agriculture.

At the European level, Eurostat compiles annually the freshwater resources by country. The procedure is similar to that of FAO in the sense of using a set of rules for water balance in a country. In addition, a methodology has been adopted for countries to supply comparable information. Data are available through the New Cronos database. ETC Water, for the purposes of Eurowaternet Quantity has proposed to Eurostat a methodology for internal flow and actual outflow estimation in order to have better comparable information on water resources in Europe (see Section 5 for more details).

Table 3.2 illustrates the variability of the results for estimating the internal flow in countries obtained from some of the mentioned international initiatives.

4. The relationship between Eurowaternet Quantity and the water framework directive (WFD) (2)

The purpose of the WFD (EC, 2000) is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater, which, in relation to water quantity aspects, promotes sustainable water use based on the long-term protection of available water resources and contributes to mitigating the effects of floods and droughts.

Eurowaternet Quantity is designed to provide the information related to the availability of freshwater resources and to enable detection of extreme events by the analysis of the precipitation and discharge datasets.

According to the directive, Member States shall protect, enhance and restore all bodies of surface water with the aim of achieving good surface water status (good ecological potential and good surface water chemical status for artificial and heavily modified bodies of water). Good ecological status (potential) will be achieved by making operational programmes of measures. In order to make a classification of the status of water bodies, Member States shall ensure the establishment of programmes for the monitoring of water status within each basin.

According to Article 8, for surface waters, monitoring programmes shall cover: (i) the volume and water level or rate of flow to the extent relevant for ecological and chemical status and ecological potential, and (ii) the ecological and chemical status and ecological potential. For groundwaters, monitoring programmes shall cover monitoring of the chemical and quantitative status.

The directive specifies quality elements for the classification of ecological status that include hydromorphological elements supporting the biological elements and chemical and physicochemical elements supporting the biological elements.

The hydromorphological quality elements for rivers should be descriptive of their hydrological regime, continuity and morphological conditions. Those which are mandatory (Annex V) are: quantity and dynamics of water flow, connection to groundwater bodies, river continuity, river depth and width variation, structure and substrate of the river bed, structure of the riparian zone, current velocity and channel patterns.

Eurowaternet Quantity provides data of water flows and will help to provide information on dynamics, that is, by using data on water flows and supplementary information from the gauging stations. In addition, Eurowaternet Quantity will be able to supplement the information on pressures that are already available in Waterbase and therefore will help to make assessments of the status of rivers.

For surface water bodies, the directive requires that sufficient surface water bodies are required to be monitored in surveillance programmes to provide an assessment of the overall surface water status within each catchment and sub-catchment within the river basin district. Operational monitoring is to establish the status of those water bodies identified as being at risk of failing their environmental objectives, and to assess any changes in their status from the programmes of measures. For surveillance monitoring, parameters indicative of all the biological, hydromorphological and all general and specific physico-chemical quality elements are required to be monitored. For operational monitoring, the parameters used should be those indicative of the biological and hydromorphological quality elements most sensitive to the pressures to which the body is subject, and all priority substances discharged and other substances discharged in significant quantities. The directive requires that sufficient water bodies should be included in the surveillance monitoring

(2) The information related to the WFD monitoring programmes has been extracted from the monitoring guidance by CIS WG 2.7 (EC, 2003).

programme to provide an assessment of the overall surface water status within each catchment and sub-catchment within the river basin district. Surveillance monitoring is also required to provide information on long-term natural changes and long-term changes resulting from widespread anthropogenic activity.

According to the types of monitoring of the directive and following what was said in Section 1, the data-flow established by Eurowaternet Quantity is closer to a surveillance-type monitoring network. Firstly, because it holds data on water outflows to the sea or to boundary countries, which includes the discharges of large rivers, and secondly, because it gives information on the changes resulting from widespread anthropogenic activity. According to the directive, surveillance monitoring should be carried out at points where the rate of water flow is significant or significant bodies of water cross a Member State boundary. Finally, Eurowaternet Quantity is designed to give information on natural resources based on a selection of gauging stations located in basins that are less altered by anthropogenic activity. One of the objectives of surveillance monitoring is the assessment of long-term changes in natural conditions, for which Eurowaternet Quantity will be able to provide such information.

The most significant difference between Eurowaternet Quantity and a surveillance-type monitoring network in the sense of the directive is the number of parameters to be monitored. The directive requires that all hydromorphological parameters be monitored in surveillance monitoring, whilst Eurowaternet Quantity does not currently demand such comprehensive information.

Operational monitoring uses those parameters to be monitored in order to establish the ecological status of rivers. The approach of Eurowaternet Quantity to an operational-type monitoring network requires the collection of additional information, mainly based on river discharges at sites additional to those provided by the EEA countries through Eurowaternet Quantity. This additional information could be obtained from existing databases, and would be very useful supportive information to that from the main components of Eurowaternet Quantity. These datasets would also populate the database which would hold both the Eurowaternet Quantity data and the additional data and will provide the EEA with information to be used in the development of some specific indicators as required, for example, for climate change. In this sense, the cooperation with institutions such as WMO would add a great value to the network. The limitations of this mixed approach should also be taken into account when making the assessments, in particular as regards the data comparability which has been discussed in Section 3.

5. The relationship between Eurowaternet Quantity and Eurostat

The Statistical Office of the European Commission (Eurostat) has the responsibility to provide the European Union with high-quality statistical information. Eurostat's work programme on environment statistics includes a regular data collection on water statistics. Data are collected biannually through the inland water section of the joint Eurostat/OECD questionnaire (JQ) on the state of the environment, and in some cases supplemented by the reports on the state of the environment or national water statistics and other specialised publications.

Eurostat and OECD have undertaken a revision of the inland water section of the JQ to improve the data collection on water by improvement of the contents of the questionnaire, simplification of a number of tables, clarification of the variables requested, and harmonisation with related definitions of EU water directives.

In the context of this strategy, Eurostat is developing a manual for water data collection. Its main objective is to provide guidance, best practices and standards in collecting, estimating, compiling and analysing water data to be used as a tool for data-collection purposes. The aim is to have a comprehensive description of the terminology and methodology for water statistics including the different sectors involved in the water cycle from water abstractions to discharges (Eurostat, in prep.).

The freshwater resources section of the manual for water data collection develops a compilation of the methodologies that countries use to estimate and collect data on freshwater resources. In the first part of that section, a review of the existing raingauges and flow gauging networks in some countries has been fulfilled, jointly with the institutions that are responsible for the networking and those for the data-holding and validation.

The second part focuses on the different methods used for the estimation of freshwater resources. A review of several methodologies used based either on evapotranspiration measures, or on internal flow modelling or monitoring has been done. In this part, the different approaches used for freshwater resources assessments are highlighted, describing the lack of comparability between countries. Some other aspects of the freshwater resources assessments are approached, such as the estimation of low flows and recharge to aquifers. Finally, the third part is devoted to making recommendations for freshwater resources estimation. In this part, a methodology for computing the mean annual precipitation and the mean annual internal flow has been proposed and adopted. This is the identical methodology to be used by Eurowaternet Quantity in order to estimate the mean annual internal flow and precipitation in countries through the data provided by the selected raingauges and gauging stations of the network.

The adoption by Eurostat and the EEA of a common methodology for water resources estimation means that countries are able to use that methodology for precipitation, internal flow and actual outflow estimation which are required both by Eurostat and EEA/ETC. However, countries do not provide any information from individual stations used for that exercise to Eurostat who require only the nationally aggregated values. This makes Eurowaternet Quantity complementary to Eurostat since the EEA/ETC will hold the time series, information at the station level, and the spatial values estimated by the adopted methodology. Eurostat will hold only the nationally aggregated values which, of course, will be identical to those held by EEA/ETC. Indeed, there could be agreement as part of the effort on streamlining for EEA/ETC to pass those aggregated values to Eurostat/OECD.

6. Questions to be answered by Eurowaternet Quantity and related indicators

The sixth environmental action programme (6th EAP) of the EC (2001/0029 COD), has as one of its major objectives the sustainable use of natural resources: 'The overall extraction and consumption of water resources in the EU is currently sustainable in the long-term perspective. However, some areas may be facing unsustainable trends, especially in southern Europe. (…) Demand for freshwater is now often above the rate of replenishment in many parts of the world. Similarly, many areas are suffering desertification, deforestation, and the degradation of soils of alarming proportions.'

As previously stated, Eurowaternet Quantity will form a network of stations that will provide comparable information on freshwater resources. A database of the raw data on discharges and precipitations and their metadata at selected stations will be constructed (see Section 11). Eurowaternet Quantity will be able to provide information related to the WFD purposes in terms of surveillance monitoring, and when possible and in the case of further data availability, operational monitoring purposes. Since there is a common methodology for freshwater resources assessment, the estimations computed by using the data from Eurowaternet Quantity would be the same as those of Eurostat. Eurowaternet Quantity will also contribute to the trend analysis of water available for use and to identify problems of low availability and extreme events.

Eurowaternet Quantity will be able to answer questions related to the relevant policy issues that arise from the existing European legislation and the 6th EAP. Those policy questions are summarised in Table 6.1 and are the basis for the information to be provided by the EEA core set of indicators relating to water. This core set is currently under review by EEA member countries and other stakeholders.

Summary of the policy questions and the indicators that can be used for answering them by means of Eurowaternet Quantity Table 6.1

Policy issue	Policy question	Example of Determinand or Indicator
Water availability	How much water is naturally available for use?	Freshwater resources
	How much water is internally generated in a country/ territory?	Internal flow
	How much does a country/territory depend on external water resources?	Outflow to neighbouring countries
Long-term changes in natural conditions	Is there any indication of lower freshwater availability?	Discharges in undisturbed catchments
Droughts	Is there any indication of more frequent droughts in a country/territory due to natural causes?	Trends of annual precipitation.
Lower water availability	Is there any indication of lower availability due to increasing water use?	River discharges. Low flow regime
High flows	Is there any indication of changes in the frequency of high flows? Is there any indication of changes in the frequency of highest precipitations?	Maximum annual discharge Maximum annual Precipitation
Hydromorphological quality elements	Are we enhancing the status of the aquatic ecosystems?	River discharges. Low flow regime. At some specific locations: water levels, velocity.

7. Network description

7.1. Definition of the measured variables and their relationships

Natural basins
In its natural state, water moves in a sequence of physical processes that constitute the **hydrological cycle** which is the process by which the overall transfer of water between the atmosphere, the sea and the land is made as solid, liquid or gas state. The driving force behind these transfers is the sun. The set of water processes that have taken place or will do so in nature without any kind of human interference is the **natural hydrological cycle**.

The basic processes in the natural hydrological cycle are precipitation, evapotranspiration, infiltration, percolation and runoff. **Evapotranspiration** is the overall effect of the **evaporation** of the water from soils, seas, rivers and lakes, and **transpiration** loss of water from living organisms (such as plants). Evapotranspiration gives rise to the formation of vapour in the atmosphere that, on condensing under certain conditions, partly returns to the surface in the form of liquid or solid **precipitation**. A proportion of this precipitation **infiltrates** into the soil, from which it evaporates again, or **percolates** into the subsoil and the rest runs off over land or in the drainage network. The percolated water in the subsoil builds up in the pores, cracks and fissures below the ground surface that, because of its physical characteristics, has a greater or lesser capacity to store water. The geological formations that can store and transfer water are known as **aquifers**. The proportion of water that **recharges** the aquifers by percolation, and then reappears in the river network at some later date, is referred to as **groundwater flow**.

The term **natural internal flow** at a particular point on a river is used to define the volume of water that runs through that point in a given period of time. This includes the total **runoff** for the entire basin lying upstream of that point, plus the **groundwater flow** that flows into the riverbed upstream from that same point (the **base flow**).

Altered basins
The **natural internal flow** is not always the same as the river discharge that is measured at the gauging stations, because transfers might take place from adjacent basins and human activity can, in other ways, alter the natural flow conditions.

Water is an essential element for the development of civilisation, and mankind has severely modified the natural water flows and storage in the hydrological cycle. Growth of cities, food production using irrigation in agriculture or energy production, have made it necessary to divert water from its natural location, that is, rivers, lakes or aquifers, and use it for those purposes, thereby modifying the flows that would have taken place without human intervention.

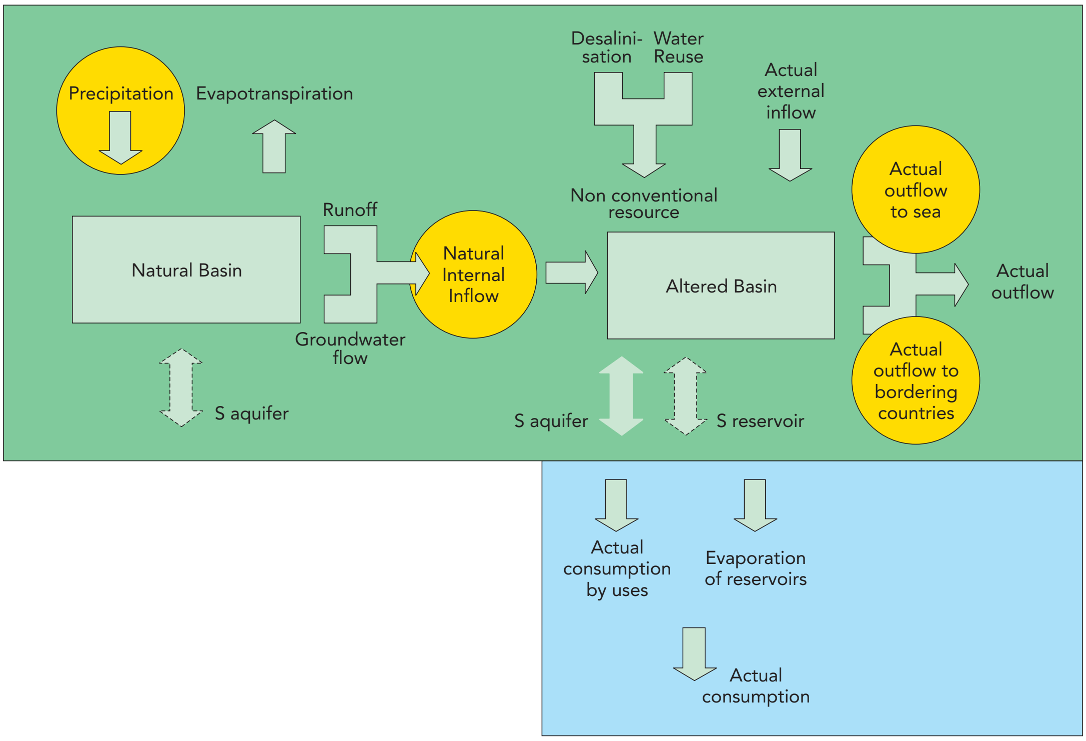
There have been major interventions in many regions of Europe, and these have often given rise to a hydrological cycle that is very different from the natural cycle. The result of such modifications to the natural flows and storage by human activities is referred to as **the altered hydrological cycle**.

From a quantitative point of view, the most significant effect on the natural flow cycle is the reduction of natural internal flow due to **actual consumption by uses**. This water generally comes from groundwater and the resources stored in reservoirs, whose yield is also reduced by evaporation.

Apart from the natural internal flow, the **actual external inflow** coming from adjacent basins must also be considered as forming part of the altered system, and the same applies to the **non-conventional resources** if they happen to be used, the latter mainly consisting of resources that come from **desalinisation** and **water reuse**.

The outflows from the system would comprise the actual consumption and the **actual outflow**. With respect to the latter, a distinction can be made between the **actual outflow to sea** and the **actual outflow to bordering countries**.

Components of the natural and altered hydrological cycles and the relationships between them — Figure 7.1



7.2. The components of Eurowaternet Quantity and related indicators

The different elements in the natural and altered cycles, as described in Section 7.1, and the main relationships between them can be charted according to Figure 7.1.

The circled elements in Figure 7.1, that is, precipitation, natural internal flow and actual outflow, are the components of Eurowaternet Quantity. Each component is a network of selected stations that provide rainfall or discharge data. The rest of the variables of Figure 7.1 are (a) indicators relating water uses and non-conventional water resources, and (b) indicators relating to storage. Eurowaternet Quantity does not provide data either on the (a) or on the (b) types of indicator. The exception is the 'actual external inflow', which is calculated from the actual outflow entering from other countries.

The indicators that can be developed using the Eurowaternet Quantity dataflow are summarised in Table 6.1. Some indicators derive from the measurement of one single determinand, whilst others need a combination of determinands. Table 7.2 shows the determinands required for developing indicators. It should be borne in mind that one outstanding characteristic of Eurowaternet is that it is designed on the basis of annually and nationally aggregated data.

Some of the determinands shown in Table 7.2 can be either an indicator itself or a component of other indicators related to a particular policy question. A widespread indicator for water stress is the 'water exploitation index (*wei*)' (Raskin, P. et al., 1997; Lane, M. et al., 1999, Alcamo, J. et al., 2000), which relates water uses and freshwater resources. In this case, the freshwater resources indicator is needed in order to compute the *wei*, and, as can be seen in Table 7.2, a combination of the internal flow and actual outflow indicators is needed in order to compute the freshwater resources. The combination of a low flow determinand, i.e. Q_{95}, and the mean annual discharge at any station, is representative of the proportion of streamflow originating from groundwater stores (Smakhtin, V. U., 2001; Young, A. et al., 2000), which then could be an indicator of change of groundwater resources. The combination of a determinand for extreme precipitation, i.e. the standard deviation of annual precipitation, and the mean annual precipitation at any station is representative of the natural hydrological patterns (Raskin,

Table 7.2 **Data and methodology needs for water quantity indicators based on Eurowaternet Quantity**

Indicator	Determinand (data needs)	Computation (methodology needs)
Natural Internal flow	Q_{ref}	✓
Freshwater resources	Q_{ref}, Q_{flux}	✓
Dependency on external resources Actual outflow to neighbouring countries/sea	Q_{flux}	✓✓
Long-term flow changes in natural conditions	Q_{ref}	✓✓
Droughts identification	P	✓✓
Water availability	Q_{addin}, Q_{ref}, Q_{flux}	✓✓
Less availability due to overabstraction	Q_{95}	✓✓
High flows	Q_{max}	✓✓
Low flows	Q_{95}	✓✓
Natural variability of hydrological patterns	P, P_{max}	✓✓

Key to the type of determinands:
P mean annual precipitation
Q_{ref} mean annual discharge at reference stations of the internal flow network
Q_{flux} mean annual discharge at flux stations of the actual outflow network
Q_{addin} mean annual discharge at additional intermediate stations
Q_{95} annual discharge exceeded 95 % of the time at all gauging station-types
P_{max} annual daily maximum precipitation
Q_{max} annual maximum discharge at all gauging station-types
See Section 7.4 for types of stations.

Key to the type of computation:
✓ an interpolation technique is needed in order to develop the indicator
✓✓ a trend analysis technique is needed in order to develop the indicator

P. et al., 1997). As the former determinand is not expected to be provided through Eurowaternet, one insight to the natural change in frequency of extreme rainfall can be provided by P_{max}.

7.3. The computation of freshwater resources

The simplest hydrologic model which is valid across all spatial and temporal scales is the continuity equation applied at any watershed:

$$\frac{dS}{dt} = P - E - Q - G \qquad (1)$$

where *P*, *E* and *Q* are the mean precipitation, evapotranspiration and natural internal flow respectively, *G* is the net amount of groundwater that leaves the aquifer storage, and *dS* is the change in storage in the basin over the time interval *dt*. Equation (1) is commonly used as the basis for describing the natural hydrological cycle of a region. Assuming negligible net changes in basin storage on an annual scale, it leads to:

$$\overline{Q} = \overline{P} - \overline{E} \qquad (2)$$

where $\overline{Q}$, $\overline{P}$ and $\overline{E}$ are the mean annual natural internal flow, precipitation and evapotranspiration. Total freshwater resources could be estimated if the natural inflow coming from neighbouring countries was known. Since it is usually not the case, unless the actual external inflow was naturalised, then it is summed up to the natural internal flow.

$$\overline{FR} = \overline{Q} + \overline{O} \qquad (3)$$

where $\overline{FR}$ is the mean annual freshwater resources and $\overline{O}$ is the actual inflow coming from neighbouring countries, that is, the actual outflow from neighbouring countries to that country.

Accurate estimations of the actual evapotranspiration $\overline{E}$ may be obtained from Equation (2) only when reliable estimates of $\overline{P}$ and $\overline{Q}$ are available from observed records or from maps or from digital grids of precipitation and runoff (Sankarasubramanian, A. et al., 2002).

Long-term annual average of water balance components (Data source: Eurostat New Cronos). Units are Mm³ Table 7.3

Country	$\overline{Q}$	$\overline{O}$	$\overline{FR}$	Outflow	$\overline{FR}$ — Outflow
Belgium	12 400	4 100	16 500	8 400	8 100
Denmark	6 115	0	6 115	6 000	115
Germany	111 000	74 000	182 000	182 000	0
Greece	60 000	12 000	72 000		
Spain	111 133	0	111 133	111 133	0
France	180 231	11 000	191 000	168 000	23 000
Ireland	49 000	1 287	46 760	45 473	1 287
Italy	167 000	8 000	175 000	155 000	20 000
Luxembourg	905	739	1 644	1 600	44
Netherlands	8 480	81 200	89 680	86 300	3 380
Austria	55 000	29 000	84 000	84 000	0
Portugal	38 593	35 000	73 593	34 000	39 593
Finland	107 000	3 200	110 000	110 000	0
Sweden	170 000	9 000	179 000	179 000	0
United Kingdom	157 886	2 744	160 630	160 630	0
Iceland	170 000	0	170 000	170 000	0
Norway	358 671	10 329	369 000	369 000	0
Switzerland	40 150	13 100	53 250	53 500	-250
Cyprus	781	0	781	113	668
Czech Republic	15 237	740	15 977	15 977	0
Estonia	12 044	9 070	21 114	11 920	9 194
Hungary	6 000	114 000	120 000	120 400	– 400
Lithuania	15 510	8 990	24 500	25 897	– 1 397
Latvia	18 444	17 748	36 192	36 192	0
Malta	67.11				
Poland	54 800	8 300	63 100	63 100	0
Romania	39 415	2 878	42 293	17 930	24 363
Slovakia	13 074	67 252	80 326	81 680	– 1 354
Slovenia	7 406	13 495.88	20 902	32 651	– 11 749
Turkey	227 400	6 900	234 300	178 000	56 300

Eurowaternet Quantity proposes a methodology for the selection of raingauges and gauging stations with the aim of getting accurate estimates of $\overline{P}$ and $\overline{Q}$, and to get information of $\overline{O}$, and thus to estimate $\overline{FR}$ in a country. This type of water balance can, in theory, be fulfilled from the data contained in databases such as New Cronos. However, the calculations provide evidence that there are different approaches for the estimations of the freshwater resources between countries and that this can give rise to significant inconsistencies. Examples shown in Table 7.3 are the negative values for the difference between the mean annual freshwater resources ($\overline{FR}$) and the outflows to neighbouring countries or to the sea, as demonstrated in, Hungary, Lithuania, Slovakia, Slovenia and Switzerland which means these countries are consuming more water than they have — clearly not a true situation. Countries with a high level of water consumption for irrigation, for example France, Italy, Portugal and Turkey, show a large positive difference between the annual resources and the outflow, but in the case of Spain (also with high water consumption) the difference is zero which is clearly inconsistent with the other countries.

The criteria for station selection for Eurowaternet Quantity results in a standardised estimate of the national aggregated values of precipitation, internal flow and freshwater resources through an interpolation criterion (described in detail in sections 8, 9 and 10) thereby eliminating the problems exampled from the New Cronos database.

Table 7.4 **The networks and type of stations of Eurowaternet Quantity**

Network	Station type	Country request
Precipitation	Raingauge (RGS)	P
Internal flow	Reference gauging station (BGS)	P
Actual outflow	Flux gauging station (FGS)	P
Additional intermediate	Additional intermediate gauging station (Addings)	O (from international sources)

Furthermore, the annual data from the selected stations will allow the production of time series whose trends can be analysed in order to support the development of robust and comparable indicators (see Table 6.1 and Table 7.2).

7.4. The networks and types of stations

Eurowaternet Quantity comprises three networks: precipitation, internal flow and actual outflow. Each network has its own station type and monitoring equipment as summarised in Table 7.4. Countries will be requested, as part of the annual priority data flows for water, to provide data from these three types of station. A fourth type of station has been additionally identified but data for this type will be obtained from international sources.

The precipitation network is made up of raingauge stations (RGS). RGSs are also intended to measure snowfall.

The internal flow network is made up of reference gauging stations (BGS). BGSs are intended to be located in rivers with a flow regime as natural as possible, which implies that the BGS basin is also undisturbed by human interventions.

The actual outflow network is intended to monitor fluxes to neighbouring countries and to the sea through the flux gauging stations (FGS). FGSs are intended to be located in the mouth of rivers or on national boundaries, and particularly focus on the large rivers.

A fourth type of station is defined with the aim of including information from gauging stations that are not of any of the former types and provide data on river-discharge type indicators for any particular requirement of the EEA, such as developing an indicator for the assessment of the impacts of climate change on water resources. The information provided by these stations supplements the assessments on water resources developed from the three Eurowaternet Quantity networks. These stations are grouped under the additional intermediate gauging station (Addings) type.

The data of the Addings type will be derived by ETC Water from existing discharge datasets or as a result of cooperation with international organisations holding national datasets.

7.5. Station selection — basic procedure and ETC support provided

The selection procedure should follow three iterative processes:

- selection of the stations of the network;
- estimation of the (long-term) annual precipitation and natural internal flow at national level;
- comparison of the estimations with existing validated data.

Sections 8, 9 and 10 describe how to select the stations for each network and how to perform the estimations of the mean annual precipitation and natural internal flow.

Eurowaternet Quantity stations should be selected from existing national networks by experts in each country using these guidelines. The main reasons for this recommendation are: (a) countries have a deeper knowledge of their freshwater resources so they can make a better selection; (b) the methodology for station selection can be supplemented with other criteria based on the knowledge of their freshwater resources that can improve the results of the estimations; and (c) countries do not have to provide ETC/WTR with large data files. Once the selection has been made, a report of the stations and results obtained should be made to ETC/WTR, through the contact persons identified below, in order to populate the database with the information of the selected stations.

However, ETC Water provides a support and helpdesk function to the countries. Should countries wish, the ETC Water can make a preliminary selection of stations, which will then need to be validated by national experts.

In order to make the selection, precipitation and discharges recorded in the last 10 years in all the stations of the country are needed. The data requirements are as follows:

Precipitation data: A file containing all the rain gauge stations in the country is needed. For each station provide in ASCII file format if possible:

- ID (number and/or name with which the station is identified);
- longitude and latitude of the station;
- mean annual precipitation for the last 10 years (1989–99).

Data on discharges for the internal resources and actual outflow assessment: A file containing all the gauging stations in the country is needed. For each station provide in ASCII file format if possible:

- ID (number and/or name with which the station is identified, and/or the name of the stream where the station is located);
- longitude and latitude of the station;
- surface area of the gauge station catchment;
- mean annual discharge for the last 10 years (1989–99);
- a descriptor identifying how much the river's natural regime at the station is altered. This descriptor should be: **natural** (if there is not much alteration in the river catchment associated with that station, with little influence from human activities such as abstraction or regulation), **altered** (if the regime at the gauging station is strongly altered by human activities) or **medium** (if the regime is neither natural nor strongly altered.

The following people should be contacted if assistance or advice is required:

Conchita Marcuello (Cedex, Madrid)
E-mail: concepcion.marcuello@cedex.es

Manuel Menendez (Cedex, Madrid)
E-mail: manuel.Menendez@cedex.es

Concha Lallana (Cedex – Core Team WRc)
E-mail: lallana_c@wrcplc.co.uk

8. Precipitation network

Basic requirements
Only raingauge stations that fulfil the following requirements are recommended to be included in the network:

- they must be in service;
- they must have at least 30 years of daily precipitation data.

These will be RGS-type stations. The determinands requested for the RGSs are: mean annual precipitation (P) and maximum daily precipitation (P_{max}). RGSs should include the measurement of snowfall, in which case the water equivalentshould be provided.

Geographical distribution
The required number of rain-gauge stations should be geographically spread across a member country with a density of one station per 5 000 km², with a minimum of four stations. The spatial distribution must be as even as possible.

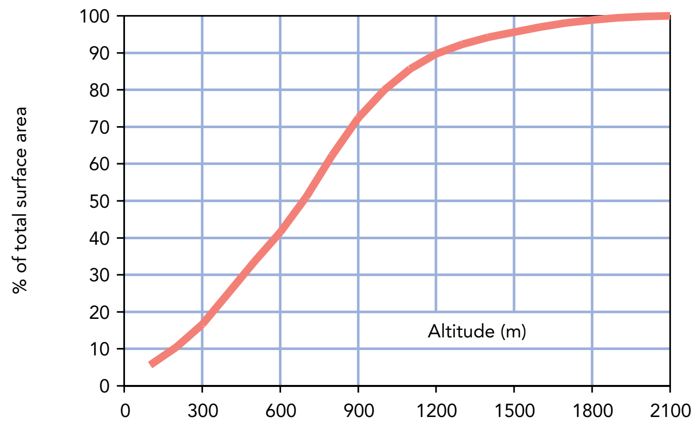
Distribution of the stations by altitude
The percentage of raingauge stations lying between two elevations should be approximately the same percentage of the total surface area between them. If, for example, the altitude contours embrace the percentages of the total surface area as Figure 8.1 shows, the curve for the elevations of the selected raingauge stations should have approximately the same shape.

It can be deduced from the above example that the number of raingauge stations with altitudes ranging from 600 to 900 m, should be approximately 30 %, that is, the difference between 70 and 40 %, of the total number of selected stations.

Estimating the mean annual precipitation
Once the rain gauge stations have been selected, the distributed precipitation values for the country will be obtained using the following interpolation technique:

- determinand to be estimated for the area: mean annual precipitation (mm);
- methodology: squared inverse of the distance;
- number of nearby points to be considered in the interpolation: 3.

Figure 8.1 **Distribution of the surface area with the altitude**



9. Internal flow network

General characteristics
The stations should be selected according to the following criteria:

- the flow regime at the station must be as natural as possible, with little influence of human activities (for example, abstraction or regulation);
- stations should have a minimum record period of 25 years from 1960 to 1990;
- stations must be in service.

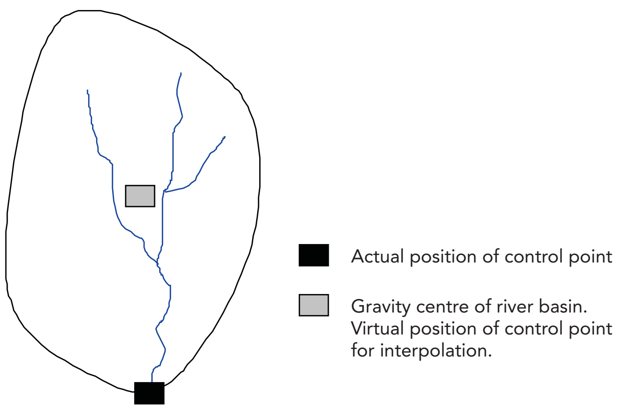
These will be BGS-type stations. The determinands requested for the BGSs are: mean annual discharge (Q_{ref}), maximum annual discharge (Q_{max}) and date of that discharge.

Geographical distribution
The natural regime condition generally makes it necessary to select stations lying in sub-basins that are located in the upper reaches of rivers close to the headwaters. The geographical distribution of these sub-basins must be as even as possible in the area considered taking the aforementioned condition into account. The station density sought is approximately between one station per 20 000 km² to one per 5 000 km² depending on the covered area and its hydrological homogeneity, with a minimum of four stations.

Estimating the internal flow
Once the gauging stations have been selected and their catchment areas have been defined, the distributed run-off values in a particular zone will be obtained using the following interpolation technique:

- specific value to be estimated for the area: mean annual discharge. For interpolation purposes, the station location is moved to the centre of gravity of the watershed, as Figure 9.1 shows, or any other point that is considered representative for that purpose;
- methodology: squared inverse of the distance;
- number of nearby points to be considered in the interpolation: 3.

Virtual position of control points for interpolation — Figure 9.1



10. Actual outflow network

General characteristics
Unlike the RG stations (precipitation) and BG stations (internal flows), which are selected to be representative of the national network, countries are asked to provide details from all the flux gauging stations that currently exist within the country. This is because the quantification of the outflows is extremely important in countries that are islands or with a relatively long coastline (high fluxes to sea) and in countries with large shared water resources (transboundary fluxes) for example, countries in the Danube river basin.

The stations should meet the following criteria:

- stations should be at the estuary or sea boundary (marine fluxes) and at the point where administration of the river passes from one nation to another (transboundary fluxes);
- stations should have a minimum record period of 25 years from 1960 to 1990;
- stations must be active.

These will be FGS-type stations. The determinands requested for the FGSs are: mean annual discharge (Q_{flux}), maximum annual discharge (Q_{max}) and date of that discharge.

Geographical distribution
All flux stations within the existing national network are to be included.

Estimation of actual outflow
This is assumed to be the sum of all the gauging stations.

11. Waterbase quantity

Introduction
Waterbase Quantity is the working database held and maintained by Cedex as the partner responsible for Eurowaternet Quantity in ETC/WTR. It is designed to hold the information obtained through Eurowaternet Quantity and to make queries in order to get the information needed for developing indicators. The database is designed taking into account that there are different methods for reporting and illustrating the indicator values. In due course, the data held in the working database Waterbase Quantity will be transferred (after validation by the member countries) to the Reference Waterbase which is maintained on the EEA server as part of the EEA Data Service and is the public access point for all water data.

Waterbase Quantity has the capability for queries and data uploading through the Internet by means of an application developed on the web server. The data exchange module (DEM) can be either an Access (or Excel) file or an Internet-based template. The following information is provided to standardise the flow of data from each country to ETC/WTR (in the short-term) and the EEA Central Data Repository, in the longer term.

Description of the alphanumeric database
The alphanumeric data will be stored in the following tables, where the key fields are in italics, of the HIDRO database:

Table of stations, which holds the descriptive features of each station.

Field	Description	Type
Station_id	National code for the station	Character 10
Country_id	Country code	Character 20
Station_descr	Description of the	Character 80
Determinand_id	Code for type of determinand	Integer
Longitude	Longitude (DDMMSS)	Integer
Latitude	Latitude (DDMMSS)	Integer
Altitude	Altitude	Integer
Catch_area	Area of the catchment for the gauging station	Real 9.1
Catch_name	Name of the catchment for the gauging station	Character 30

Table of types of determinands, which relates to the stations table.

Field	Description	Type
Determinand_id	Code for the type of determinand	Integer
Determinand_descr	Description of the type of determinand	Character 30
Determinand_symbol	Symbol used for the determinand	Character 10

The types of determinands, according to Table 7.1, will be:

Determinand_id	Determinand_descr	Determinand_symbol
1	Mean annual precipitation at RGS (mm)	P
2	Mean annual discharge at BGS (m^3/s)	Q_{ref}
3	Mean annual discharge at FGS (m^3/s)	Q_{flux}
4	Annual discharge exceeded 95 % of the time at all gauging station types (m^3/s)	Q_{95}
5	Annual maximum discharge at all gauging station-types (m^3/s)	Q_{max}
6	Annual daily maximun precipitation (mm)	P_{max}
7	Mean annual discharge at Addings (m^3/s)	Q_{addin}

Table of types of countries, which relates to the types of determinands table.

Field	Description	Type
Country_id	Country code	Integer
Country_name	Name of country	Character 30

Table of types of time series, which relates to the types-of-determinands table and the stations table.

Field	Description	Type
Station_id	National code for the station	Character 10
Determinand_id	Code for the type of determinand	Integer
Year_all	Year for the value of the determinand	Integer
Month_max	Month for the maximum value of the determinand (*)	Integer
Day_max	Day for the maximum value of the determinand*	Integer
Determinand_value	Value for the determinand	Real 9.3

(*) Only for Q_{max} and $P_{max.}$

Description of the cartographic database
The GIS Arcview, which is linked to the external alphanumeric database, is designed to allow a set of queries that will be graphically displayed as follows:

- maps of countries displaying the queried stations, determinand and year;
- maps of countries displaying the queried stations and percentiles of the time series;
- graphs of the status of the information held by Waterbase Quantity;
- line charts of queries of time series;
- maps of the areal values of mean annual precipitation and inland flow.

12. Testing of Eurowaternet Quantity concepts and procedures through pilot studies

Pilot testing was first carried out in Spain and was then extended to 10 other countries: Denmark, Estonia, France, Germany, Greece, Hungary, Latvia, Lithuania, Slovenia, and the United Kingdom. For all of them, the same methodology has been applied in order to better assess water resources at national level. The selection of stations was carried out by an ETC/WTR partner (Cedex) except for Hungary and the UK, who performed their own selections. The selections made by Cedex were discussed and agreed with national experts.

Full details of the pilot testing have been published on the web page of ETC/WTR and can be downloaded from the following URL:

http://eea.eionet.eu.int:8980/Members/irc/eionet-circle/water/library?l=/eurowaternet_guidelines&vm=detailed&sb=Title

13. References

Alcamo, J.; Henrich, T.; Rösch, T., 2000. *'World water in 2025 — Global modeling and scenario analysis for the World Commission on Water for the 21st century'.* Report A0002, Centre for Environmental System Research, University of Kassel, Germany.

CEH, 2002. *Friend, a global perspective 1998–2002.* Gustard, A. and Cole, G. eds. Centre for Ecology and Hydrology, Wallingford, UK. ISBN 1 903741 03 3.

EC, 2000. Directive 2000/60/EC establishing a framework for Community action in the field of water policy. (OJ L 327, 22.12.2000).

EC, 2003. Water Framework Directive Common Implementation Strategy Working Group 2.7 Monitoring. Guidance on monitoring for the water framework directive. Final version, 23 January.

EEA, 1998. *Eurowaternet. The European Environment Agency's monitoring and information network for inland water resources: technical guidelines for implementation.* Technical report No 7.

EEA, 2002a. *Providing policy relevant information for Europe's environment. The EEA strategy.* Manuscript 8 pp. http://org.eea.eu.int/documents/strategy/strategy/strategy.pdf

EEA, 2002b. *Development of common tools and an information infrastructure for the shared European environment information system. Preparatory report for Reportnet.* Technical report No 83.

EEC, 1990. Council Regulation (EEC) No 1210/90 on the establishment of the European Environment Agency and the European environment information and observation network (OJ L 120, 11.5.1990), amended by the Council Regulation (EC) No 93/1999 (OJ L 117, 5.5.1999).

Eurostat, In preparation. *Manual for water data collection.* (Draft of the second intermediate report: Identification, description and evaluation of methodologies for water data collection and estimation. Compiled by Cedex).

FAO, 2003. *Review of world water resources by country.* Report No 23. ISBN 92-5-104899-1. E-version at: http://www.fao.org/docrep/005/y4473e/y4473e00.htm.

Fekete, B.M.; Vörösmarty, C. J.; and Grabs, W., 2000. *Global composite runnoff fields based on observed river discharge and simulated water balances.* GRDC report No 22.

GPCC. Global Precipitation Climatology Centre homepage. http://www.dwd.de/research/gpcc.

GRDC, 2000. *Modelling raster-based monthly water balance components for Europe.* Report No 26.

Huffman, G.J.; Adler, R.F.; Arkin, P.A.; Chang, A.; Ferraro, R.; Gruber, A.; Janowiak, J.; McNab, A.; Rudolf, B.; Schneider, U., 1997. The Global Precipitation Climatology Project (GPCP) combined precipitation dataset. *Bull. Americ. Meteor. Soc.*, 78(1), 5–20.

Lane, M.; Kirshen, P. H.; Vogel, R. M., 1999. 'Indicators of impacts of global climate change on US water resources'. *J. Water Planning and Assessment*, Vol. 125 (4).

Mitchell, T.D.; Hulme, M., and New, M., 2002. 'Climate data for political areas'. *Area 34,* 109–212.

Mitchell, T. D., et al., In preparation. *A comprehensive set of climate scenarios for Europe and the globe.*

NOAA, 2001. Asheville World Data Center for Meteorology web page. US Department of Commerce, National Oceanic and Atmospheric Administration (http://www.ncdc.noaa.gov/oa/wmo/wdcamet.html).

Raskin, P.; Gleick, P.H.; Kirshen, P.; Pontius, R. G. Jr, and Strzepek, K.,1997. *Comprehensive assessment of the freshwater resources of the world.* Stockholm Environmental Institute, Sweden.

Rösner, S.; Fuchs, T.; Lefebvre, C., 2000. *The GCOS Surface Network Monitoring Centre (GSNMC). Results for WMO RA VI Europe.*

Sankarasubramanian, A.; Vogel, R. M., 2002. 'Annual hydroclimatology of the United States'. *Water Resources Research*, Vol 38 (6).

Smakhtin, V. U., 2001. 'Low flow hydrology: a review'. *Journal of Hydrology*, 240, pp. 147–186.

Unesco, 2001. International Hydrological Programme. IHP-VI plan (2002–07) homepage (http://www.unesco.org/water/ihp/ihp_six.shtml).

Whycos, 2002. Status of Whycos components, updated 1 May 2002 (http://www.wmo.ch/web/homs/projects/status.html).

WMO, 1999. *'Annual bulletin on the climate in WMO Region VI — Europe and the Middle East'.* WMO, ECSN, DWD. ISSN: 1438-7522; e-copy at http://www.gcmp.dwd.de/.

WMO, 2000a. *'Annual bulletin on the climate in WMO Region VI — Europe and the Middle East'.* WMO, ECSN, DWD. ISSN: 1438-7522; e-copy at http://www.gcmp.dwd.de/.

WMO, 2000b. *'Establishment of a global hydrological observation network for climate'. Report of the GCOS/GTOS/HWRP Expert Meeting. Germany, June 2000.* Report GCOS 63. Report GTOS 26. WMO/TD- No 1047.

Young, A. R.; Round, C. E.; Gustard, A., 2000. 'Spatial and temporal variations in the ocurrence of low flow events in the UK'. *Hydrology and Earth System Sciences*, 4(1), pp. 35–45.

European Environment Agency

Eurowaternet Quantity

2003 – 31 pp. – 21 x 29.7 cm

ISBN 92-9167-627-6