CHAPTER 2

EARLY STUDIES AND FLOW MEASUREMENT

INTRODUCTION

The geography of the Nile basin, including its geology, topography, channel characteristics, and vegetation, could be deduced from exploratory travels and investigations. This information is easily stored in the form of maps and detailed descriptions. Indeed, a fairly comprehensive description of the Nile basin (Lyons, 1906) was based on early accounts and personal travels. Information can now be obtained from satellite imagery.

By contrast, the hydrological behaviour of the various tributaries can only be deduced from river flow records compiled over many years of field work. In this respect the countries of the Nile basin (Fig. 2.1) are fortunate that the importance of accurate and continuous records was understood by early investigators and as a result long records exist. It will be shown, in subsequent chapters, that the tributaries of the basin behave very differently from each other. They are also subject to fluctuations in rainfall and river flow which are maintained over periods of years. It is therefore important that flow records of consistent accuracy cover the whole river system. Records must be maintained continuously to monitor variations which occur in different basins over the years. An outline of early studies and available records provides an introduction to the hydrology.

EARLY INVESTIGATIONS

The early explorations of the White and Blue Nile basins have been described by a number of authors; Moorehead (1960, 1962) provides an easily accessible example. The sources of the White Nile were not known until the 1860s. Travel up the Bahr el Jebel was prevented by the physical barrier posed by the swamps of the Sudd. The floating vegetation, also known as "Sudd", made it impossible for boats to pass through the area without the considerable task of clearing blockages. Indeed, the Arabic word "Sudd" (pronounced as in "flood") means blockage or barrier. In spite of the interest and importance of the regime of the White Nile to Egypt, little was known for certain about its source. Herodotus had reached the first cataract at Aswan about 460 BC, but an expedition sent by Nero some 500 years later returned after being blocked by an impenetrable swamp.

In the end a combination of travels up the Nile and from the East African coast solved the problem. Egyptian expeditions opened up the White Nile from 1840 (Werne, 1849) and established stations like Gondokoro on the Bahr el Jebel. Burton and Speke left Zanzibar in 1857 and Speke reached the southern shore of Lake Victoria in 1858; it was not until 1862 that Speke and Grant established that a large river flowed north out of Lake Victoria. They then travelled north to Gondokoro and met Baker, who reached Lake Albert in 1864. He established the connection between the Lake Victoria outfall through Lake Kyoga and Lake Albert to the Bahr el Jebel. Thereafter little time was wasted before scientific exploration began, though access through the Sudan was effectively closed between about 1882 and 1898. Gordon mapped the course of the Bahr el Jebel in 1874, and climate data and subjective river level observations were recorded at Lado by Emin and others. The scientific expeditions of

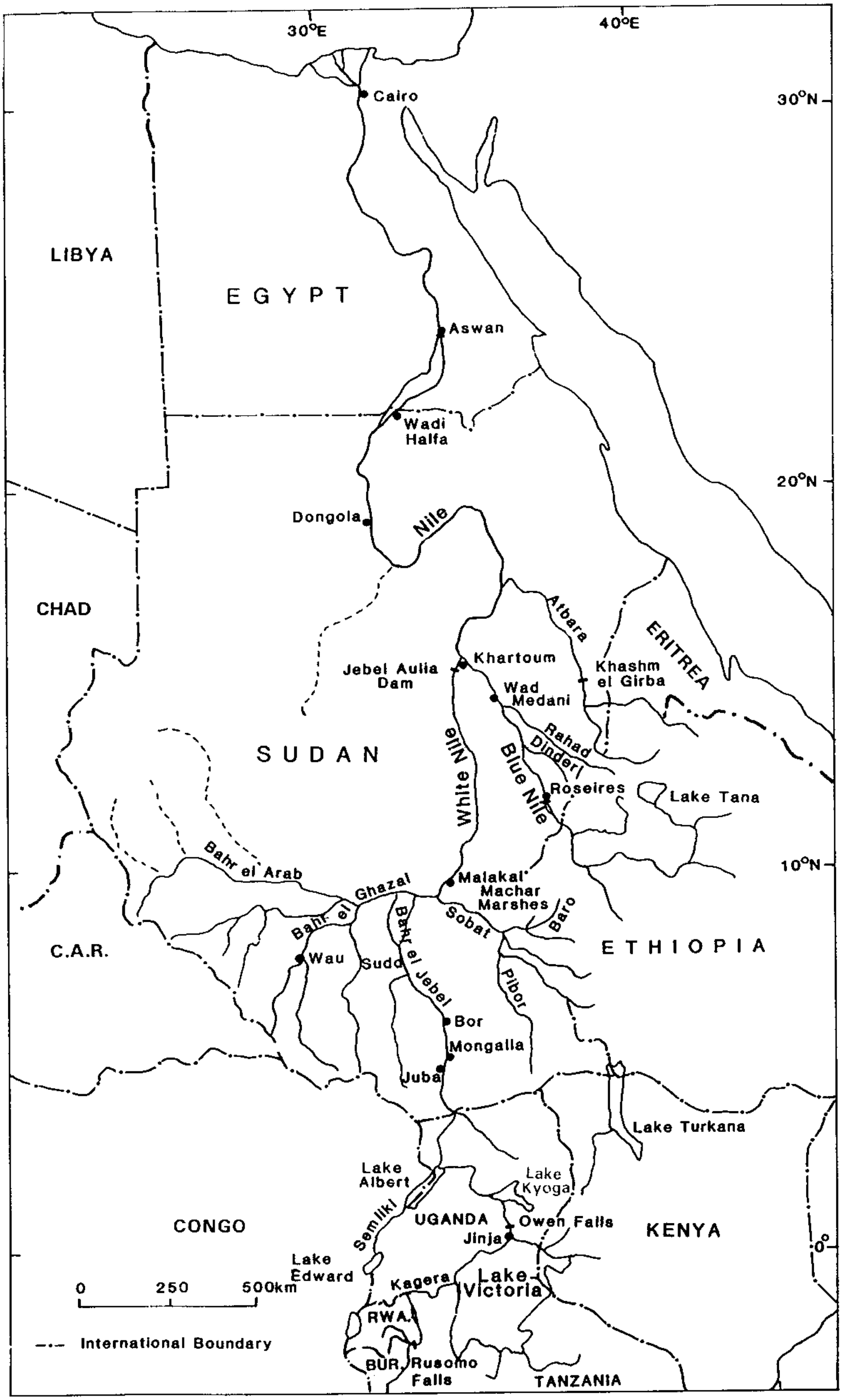

Fig. 2.1 Key sites of the Nile basin.

Garstin and Lyons between 1899 and 1903 led to the start of systematic hydrological measurements.

Garstin's tour of the White Nile and the East African lakes resulted in detailed mapping of certain reaches. It led to the proposal (Garstin, 1904) to bypass the Sudd by a channel to reduce the evaporation loss, which had been observed to amount to about half the inflow. Lyons (1906) published an account entitled *The Physiography of the River Nile and its Basin.* This included a great deal of information on the topography of the basin, and also some of the early hydrological records, including Lake Victoria levels. He was able to discuss channel changes in the Bahr el Jebel by comparing surveys, and to describe the different flooding conditions tolerated by the main species of swamp vegetation. He also noted (p. 26) that the interaction of the lake breeze and the prevailing winds was a likely cause of the high rainfall to the west of Lake Victoria.

Lake Victoria and the White Nile played an important part in regulating seasonal and annual flows before flow control was introduced with the first reservoirs downstream. However, the Lake Plateau basin was the last of the Nile sources to be delineated, and hydrological study did not start as early as on the other tributaries. Garstin (1901, 1904) and Lyons (1906) studied the lake levels as part of their investigation of the East African lakes, which they suggested as a possible site for water storage (Garstin, 1904, p. 165). They obtained information on the history of the lakes before formal level measurements began. They found that the levels of Lake Victoria had been high in 1878 and 1892–1995, and that the start of gauge readings in 1896 marked the recession from a period of high lake levels.

Hurst explored the southern shore of the lake in 1926 and measured flows on several branches of the Kagera tributary. Regular gaugings began in 1940, though levels were read from 1933. Hurst & Phillips (1938) made the first study of the water balance of Lake Victoria. They noted that the data were very scanty, with lake levels and rainfall observations at some stations for about 30 years.

The area between Lake Victoria and Lake Albert has received less scientific study than the Lake Victoria basin. Its geography was investigated by a number of travellers after Speke and Baker. After Gordon transferred the capital of Equatoria from Gondokoro to Lado in 1874, Emin Pasha occupied a number of sites as Governor of Equatoria from 1878 until the Stanley Relief Expedition forced him to leave during the Mahdiya in 1889. As a result there are early observations of climate from the 1880s (Lyons, 1906, pp. 82–86) and notes of river levels (Lyons, 1906, p. 102 and p. 362), but no systematic flow records. There is evidence from Lado (Lyons, 1906, p. 103) that Lake Albert was exceptionally high in 1878, and other evidence of lake levels similar to that on Lake Victoria. An example of such evidence of early high levels is a photograph of the Murchison Falls, probably taken in 1887, in the memoirs of Casati (1891, vol. II, p. 136). This appears to show the extension of the falls to the north, in contrast to the single channel sketched in 1864 by Baker (1866, vol. II, p. 143). A similar change also occurred after 1964 with the rise in Lake Victoria and the doubling of the outflow.

The first water balance of the lake basins was given by Hurst & Phillips (1938). They compared inflow with outflow for the Victoria Nile through Lake Kyoga. Similar estimates were made for the Lake Albert basin, and they estimated the torrent flows above Mongalla. The possibility of a reservoir on Lake Albert was discussed by Hurst & Phillips (1938, p. 81); it was noted that contours at a level of 20 m on the Butiaba gauge had been deduced by air survey.

River flows above and below the Sudd were measured during Garstin's visits to the upper Nile, suggesting that the outflow was only about half the inflow (Garstin, 1901, 1904). Willcocks had proposed the use of the East African lakes as reservoirs in 1893, and Garstin suggested a canal from Bor to the Sobat mouth in 1904. The main scientific information from the early studies was Garstin's and Lyons' accounts of the topography (Lyons, 1906) and their compilation of early levels. High and low years were summarized by Lyons, who also pointed out that Sudd blockages in 1863, 1872 and 1878–1880 were associated with water level rises.

The topography of the Sudd was described by Garstin (1901, 1904) following several reconnaissance journeys. The spilling through the banks was observed, and it was noted (Garstin, 1904, p. 94) that the character of the marshes changed near Bor: ..."North of this place papyrus and ambatch, with those reeds which require to have their roots under water for a great portion of the year, take the place of the grasses met more to the south. The general level of the swamps, too, is much lower". Hope (1902) described the effect of the flood of 1878 on the White Nile. Enormous quantities of vegetable debris were carried off by the current and communication was not restored until 1880. A more comprehensive account of the vegetation followed the botanical investigations of Migahid and others (Migahid, 1948, 1952). They identified the main species of the permanent swamp as *Cyperus papyrus*, *Vossia cuspidata*, *Phragmites communis* and *Typha australis* and identified the main controls as water depth, current velocity and ground level.

A preliminary water balance of the Bahr el Ghazal swamps was outlined in Hurst & Phillips (1938). During reconnaissance in 1930–1931, Hurst had been able to establish, in general terms, the areas of runoff accumulation and those of spill and evaporation. The tributary inflows were measured regularly at a series of sites along the main road from Juba to Wau and Nyamlel, at the limit of the zone of runoff generation. The Bahr el Ghazal measurements were interrupted about 1961, but were resumed by the Sudan authorities at several sites about 1970.

The hydrology of the Sobat basin was studied because of the spills from the Baro and Akobo, and the possibility of reducing the losses in the Machar marshes. Hurst (1950) investigated the losses from the upper Baro. Flow measurements revealed a succession of inflows, outflows and overbank spills. The Baro loses water by spill over the bank and through the Khor Machar channel towards the Machar marshes. However, the Machar marshes were the least known of the southern Sudan wetlands, and the sparsity of hydrological data for aspects of their water balance made it difficult to analyse their regime completely.

ESTABLISHMENT OF THE HYDROLOGICAL NETWORK

The history of the establishment of the hydrometric system is summarized by Hurst & Phillips (1932) and by Hurst (1952, chapter 14). Although Nilometers, to measure flood levels, had been used for thousands of years, and a level gauge was read daily at the Delta Barrage below Cairo from 1846 to 1878, the first modern staff gauge at Aswan was erected in 1869. Another was established about 1864 (Lyons, 1906, p. 261) at Khartoum near the confluence of the Blue Nile with the White Nile (Walsh *et al.*, 1994); 10-day levels at Khartoum during the flood season from 1869 to 1883 are available (*The Nile Basin*, vol. III).

Scientific measurement began about 1900, when Lyons introduced Price current meters for river flow measurements. Discharge measurements of the Blue and White Niles were made by staff of the Survey Department of Egypt from 1900. Two Irrigation Department expeditions started, one under C. E. Dupuis to visit Lake Tana and the Blue Nile, and the other under Sir William Garstin to visit the White Nile and the East African lakes. The Sudan branch of the Egyptian Irrigation Service was formed in 1905 to erect gauges on the different branches of the Nile. They also undertook lines of levelling as far as the East African lakes. They established, for example, a network of benchmarks on both sides of the Bahr el Jebel with known levels from which surveys could be based. By 1912 gauges had been established on most of the important sites on the river system within the Sudan.

Meanwhile Lyons, who was at the time Director General of the Survey Department of Egypt, had recruited H. E. Hurst to the Egyptian Service (Sutcliffe, 1979). Hurst subsequently became head of the Meteorological Service and in 1915 of the Physical Department. He established the comprehensive network of gauges throughout the Nile basin. He made many journeys to the upper Nile, where the hydrology of the Sudd was a particular concern. He also travelled to the Kagera and other tributaries of Lake Victoria, Lake Edward and the Semliki system, the Baro and the Bahr el Ghazal tributaries. The different basins are well described in the relevant volumes of *The Nile Basin*, which are fully illustrated with photographs giving a vivid impression of the variety of terrain, vegetation and river characteristics.

The Physical Department was responsible for establishing and maintaining river level gauges on the different tributaries. They established discharge measurements, usually with the aid of cableways, and derived rating curves from which the level records could be converted to river discharges. The discharge measurements were made, with the current meter at half depth, at about 20 points evenly spaced across the river; the mean water velocity at each point has always been taken as the measured velocity multiplied by 0.96. This was checked at a number of points by measuring the velocity–depth profile. Flows over 10-day and monthly periods were deduced by means of annual rating curves, though in some cases flows were interpolated.

The results of this work were published as successive volumes and supplements of *The Nile Basin*. Over 60 volumes and supplements of *The Nile Basin* have now been published. This comprises perhaps the most detailed set of records available for any river system in the world, and constitutes a major asset for the countries of the basin.

At the present time these volumes and supplements comprise:

vol. I: General description of the White Nile basin

vol. II and supplements 1–13: Measured discharges of the Nile and its tributaries

vol. III and supplements 1–13: Ten-day and monthly mean gauge readings

vol. IV and supplements 1–13: Ten-day and monthly mean discharges

vol. V: The hydrology of the Lake Plateau and Bahr el Jebel

vol. VI and supplements 1–11: Monthly and annual rainfall

vol. VII: The future conservation of the Nile

vol. VIII: The hydrology of the Sobat and White Nile and the topography of the Blue Nile and Atbara

vol. IX: The hydrology of the Blue Nile and Atbara and of the main Nile to Aswan, with some reference to projects

vol. X: The major Nile projects

vol. XI: The hydrology of the Sadd al Aali and other topics.

The titles are abbreviated in the list above but given in full at the beginning of the References.

NUMBERS OF GAUGING STATIONS

The river flow records available for the basin are best summarized by statistics concerning numbers of gauges, the number of gaugings carried out annually and the duration of records at key sites.

In the first summary of river levels (*The Nile Basin*, vol. III, 1933) the records of 100 gauges are listed. These include two on Lake Tana and one at Gambeila on the Baro, in

Ethiopia, and 15 on lakes and rivers in Uganda and Kenya. By 1952, in the 5th supplement, the total number had risen to 174; this included eight stations on the Baro system and 25 stations on the Nile system in East Africa including the Kagera. By 1957 this number had risen to 179 and to 189 in 1962 but had reduced to 165 in 1967 and to 129 by 1977. By this time all the countries of the Nile basin were independent and had established their own hydrological services.

A similar progression has occurred in the records of 10-day, monthly and annual discharges, which require a number of gaugings and considerable analysis before discharge totals can be published. In the first record (*The Nile Basin*, vol. IV, 1933), covering flows up to 1927, 42 stations were listed. By 1943 this number had risen to 144. These were to a large extent concentrated in the Bahr el Jebel, Bahr el Ghazal and Sobat basins for projects to reduce the losses from wetlands. By 1953 the number of flow records reached a maximum of 159 and in 1958 there were 135. In 1963 this had been reduced to 86 and continued at this level until 1978; the flows of the Sobat tributaries and minor Bahr el Jebel stations were very intermittently observed, and the upper Bahr el Ghazal records discontinued. Hydrological measurements within Ethiopia were taken over by the Ethiopian authorities. Political problems in the southern Sudan prevented the network from being reinstated completely, though several records for the Bahr el Ghazal tributaries were maintained by the Sudan authorities in the 1970s (see Chapter 6). Since about 1985 measurements have not been carried out south of Malakal.

The accuracy of flow records is largely determined by the frequency with which gaugings have been carried out. The accuracy also depends on the precision and stability of the relation between level and flow at a particular site. The frequency of gaugings at key sites indicates the effort undertaken over the years, mostly by the Egyptian authorities.

The annual gaugings at key stations are given in Table 2.1; some explanation of the table may be necessary. The gaugings at Namasagali and subsequently at Mbulamuti were taken some 80 and 60 km below the Ripon Falls, but related to the Lake Victoria lake level, in order to derive a relation between lake level and outflow. After the lakes rose in 1961–1964 the gauging site was moved to Mbulamuti. Between Lake Kyoga and Lake Albert gaugings have been made at various sites; it will be seen in Chapter 4 that because the river flow is stable these gaugings can be combined to derive rating curves. Conditions led to an interruption of gauging after 1978 in Uganda, and at Mongalla and Doleib Hill in 1984. The gauging site for the natural river above Aswan dam had to be moved from Wadi Halfa to Kajnarty and to Dongola as the dam was raised, but the record can be regarded as continuous. At Aswan itself the gaugings were used to supplement sluice measurements. At most sites the number of gaugings reached a peak in the 1920s, when interpolation of gauged flows was used at several sites to estimate volumes. After this period annual rating curves, derived from gaugings during the year, were used in most cases to estimate flows. In general terms the number of measurements was entirely adequate to monitor any changes in channel rating.

Although the rating curves at some key stations are discussed in subsequent chapters, an overview of the precision and form of the ratings may be derived from Shahin (1985, appendix E), where 35 sites are illustrated. Ratings are looped, with separate curves for rising and falling stage, at sites above junctions, like the Sobat at Doleib Hill or the Blue Nile at Khartoum. This is also true below junctions like the White Nile at Malakal and the main Nile at Tamaniat. At other sites, such as the White Nile near Lake No, or the White Nile above the confluence with the Blue Nile, the relation is so poor that only interpolation is possible. At some sites where the rating is straightforward, the rating is stable as at Jinja at the outfall from Lake Victoria. At other sites, like the Bahr el Jebel at Mongalla, there have been changes over the years. Thus the precision and stability of the rating depend on the site.

Table 2.1 Annual numbers of gaugings at key sites.

	Namasagali/ Mbulamuti	Masindi Port	Kamdini	Fajao/ Paraa	Mongalla	Doleib Hill	Malakal	Mogren	Khartoum	Tamaniat	Atbara	Wadi Halfa	Kajnarty	Dongola	Aswan
1901															
1902									30		8				
1903									43		17				
1904									3						
1905					2				8						
1906					1	3	7		7						
1907				2	1		13		12	4					
1908					5	7	38	5	8	1					
1909					5	16	32		7	1					
1910						29	43	8	27	3					
1911					5	34	25	15	28	28		33			
1912					3	23	10	26	91	42		88			
1913					2	24	2	85	110	99	80	119			
1914					3	23	20	105	32	88		80			18
1915						23	45	107	40	50					
1916					5	17	28	92	4	54					
1917					2	20	31	91	43	73					
1918						27	78	69	73	66					56
1919						21	74	98	96	21					117
1920						14	63	50	19	49		4			166
1921					1	24	71	64	72	65	21	166			206
1922				2	223	44	72	93	101	114	36	147			126
1923	3			2	201	75	72	97	110	108	81	125			111
1924					303	71	72	93	100	114	75	132			131
1925					294	72	71	117	108	142	52	94			113
1926	2				242	72	74	113	149	147	56	150			48
1927					310	72	86	147	160	205	64	109			53
1928					287	71	94	206	205	192	71	169			40
1929					304	72	86	185	186	155	61	190			51
1930					268	72	91	122	132	129	34	220			
1931					175	71	81	71	71	72	34	197	76		38
1932				60	72	69	82	72	72	72	40	50	163		84
1933					72	72	87	72	74	71	35	64	161		26
1934					72	72	86	72	78	77	44	28	165		11
1935	2	1			70	72	84	69	73	72	40	15	178		12
1936	1	1			58	52	86	73	72	71	34	36	185		
1937					60	46	86	71	73	72	38	84	128		
1938					60	48	84	68	75	74	34	125	156		64
1939		2			44	48	88	103	72	71	34	14	289		
1940	10	8	5	5	22	48	94	74	72	71	39		354		
1941	10	10	7	8	24	47	87	80	72	72	36		210		42
1942	11	11	6	11	26	47	87	103	78	74	34		241		32
1943	12	11	10	9	22	47	97	72	70	73	44		228		33
1944	7	7	8	1	23	48	89	58	72	72	36		295		
1945	8	2	8		24	48	90	58	70	71	38		215		
1946	8		5		24	48	93	60	76	75	41		168		34
1947	11		5	4	23	48	91	52	72	72	39		121		29
1948	10		6	4	24	47	87	48	70	68	40		132		83
1949	5		8	6	24	48	86	55	55	57	38		139		
1950	14		11	9	24	46	84	53	64	63	39		125		29
1951	48		7	9	18	48	86	44	56	55	40		150		29
1952	46		9	11	23	25	87	50	56	47	35		136		31
1953	46		10	10	19	31	87	54	67	67	44		112		37
1954	48		7	11	12	26	88	45	70	66	45		150		50
1955	48			11	11	20	87	45	71	68	38		144		43
1956	48		4	12	12	23	87	39	68	68	48		149		39
1957	47		4	12	12	26	89	48	65	60	59		139		35
1958	12		10	12	12	50	88	41	72	66	50		152		46
1959	11		11	12	12	36	87	44	67	63	40		158		63
1960	12			12	11	22	88	44	70	63	47		158		81
1961	13			11	10	26	87	42	67	69	44		156		205

	Namasagali/ Mbulamuti	Masindi Port	Kamdini	Fajao/ Paraa	Mongalla	Doleib Hill	Malakal	Mogren	Khartoum	Tamaniat	Atbara	Wadi Halfa	Kajnarty	Dongola	Aswan
1962	12			5	9	29	86	48	70	70	40		176	61	76
1963	32			10	10	27	87	47	69	67	46		168	129	50
1964	24			12	9	22	87	42	67	65	47		76	134	58
1965	34			11			87	41	65	66	80			129	43
1966	18			12		1	84	49	70	68	74			126	121
1967	19			12	12	10	87	46	68	68	92			100	76
1968	19			1	17	11	72	47	69	69	81			150	86
1969	13				19	18	72	40	65	65	60			139	86
1970	5			16	18	18	72	39	65	64	62			127	68
1971	33	2		11	15	5	71	39	66	60	43			126	113
1972	30			5	14	13	72	49	63	67	28			127	51
1973	21			3	11	12	68	43	63	62	30			125	42
1974	12			4	4	7	72	33	62	68	23			103	70
1975	3			4	5	7	67	32	68	60	17			106	56
1976	6	1		1	10	8	72	34	52	61	4			80	70
1977	4	12		4	8	8	72	27	41	46	5			84	97
1978	18	12		4	8	8	71	32	49	47	8			108	85
1979				1	7	12	72	38	54	58	4			104	84
1980					3	5	72	25	38	30	9			103	70
1981					8	7	72	24	33	37	5			123	79
1982					6	7	72	23	33	51	8			87	81
1983					7	10	72	30	17	51	11			83	113
1984					3	2	72	44	15	49	8			79	174
1985							72	32	22	49	3			113	200
1986							72	36	23	26				106	168
1987							72	27	50	36				110	182
1988							72	24	47	38				113	172
1989							72		61	43	9			119	173
1990							69	1	53	43	7			119	162
1991							72		34	20	10			117	143
1992							64		34	27				122	162

COLLABORATION WITH OTHER HYDROLOGICAL SERVICES

From about 1950 hydrological services were established by Uganda, Sudan and Ethiopia. Responsibility for measuring most levels and river gaugings was taken over by the upstream countries. Inevitably, the objectives of these hydrological services were redirected to focus on local water resources development rather than the integrated development of the Nile basin. However, the key hydrological stations have been maintained, often in collaboration, and many of the records have been published in *The Nile Basin.*

In Uganda the Department of Hydrological Survey was established in 1947 and became the Water Development Department in 1956. The number of discharge sites operated by the department rose from 8 in 1948 to 95 in 1956 (Water Development Department, 1957); most of these stations were on small tributaries of Lakes Kyoga, Edward and George. Flow records for 24 stations for the period up to 1968 were published in 1970 (Water Development Department, 1970). The Egyptian Irrigation Service continued to carry out gaugings on the main river; in fact the calibration of some stations is best carried out by using both sources of data (see Chapter 4). Flow measurement in the East African lake basin was stimulated by the establishment in 1967 of the WMO/UNDP Hydrometeorological Survey, which measured inflows to Lake Victoria. After 1979, when most of the equipment was destroyed, the political situation in Uganda resulted in the suspension of much hydrological work. After about 1987 the rehabilitation of the network began. Since then the hydrological data have been computerized but there was a gap in the continuity of all but the outflows from Lake Victoria.

The Sudan Ministry of Irrigation also set up a hydrological organization in about 1964 which has been responsible for producing yearbooks since 1971. However, the responsibility for gauging some of the major Nile stations has been shared between Egypt and Sudan, who established the Permanent Joint Technical Committee to coordinate investigations. In general the Egyptian service, which maintains offices in Khartoum and Malakal, has continued to measure flows on the main Nile, the Blue Nile and White Nile, Sobat and Bahr el Jebel. The Sudan Ministry of Irrigation has measured flows on the upper Atbara, the Dinder and Rahad, the Blue Nile at el Deim, and also the upper tributaries of the Bahr el Ghazal. The flow records for which the Sudan has been responsible have been published in yearbooks and are maintained in computer form in the Ministry.

During the first half of this century the Egyptian Irrigation Service undertook investigations and flow measurements in the Ethiopian portion of the Nile basin. In particular they studied the flows around Lake Tana in 1920–1933, where the possibility of storage was envisaged. They also studied the Baro from 1928 to 1959 below Gambeila, where an outpost of the Sudan Government was maintained for many years and a staff gauge had been established in 1905. Flows were measured at a number of points to investigate the regime of the Baro above its confluence with the Sobat. Spill from the river was noted to truncate the high flows where the Baro emerges from the Ethiopian frontier to the Sudan.

Hydrological investigation of the Blue Nile basin within Ethiopia was undertaken by the United States Government between 1959 and 1964 at the request of the Ethiopian Government (US Bureau of Reclamation, 1964; Said, 1993). During this study river gauges were established at about 60 sites within the Blue Nile basin, and flows were calculated for over 50 sites. The Ethiopian Hydrological Service has taken over the responsibility for flow measurement within its territory. At present (Asefa, 1997) the network of stations in the Baro-Akobo basin, draining to the Sobat, consists of 24 stations. The network in the Abbay or Blue Nile basin has 100 stations, while that in the Tekeze or Atbara basin has 26 stations. Discharge measurements are taken using Price current meters, and standard techniques are used to derive rating curves. Hydrological yearbooks have been compiled up to 1980, and manuscript data are available up to 1996. Although yearbooks have not been published in the same way as *The Nile Basin,* government organizations have free access to the data. The HYDATA system for processing of hydrological data has been installed, and data entry is in progress.

The Egyptian authorities have also published in *The Nile Basin*, vol. VI, rainfall records for stations throughout the basin, though these records were provided by the national meteorological services.

From 1967 to 1992, collaboration between the countries of the Nile basin has been focussed on the work of the Hydrometeorological Survey of the East African Lakes. This project was supported for much of this period by WMO/UNDP and produced reports in 1974 and 1982 (WMO, 1974, 1982). This joint investigation was responsible for collating measurements throughout the East African basin of the Nile, including tributaries of the Lake Victoria basin within Kenya, Tanzania, Uganda, Rwanda and Burundi. From 1980 the project was administered by its Technical Committee and financed by the participants. In 1992 (Bakhiet, 1996) the project changed its name to Tecconile, based at Entebbe, with objectives set by Ministerial meetings. Since 1993, a series of conferences named the Nile 2002 series, held in different basin countries, has led to informal exchange of technical findings and views.

RECORDS AVAILABLE AT KEY SITES

The extent of records at some of the key stations is shown below. The dates in brackets indicate that records have been derived in this study, or that flows have been deduced by correlation. A number of these stations are still being maintained, so that no end date is given:

Kagera at Kyaka Ferry/Nyakanyasi	1940–1978
Victoria Nile at Jinja	1896–1897, 1898–
Kyoga Nile at Kamdini	1940–1980
Semliki at Bweramule	1940–1978
Bahr el Jebel at Mongalla	1905–1983
Jur at Wau	(1904–1941), 1942–1961, 1970–1986
Baro at Gambeila	(1905–1927), 1928–1959
Sobat at Doleib Hill	1905–1983
White Nile at Malakal	1905–
Blue Nile at Roseires/el Deim	1912–
Dinder at mouth/Gwasi	1907–1951, (1952–1971), 1972–
Rahad at mouth/el Hawata	1908–1951, (1952–1971), 1972–
Blue Nile at Khartoum	1900–
Main Nile at Tamaniat	1911–
Atbara at mouth	1903–
Main Nile at Wadi Halfa/Kajnarty/Dongola	1890–
Main Nile at Aswan	1869–

It will be seen that records began at most sites between 1905 and 1912, though some records began earlier. On the other hand, most of the records in the southern Sudan and Uganda were interrupted about 1980, though some have been continued and others are being reinstated. These records are the raw material for study of the hydrology of the various tributaries, so it can be seen that discussions are not always based on a common period of record