DRAINAGE BASIN OF THE NORTH SEA AND EASTERN ATLANTIC

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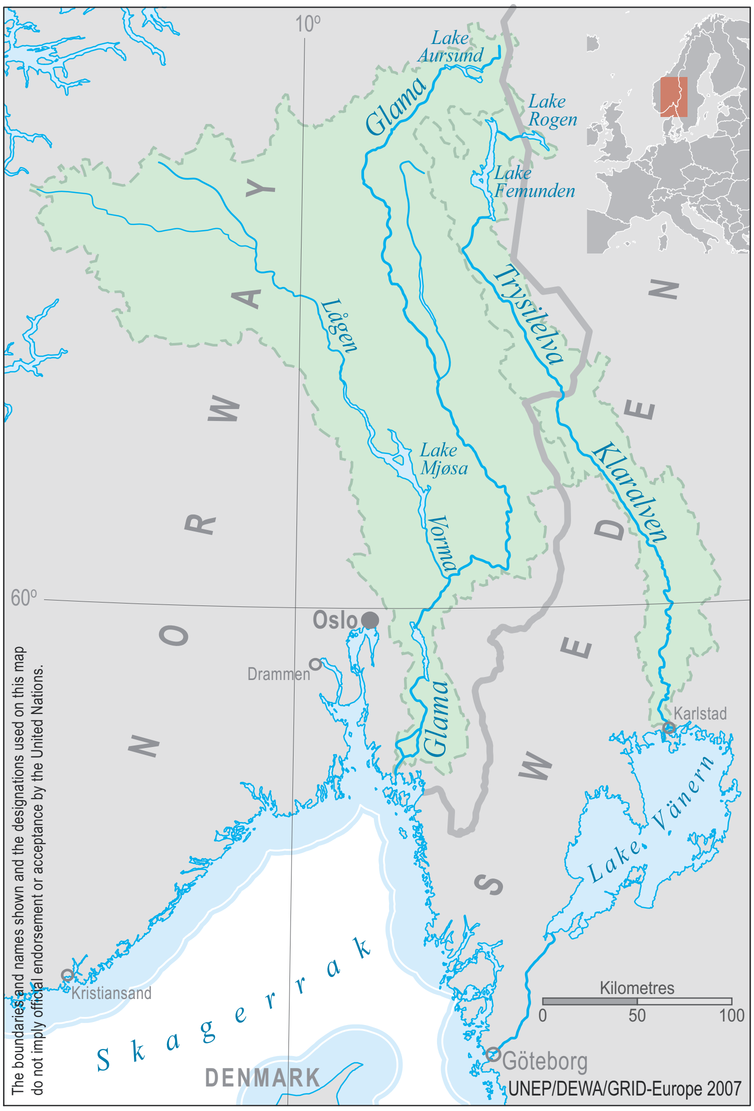
This chapter deals with major transboundary rivers discharging into the North Sea and Eastern Atlantic as well as with some of their transboundary tributaries. It also includes lakes located within the basins of the North Sea and Eastern Atlantic.

TRANSBOUNDARY WATERS IN THE BASINS OF THE NORTH SEA AND EASTERN ATLANTIC[1]

Basin/sub-basin(s)	Total area (km²)	Recipient	Riparian countries	Lakes in the basin
Glama	42,441	North Sea	NO, SE	…
Klaralven	11,853 [2]	North Sea	NO, SE	…
Wiedau	1,341	North Sea	DE, DK	…
Elbe	148,268	North Sea	AT, CZ, DE, PL	…
Ems	17,879 [3]	North Sea	DE, NL	…
Rhine	197,100 [4]	North Sea	AT, BE, CH, DE, FR, IT, LI, LU, NL	Lake Constance
- Moselle	28,286	Rhine	BE, DE, FR, LU	…
- Saar	7,431	Moselle	FR, DE	…
- Vechte	2,400	Swarte water > Ketelmeer > Ijssel-meer > North Sea	DE, NL	…
Meuse	34,548 [5]	North Sea	BE, FR, NL	…
Scheldt	36,416 [6]	North Sea	BE, FR, NL	…
Yser	[7]	North Sea	BE, FR	…
Bidasoa	*500*	*Eastern Atlantic*	*ES, FR*	…
Mino	17,080	Eastern Atlantic	ES, PT	Frieira reservoir
Lima	2,480	Eastern Atlantic	ES, PT	Alto Lindoso reservoir
Douro	97,600	Eastern Atlantic	ES, PT	Miranda reservoir
Tagus	80,600	Eastern Atlantic	ES, PT	Cedillo reservoir
Guadiana	66,800	Eastern Atlantic	ES, PT	…
Erne	4,800	Eastern Atlantic	GB, IE	…
Foyle	2,900	Eastern Atlantic	GB, IE	…
Bann	5,600	Eastern Atlantic	GB, IE	…
Castletown	*400*	*Eastern Atlantic*	*GB, IE*	…
Fane	*200*	*Eastern Atlantic*	*GB, IE*	…
Flurry	*60*	*Eastern Atlantic*	*GB, IE*	…

[1] The assessment of water bodies in italics was not included in the present publication.
[2] Basin area until Lake Värnern.
[3] Area for the Ems River Basin District.
[4] Area for the Rhine River Basin District.
[5] Area for the Meuse River Basin District.
[6] Area for the Scheldt River Basin District.
[7] The Yser is part of Scheldt River Basin District.

GLAMA RIVER BASIN[1]



The Glama River, also known as the Glåma and the Glomma, is shared by Norway and Sweden.

With a total length of some 604 km, the Glama runs from Lake Aursund near Røros in Sør-Trøndelag (Norway) and empties into the Oslofjord at Fredrikstad. Major tributaries include the Vorma and Lågen rivers. The Vorma River drains Lake Mjøsa and joins the Glama at Nes. The Lågen River drains into Lake Mjøsa, collecting water from the large Gudbrandsdal valley and significantly increasing the Glama's flow.

The Glama has experienced several major floods due to melting snow from Jotunheimen, Rondane and other mountain areas in Norway. A number of hydroelectric stations were built to provide electricity to the urban-industrial complex in the lower part of the river between Sarpsborg and Fredrikstad. Today, the hydropower stations on the rivers Glama and Lågen cover about 9% of Norway's electricity demand.

The Glama, passing through a heavily forested region, is Norway's chief timber-floating river. The total agricultural area in the basin, mainly located in the southern part, is about 1,500 km^2.

The lower part of the river was industrialized in the beginning of the 20th century, the main activities being pulp and paper industries and a zinc smelter. Today, one of the main industrial activities is a chromium-titanium plant situated close to the river mouth. There is also a big plant for waste incineration.

Basin of the Glama River			
Area	**Country**	**Country's share**	
42,441 km^2	Norway	42,019 km^2	99%
	Sweden	422 km^2	1%

Source: Ministry of Environment, Norway, and Swedish Environmental Protection Agency.

From 1986 to 1995, the Glama carried between 120,000 and 440,000 tons per year of suspended particulate matter. The yearly contribution of lead by the Glama is about 10-20 tons; it is a mixture of natural lead from minerals, atmospherically long-range transported lead and lead from local anthropogenic sources. Studies of the bottom sediments in the estuary show an increasing concentration of lead, with increasing distance from the river mouth. The estuary is affected by material transported by the river and autochthonous material due to the highly productive conditions in the estuary itself. Eutrophication is also a common phenomenon.

[1] Based on information submitted by the Governments of Norway and Sweden as well as information from a joint project by the Institute for Energy Technology of Norway and the Norwegian Institute for Water Research.

KLARALVEN RIVER BASIN[2]

The Klaralven River, also known as the Klarälven, is shared by Norway (upstream country) and Sweden (downstream country).

Basin of the Klaralven River			
Area	Country	Country's share	
11,853 km^2	Norway	2,872 km^2	24.2%
	Sweden	8,981 km^2	75.8 %

Source: Swedish Environmental Protection Agency ("Statistics Sweden, 2000").

The almost 460-km-long Klaralven ("clear river" in Swedish) runs for almost 300 km on Swedish territory. The river begins with a number of streams flowing into Lake Femunden on the Norwegian side of the border. Some of these watercourses also come from Sweden, mainly from Lake Rogen in Härjedalen. The river flowing south from Lake Femunden is first called the Femundselva and later the Trysilelva. The river crosses the border and changes its name to the Klaralven. It flows through northern Värmland, where it follows a valley towards the south. The river empties into Lake Vänern in Sweden with a delta near Karlstad.

The river's average discharge is 165 m^3/s. The maximum measured discharge was 1,650 m^3/s.Spring floods are common, mainly caused by run-off from the snowy mountains in the northern areas of the basin.

The Klaralven has clean and fresh water, suitable for bathing. The river is internationally recognized as excellent sport fishing watercourse. Following Norwegian data for the period 1969-2002, the river carried some 48,000 tons TOC, 75 tons phosphorus and 2,600 tons nitrogen per year. However, these determinands were not analysed in Sweden.

WIEDAU RIVER BASIN[3]

The Wiedau River, also known as the Vidå, is shared by Denmark and Germany.

Basin of the Wiedau River			
Area	Country	Country's share	
1,341 km^2	Denmark	1,080 km^2	81%
	Germany	261 km^2	19%

Sources: Ministry for the Environment, Nature Protection and Nuclear Safety (Germany) and LIFE Houting-project.

The Wiedau is a typical lowland and tidal river. It starts east of Tønder (Denmark) and flows to the west, ending in the Wadden Sea at the German-Danish North Sea coast.

The mean water flow at the outflow into the Wadden Sea is approximately 15,000 l/s (minimum 4,000 l/s, maximum 95,000 l/s). The Wiedau is highly controlled by weirs and gates to protect it from tides and surges, and yet does discharge its water into the North Sea. The sluice at Højer town regulates the water exchange with the Wadden Sea.

The river's important uses are fishing and canoeing. 90% of the basin area is arable land.

In the past, the main parts of the watercourses in the basin were heavily modified through drainage, dredging and physical alterations. During the last decade, Denmark has completed a number of nature restoration projects, including the reconstruction of 27 smaller weirs to make them passable for migrating fish. Other projects brought 37 km of straightened, modified water stretches back to original meandering.

[2] Based on information submitted by the Governments of Norway and Sweden.
[3] Based on information submitted by the Government of Germany and information from the LIFE Houting-project.

Nowadays, the river system is inhabited by 24 different fish species, which is considered high in Danish terms. However, the sizes of a number of the populations are quite small and they only occur in limited parts of the river system.

ELBE RIVER BASIN[4]

Four countries (Austria, Czech Republic, Germany and Poland) share the basin of the Elbe River.

[4] Based on contributions by the International Commission for the Protection of the Elbe River and the Ministry of the Environment of the Czech Republic.

Basin of the Elbe River			
Area	**Country**	**Country's share**	
148,268 km^2	Austria	920.7 km^2	0.62%
	Czech Republic	49,933 km^2	33.68%
	Germany	97,175 km^2	65.54%
	Poland	239.3 km^2	0.16%

Source: International Commission for the Protection of the Elbe River.

Hydrology

The Elbe River, with a total length of 1,094.3 km, originates in the Giant Mountains in the northern Czech Republic. Its main tributary is the Vltava River in Southern Bohemia (Czech Republic). Other tributaries of the Elbe River include the Ohre River in the Czech Republic as well as the Schwarze Elster, Mulde, Saale and Havel rivers in Germany.

The mean annual discharge at the border between the Czech Republic and Germany (catchment area – 51,394 km^2) is 311 m^3/s. At Cuxhaven (Germany), the Elbe discharges into the North Sea. The mean annual discharge at the mouth is 861 m^3/s.

In the Czech Republic, except some small ones, there are almost no natural lakes. In the German part of the Elbe River basin, specifically the Middle and Northern German lowlands, there are a number of natural lakes, such as the Mueritz See, Schweriner See, Plauer See, Koelpinsee and Schaalsee.

The largest hydraulic structures include the Lipno, Orlik, Slapy, Svihov and Nechranice reservoirs in the Czech Republic and the Bleiloch, Hohenwarte, Bautzen and Eibenstock reservoirs in Germany. Water-quantity problems are linked to floods (e.g. in August 2002) and droughts (e.g. in the summer of 2003).

Pressure factors

In the Czech part of the Elbe basin, the principal pressure factors are similar to those in Germany (see below). The main problems are related to point sources, which cause pressures on the oxygen balance, emit specific pollutants, partially also nutrients, and lead to salinization, acidification and thermal pollution. As for non-point sources, agriculture and forestry with nutrient inputs are of utmost concern. One of the main problems is eutrophication, particularly of some reservoirs.

In the German part of the Elbe basin, the principal pressure factors include pressures on the oxygen balance, nutrient pressures, pressures by specific pollutants, thermal pollution, salinization, acidification, water abstractions, flow regulation and morphological alterations. These pressure factors have sometimes led to situations in the Elbe and its tributaries, which were assessed as "slightly polluted by non-point and point sources of pollution". Eutrophication of reservoirs is also a problem in the German part of the basin.

In the 1990s, a comprehensive monitoring network was established to provide insight into over 100 physico-chemical and biological determinands of the Elbe and its major tributaries based on identical or comparable analytical methods.

Transboundary impact

In the 1980s, the Elbe was still one of the most polluted transboundary rivers in Europe.

Water pollution has substantially decreased from the 1990s onwards. Oxygen concentrations have been improved almost in the whole Elbe River; at present, the oxygen status is "mostly satisfactory". Likewise, the nutrient load has progressively decreased. The phosphorus load in Germany has also diminished, especially from point sources. In the Czech Republic, substantive progress was achieved, above all due to the operation of efficient wastewater treatment plants with phosphates' reduction.

The reduction of the pollution of the Elbe with heavy metals, organic hazardous substances and nutrients was mostly due to decreasing or ceasing industrial production, as well as to the construction of new municipal and industrial wastewater treatment plants. This is shown in the following table, which provides calculated load values (based on measured concentrations and river discharges) for two years (1989 and 2004) with almost equal river discharges.

Pollution load of the Elbe River for two years with approximatelythe same river discharge				
Determinands	Unit	Year 1989	Year 2004	Reduction (in %)
Mean annual discharge	m^3/s	520	511	...
Mercury	t/a	12	1.0	92
Lead	t/a	110	59	46
Cadmium	t/a	6.4	5.2	19
Zinc	t/a	2,400	700	71
Chromium	t/a	190	26	86
Nickel	t/a	200	54	73
Arsenic	t/a	52	45	13
Hexachlorobenzene	kg/a	150	19	87
Hexachlorobutadiene	kg/a	96	<1	>99
Trichloromethane	kg/a	13,000	160	99
Trichloroethene	kg/a	7,300	<16	>99
Tetrachloroethene	kg/a	8,300	120	99
1,2,4-Trichlorobenzene	kg/a	570	<9.7	>98
Total nitrogen	t/a N	140,000	75,000	46
Total phosphorus	t/a P	9,100	3,100	66
AOX (Cl)	kg/a	1,600,000	350,000	78
BOD_{21}	t/a O_2	430,000	210,000	51
COD	t/a O_2	760,000	440,000	42

Source: International Commission for the Protection of the Elbe River.

Despite these positive developments, diffuse pollution sources and "old pollution sites" are still of concern and have to be dealt with more intensively.

According to an analysis of the Elbe River basin characteristics in 2004[5], the status of surface water bodies was estimated as follows: 11% of water bodies "not at risk", 26% of water bodies "needing further assessment to determine risk", and 63% "at risk of failing the environmental objectives". This analysis provides the grounds for further measures to achieve the objectives of the Water Framework Directive (WFD).

Trends

The transboundary impact from the Czech Republic on German territory is decreasing. Eutrophication will remain one of the main problems.

A higher number of wastewater treatment plants and their improved efficiency as well as the implementation of a River Basin Management Plan will substantially improve the status of water bodies.

[5] Prepared for the 2005 reporting under the Water Framework Directive.

EMS RIVER BASIN DISTRICT[6]

Germany and the Netherlands share the Ems River basin. As the management unit, the Ems River Basin District[7] was created, which includes the Ems-Dollart estuary.

Ems River Basin District			
Total area	**Country/area**	**Country's/area's share**	
17,879 km²	Germany	15,008 km²	84%
	Netherlands	2,389 km²	13%
	Ems-Dollart estuary	482 km²	3%

Sources: International River Basin District Ems: features, pressures and assessment of the impact of human activities on the environment, Part A, 2005. International Steering Group on the Ems River basin district, Germany and the Netherlands.

[6] Source: International Steering Group on the Ems River basin district, Germany and the Netherlands.
[7] According to the EU WFD, a River Basin District is an area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters, which is identified under Article 3 (1) as the main unit for management of river basins.

The Ems, also known as the Eems, is a river in north-western Germany and north-eastern Netherlands. It runs through the German States of North Rhine-Westphalia and Lower Saxony. The Ems' tributaries in the Netherlands (Provinces of Groningen and Drenthe) discharge directly into the Ems-Dollart tidal system.

The source of the river is at the southwest edge of the Teutoburg Forest in North Rhine-Westphalia. At Meppen, the Ems is joined by its largest tributary, the Hase. Near the city of Emden, the Ems flows into Dollart bay and then continues as a tidal river towards the Dutch city of Delfzijl. The total length of the Ems is 371 km.

At the Rheine gauging station (Germany) the discharge values are as follows: HHQ – 332 m^3/s; MQ – 37 m^3/s and MNQ – 5.8 m^3/s. At this gauging station, the discharge during the 1946 flood event with a recurrence interval of 100 years amounted to 1,030 m^3/s.

Hydromorphological changes have a high or very high influence on the ecological quality of the water bodies. The water bodies in the river basin are loaded by nutrients, especially nitrates.

RHINE RIVER BASIN DISTRICT[8]

The International River Basin District Rhine, established as the management unit under the WFD, has a size of approximately 200,000 km² and is shared by nine countries.

Basic figures for the Rhine River Basin District

Indicator	RBD	IT	CH	LI	AT	DE	FR	LU	BE	NL
Countries' area in km²	197,100	<100	27,930	<200	2,370	105,670	23,830	2,530	<800	33,800
Countries' areas share in km²	100	<1	14	<1	1	54	12	1	<1	17
Countries' population share in %	100	…	9	<1	1	64	6	1	<1	20
Urban areas in km²	14,800	…	950	…	70	9,750	1,490	160	40	2,340
Agricultural land in km²	99,310	…	9,620	…	990	56,000	13,000	1,410	430	17,860
Forests in km²	69,040	…	16,290	…	1,270	38,990	9,040	940	290	2,220
Wetlands in km²	370	…	<20	…	<5	100	<20	0	<5	230
Water bodies in km²	13,350	…	1,200	…	40	790	150	10	0	11,160

Source: Internationale Flussgebietseinheit Rhein: Merkmale, Überprüfung der Umweltauswirkungen menschlicher Tätigkeiten und wirtschaftliche Analyse der Wassernutzung (International River Basin District Rhine: features, assessment of the impact of human activities on the environment and economic analysis of water uses). International Commission for the Protection of the Rhine.

RHINE RIVER

Hydrology

The Rhine River, with a total length of 1,320 km, is one of the most important transboundary watercourses in western Europe. Its source is in the Swiss Alps. The Rhine passes through Lake Constance (see separate assessment below). Important transboundary tributaries include the Moselle and Vechte rivers, which are separately assessed below.

The long-term mean annual discharge (MQ) at the Konstanz gauging station (Germany) is 338 m³/s; at Karlsruhe-Maxau (Germany), 1,260 m³/s; and at Rees, upstream of the German-Dutch border, 2,270 m³/s.

Pressure factors and transboundary impact

The Rhine is one of the most intensively used water bodies in Europe. Some 58 million people live in the Rhine basin and some 20 million people depend on the Rhine as their main source of drinking water supply, either through direct abstraction (Lake Constance), bank filtration or abstraction of groundwaters, which are artificially recharged by Rhine water infiltration through dunes.

96% of the population in the Rhine basin is connected to some 3,200 municipal wastewater treatment plants, which also treat wastewater from small industries and run-off water from sealed surfaces.

[8] Based on information by the International Commission for the Protection of the Rhine as well as the publication "Internationale Flussgebietseinheit Rhein: Merkmale, Überprüfung der Umweltauswirkungen menschlicher Tätigkeiten und wirtschaftliche Analyse der Wassernutzung" (International River Basin District Rhine: features, assessment of the impact of human activities on the environment and economic analysis of water uses), International Commission for the Protection of the Rhine, 18 March 2005.

Currently, over 950 of major industrial point pollution sources have been identified. These big and medium-sized enterprises operate their own treatment plants. In 2000, eight industrial enterprises were responsible for a considerable share of the total emission of at least one of the following substances: Hg, Cr, Cu, Ni, Pb, N-total and P-total. The share of single enterprises varied between 1% (N-total) and 18% (Cr). There were no single enterprises that discharged more than 1% of the total emission of Zn, Cd or Lindan.

Nitrogen, phosphorus and pesticides originate from diffuse pollution sources in agriculture or run-off in rural areas. Run-off water, including water from sealed surfaces and streets is also responsible for heavy metal inputs into the watercourses of the basin. The table below shows the significant share of pollution from diffuse sources.

Mining activities, although decreasing, have an impact on the sub-basins of the Moselle and Saar rivers, the Ruhr area in Germany and the western side of the Lower Rhine area. Adverse effects, sometimes visible over the whole length of the Rhine downstream of the confluence with the Moselle, include hydraulic changes, thermal pollution and pollution by chlorides and heavy metals. Mining of hard coal has significantly changed groundwater flow (see assessment of the Moselle sub-basin), and opencast mining of brown coal is lowering the groundwater level in parts of the Lower Rhine area, with adverse impacts on aquatic and terrestrial ecosystems.

The Rhine is an important shipping route. Apart from hydromorphological changes, required for shipping purposes, ship transport adversely affects riverbanks and their ecology and leads to higher turbidity (raising of sediments). Other pressure factors include water abstraction for cooling purposes, hydropower production and agriculture.

Emissions in the Rhine River Basin District				
Emissions upstream of Lake Constance (average for 1996–1997)				
Determinands	**Municipal and industrial sources**		**Diffuse pollution**	**Total**
N-total (in kg)	3,630,000		13,000,000	16,630,000
P-total (in kg)	140,000		370,000	510,000
Emissions downstream of Lake Constance				
Determinands	**Municipal sources**	**Industrial sources**	**Diffuse pollution**	**Total**
N-total (in kg)	107,120,000	22,853,000	289,881,000	419,854,000
P-total (in kg)	9,719,000	2,424,000	14,032,000	25,175,000
Cr (in kg)	11,467	34,971	88,205	134,643
Cu (in kg)	56,820	48,139	213,627	318,586
Zn (in kg)	357,689	107,071	1,223,103	1,687,863
Cd (in kg)	863	809	6,350	8,022
Hg (in kg)	353	306	1,222	1,881
Ni (in kg)	31,979	30,993	105,036	168,008
Pb (in kg)	23,827	19,265	148,882	191,974
Lindan (in kg)	0	1	219	220

Source: Internationale Flussgebietseinheit Rhein: Merkmale, Überprüfung der Umweltauswirkungen menschlicher Tätigkeiten und wirtschaftliche Analyse der Wassernutzung (International River Basin District Rhine: features, assessment of the impact of human activities on the environment and economic analysis of water uses), International Commission for the Protection of the Rhine.

Share of nitrogen and phosphorus emission in various transboundary sub-basins						
Sub-basins	**N-total (in %)**			**P-total (in %)**		
	Municipal sources Industrial sources		**Diffuse sources**	**Municipal sources Industrial sources**		**Diffuse sources**
Alpine Rhine and Lake Constance	22		78	27		73
Upper Rhine	12	4	85	21	4	75
Moselle and Saar	9	1	90	58	2	40
Delta Rhine (Netherlands)	13	4	83	35	7	58

Source: Internationale Flussgebietseinheit Rhein: Merkmale, Überprüfung der Umweltauswirkungen menschlicher Tätigkeiten und wirtschaftliche Analyse der Wassernutzung (International River Basin District Rhine: features, assessment of the impact of human activities on the environment and economic analysis of water uses), International Commission for the Protection of the Rhine.

Trends

Owing to heavy investments into wastewater treatment and industrial safety technology over a long period of time, the pollution of the Rhine River has been significantly reduced. The salmon, one of the indicator species for demonstrating the success of pollution abatement measures, recently returned to the river. The remaining pollution stems mainly from diffuse sources. Therefore, agriculture is one of the target areas for further improving the status of watercourses in the International River Basin District Rhine.

In order to achieve the targets of the WFD related to the status of surface waters, further measure have been identified as to nutrients, chromium, copper, zinc and PCB-153 as the relevant pollutants; further "target" substances include nickel and its compounds, HCB and tributyl-tin. As to groundwaters, there is hardly a quantity problem, however, nitrates and some pesticides have been identified as target substances to improve groundwater quality.

LAKE CONSTANCE[9]

Lake Constance, which belongs to the Rhine basin, is the second largest pre-Alpine European lake and serves as an important drinking water supply for 4 million people. A major tributary to Lake Constance is the Alpine Rhine with its sub-basin in Italy, Switzerland, Liechtenstein and Austria.

The lake basin is situated in the Molasse basin of the northern Alpine foreland and was mainly formed by water and ice activity during the last Quaternary glaciation period more than 15,000 years ago. The lake basin area of about 11,000 km² (~20 times the lake surface) covers the territories of the five European countries: Germany (28%); Switzerland, Liechtenstein and Italy (48%); and Austria (24%). With an area of 572 km^2 and a total volume of 48.5 km^3, Lake Constance lies 395 m above sea level. Its two major parts are the Upper Lake Constance (472 km^2, 47.6 km^3, max. depth 253 m, mean depth 101 m) and Lower Lake Constance (62 km^2, 0.8 km^3, max. depth 40 m, mean depth 13 m). More than 75% of the water inflow originates from the Alps, mainly through the tributaries Alpine Rhine (Alpenrhein) and Bregenzerach. The lake has a water retention time of 4.3 years.

The phytoplankton succession typically shows a spring bloom followed by the "clear water" phase with very low phytoplankton abundance due to zooplankton grazing. Diatoms contribute up to 90% of the phytoplankton biovolume in spring. Phytoplankton, bacteria and crustaceans are the most important contributors of biomass. During summer, zooplankton is the main food source for most fish in Lake Constance. About 30 species of fish contribute to the fauna of Lake Constance. The dominant species are whitefish (*Coregonus lavaretus L.*) and perch (*Perca fluviatlis L.)* – contributing to 90% of total commercial fishing yield (1032 tons, annual mean for the period 1995–2004).

Lake Constance is certified by the Ramsar Convention as a habitat of international importance especially for water and wading birds. It is an intensively monitored hard-water lake with low-phosphorus content - overall mesotrophic (the Upper Lake is almost oligotrophic: phosphorus levels <10

[9] Based on information provided by the Governments of Austria, Germany and Switzerland.

µg/l since 2005). Originally an oligotrophic water body, eutrophication started to threaten the lake in the late 1950s and remarkably affected the species composition of the biota. Starting in the early 1980s, phosphorus concentrations strongly declined, and overall water quality improved. This was due to reduced nutrient loads (more than €4 billion have been invested to improve sewage treatment).

In recent times, the pressures by rising population figures and industrial and agricultural activities may deserve concern. Today, some 60% of shore and shallow-water zones are characterized as deviating from the natural state, and therefore a main focus is on ecological improvement by shoreline restoration. For this purpose, the International Commission for Protection of Lake Constance has initiated an action programme "Shore-water and Shallow-water Zone".

The biological quality of tributaries discharging into the lake varies from unpolluted headwater rivers to slightly polluted lower reaches. Hydromorphological changes have been severe in these areas, as canalization and artificial riverbeds and banks are common. Recently, revitalization has been undertaken in the floodplains of the Alpine Rhine, the main tributary discharging into the lake.

Lake Constance is also facing climate change with increasing winter temperatures and higher precipitation in the form of rain. The summers will be dryer and hotter resulting in lower water levels and changes in the littoral zone. This climatic change might be accompanied by an increasing number of exotic species in the future, which may threaten indigenous biota.

MOSELLE RIVER[10]

Belgium, France, Germany and Luxembourg share the sub-basin of the Moselle River, which includes the transboundary Saar River.

Sub-basin of the Moselle River			
Area	**Country**	**Country's share**	
28,286 km²	France	15,360 km²	54.3%
	Luxembourg	2,521 km²	8.9%
	Belgium	767 km²	2.7%
	Germany	9,637 km²	34.1%

Source: International Commission for the Protection of the Moselle and Saar.

Hydrology

The Moselle, also known as the Mosel, Musel and Moezel, is one of the largest tributaries of the Rhine. The source of the Moselle is at the western slope of the Ballon d'Alsace in the Vosges mountains (France). Its total length from source to mouth at the confluence with the Rhine at the city of Koblenz (Germany) is approximately 545 km. Based on measurements at the gauging station Cochem, the calculated average discharge at the mouth is 328 m^3/s.

The Saar River is the largest transboundary tributary of the Moselle. The 227-km-long Saar joins the Moselle next to the city of Trier. The Saar catchment area of 7,431 km² is almost equally shared by France and Germany. Its discharge at the confluence with the Moselle is 80 m^3/s.

The Moselle has been made navigable for large cargo ships from the Rhine at Koblenz up to Neuves-Maisons, south of Nancy. For smaller ships, it is connected to other French rivers through the Canal de l'Est and the Canal de la Marne au Rhin.

Pressure factors and transboundary impact

The Moselle valley between Nancy, Metz and Thionville is an industrial area, with coal mining and steel manufacturing. Hard coal mining in the Moselle and Saar region also causes significant transboundary impacts on groundwaters.

[10] Based on information contained in the publication: Richtlinie 2000/60/EG - Internationale Flussgebietseinheit Rhein, Internationales Bearbeitungsgebiet „Mosel-Saar": Bestandsaufnahme (Directive 2000/60/EG – International River Basin District Rhine, International area Moselle-Saar: Inventory). International Commission for the Protection of the Moselle and Saar, June 2005.

At Cattenom (France), one of the most powerful European nuclear power stations uses the Moselle for cooling purposes. Water transfer from the Vieux-Pré reservoir in the Vosges usually compensates its thermal pollution;[11] and pollution by radioactive substance, with the exception of tritium, is below measurement level. The relatively high chloride level is both of natural origin and due to emissions from French sodium industry. In 2003, the chloride concentration in the upper reaches of the Moselle was still around 330 mg/l and at Koblenz 200 mg/l.

Transboundary impact from Luxembourg is mainly related to nitrogen (from animal husbandry and from some municipal wastewater treatment plants, which are not yet eliminating nitrogen). The impact from Belgium is similar to that from Luxembourg. The German impact, mostly related to ongoing and ceased mining activities, is decreasing although some hazardous substances and chlorides are still entering the Saar.

VECHTE RIVER

Germany (upstream country) and the Netherlands (downstream country) share the sub-basin of the Vechte River.

Sub-basin of the Vechte River			
Area	**Country**	**Country's share**	
2,400 km^2	Germany	1,536 km^2	64%
	Netherlands	864 km^2	36%

Source: Netherlands Institute for Inland Water Management and Waste Water Treatment (RIZA).

The Vechte, also known as the Overijsselse Vecht, has a length of 167 km. 107 km of the river is on German side and 60 km in the Netherlands. The mean discharge at the mouth of the Vechte[12] is 50 m^3/s, at low water 5 m^3/s, and under conditions of high water, about 300 m^3/s.

The Vechte originates in the Baumberge hills in the German State of North Rhine-Westphalia near the city of Münster and flows across the border into the Dutch province of Overijssel. There, it confluences with the River Zwarte Water near the town of Hasselt.

The total population in the catchment is about 800,000 people. The Dutch part of the basin is more intensively used than the German part. The human pressure on the aquatic environment is high, both from cities and from intensive agriculture. Discharges from many sewage treatment plants end up in relatively small tributaries. Most of the watercourses in the sub-basin have been strongly regulated by river straightening and dams. In large parts of the area, water inlet from outside the basin plays an important role for agriculture in the summer.

[11] Law regulates the possible increase of water temperature; thus, under extreme weather events, the power station may experience operational difficulties.
[12] Source: EUROHARP project (http://www.euroharp.org/).

MEUSE RIVER BASIN DISTRICT[13]

Belgium, France, Germany, Luxembourg and the Netherlands share the Meuse River basin. The International River Basin District Meuse is the management unit under the WFD.

Meuse River Basin District			
Area	Country	Country's share	
34,548 km²	France	8,919 km²	25.8%
	Luxemburg	65 km²	0.2%
	Belgium	13,896 km²	40.2%
	Netherlands	7,700 km²	22.3%
	Germany	3,968 km²	11.5%

Source: Roof report under the WFD for the International River Basin District Meuse.

Hydrology

The Meuse River takes its source at an altitude of 384 m above sea level at Pouilly-en-Bassingy in France. Having a total length of 906 km, it flows through France, Belgium and the Netherlands before entering the North Sea. The average discharge at the mouth is 230 m^3/s.

The peak run-off usually occurs in winter and spring. A maximum flow of 3,100 m^3/s was measured in 1993 at Eijsden (border station between Belgium and the Netherlands). Summer and autumn are mainly characterized by longer periods of low flows, for example, 10 m^3/s to 40 m^3/s at Eijsden.

A number of locks and dams were built in the river for navigation purposes or protection against floods, leading to significant modifications of the natural character of the river in most of its sections.

Majors tributaries of the Meuse, some of them transboundary, include the Chiers, Semois, Lesse, Samber, Ourthe, Rur, Schwalm, Niers and Dommel rivers.

Pressure factors

Some 8.8 million people live in the International River Basin District Meuse and use water for drinking and domestic purposes, agriculture and industry, hydropower generation, navigation and recreation. The water of the Meuse also supports surrounding ecosystems, and is exported by pipelines and canals to provide drinking water to people living outside the basin.

The basin of the river Meuse can be divided into three sections, with differing geomorphological and physical features and human impacts.

The first section, from the source to the city of Charleville-Mézières (France), is characterized by low-flow velocity and low pressure from industry and municipalities.

The second section, where the Semois, Lesse, Sambre and Ourthe rivers join the Meuse, stretches from Charleville-Mézières to Liège (Belgium). During periods of heavy precipitation, these tributaries contribute substantially to the flow of the Meuse and may cause rapid water level rises. The sub-basins of these tributaries make up the principal natural values of this river section and are especially important as spawning grounds and growth areas for rheophile fish. A few small islands in the river and parts of the banks have remained in their natural condition, offering habitats for a variety of species of plant and animal life. The section has also many heavily urbanized and industrial sites, both along the main watercourse as well as along the Sambre, one of the tributaries. In the upper part of this section of the river, there are a few small islands in the river and parts of the banks that remained natural and offer habitats for a variety of plant and animal life. There was major development of the principal Meuse watercourse to make it navigable.

[13] Source: International Meuse Commission ("Characteristics, Review of the Environmental Impact of Human Activity, Economic Analysis of Water Use - Roof report under the Water Framework Directive" and "The international river district Meuse: a status assessment").

The third section, a flood plain area, stretches from Liège to the mouth. This section is navigable, which limits the possibilities for a natural low-water channel and severely reduces the fluvial dynamics. This region is also characterized by dense population, intensive agriculture and many industries. Areas of great ecological value exist (e.g. woods, heather fields and marshlands), but their area has been reduced and they are widely dispersed. The north-western part offers an attractive and relatively open area that is surrounded by urban harbour areas.

Further urban development and increasing transport, as well as industrial and agricultural activities, are significant pressures for the water systems. Safety and flood control measures (e.g. delta works and the closure of the Haringvliet in the Netherlands) in the 1970s were essential social measures, but deprived the area of tidal dynamics, resulting in a decreased ecological potential. Recently, the Dutch Government decided to introduce, by 2008, a different modus operandi for the floodgates of the Haringvliet, with the aim of reintroducing the tidal influence.

Transboundary impact

Human impact has altered the natural hydromorphological and ecological conditions. The main driving forces for these alterations are urbanization, industrialization, agriculture, shipping and flood protection - which have a transboundary impact - and drinking-water supply.

For the French part of the river basin, agriculture is the main driving force. In the Walloon region (Belgium), the more densely populated and industrialized sub-basins of the Vesdre and Sambre rivers experience urbanization as major driving force. For the Semois and Lesse rivers, only smaller longitudinal obstacles are present, with no strong driving forces restricting restoration potentials.

In the German, Flemish and Dutch lowlands, urbanization and agriculture are the major cause to alterations in hydromorphological characteristics. In the Dutch part of the Meuse River, most pressures derive from flood defence and shipping. For the smaller tributaries, especially in the Netherlands, agriculture remains a major driving force. In addition to the strongest estimated impact of longitudinal obstacles and changes in river discharge over the basin, local pressures affecting the habitat quality can seriously affect the ecological integrity of the river’s water.

Based on the results of the internationally coordinated bio-monitoring of the Meuse, the artificial alterations of the riverbanks and a lack of natural substrates, together with poor water quality, were identified as major threats to the river’s benthic macro-invertebrate communities. Changed flow conditions and bed characteristics are among the major causes for the absence of natural rheophilic fish communities. Some weirs represent a considerable obstacle for organisms to move upstream, especially for migration of fish.

Trends

The riparian countries (including the Belgian regions) are implementing the decisions of their own Governments as well as recommendations of the International Meuse Commission (IMC). The IMC has been established under the Agreement on the River Meuse (Ghent, 2002) and acts as the platform for international coordination to implement obligations under the WFD for the International River Basin District Meuse.

The measures taken in the past have led to an improvement of the water quality. Further improvements are expected in the future due to more stringent policies at the national and EU levels.

SCHELDT RIVER BASIN DISTRICT[14]

Belgium, France and the Netherlands share the Scheldt River basin (22,116 km²). The Scheldt has the Lys (Leie), Zenne and Dender rivers as major transboundary tributaries.

As management unit, the Scheldt International River Basin District was established (36,416 km²). Apart from the Scheldt and Yser basins, the International River Basin District Scheldt also includes basins of national rivers, most notably the basins of the Somme, Authie and Canche rivers, which are located entirely in France, as well as transitional and coastal waters.

The basin of the Yser (Ijser), shared by Belgium and France, has an area of 1,750 km².

Scheldt River Basin District		
Area	**Country/region**	**Country's or region's share**
36,416 km²	Belgium (Flemish region)	33%
	Belgium (Walloon region)	10%
	Belgium (Brussels capital region)	0.44%*
	France	50%
	Netherlands	6%

* Equals 10% of the population of Belgium
Source: Scheldt International River Basin District, Roof report, February 2005. Internationale Scheldecommissie (ISC) – Commission Internationale de l'Escaut (CIPE).

[14] Source: Scheldt International River Basin District. Roof report. February 2005. Internationale Scheldecommissie (ISC) – Commission Internationale de l'Escaut (CIPE).

Hydrology (rivers Scheldt and Yser)

The 350-km-long Scheldt River has its source on the Saint-Quentin plateau, near the village of Gouy-Le-Catelet in France in the Artois hills. The river courses through Northern France, Belgium (Flemish and Walloon regions) and the Netherlands before it discharges into the North Sea via a long estuary. The estimated average discharge at Lillo is 130 m^3/s. The wide and flat valleys in the Scheldt basin suffer from numerous floods, especially in winter, when the groundwater level and water flow is highest. The water of the Scheldt estuary is by nature very nutritious. Therefore, it is an important place for fish and other animals to reproduce. In the Scheldt, fishery mainly fishes for cockles, eels and soles.

The Yser River is approximately 80 km long, rising in northern France and flowing generally northeast through north-western Belgium and into the North Sea at Nieuwpoort. It connects a network of canals.

Pressure factors having adverse effects on water quality

The Scheldt International River Basin District is a highly urbanized, densely populated, and heavily built-up area. As in some areas the European Waste Water Treatment Directive has not yet fully implemented but is scheduled for the near future, the impact of the urban pollution will decrease.

There are a number of major industrial areas (e.g., around the towns of Kortrijk and Ostend; in the ports of Zeebrugge, Ghent, Antwerp, Vlissingen and Terneuzen, Calais, and Dunkerque; along the Antwerp-Brussels-Charleroi axis, in particular the petrochemical site of Feluy-Seneffe-Manage in the Walloon Region; along the Albert Canal; near the agglomeration Lille-Roubaix-Tourcoing; in the Valenciennes area; and around the towns of Mons, Saint-Ghislain, La Louvière, Tournai and Mouscron).

There is also a dense transport infrastructure including railways, waterways and motorways. The shipping trade uses the Scheldt intensively. The river provides the connection between the North Sea and the harbours of Antwerp, Ghent, Terneuzen and Vlissingen. Thanks to this accessibility, many industrial activities take place on the banks of the Scheldt. These industries pollute the Scheldt with wastewater containing chemicals, nutrients and heavy metals.

Agriculture covers 61% of the total area of the International River Basin District Scheldt. In the northern part, the main agricultural activity is live-stock farming, whereas crop farming is the main agricultural activity in the southern part.

The relative importance of the pressure factors in transboundary sub-basins of the International River Basin District Scheldt are summarized in the table below.

Pressure factors for transboundary sub-basins in the Scheldt International River Basin District

Sub-basin	Main pressures			
	Population	Industry	Agriculture	Transport
Scheldt, upper course	++++	+++	++++	**
Scheldt, middle course	+++	++	++	***
Scheldt, lower course	++++	++++	++++	***
Zenne	++++	++	++	***
Dender	++	++	++	**
Lys/Leie	++++	+++	++++	**
Yser (IJser)	++	+	++++	**
For population, industry and agriculture: Very high pressure: ++++ High pressure: +++ Moderate pressure: ++ Low pressure: +		For transport: Indicator values higher than RBD averages: *** Some indicator values higher than RBD averages: **		

Source: Scheldt International River Basin District. Roof report. February 2005.

It should be noted that indicators to characterize the pressure from the population included the discharged nitrogen load, the discharged phosphorus load and the discharged load of suspended solids. Indicators for pressures from industry covered metal micro-pollutants, organic micro-pollutants, macro-pollutants (nitrogen, phosphorus, total organic carbon), and salts (chlorides, cyanides, fluorides). For agriculture, the share of cultivated area in the total area of the sub-basin; the share of commercial crops in the total cultivated area of the sub-basin; the percentage of the total cattle, pig and poultry livestock present in the area of the sub-basin; and the livestock density for cattle, pigs and poultry were taken into account. The pressure of transport on the aquatic environment was difficult to estimate as accurate data were lacking; but it is important to mention transport regarding the impact of polycyclic aromatic hydrocarbons on the aquatic environment.

Other pressure factors (hydromorphology)

The probable impact of the envisaged deepening of the Scheldt waterway to 14.70 meters below mean sea level (13.10 meter tide-independent accessibility) to keep the harbour of Antwerp accessible to larger vessels – as part of the Scheldt Estuary Development Outline 2010[15] – was thoroughly evaluated. Several studies were carried out during recent years, including: (a) a strategic environmental impact report; (b) social cost/benefit analysis, (c) studies on the development of the natural environment; and (d) birds and habitat criteria. Comprehensive consultations with all stakeholders were held and communications were widely issued.

[15] The Dutch-Flemish bilateral Technical Scheldt Commission developed a long-term vision for the Scheldt estuary with three objectives:
- Safety maximum protection against flooding in the region
- Accessibility optimum accessibility to the harbours on the Scheldt estuary
- Natural environment – a dynamic, healthy natural environment (see http://www.ontwikkelingsschets.nl/).

The deepening will cause minor effects due to (a) a new flexible dumping strategy and (b) a nature restoration programme including de-poldering along the river. Specific monitoring programmes are established to continuously follow-up the changes of the estuary and its ecological quality.

The Wild Birds and Habitat Directives[16] prohibit interventions that cause damage to protected natural environments unless the intervention serves a major social interest and no alternatives are available. The WFD also stresses restricting adverse effects of man-induced morphological changes, such as deepening waterways or building dikes. Study results show that the overall package of measures in the Development Outline would not cause any damage to protected natural environments. In fact, these measures would increase the robustness of the natural environment of the Scheldt estuary. In the coming years, part of this package will be carried out in a nature restoring programme that includes 600 ha and 1,100 ha of de-poldering along the Dutch and Flemish (Belgian) parts, respectively, of the Scheldt. The major adverse effects on protected natural habitats of deepening the waterway and more than 150 years of poldering are not completely restored, but sufficiently counteracted to ensure compliance with the targets of the Birds and Habitat Directive as well as the EU WFD. For the upcoming deepening of the waterway and the implementation of a flexible strategy of dumping adverse effects are estimated as minor. In this way, the positive effects of the nature restoration programme will be maintained.

Transboundary impact

It was not yet possible for the International Scheldt Commission to carry out a transnational comparison of the current chemical status because joint standards have not yet been established for the Scheldt International River Basin District and the countries/regions still use different monitoring and assessment methods. A general and complete transnational comparison of the ecological status is also lacking. Preliminary assessments were made on the basis of available data and expert judgment.

The roof report of the International Scheldt Commission[17] concluded that very few waterbodies in the Scheldt International River Basin District are currently "in good ecological status".

On the basis of the collected data, the International Scheldt Commission concluded in 2005 that none of the examined transboundary watercourses (Scheldt, Yser, Lys/Leie, Zenne and Dender) were in good physico-chemical status. Most of the watercourses also showed bad oxygen balances. Nutrients were a problem everywhere, and national/local metal standards had been exceeded for copper, zinc, lead and cadmium at a number of monitoring sites.

In the coastal waters of the International River Basin District, the overall quality of macrofauna is "good", but the quality of phytoplancton is "generally insufficient", and PCBs, PAH, lindane, organotin compounds and nutrients are a problem.

Trends

The three riparian countries are implementing the decisions of their own Governments as well as recommendations of the International Scheldt Commission. The Commission has been established by the signatories under the Agreement on the River Scheldt (Ghent, 2002) and acts as the platform for international coordination to implement obligations under the WFD for the International River Basin District Scheldt.

This has lead to an improvement of the water quality in France, Belgium and the Netherlands.

Further improvements are expected in the future due to more stringent policies, i.e. better implementation and enforcement, as well as new or improved policies, at the national and EU levels.

[16] Council Directive 79/409/EEC on the conservation of wild birds and Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora.
[17] Scheldt International River Basin District. Roof report. February 2005.

MINO RIVER BASIN[18]

The basin of the Mino River, also known as Miño (in Spain) and Minho (in Portugal), is shared by Spain (upstream country) and Portugal (downstream country).

[18] Based on information submitted by the Portuguese National Institute of Water (Instituto da Agua, INAG) as well as Freshwater in Europe – Facts, Figures and Maps United Nations Environment Programme Division of Early Warning and Assessment, Office for Europe, 2004.

Basin of the Mino River			
Area	**Country**	**Country's share**	
17,080 km^2	Portugal	850 km^2	5%
	Spain	16,230 km^2	95%

Source: Portuguese National Water Plan (Instituto da Agua, INAG,2002).

MINO RIVER

Hydrology

The Mino River has its source in Spain in the Meira Mountains (750 m) and empties into the Atlantic Ocean at Caminha. The basin has a pronounced mountainous character with an average elevation of about 683 m above sea level.

A major transboundary tributary to the Mino is the Trancoso. The major Portuguese tributaries are the rivers Gadanha, Mouro and Coura. One major Spanish tributary is the Louro (see below).

Discharge characteristics of the Mino River at the station Foz do Mouro (Portugal)		
Discharge characteristics	**Discharge, m^3/s**	**Period of time or date**
Q_{av}	314	1 March 1973 – 31 January 2007
Q_{max}	4,681	1 March 1973 – 31 January 2007
Q_{min}	7	1 March 1973 – 31 January 2007

Source: Portuguese National Institute of Water (Instituto da Agua, INAG).

In Portugal, there are two reservoirs on the Coura tributary; lakes and reservoirs occupy some 2.8% of the basin area.

Pressure factors

In Portugal, agriculture uses about 95% and the urban sector about 5% of the available water resources. The main forms of land use are forests (62.7%) and cropland (30.8%).

The population density is about 92 persons/km^2.

Pressures on water resources from agricultural activities are mainly due to the use of fertilizers and pesticides, as well as irrigation. Some untreated or insufficiently treated wastewater discharges, mainly from Spain, cause additional pressures.

Eutrophication is generally decreasing along the main stem of the river, mainly due to the river's self-purification capacity.

In Portugal, manufacturing industry is almost not present and causes hardly any impact. There are, however, two abandoned wolfram mines that have a local impact on the quality of water resources. Transport is another pollution source, due to exhaust gases, fuel transport and spills or leakages of dangerous substances.

During flood events, unsafe and/or irregular drinking-water supply is of concern.

Transboundary impact

The waters of the river Louro, a Spanish tributary to the Mino, have a significant impact on Portuguese territory. The river drains important agglomerations in Spain and carries insufficiently treated industrial and municipal wastewaters from the industrial area of Porriños and the city of Tuy in Spain.

Organic matter from wastewater discharges and pathogens from wastewater discharges and pesticides are mostly of local significance. Nitrogen forms are both of local and transboundary significance and have also an adverse impact on the marine environment.

Trends

Since 2002, the status of the Mino River in Portuguese territory has improved significantly. This was mainly due to the implementation of the Portuguese National Water Plan (PNA) and the Portuguese Water Supply and Residual Water Treatment Plan (PEAASAR), notably the specific Residual Water Treatment Plants (ETARs) to treat industrial and urban sewage. Some occasional pollution events still occur due to inappropriate agricultural practices. Transboundary pollution originating from Spain is still significant, and requires more stringent control measures by Spain.

FRIEIRA RESERVOIR[19]

The Frieira Reservoir is an artificial lake constructed for hydroelectric power production. The reservoir is situated in Spain in the Mino River basin in the border area between Spain and Portugal, but both countries jointly manage it.

Constructed for hydropower production purposes, the Frieira Reservoir is shallow (mean depth 20 m, maximum depth 27 m) and has a surface area of 4.66 km^2. Due to its shallowness, the water storage capacity of the reservoir is relatively small (0.044 km^3). The mean inflow is 9.524 km^3/year and the minimum outflow 3.7 km^3/year.

The status of the reservoir is "mesotrophic" (mean total phosphorus concentration 29 µg/l); its water quality and quantity is regularly monitored.

The management of the reservoir is mainly based on the Convention on cooperation for the protection and sustainable use of the waters of the Spanish-Portuguese catchment areas that was signed in 1998 and entered into force in 1999.

[19] Based on information from the Government of Spain as well as the publication Monitoring of International Lakes - Background document for the Guidelines on Monitoring and Assessment of Transboundary and International Lakes (UNECE, 2002).

LIMA RIVER BASIN[20]

The basin of the Lima River, known as the Limia in Spain, is shared by Spain (upstream country) and Portugal (downstream country).

Basin of the Lima River			
Area	Country	Country's share	
2,480 km²	Portugal	1,180 km²	48%
	Spain	1,300 km²	52%

Source: Portuguese National Water Plan (Instituto da Agua, INAG, 2002).

LIMA RIVER

Hydrology

The Lima has its source in Spain at Lake Beon (975 m) and ends up in the Atlantic Ocean at the city of Viana do Castelo. The basin has a pronounced mountainous character with an average elevation of about 447 m.

A major transboundary tributary to the Lima is the Castro Laboreiro. The Vez is a major Portuguese tributary.

Discharge characteristics of the Lima River (monitoring site Snirh)		
Discharge characteristics	Discharge, m³/s	Period of time or date
Q_{av}	68	16 April 1945 – 30 September 1990
Q_{max}	1,380	16 April 1945 – 30 September 1990
Q_{min}	0	16 April 1945 – 30 September 1990

Source: Portuguese National Institute of Water (Instituto da Agua, INAG).

There are two major reservoirs on the Lima: the transboundary reservoirs of the Alto Lindoso Dam and the Touvedo Reservoir. These dams were constructed in 1992 and 1993, respectively.

Ponte de Lima, Ponte da Barca and Arcos de Valdevez in Portugal are the urban areas mostly affected by floods. The existing reservoirs, constructed for hydropower production, reduce the risks of flooding in the first two villages; however, due to the specifics of flow formation after heavy precipitation in the Serra da Peneda/Peneda mountain range, the resulting increased flood discharges cannot always be stored in the existing reservoirs.

In Portugal, lakes and reservoirs occupy some 1.6% of the basin area. Protected areas include the Lagoas de Bertiandos and San Pedro dos Arcos, which are – permanent and temporary, respectively – freshwater lagoons on the right bank of the Lima in Portugal.

Pressure factors

In Portugal, agriculture uses about 90%, industry about 6%, and the urban sector about 4% of the available water resources. The main forms of land use are forests (70.9%) and cropland, which cover 25.4% of the Portuguese part of the basin. The population density is about 130 persons/km².

In Portugal, pressures on water resources from agricultural activities are mainly due to the use of fertilizers and pesticides, as well as irrigation. There is a risk of contamination due to several abandoned ore mines. There is also some risk of accidental water pollution from industrial wastewater discharges. The former dumpsites were recently closed.

[20] Based on information submitted by the Portuguese National Institute of Water (Instituto da Agua, INAG) as well as the publication Freshwater in Europe – Facts, Figures and Maps (UNEP/DEWA-Europe, 2004).

Due to road and railroad crossings, there is also a risk of water pollution if road/railroad accidents should occur.

Trends

Since 2002, the status of the Lima on Portuguese territory has improved significantly, mainly due to the measures described in the above chapter on the Mino. Some occasional pollution events still occur due to inappropriate agricultural practices. Transboundary pollution originating from Spain is still significant, and requires more stringent control measures by that country.

ALTO LINDOSO RESERVOIR[21]

The Alto Lindoso Reservoir is an artificial water body in the Lima River basin on the border between Spain (upstream country) and Portugal. The reservoir was reconstructed in the 1980s for hydropower purposes. Alto Lindoso is one of the most important hydropower plants for Portugal's energy sector. The reservoir has also significance for recreational uses.

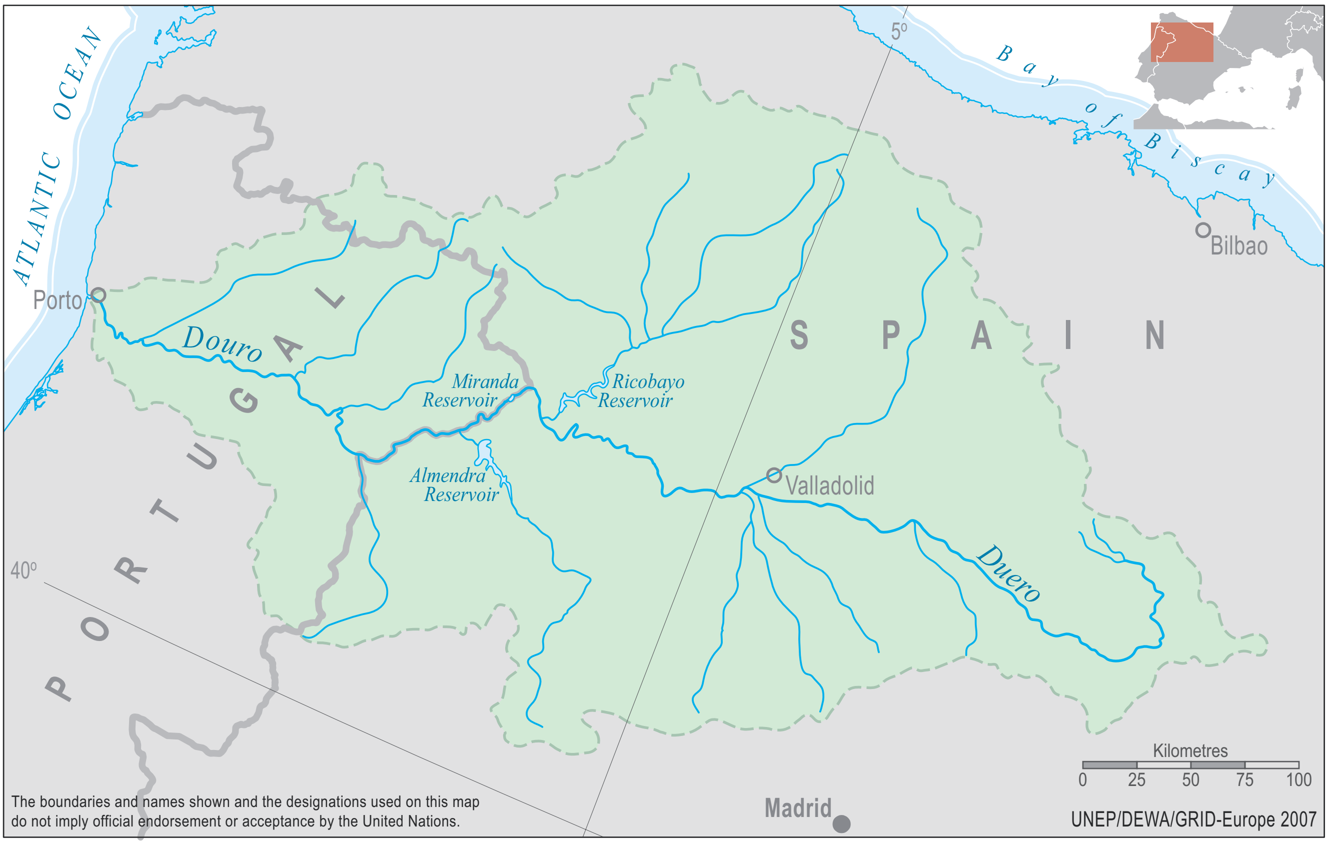
The total surface area of the Alto Lindoso Reservoir is 10.72 km^2. The reservoir is relatively deep (maximum depth 109 m, mean depth 73 m) and its water storage capacity is relatively high (0.379 km^3). The maximum and average inflows are 1.39 km^3/a and 0.65 km^3/a, respectively. The total basin area of the reservoir is 1,525 km^2, from which 1,300 km^2 are in upstream Spain.

The status of this important hydropower reservoir is "mesotrophic". The main sources of nutrient loading are in the Spanish part of the basin.

[21] Based on information from the Government of Spain as well as the publication Monitoring of International Lakes - Background document for the Guidelines on Monitoring and Assessment of Transboundary and International Lakes (UNECE, 2002).

DOURO RIVER BASIN[22]

The basin of the Douro River, known in Spain as the Duero, is shared by Spain (upstream country) and Portugal (downstream country).



Basin of the Douro River			
Area	**Country**	**Country's share**	
97,600 km²	Portugal	18,600 km²	19%
	Spain	78,832 km²	81%

Source: Portuguese National Water Plan (Instituto da Agua, INAG,2002).

[22] Based on information submitted by thze Portuguese National Institute of Water (Instituto da Agua, INAG) as well as the publication Freshwater in Europe – Facts, Figures and Maps, United Nations Environment Programme (UNEP/DEWA-Europe, 2004).

DOURO RIVER

Hydrology

The Douro rises in the Sierra de Urbión (2080 m) in central Spain and crosses the Numantian Plateau. The river mouth is at Foz do Douro (city of Porto).

The basin has a pronounced mountainous character with an average elevation of about 700 m above sea level. Major transboundary tributaries include the rivers Tâmega, Rabaçal, Tuela, Sabor, Maças and Águeda. The major Portuguese tributaries are the rivers Sousa, Paiva, Corgo, Távora, Pinhão, Tua and Côa.

The river has extensive barge traffic in its Portuguese section, but silting rapids and deep gorges make the other parts of the Douro un-navigable. The Douro has been harnessed for hydropower production.

Discharge characteristics of the Douro River at the station Crestuma Dam (Portugal)		
Discharge characteristics	**Discharge, m³/s**	**Period of time or date**
Q_{av}	567	22 January 1998 – 13 December 2007
Q_{max}	8,835	22 January 1998 – 13 December 2007
Q_{min}	0	22 January 1998 – 13 December 2007

Source: Portuguese National Institute of Water (Instituto da Agua, INAG).

Pressure factors

In Portugal, the population density is 98 persons/km².

Agriculture (86% of total water use in the Portuguese part of the basin) relies on the use of fertilizers and pesticides as well as irrigation. In Spain, the middle Douro is also extensively used by irrigational agriculture.

In Portugal, there is a risk of contamination from abandoned ore mines. Untreated or insufficiently treated industrial wastewater is still of concern and breakdowns of municipal wastewater treatment systems are the reasons for significant discharges of polluted water into the river. Due to the many road and railway crossings, there is also a risk of water pollution should traffic accidents occur.

Transboundary impacts

Some Spanish tributaries of the Douro have a high phosphate concentration due to urban and industrial effluents. The local presence of nitrates affects different areas in the Spanish part of the basin, but does not cause significant transboundary impact.

Trends

Since 2002, the status of the Douro on Portuguese territory has improved significantly, mainly due to the measures described in the above chapter on the Mino. Some occasional pollution events still occur due to inappropriate agricultural practices. Transboundary pollution originating from Spain is still significant, and requires more stringent control measures by Spain.

MIRANDA RESERVOIR[23]

The Miranda Reservoir is a man-made lake situated in the Douro River basin on the border between Spain (upstream country) and Portugal. The reservoir was constructed for hydropower purposes. It is also used as a source for water supply and for recreation, especially bathing.

The total surface area of Miranda Reservoir is small, only 1.22 km². The maximum depth is 68 m and mean depth 45 m. Due to its small surface area, the reservoir's water storage capacity is also small (0.0281 km³). The mean water inflow and outflow is relatively high and equals 284 m³/s.

Eutrophication is a particular issue in this hypertrophic reservoir.

[23] Based on Monitoring of International Lakes - Background document for the Guidelines on Monitoring and Assessment of Transboundary and International Lakes (UNECE, 2002).

TAGUS RIVER BASIN[24]

Spain (upstream country) and Portugal (downstream country) share the basin of the Tagus River, known as Tejo (in Portugal) and Tajo (in Spain).

Basin of the Tagus River			
Area	Country	Country's share	
80,600 km²	Portugal	24,800 km²	31%
	Spain	55,800 km²	69%

Source: Portuguese National Water Plan (Instituto da Agua, INAG, 2002).

TAGUS RIVER

Hydrology

The Tagus rises in east-central Spain in the Sierra de Albarracín at an altitude of 1,590 meters and empties into the Atlantic Ocean near Lisbon. The basin has a pronounced lowland character with an average elevation of about 633 m above sea level.

The river is navigable for about 160 km from its mouth.

Dams harness its waters for irrigation and hydroelectric power, creating large artificial lakes.

Transboundary tributaries of the Tagus include the rivers Erges and Sever. In Portugal, the rivers Alviela, Almonda, Zêzere, Ocreza, Ponsul, Nisa and Sorraia are major tributaries to the Tagus.

Discharge characteristics of the Tagus River at the station Almourol (Portugal)		
Discharge characteristics	Discharge, m³/s	Period of time or date
Q_{av}	316	2 October 1973–31 December 2006
Q_{max}	13,103	2 October 1973–31 December 2006
Q_{min}	0	2 October 1973–31 December 2006

Source: Portuguese National Institute of Water (Instituto da Agua, INAG).

[24] Based on information submitted by the Portuguese National Institute of Water (Instituto da Agua, INAG) as well as the publication Freshwater in Europe – Facts, Figures and Maps, (UNEP/DEWA-Europe, 2004).

Pressure factors and transboundary impacts

Two European capitals (Madrid and Lisbon) depend on the river for their water supply and significantly affect the chemical and ecological status of the river.

In upstream Spain, part of the river's flow is diverted to the (national) Segura basin, supplying 1.5 million people in southern Spain with drinking water, and providing irrigation and supporting the ecosystem in the La Mancha Nature Reserve. There is much controversy about this water diversion from an international basin to a national basin, as it has negative consequences on the Tagus itself (increasing concentrations of polluting substances due to decreasing flow and causing a deterioration of the river's ecosystem). [25] All in all, the legal minimum flow in the Spanish part of the Tagus (6 m^3/s) is not respected.

In Portugal, the basin is mainly covered by forests (51%) and used as cropland (44%).

Water use by different sectors is as follows: agriculture – 70%, urban uses – 8%, industrial uses 5%, and the energy[26] sector – 17%. Irrigational agriculture relies on the use of fertilizers and pesticides. Mining activities are carried out at the Pansqueira and Rio Maior mines; however, the risk of contamination is insignificant. On the contrary, there is a high risk of breakdowns of wastewater treatment systems, which can result in significant discharges of polluted water into the river. Due to the many road and railway crossings, there is also a risk of water pollutions should traffic accidents occur.

A multi-product pipeline from Sines to Aveiras crosses several water bodies, among them the Lagoa de Santo André (Santo André lagoon) and the rivers Sado and Tagus. In the event of an accident, contamination of these water bodies by hydrocarbons could occur.

There are no nuclear power plants in the Portuguese part of the basin. However, the nuclear power plant at Almarez (Spain) has a potential to contaminate the Tagus with radioactive substances. Such contamination risk also exists in the Tagus estuary, should an accident involving nuclear powered vessels (submarines and aircraft carriers) occur.

Trends

Since 2002, the status of the Tagus in Portuguese territory has improved significantly, mainly due to the measures described in the above chapter on the Mino. Some occasional pollution events still occur due to inappropriate agricultural practices. Transboundary pollution originating from Spain is still significant, and requires more stringent control measures by Spain.

CEDILLO RESERVOIR[27]

The Cedillo (also known as Cedilho) Reservoir in the Tagus River basin on the border between Spain and Portugal was constructed for hydroelectric power production. With a depth of 117 m, the reservoir is a "deep water body". It has a total surface area of 14 km^2. The total volume of the reservoir is 0.260 km^3; the mean inflow equals 10.265 km^3 and the minimum outflow should not be lower than 2.7 km^3. The total basin area of the reservoir is relatively large (59,000 km^2), from which 55,800 km^2 are located in upstream Spain.

The reservoir has steep banks and occasional cliffs. It is also known as an important bird area and a potential site under the Ramsar Convention on Wetlands. The surrounding vegetation mainly comprises Mediterranean scrub, Quercus woodland, and some olive groves. The main human activities in the vicinity of the reservoir are livestock farming and hunting.

The reservoir has a high, but very varying mean concentration of phosphorus (varying between 97–325 µg/l in 2001–2006). For the same period of time, the BOD_5 concentrations varied between 1.2 and 3.0 mg/l; and NO_3 was between 2.3 and 4 mg/l.

The management of the reservoir is mainly based on the Convention on cooperation for the protection and sustainable use of the waters of the Spanish-Portuguese catchment areas that was signed in 1998 and entered into force in 1999.

[25] Freshwater in Europe – Facts, Figures and Maps (UNEP/DEWA-Europe, 2004).
[26] This figure includes thermoelectric power plants. Although they are classified as a non-consumptive user, the power plants at Pego, Carregado and Barreiro, for example, are a major consumer, as they abstract 477 hm^3/year and discharge only 317 hm^3/year.
[27] Based on information from the Government of Spain as well as the publication Monitoring of International Lakes - Background document for the Guidelines on Monitoring and Assessment of Transboundary and International Lakes (UNECE, 2002).

GUADIANA RIVER BASIN[28]

Spain (upstream country) and Portugal (downstream country) share the basin of the Guadiana River.

Basin of the Guadiana River			
Area	Country	Country's share	
66,800 km²	Portugal	11,500 km²	17%
	Spain	55,300 km²	83%

Source: Portuguese National Water Plan (Instituto da Agua, INAG,2002).

Hydrology

The Guadiana has its source in Spain at Campo Montiel (1700 m) and discharges into the Atlantic Ocean at Vila Real de Santo António. The basin has a pronounced lowland character, with an average elevation of about 237 m above sea level (in Portugal).

Major transboundary tributaries include the rivers Xévora, Caia, Alcarrache, Ardila, Múrtega and Chança. The major Portuguese tributaries are the rivers Degebe, Cobres, Oeiras, Vascão, Foupana and the Beliche.

The Alqueva Dam, the biggest man-made dam on the Portuguese part, became operational in 2002. The reservoir is 82 km long and covers an area of 250 km² (63 km² in Spain). The reservoir's total capacity is 4,150 billion m³, with a useful capacity of 3,150 billion m³.

Discharge characteristics of the Guadiana River at the station Pulo do Lobo (Portugal)		
Discharge characteristics	Discharge, m³/s	Period of time or date
Q_{av}	162	1 October 1946 – 31 January 2007
Q_{max}	10,072	1 October 1946 – 31 January 2007
Q_{min}	0	1 October 1946 – 31 January 2007

Source: Portuguese National Institute of Water (Instituto da Agua, INAG).

[28] Based on information submitted by the Portuguese National Institute of Water (Instituto da Agua, INAG) as well as the publication Freshwater in Europe – Facts, Figures and Maps (UNEP/DEWA-Europe, 2004).

The Sapais de Castro Marim area in Portugal is protected under the Ramsar Convention on Wetlands.

Pressure factors

In Portugal, the basin is mainly covered by forests (29%) and used as cropland (69%).

Approximately 17 persons/km^2 live in the Portuguese part of the basin. Irrigational agriculture relies on the use of fertilizers and pesticides. There is a risk of water contamination by leakages from several abandoned ore mines (S. Domingos and Tinoca). There is also a high risk of breakdowns of wastewater treatment systems, which can result in significant discharges of polluted water into the river. Due to the many road and railway crossings, water pollution in case of traffic accidents may occur.

Trends

Since 2002, the status of the Guadiana in Portuguese territory has improved significantly, mainly due to the measures described in the above chapter on the river Mino. Some occasional pollution events still occur due to inappropriate agricultural practices. Transboundary pollution originating from Spain is still significant, and requires more stringent control measures by Spain.

ERNE RIVER BASIN[29]

Ireland and the United Kingdom share the basin of the River Erne, also known as Ûrn.

The 120-km-long Erne rises from Lough Gowna in County Cavan (Ireland). The river is very popular for trout fishing, with a number of fisheries along both the river itself and its tributaries.

In Northern Ireland, the river expands to form two large lakes: the Upper Lough Erne (16 km long) and the Lower Lough Erne (29 km long). A bilateral flood-control scheme is operational to manage the water level in the lakes. Hydroelectricity is produced along the 46 m drop in the river's course between Belleek and Ballyshannon.

Basin of the River Erne			
Area	**Country**	**Country's share**	
4,800 km²	United Kingdom	1,900 km²	59.3%
	Ireland	2,800 km²	40.7%

Source: United Nations World Water Development Report, 2003.

Water-quality classes and determinands in the UK classification systems for the chemical status			
Class	**Dissolved Oxygen** (% saturation)10-percentile	**BOD** (mg O_2/l) 90-percentile	**Ammonia** (mg N/l) 90-percentile
A (Very Good)	80	2.5	0.25
B (Good)	70	4	0.6
C (Fairly Good)	60	6	1.3
D (Fair)	50	8	2.5
E (Poor)	20	15	9.0
F (Bad)	less than 20	-	-

Following recent analysis[30] of pressures in the Irish part of the basin, the following ranking of pressure factors was established: first, diffuse pressures (agriculture, non-sewered population, urban land use, transport, some industrial activities, peat exploitation and forestry activities); second, morphological pressures (hydroelectric dams, reservoirs, channel alterations, agricultural enhancement and flood defences); third, point pressures (urban wastewater treatment plants, storm overflows, sludge treatment plants, IPPC industries[31] and non-IPPC industries); and fourth, abstraction pressures (public and private water supply, and industrial use). Eutrophication, caused mainly by agricul-

[29] Based on information posted by government agencies from Ireland and United Kingdom on the Internet.
[30] See "Ireland's environment 2004" at www.epa.ie
[31] Industries that fall under the Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control.

tural sources and municipal sewage, has been identified as the single most important problem affecting the quality of surface waters in Ireland. Of Irish rivers, 30% are affected by it.According to UK classifications, the chemical status of the Erne for the period 2002–2005 was classified as "fairly good" to "good".[32] The Erne's biological status has fallen in the same two classes. Zebra mussels are a major problem. They first appeared in the Erne system in 1996.

FOYLE RIVER BASIN[33]

Ireland and the United Kingdom share the basin of the River Foyle.

Basin of the Foyle River			
Area	Country	Country's share	
2,900 km^2	United Kingdom	2,000 km^2	67.3%
	Ireland	1,000 km^2	32.7%

Source: United Nations World Water Development Report, 2003.

The River Foyle flows from the confluence of the rivers Finn and Mourne at Strabane in County Tyrone, Northern Ireland, to the city of Derry, where it discharges into Lough Foyle and, ultimately, the Atlantic Ocean.

The fertile Foyle basin and valley support intensive and arable farming. Pressure factors in the Irish part of the basin are principally the same as described in the chapter on the River Erne.

According to UK classifications, the chemical status of the Foyle for the period 2002-2005 was classified as "good". Its biological status was also "good".[34]

BANN RIVER BASIN[35]

Ireland and the United Kingdom share the basin of the River Bann

Basin of the Bann River			
Area	Country	Country's share	
5,600 km^2	United Kingdom	5,400 km^2	97.1%
	Ireland	200 km^2	2.9%

Source: United Nations World Water Development Report, 2003.

The 129 km long river has played an important part in the industrialization of the north of Ireland, especially in the linen industry. Today, salmon and eel fisheries are the most important economic features of the river.

The land around the Lough Neagh (which is, with 396 km^2 the largest freshwater lake in the British Isles) is typified by improved pasture but also includes some important wetland habitats.

The Lower Bann valley is very fertile and supports highly productive farmland. Pressure factors in the Irish part of the basin are principally the same as described in the chapter on the River Erne.

According to UK classifications, the chemical status of the Bann for the period 2002-2005 was classified as "fair" to "good". Its biological status was also "fair" to "good".[36]

[32] Source: Environment and Heritage Service (EHS), United Kingdom, (see http://www.ehsni.gov.uk/).
[33] Based on information posted by government agencies from Ireland and United Kingdom on the Internet.
[34] Source: Environment and Heritage Service (EHS), United Kingdom, (see http://www.ehsni.gov.uk/).
[35] Based on information posted by government agencies from Ireland and United Kingdom on the Internet.
[36] Source: Centre for Ecology and Hydrology, United Kingdom.