Annotations for

Monthly Discharge Data for World Rivers (excluding former Soviet Union)

Version 1.3, September 2001

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Disclaimer

Users assume responsibility for errors in the river and stream discharge data, associated metadata [river names, gauge names, drainage areas, and geographic coordinates], and the annotations contained herein.

No doubt errors and discrepancies remain in the metadata and discharge records. Anyone data set users who uncover further errors and other discrepancies are invited to report them to NCAR.

Appeal for Discharge Records

Discharge data availability remains poor over much of the globe particularly the less developed world. Anyone with discharge records in the public domain or otherwise not subject to severe restrictions is invited to forward them to myself [babodo@eol.ca] or to Roy Barnes at NCAR [bozo@ucar.edu] for inclusion in ds552.1.

Foreword

How to Use This Document

This report is intended for on-screen viewing. Clicking on the page number in the Table of Contents of the MS Word doc file [not the pdf version] will jump to the section of interest. If using the MS Word version, use "Normal" view and turn on "Gridlines" in the "Table" menu. A few math symbols may not be rendered correctly in the pdf version created by NCAR [the result may manifest as a "hole" in the text of a page or more in the worst case]. Check the MS Word version if anything appears suspect in the pdf file. Printing is not recommended as sections, tables and graphics will sprawl across page breaks. The internet addresses [URLs] given herein are not live. URLs have to be copied and pasted into your internet browser.

Distribution Package

Files in the distribution package are listed below. The spreadsheet inventory file global_cat.xls has basic summary statistics [mean annual discharge, specific runoff and period of record] and a table of ISO country codes. The spreadsheet is useful for quick sorting and selection of sites by country, continent, drainage area, etc..

File name	Format	Contents
readme	**ascii**	**description of distribution files & formats**
abstract	**ascii**	**abstract**
global.cat	**ascii**	**site catalogue / metadata list**
global_cat.xls	**MS Excel 8**	**site catalogue with summary statistics and additional information**
code_tables.xls	**MS Excel 8**	**site ID code translation tables for Argentina, Australia, Brazil, Canada, USA, UK**
global.q	**ascii**	**monthly discharge data**
global.doc	**MS Word 6**	**notes — this document**

Updates: v1.3 September 2001

- 84 “new” records: Mexico (57), China (10), Sudan (4), Namibia (3), Brazil (2), Antarctica (2), Argentina (2), Paraguay (1), Uganda (1), Zambia (1), Zimbabwe (1)
- updates for 15 records previously available in v1.0–v1.2
- updates are concentrated mostly at 8 sites [Mexico (4), Colombia (2), Sudan (2)]
- dubious segments deleted from two New Zealand records
- new information derives from the GHCDN [Global Hydroclimatic Data Network] compilation [V1.0a Sep 2000] by Dettinger and Diaz (2000)
- this was a quick update; for expediency, notes on GHCDN records have been consigned to Section 15 rather than broken out by geographic divisions

Updates: v1.2 August 2001

- net gain of 915 new Brazilian records
- updates for ca. 500 Brazilian records previously available in v1.0/v1.1
- revision of gauge ID numbers for Brazilian records
- revision of Brazilian annotations into a single chapter [14]

- 17 Bolivian records added; 2 existing Bolivian records updated
- minor metadata fixes

Updates: v1.1 June 2001

- 30 records for northeastern South Africa
- one redundant Thai record deleted; two Thai records added
- provisional 1996-1999 data at some UK gauges replaced with current versions
- clarification of pseudo records at Thames and Lee rivers [see UK section]
- many metadata [names, coordinates, drainage areas and/or gauge elevations] fixes

- **anyone who has previous versions [v1.0–v1.2] should scrap the files and use the present version**

Table of Contents

Part I: Preliminaries

1.0 Introduction

Regarding preparation of the Global Water Resources Assessment for the World Water Forum held in March 2000, Shiklomanov (2000) lamented that "At end of the 1990s, it was only possible to analyze global river runoff data for the period to 1985, in contrast to meteorological information (air temperature and precipitation), which is generated for the entire globe with only a few months delay." Despite calls for timely processing and improved exchange of hydrologic information, it may be many years before circumstances improve. Although discharge data are becoming more widely available, they are often difficult and expensive to obtain, and frequently subject to severe use restrictions.

Currently, few countries make hydrologic data freely available. Fortunately, some large countries (USA and Brazil) have made stream discharge data freely available from data bases that are updated regularly, and some others including Russia and Argentina have made large static discharge data sets available which will hopefully be updated occasionally. Some smaller national and international jurisdictions have also now made regularly updated or static data sets available. Regrettably for much of the world, national policies on hydrologic data dissemination remain very restrictive, and beyond elite groups, hydrologic data availability is restricted to irregular and limited contributions to international archives and compilations.

The present data set is a compilation of hydrologic records from freely available international compilations, national and international sources, and some independently obtained files. ***The geographic scope is global, but excludes data for the 15 nations of the former Soviet Union [FSU], and includes only a limited selection of data for the USA and Canada.*** Extensive data for the FSU, USA and much of Canada can be obtained from other sources and readily merged with the present data set to create a global data set of 7,000+ monthly discharge records [see **5.0 Building a Global Data Set**].

Many of the records are dated, of short duration, and coverage remains sparse for large parts of the world. Nonetheless, the present data offers considerable improvement over most available compilations, and ***these data are freely available for unrestricted use***, with the potential exception of some MED-HYCOS data [see section **3.3 MED-HYCOS warning**].

Data Set Summary

This data set is a compilation of 4,425 monthly discharge records for gauges from around the world excluding the 15 countries of the former Soviet Union [FSU] including Russia. This set combines 3,455 gauge records not currently in other NCAR data sets, plus the 970 records found in ***ds552.0*** [nominally, the "***UNESCO***" set]. The two were combined because (a) they have the same geographic scope and it is natural to combine the two, and (b) they were stored as subsets of the same data base. The UNESCO set ***ds552.0*** retains some distinct interest because many of these gauges have been used and continue to be used in many studies (e.g., Arora and Boer, 2001; Oki et al., 1995). Sites of the UNESCO set are clearly marked in the present metadata.

Data availability is summarized below by continent and region in Table 1. South America has largest gain in site coverage over ***ds552.0*** due to large data sets for Brazil (1,948 gauges total) and Argentina (310 total). Although more than half the gauges are in Western Australia, Australian geographic coverage improves significantly over ***ds552.0***. Enhanced European coverage is broadly dispersed except for a concentration of gauges in central Italy. Gains in Africa are modest and significant areas of the continent continue to have sparse or dated coverage. Asian gauges more than double, but coverage is sparse or temporally limited for large areas of the continent. Gains in Oceania are concentrated mainly in New Zealand.

Table 1. Site summary by continent and region.

Continent / region	UNESCO ds552.0	v1.2	new in v1.3	total
Europe	126	215		341
Africa	275	126	10	411
Middle East [a]	21	14		35
Indian Ocean [b]	6			6
Asia	146	207	10	363
Australia	10	361		371
Oceania [c]	20	45		65
Antarctica			2	2
North America [d]	204	76	57	337
Central America	39	1		40
Caribbean	17	5		22
South America	106	2,321	5	2,432
totals	970	3,371	84	4,425

[a] Turkey, Jordan, Israel, Cyprus, Syria, Iraq [Asia Minor or "Western Asia" in some recent UN agency documents]

[b] Mauritius

[c] New Zealand, Papua New Guinea, New Caledonia, French Polynesia, American Samoa, Guam, Micronesia, Palau

[d] Canada, US, Mexico

Gross summary statistics for the data set are given below. Net years are total months / 12.

	Sites	Records	Net yrs	Net yrs/site
non-Brazil	**2,477**	**73,150**	**70,145.3**	**28.3**
Brazil	**1,948**	**52,343**	**49,226.4**	**25.3**
Totals/means	**4,425**	**125,493**	**119,371.8**	**27.0**

The distributions of records lengths are listed below:

net yrs	BR	%	non-BR	%	all	%
100 ≤ y			**28**	**1**	**28**	**1**
50 ≤ y < 100	**222**	**11**	**346**	**14**	**568**	**13**
25 ≤ y < 50	**583**	**30**	**755**	**30**	**1,338**	**30**
10 ≤ y < 25	**827**	**42**	**762**	**31**	**1,589**	**36**
5 ≤ y < 10	**213**	**11**	**314**	**13**	**527**	**12**
0 ≤ y < 5	**103**	**5**	**272**	**11**	**375**	**8**
totals	**1,948**		**2,477**		**4,425**	

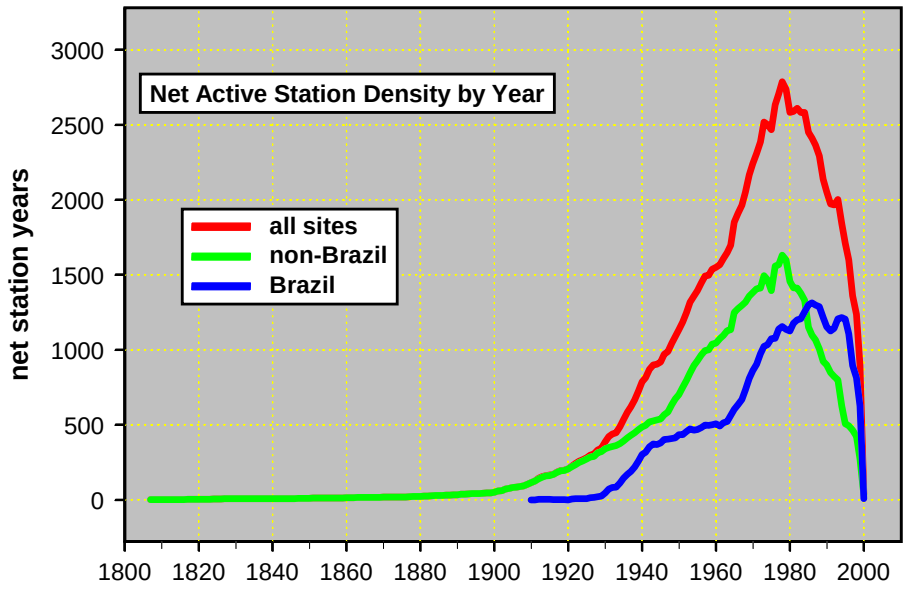
- gross station year counts give another view of the data set
- for each unique calendar year in the data set, the total months of data for all sites are divided by 12 to give a measure of the temporal data density which is also the ***net active station density*** in any year

- as the plot below shows, the ***net active station density*** peaks in the late 1970s and declines rather steeply thereafter

- the trend in the non-Brazilian world reflects two factors: (1) general global decline in stream monitoring due to budget cutbacks, and (2) lags in data processing and restrictions on public data release by many governments

- Brazil is a global exception, as ***net active station density*** peaks in the early 1980s and falls only modestly before the mid-1990s when the steep decline indicates the lag in data processing

- the ***gross active station density*** determined as the number of stations reporting at least one month of data in a calendar year is greater than the ***net active station density*** by 3-7% through the most active period of 1940–1990
- after 1990, the percentage increases because many gauges have incomplete data during their final years of record



Drainage Areas

- the distribution of gauges with reported drainage areas is shown below:

km^2	BR	%	non-BR	%	all	%
$10^6 < a$	6	0	27	1	33	1
$10^5 \leq a < 10^6$	101	5	213	9	314	7
$10^4 \leq a < 10^5$	449	23	581	25	1,030	24
$10^3 \leq a < 10^4$	860	45	805	35	1,665	40
$10^2 \leq a < 10^3$	490	26	512	22	1,002	24
$0 \leq a < 10^2$	9	0	161	7	170	4
totals	1,915		2,299		4,214	

2.0 Data Sources

Discharge data in the present set derive from sources listed below in Table 2. When data from multiple sources data were available for the same gauges, records were accepted according to the following rules:

- data from national sources took precedence over data from other sources,
- data from sources with the most recent records took precedence over data from sources with less recent data.

Table 2. Data sources.

A. International Compilations	
UNESCO	**global data from UNESCO sources — dss.ucar.edu/datasets/ds552.0.0/**
SHI	**global data from the archives of Russia's State Hydrological Institute [SHI], St. Petersburg — espejo.unesco.org.uy/index.html**
GHCDN	**global data — Dettinger–Diaz *Global Hydroclimatic Data Network***
PACRIM	**Chile, Peru, New Zealand, Australia, Taiwan — www.seas.ucla.edu/chpr/pacrimst.htm**
R-Arcticnet	**Norway, Iceland, Mongolia, and some Canadian gauges — www.R-arcticnet.sr.unh.edu/**
R-Hydronet	**Argentina — www.R-hydronet.sr.unh.edu/**
LBA-Hydronet	**Bolivia — www.lba-hydronet.sr.unh.edu/**
MED-HYCOS	**Mediterranean tributaries — medhycos.mpl.ird.fr/**
AP-Friend	**Indonesia, Malaysia, South Korea, Japan, Thailand — titan2.cee.yamanashi.ac.jp/FRIEND Australia — www.bom.gov.au/hydro/wr/unesco/friend/data.shtml**
IBWC	**Colorado and Río Grande tributaries: Mexico and USA — www.ibwc.state.gov/**
USGS	**some Canadians sites near US border, and small streams of Guam, Marshall Islands, Micronesia, Palau to 1988 included in a US compilation wwwrvares.er.usgs.gov/hcdn_cdrom/1st_page.html**
B. National and Intra-National Compilations	
ANEEL	**Brazil — hidroweb.aneel.gov.br/Login.asp**
SIGRH	**São Paulo state, Brazil — www.sigrh.sp.gov.br/sigrh/basecon/bancodedados/index.html**
WA	**Western Australia — www.wrc.wa.gov.au/waterinf/wric/SearchByCriteria.asp**
VIC	**Victoria State, Australia — www.vicwaterdata.net/**

JP	**Japan — wdb-kk.river.or.jp/e/zenkoku/title.html**
INAG	**Portugal — www.inag.pt/cgi-bin/snirh/callsnirh**
UK-ENV	**England, Wales 30 sites — www.environment-agency.gov.uk/gui/dataset4/4nation.htm** **Address no longer available in early 2001; data removed or url changed**
UK-NRFA	**recent data (1996-1999) for UK sites from UK National River Flow Archive [www.nwl.ac.uk/ih/nrfa/index.htm]**
IT	**central Italy — www.gndci.pg.cnr.it/it/idro/table_it.htm**
USGS	**USA and Puerto Rico** **waterdata.usgs.gov/nwis-w/US/**
ZA	**Mpumalanga Region; South Africa — www-dwaf.pwv.gov.za/HydroMpumalanga/**
C.	
Other	**scattered global sites from independent files**

3.0 Data Quality Issues

Most international archives focus on assembling data without making strong commitments to data QC/QA [quality control / quality assurance]. Data from international archives and compilations often have problems created by intermediary handling. Similar problems have occurred with data in national archives of some countries where primary data are collected and processed by numerous national and local agencies.

- metadata and discharge records for the 970 gauges in the UNESCO subset were vetted as best as possible in the construction of ***ds552.0*** which has extensive annotations [see documentation for ***ds552.0***]

- ***the other 3,455 gauge records in the present set were vetted primarily for errata and inconsistencies in metadata***; most comments in the present notes pertain to metadata problems

- discharge records were subjected to cursory scans for certain kinds of common errata such as replicated records, spurious zeros, spurious missing values, and egregiously abnormal entries

- ***Undoubtedly, errors and discrepancies remain in the metadata and discharge records***. Rigorous vetting of discharge records by statistical and other methods will

likely reveal other errata many of which may not be resolvable without direct access to source agencies

- the present notes are not a complete accounting of certain dubious records that were deliberately discarded from some source data sets during preliminary inspections
- likewise, some readily resolvable errata that were corrected during preliminary inspections were not recorded

3.1 Metadata Validation

Gauge metadata (river name, gauge location name, location coordinates, drainage areas and gauge elevations) problems were mostly identified by cross-comparisons between alternative data sets and gauge inventories, site mapping to evaluate geographic coordinate validity, and checks against the US NIMA gazetteer [**164.214.2.59/gns/html/index.html**], a gazetteer file from Digital Chart of the World, and occasionally some other sources.

For the most sites, the river and gauge names are reasonably correct and given in widely accepted forms. The location coordinates are generally good, ***but there are many sites for which the gauge locations are too obscure to be verified***. For most of these, it was possible to at least assure that the coordinates placed the site somewhere in the correct watershed.

Some data sources are more troublesome. SHI lacks coordinates for many sites, gives inaccurate coordinates for others, and gives many river and gauge names in unconventional forms. The Argentine metadata from R-Hydronet have many erroneous drainage areas.

3.2 Digital Precision / Units

- the present discharge data are given to 5 significant digits to the right of the decimal
- this is excessive for most sites, but was adapted because there are as many as 90 records for low discharge watersheds, mainly streams on small islands and arid regions, where monthly discharges fall below 0.001 m^3/s; and there may be 150 or more other gauges that may fall into this category if discharge data had not been rounded to the nearest 0.001 m^3/s

- ideally, a system of flexible reporting units would reduce the need to carry meaningless digits without jeopardizing the integrity of records for low discharge streams

- some records for low discharge sites obtained from independent sources were reported in L/s (litre/second), some Australian states give total daily discharge volumes as ML/day (Megalitre/day), and in Mpumalanga region, South Africa, monthly cumulative totals are given in 10^6 m^3

- to avoid confusion, all records were converted to mean discharge rates in m^3/s

- some source data sets rounded all discharges to the nearest 0.01 m^3/s with the result that records for some low discharge streams exhibit almost no variability

3.3 General Comments on the Quality of Specific Data Sources

GHCDN

- the Global Hydroclimatic Data Network comprises a set of monthly discharge records for 1,345 globally distributed sites compiled by Dettinger and Diaz (2000)
- ***GHCDN V1.0a, 8 Sept 2000*** was available for perusal
- GHCDN evolves with time and the current version likely differs from ***V1.0a***

- GHCDN was developed for the purpose of evaluating time trends and other features of stream discharge relative to climatic data
- thus the compilation has been deliberately biased to records with minimal anthropogenic influences, particularly strong discharge regulation
- some long historical records have been clipped at the point when large reservoirs began operations

- excluding the USA and Russia, most GHCDN records are already available in the present set
- a few "new" Russian records from GHCDN sites are available in the Sep 2001 update of **ds553.2**
- US records in GHCDN are all as given in the USGS HCDN CD-ROM

- GHCDN has 84 "new" records that fall within the purview of ds552.1 [generally, the world excluding Russia and other former Soviet Union republics, and the USA beyond sites that are already available].

- the 84 "new" sites are distributed as: Mexico (57), China (10), Sudan (4), Namibia (3), Brazil (2), Antarctica (2), Argentina (2), Paraguay (1), Uganda (1), Zambia (1), Zimbabwe (1)

- GHCDN also has additional data for 15 sites existing in v1.2 and earlier versions of ds552.1

- the gains are concentrated mostly at 8 sites [Mexico (4), Colombia (2), Sudan (2)]

AP-Friend

- FRIEND [**F**low **R**egimes from **I**nternational **E**xperimental and **N**etwork **D**ata] is a UNESCO program for process-oriented hydrologic research conducted by regional collaborative groups one of which [AP-Friend] comprises Asia-Pacific countries
- data for Australia are of high quality
- individual gauge records from several countries [China, Indonesia, Japan, South Korea] contain one or more replicated years

- data submissions to AP-Friend have been freely available for several years
- there are indications that future access to data may be restricted to project participants for some participating nations

IBWC

- IBWC is the US-Mexico International Boundary Waters Commission
- the IBWC has discharge records for sites in the Rio Grande and Colorado river basins
- although discharge records are freely available, gauge metadata are not
- data are generally good; however, records for 1999 and 2000 [or generally 2 years before present] should be considered provisional and subject to future revision

MED-HYCOS

- MED-HYCOS is the Mediterranean regional pilot project of the WMO and World Bank sponsored **W**orld **Hy**drological **C**ycle **O**bserving **S**ystem (WHYCOS)
- regional WHYCOS projects focus on improving hydrometeorological data collection and management systems

- MED-HYCOS discharge records are mostly good, but some problems were evident with particular Spanish, French and Serbian gauge records
- records for a few Spanish and French gauges were discarded because there were significant discrepancies monthly discharges derived from daily records and separately given monthly records, and no means of ascertaining which versions were correct

- one year of replicated data for a Serbian gauge on the Danube River was deleted
- these problems may have since been corrected at MED-HYCOS

Warning: new MED-HYCOS Copyright / Disclaimer March 2001

- as of late February 2001, revised MED-HYCOS www pages prominently display the following Copyright / Disclaimer statements which had not been displayed previously during 1999 and 2000 when MED-HYCOS data incorporated into the present set were retrieved

- it is unclear how copyright could be applied retrospectively to data previously made available without restrictions

COPYRIGHT : All data and information available belong to the national hydrological services. For any use, information (text, pictures, maps, tools, etc.) and hydrometeorological data, one must require the agreement of the concerned national hydrological service. Commercial use is strictly forbidden.
DISCLAIMER : In any case, the responsibility of the national hydrological services and of the MED-HYCOS Project will not be engaged.

- data are still available for retrieval from the MED-HYCOS www site
- possession of MED-HYCOS data do not violate the copyright

- ***users should exercise their own judgement about how best to respond to the Copyright according the use they make of the data***
- if data are not used, there is no violation

- this set contains 60 sites also in the MED-HYCOS gauge inventory
- these are marked in the companion spreadsheet "***global_cat.xls***"

- complete records for Greek, Portuguese and scattered gauges from other countries were freely available from other sources
- Croatia and Slovenia are the only countries having records that were only available from MED-HYCOS
- other countries have 1-4 records with data found only at MED-HYCOS
- other records comprise mostly data available from other sources which have been updated from MED-HYCOS with 1990s (mainly post 1995) data

PACRIM

- PACRIM is the ***Pacific Rim Streamflow Data Set*** assembled by researchers at the University of California at Los Angeles ca. 1996

- PACRIM discharge data are generally of good quality; however, there are a few easily rectified problems
- the units of Taiwanese discharges are not given correctly [see **Asia: Taiwan section**]
- Australian data were given in units of specific runoff depth (mm) and required conversion back to m^3/s
- Chilean gauge location coordinates require an adjustment [see **South America: Chile** section]
- two New Zealand records contain dubious record fragments that have been deleted [See **Pacific Ocean: New Zealand**]

R-Arcticnet

- see section ***5.1.2 University of New Hampshire – Global Hydrology Research Group*** for a description of R-Arcticnet

- the Canadian data appear to be as given by the Canadian source agency
- some gauge records may have been revised since the 1993 data release
- more recent data for some US-Canada border gauges, and some US gauges appearing in the set can be obtained from US sources

- the Norwegian, Icelandic and Mongolian records were also available in other sources
- one Norwegian record mixed records from two gauges with dramatically different mean discharges; about half the record that matched data from other sources was retained, and the rest discarded as the geographic source of the data were unknown
- some Icelandic records were more recent than data from other sources, and suggested that records had been revised retrospectively
- river and gauge names for Mongolian records were not clearly given; these were corrected as best as possible

R-Hydronet

- see section ***5.1.2 University of New Hampshire – Global Hydrology Research Group*** for a description of R-Hydronet

- Argentine data from R-Hydronet were incorporated into the present set
- there are ubiquitous problems with the drainage areas reported for these gauges, and some problems other metadata
- in general, discharge data quality appears good; however, there are at least two, and likely some other records that may be unidentified composites
- see the **South America: Argentina** section

LBA-Hydronet

- see section ***5.1.2 University of New Hampshire – Global Hydrology Research Group*** for a description of LBA-Hydronet

- Bolivian data from LBA-Hydronet were incorporated into the present set
- there are some problems with these records; however, because coverage for Bolivia is poor, these records are included
- see the **South America: Bolivia** section

SHI

- SHI is Russia's ***State Hydrological Institute*** located in St. Petersburg

- the most problems with metadata and discharge records were detected in the SHI data set
- many river and gauge names were given in unusual English forms, coordinates and drainage areas were often inaccurate or missing, and some gauges were assigned to the wrong countries

- discharge records are generally older than other sources and contain a higher frequency of abnormal entries which is typical for older data sets created by manual data entry and processing
- discharge data are more crudely rounded than data from other sources; this generally has little consequence except for low discharge streams

- many SHI records are rather old; comparative analysis with other versions where available in alternative sources shows that agencies have often revised gauge records significantly since the versions available in SHI
- old records from SHI were retained when mean levels, seasonal patterns and specific runoff were within the plausible ranges expected for the locality

Other (Independent) Sources

- originally, more than 200 discharge records for scattered global locations were assembled courtesy of various informal independent sources (generally, professional and academic contacts)
- in general, the quality of data from the informal sources was consistently high
- most have now been replaced by records from other national or international sources which have more recent or longer versions of the same gauge records

- <20 records from informal sources remain in the data set, but there is no reason to suspect problems with these

4.0 Metadata Notes

4.1 Site Numbering Scheme

- ***site ID numbers in the present set are purely arbitrary without hydrogeographic significance***; new sites added to the data set were merely assigned unused number sequences

- ***ID numbers assigned to Brazilian gauges were revised for v1.2 as per notes below***

- the present site ID numbers can be readily revised
- ideally, a numbering scheme based on drainage network topology is desirable

4.2 Site ID Code Translation Tables

The companion spreadsheet "***code_tables.xls***" contains gauge ID code translation tables for some of the larger national subsets in the present data set including:

1. Argentina
2. Canada
3. USA
4. Brazil
5. Australia
6. UK

For Argentina and Canada, the tables respectively list the ID codes in R-Hydronet and R-Arcticnet data sets for gauges common to the present data set. For Canada, USA, UK, Brazil and Australia, the tables give the gauge ID codes used by the national agencies.

Warning: The Australian national inventory maintained by Bureau of Meteorology may be changing from the historical 6-digit numerical codes given in "***code_tables.xls***" to a system of mixed alpha and numerical codes; however, Australian states and territories still appear to be using the 6-digit numerical codes.

4.3 Country and Continent/Region Codes

To facilitate organizing and sorting the master metadata list and data summaries, two letter codes were added for (1) country, territory or sometimes state or province, and (2) continent or region.

Country codes found in the spreadsheet catalogue file and the gauge identification headers used herein are the **ISO 3166-1** standard familiar to many as the internet country / territory codes (ISO, 2001). The complete set as given early 2001 is listed in the site catalogue spreadsheet "***global_cat.xls***" on sheet "***ISO_Country_codes***". The country code for Congo (formerly Zaire) has been changed to **CD** from **ZR** used previously. Although the current ISO code for United Kingdom is **GB**, the code **UK** has been retained for the present as **UK** appears to be the most widely used of the two, e.g., government www sites are all **UK**.

ISO codes have been supplemented with some ad hoc additions. E.g., gauges in Alaska are identified by the US state code "AK" so that Alaskan sites can be readily identified and grouped with other Arctic or Canadian gauges. Similarly, Australian gauges were identified by arbitrary codes assigned to distinguish the Australian states and territories.

The continent and region codes used here are listed below. These are arbitrary creations for my convenience. Others could be easily substituted.

Table 3. Continent / region codes.

Continent / region	Code	Continent / region	Code
Africa	**AF**	**Europe**	**EU**
Middle East [a]	**AM**	**Indian Ocean** [b]	**IO**
Asia	**AS**	**North America** [c]	**NA**
Australia	**AU**	**Oceania / Pacific Ocean** [d]	**PO**
Central America	**CA**	**South America**	**SA**
Caribbean	**CB**		

[a] once called "Asia Minor", more recently "West Asia" in some United Nations publications; includes Turkey, Jordan, Israel, Cyprus, Syria, Iraq; this group is broken out separately to facilitate grouping them with Europe, Asia, or Africa as circumstances may require.

[b] Mauritius, Comoros, Seychelles, Reunion, Maldives, and other islands

[c] Canada, US, Mexico

[d] New Zealand, Papua New Guinea, New Caledonia, French Polynesia, American Samoa, Guam, Micronesia, Palau

5.0 Building a Global Data Set

A global discharge data set can be readily constructed by merging the present data set with data from the following sources:

1. 2,400+ gauge records for the former Soviet Union [FSU] available in NCAR ***ds553.2***
2. 2,000+ gauge records for the Canadian Arctic, Hudson and Ungava Bay drainage basin from ***R-Arcticnet***
3. 450+ gauge records for the USA in NCAR ***ds550***

The FSU data set contains many sites that are likely of negligible interest for continental or global scale analysis. Likewise, the Canadian data at R-Arcticnet has many sites of local interest (e.g., drainage and irrigation canals) or limited record duration. Even under conservative selection rules, the three sources cited above can easily yield 3,000 or more gauge records to supplement the 4,425 records in the present data set.

Some sites in the present set are common to the Canadian data at R-Arcticnet and the US data in ds550. US data in the present set should be given precedence over the versions available in ds550. The companion spreadsheet "***code_tables.xls***" contains gauge ID code translation tables for the US and Canadian gauges in the present set that permit readily identifying gauges common to R-Arcticnet and ds550.

5.1 Other Data Sources

Useful additional data may be found at the following sources.

5.1.1 GRDC

The Global Runoff Data Centre [GRDC] was organized under WMO as a central repository of global stream discharge data. As of February 2001, GRDC had accumulated data for more than 5,500 stream gauges including the Arctic Basin sites which are mostly derived from the Arctic Drainage basin data at R-Arcticnet. Excluding gauges from the FSU, USA and Canada, GRDC has about 2,800 gauge records.

GRDC has records for many gauges not in the present set, and longer records for some in the present set. GRDC imposes severe restrictions on data usage. Also GRDC makes no concerted effort ensure the quality of data or metadata; hence, GRDC archives do contain significant errata not found in other sources. It can be very difficult matching gauges in the present and other sets to gauges in the GRDC metadata lists

as river and gauge names, geographic coordinates and drainage areas often differ somewhat from those in other sources including national inventories.

In 2001, GRDC catalogues have included mean annual discharge for 3,478 of 3,778 gauges in the core catalogue [not including most Arctic Basin sites]. This permits estimating specific runoff for 3,373 sites with drainage areas. Of these 41 have implausible specific runoff >10 m. Errata notwithstanding, these coarse summary statistics can be helpful for evaluating data from the present set and other sources provided that the common sites can be identified.

5.1.2 University of New Hampshire – Global Hydrology Research Group

The UNH Global Hydrology Research Group lead by Charles Vörösmarty has assembled global hydrometric data in various sub-archives including RIVDIS, R-Arcticnet, R-Hydronet, and LBA-Hydronet.

- RIVDIS has been partially incorporated into the UNESCO subset of the present data set which has more recent and revised versions of many of the records in RIVDIS.

- R-Arcticnet has data for about 3,700 gauges in the nominally Arctic drainage basins of Alaska, Canada, Iceland, Norway, Russia, Kazakhstan and Mongolia. Except for Canada, most of these data are available in the present set or in ***ds553.2***. R-Arcticnet has records for about 2,164 gauges in the Canadian Arctic, Hudson and Ungava Bay drainage basins of which 92 records are in the present set. Data are generally identical; however, some US-Canada border gauges in the present set have more recent data derived from US sources.

- R-Hydronet has discharge data for Latin America that comprise records from RIVDIS supplemented with the 300 gauge records from the Argentine INA data set. All essential data from these (subject to revisions or replacements) are included in the present data set. The R-Hydronet version of the INA Argentine data is incorporated into the present set; however, close facsimiles of this collection have surfaced from informal sources, the chief difference being that the R-Hydronet metadata have numerous errata not present in metadata of the other versions. R-Hydronet also has hydroclimatological data (precipitation and temperature) including some that may not be readily available from other sources

- LBA-Hydronet was originally the subset of R-Hydronet covering the Amazon Basin. Sometime since Jan 2001, this set has been updated with 1,636 Brazilian gauge records from ANEEL, 19 gauge records for Bolivia, the INA data set for Argentina and other climatological data. LBA-Hydronet has ca. 250 Brazilian gauge records not in the present set — mostly these represent small catchments < 500 km^2 or short records

- The essential hydrometric data in UNH archives that complement the present data are the Canadian Arctic basin discharge data from R-Arcticnet and the hydroclimatological data from R-Hydronet and LBA-Hydronet.

Part II: Annotations and Comments on National Subsets

6.0 Replicates — excluding Brazil

The following notes concern replicated records that lingered in the data base. Readily resolvable cases were usually eliminated before data entered the data base and were not noted.

- ***replicates and other problems with Brazilian records are summarized separately in Chapter 13***

Norway: Kobbelv @ Kobbvatn / Salangselv @ Vassas

		ID#	River	Gauge	Lat	Lon	km^2
NO	EU	7727	Kobbelv	Kobbvatn	67.60	16.00	390
NO	EU	7728	Salangselv	Vassas	68.88	17.88	580

- these two have the same data for 1970–1971
- both sites have similar discharge magnitudes; hence, it is unclear which is the correct location for 1970–1971 data

Indonesia: Solo @ Jurug

		ID#	River	Gauge	Lat	Lon	km^2
ID	AS	10001	Solo	Jurug	-7.55	110.86	3,220

- Apr-Dec were the same for 1972 and 1973
- rain gauge data suggest that these 9 months likely belong to 1973
- Apr-Dec 1972 were set to missing, but this may be wrong

Korea: Nam @ Jungam

		ID#	River	Gauge	Lat	Lon	km^2
KR	AS	10008	Nam	Jungam	35.31	128.30	2,984

- Apr–Nov are identical for 1960 and 1988
- Feb–Jul are identical for 1972 and 1992
- Jan–Aug are identical for 1974 and 1993

- despite the completion of a dam somewhat upstream of this gauge in 1969, these recurrent sequences seem improbable
- the Nam sub-catchment of the Nakdong River basin is one of the wettest regions of South Korea and known for erratic precipitation and frequent floods and droughts
- removing the recurrent sequences has little effect on summary statistics

- the record has been retained “as is”; but should be used cautiously

China: Suijiang @ Shigou / Beijiang @ Shijiao

		ID#	River	Gauge	Lat	Lon	km^2
CN	AS	31059	Suijiang (Beijiang ?)	Shigou	23.38	112.58	6,362
CN	AS	31060	Beijiang	Shijiao	23.57	112.95	38,363

- these data come from Ap-Friend
- ***Suijiang*** @ ***Shigou*** was mis-labelled as the Beijiang @ ***Shigou***; but, Shigou is on the Suijiang tributary about where the specified coordinates place the gauge

- both records had identical data for 1986; however, the magnitude of the discharges unequivocally indicates that these are for ***Beijiang*** @ ***Shijiao***

Argentina: Las Cañitas @ La Tapa

		ID#	River	Gauge	Lat	Lon	km^2
AR	SA	35055	Las Cañitas	La Tapa	-32.90	-64.71	160

- Apr-Dec are identical for 1947 and 1948
- it is not obvious to which year the data belong
- for the present, data were left unchanged

Tunisia: Tessa @ Sidi Medienne

		ID#	River	Gauge	Lat	Lon	km^2
TN	AF	80277	Tessa	Sidi Medienne	36.29	8.95	—

- these data derive from daily discharges obtainable from MED-HYCOS
- Jan–Aug are identical for 1983 and 1984, except that 1984 is a leap year with a Feb 29 discharge
- it is not obvious to which year the data belong
- data were left unchanged for the present as effects of retaining incorrect data are likely small

Yugoslavia: Moraca @ Podgorica (Titograd), Montenegro

		ID#	River	Gauge	Lat	Lon	km^2
YU	EU	80278	Moraca	Podgorica (Titograd), Montenegro	42.45	19.27	2,628

- these data derive from daily discharges obtainable from MED-HYCOS
- 1973 and 1974 are identical
- data from neighbouring sites in Bosnia, Croatia and Albania suggest that the data belong to 1973; and that 1974 should have discharges 27–110% (mean 50%) higher than 1973; however, the evidence is rather modest

- 1974 was deleted
- some may wish to restore this or pursue other options

7.0 Asia

Afghanistan

- Afghani data all derive from SHI
- these are rather old and of limited duration; however, these are the only data available for Afghanistan, a circumstance that is unlikely to change in the foreseeable future
- dubious location coordinates, and largely unrecognizable river and gauge names given by SHI have been corrected as best as possible

China

- Chinese data derive mainly from ***UNESCO***, ***GHCDN***, ***AP-Friend***, and ***SHI***
- some informal sources give additional years for several gauges in the other sets
- the names of some rivers and gauges were given incorrectly in metadata from AP-Friend, and SHI
- these were corrected as best as possible; a few rivers that could not be identified by name were, at least, identified as tributaries of larger rivers
- sites obtained from GHCDN were identified only by gauge names
- see notes of ds552.0 for important information on several Chinese gauge records

Japan

- Japanese data in the present set derive from ***SHI***, ***AP-Friend***, ***UNESCO***, the Japanese Ministry of Construction [***JP***] and ***Other*** informal sources
- the result is a core of long term records supplemented with scattered records of short duration, either rather old or very recent

- precipitation and specific runoff patterns vary considerably across Japan according to the cumulative influence of several geographic factors including:
  - a north-south division between temperate and monsoonal climates
  - the continent and coastal currents that affect the western and eastern coasts differently
  - the vagaries of mountainous terrain that superimpose another layer of variability on the previous influences

- until better data become available, the short records are retained in order to give a better sense of local spatial variability in runoff patterns

Taiwan

- except for one record from UNESCO files, Taiwan data all come from PACRIM
- PACRIM data are not in m^3/s as indicated in PACRIM metadata, but m^3/s X 100
- comparison of summary data with two other summaries derived for shorter periods of record at the same sites confirms that PACRIM data must be divided by 100 to obtain the appropriate order of magnitude

8.0 Australia

General Remarks

- Australian discharge data are collected by various agencies including individual states and territories, the federal Bureau of Meteorology [BOM], and other agencies
- BOM maintains a national gauge inventory and may have a national discharge data archive
- data are generally freely available, if the points of contact can be determined

- analysis of multiple versions of records available for several gauges indicates that Australian gauge records are often revised over the entire historical periods of operation

Present Collection

- the present compilation is a collation of records from UNESCO, SHI, PACRIM, AP-Friend, WA, VIC, plus a few records from independent sources
- all sources have some records not in the others

- geographically, the collection is biased to Western Australia and Victoria states due to the ubiquitous data available from sources WA and VIC both of which have considerably more data available than given in the present set

- PACRIM data are expressed in units of cumulative runoff depth (mm/month) rather than mean flow rate (m^3/s)
- these were converted back to mean monthly flow rates using the drainage areas specified in PACRIM metadata
- drainage areas in PACRIM metadata that differ from those given in more recent sources have been replaced in present metadata with the more recent estimates

- SHI has rather old data that have been replaced wherever possible; however, SHI has some early records unavailable in other sources
- when multiple versions of records were available for a gauge, the present records were constructed by taking the most recent source as the base record and pre-pending old SHI data

Warning: Australian units

- Victoria state and some other Australian jurisdictions report daily discharge as daily discharge volume in Megalitre/day [ML/d] rather than mean flow rate in m^3/s
- some intermediary sources, e.g., GRDC, have failed to convert some Australian data given in ML/d data to m^3/s

Victoria State

- much current Victoria State data originated via the on-line retrieval system operated by 3rd party contractors (source **VIC**)
- data retrieved in late 2000 proved to be corrupted by
  - spurious entries including 0s and extended runs of identical discharges that should have been presented as missing values

    - multiple entries of alternate discharges for some days and complete years at a few sites

- Victoria state officials indicated that problems were being investigated in late January 2001
- as of mid-June 2001, some lingering problems remain with data available over the internet; however, as per discussion below, there should be negligible risks associated with the monthly data series given in the present data set

- present monthly averages were derived from daily data that were cleaned of egregious spurious entries by tuning a scanning/deletion algorithm until the daily series yielded monthly averages essentially identical to concurrent records in the PACRIM set
- in general, deletion rules were conservative in the sense that spurious entries were removed at the risk of setting some legitimate days to missing values; however, after monthly averaging, the effects would be practically negligible

- previous problems aside, Victoria daily records contain sporadic gaps
- clients are left to estimate missing days according to preferences

- the present monthly average discharges were computed by an algorithm that estimated missing daily data by linear interpolation across gaps and estimated means ***only*** for months with no more than 10 estimated days.

9.0 Pacific Ocean

New Zealand

- New Zealand records derive from UNESCO, SHI and PACRIM
- the PACRIM data are the most recent and authoritative

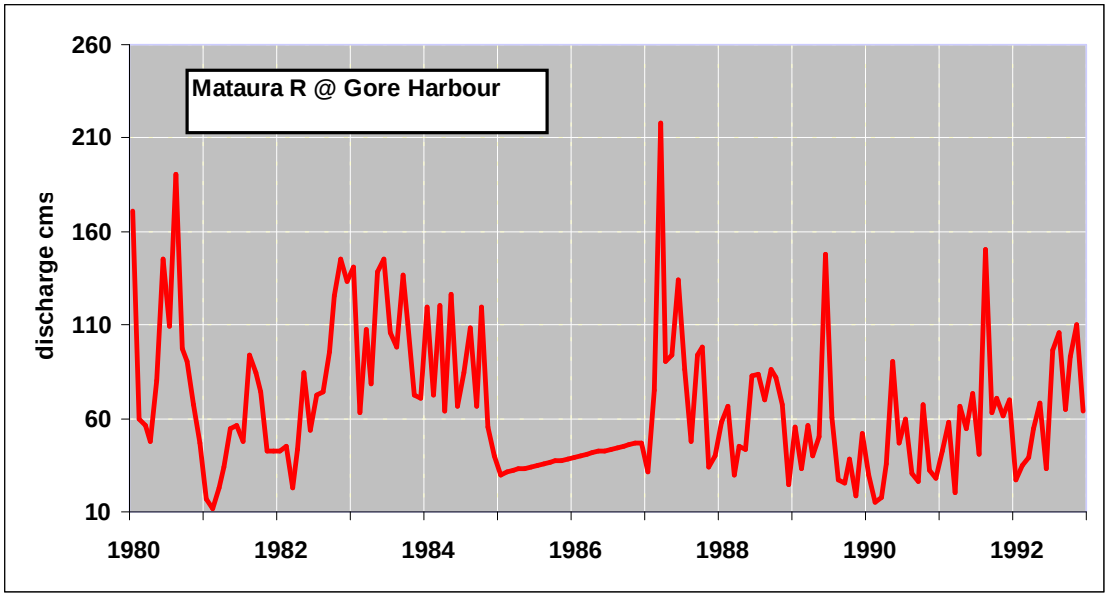
Mataura @ Gore Hbr

ID#	River	Gauge
80090	Mataura	Gore Hbr

- as per the chart and data below, discharges from Feb/Mar 1985 through Nov/Dec 1986 appear to be linearly interpolated
- the 1st differences of the series are a constant 0.7 m^3/s through this period

- at least one of the end months [Feb 1985 or Dec 1986] must be an interpolated value [likely Dec 1986 as forward interpolation is more commonly used; if so, the legitimacy of Feb 1985 would remain unclear]

	J	F	M	A	M	J	J	A	S	O	N	D
1985	29.70	31.26	31.97	32.69	33.42	34.15	34.87	35.61	36.34	37.06	37.79	38.52
1986	39.26	39.96	40.66	41.39	42.12	42.84	43.57	44.31	45.04	45.76	46.49	47.22

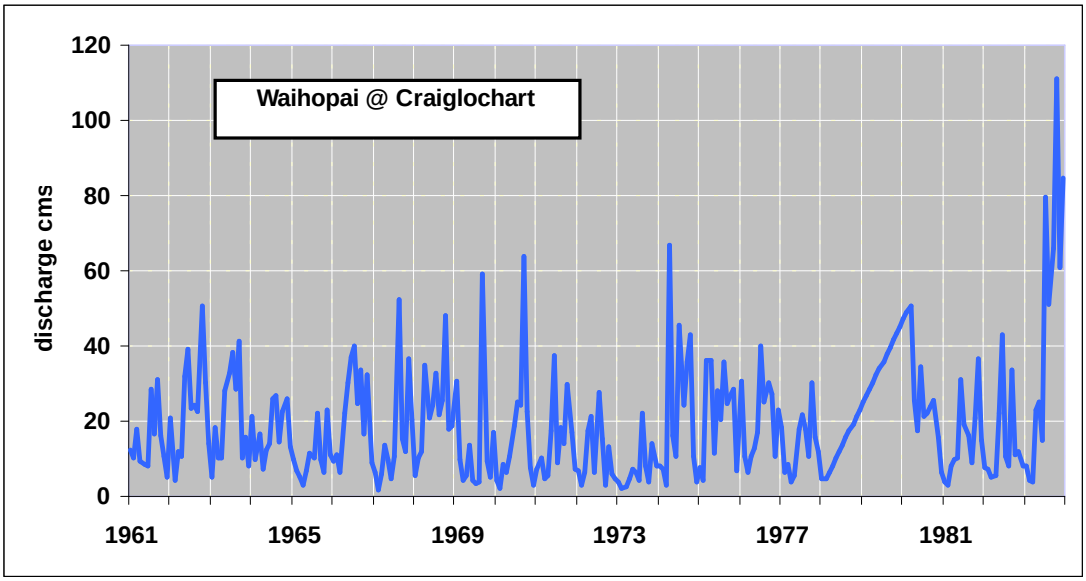


- adapting the most conservative approach, Feb 1985 – Dec 1986 were deleted

Waihopai @ Craiglochart

ID#	River	Gauge
80096	Waihopai	Craiglochart

- from Mar 1978 to Mar 1980 appear to be linearly interpolated
- from Jul – Dec 1983 have the highest 6 month discharges on record by almost 2 fold



- the suspicious data listed below:

	J	F	M	A	M	J	J	A	S	O	N	D
1978	4.51	4.58	6.37	8.22	10.07	11.92	13.77	15.65	17.50	19.35	21.20	23.05
1979	24.93	26.72	28.51	30.36	32.21	34.06	35.91	37.79	39.64	41.49	43.34	45.19
1980	47.07	48.89	50.71	25.40	17.49	34.29	21.41	22.34	23.96	25.37	15.65	6.56
1983	8.27	4.40	3.88	23.00	25.21	15.04	79.41	51.17	66.10	110.95	60.93	84.75

- assuming forward interpolation, from Mar 1978–Mar 1980 are almost surely interpolated values, but it is unclear if Feb 1978 is a legitmate discharge or an estimate

- adapting the most conservative approach, Feb 1978 – Mar 1980 were deleted
- the extreme months of Jul–Dec 1983 were also deleted

Wairau @ Hell's Gate

ID#	River	Gauge	Lat	Lon	km^2
31581	Wairau	Hell's Gate	-41.83	172.99	189

- the name for this gauge may be wrong
- the record correlates most strongly with gauges in the upper Buller/Gowan river systems
- the coordinates are an approximate guess at the gauge location which is somewhere to the east of the divide with the Buller/Gowan watershed

10.0 Europe

Germany — Warning: Dubious Records

ID#	River	Gauge	km^2	mm
33061	Mulde	Bad Dueben	5,995	3,534
33070	Spree	Spremberg	2,092	3,388
33050	Havel	Rathenow (Hauptschleuse)	19,246	1,644
33073	Unstrut	Laucha	6,218	1,740
33051	Iller	Kempten	953	1,582

- the first four records from SHI, particularly the first three, yield implausibly high specific runoff

- GRDC has other gauges on the Spree and Havel rivers that yield specific runoff an order lower than these particular records which are also in GRDC's data base
- as the drainage areas are approximately correct, and the records listed above correlate reasonably well with neighbouring gauges, there may have been some problem with improper unit conversions or mislabelled/mislocated discharge records

- the record for Iller @ Kempten is likely correct; this gauge represents a small catchment in the Bavarian Alps
- nearby gauges in Switzerland have specific runoff >2 m

- other than small headwater catchments in alpine areas, German rivers generally have low specific runoff

Europe: UK

Recent UK data now available on-line

- click on "River Flow Data" at **www.nwl.ac.uk/ih/nrfa/index.htm** for recent [1996-1999 in early 2001] daily discharge data for ca. 210 UK gauges

- click on "UK Gauging Station Network" at **www.nwl.ac.uk/ih/nrfa/index.htm** for gauge listings and metadata for the entire UK

- numerous regional and river basin agencies ["*Measuring Authorities*"] monitor stream discharges in the UK
- the National River Flow Archive [NRFA] may not have all the stream discharge records that are available

- in 1999-2000, monthly data for 30 gauges in England and Wales were available at **www.environment-agency.gov.uk/gui/dataset4/4nation.htm**

- in 2001, data have been withdrawn, or the URL has moved
- the UK Environment Agency www site has become so cluttered it is difficult to find anything

Warning: Gauged versus Naturalized Discharge Data

- for most gauges, UK agencies give both “gauged” and “naturalized” discharges
- “gauged” discharges are those measured at the gauges
- “naturalized” discharges are pseudo discharges created from gauged discharges adjusted for net upstream regulation, abstractions, return flows, etc.

- “gauged” records are generally denoted by the 5-digit UK gauge code with “g” appended, e.g., ***Thames (gauged) @ Kingston*** has code **39001g**
- “naturalized” records are generally denoted by the 5-digit UK gauge code with “n” appended, e.g., ***Thames (naturalized) @ Kingston*** has code **39001n**

- these alternate records would present no problem if correctly labelled; however, in most available non-UK sources the record identified ***Thames @ Kingston*** presents “naturalized” discharges if they were gauged discharges

- data obtained from the National River Flow Archive [www.nwl.ac.uk/ih/nrfa/index.htm] will likely be identified correctly
- NRFA appears to follow a policy of explicitly identifying “naturalized” discharges when these are given, and records with no explicit indications [most records] are generally “gauged” discharges
- ***data obtained from other agencies may not be correctly identified***

Naturalized Discharges in the Present Data Set

ID#	River	Gauge
9806	Thames (naturalized)	Kingston
10126	Thames (gauged)	Kingston
80317	Lee (naturalized)	Feildes weir
80336	Lee (gauged)	Feildes weir

- two records in the present set were not correctly identified in the source files as being “naturalized” pseudo discharges
- these have been correctly identified and 1996-1999 gauged data have been added under separate ID codes in order to permit comparisons

- the Lee is a tributary of the Thames that enters the Thames estuary below the tidal limit, i.e., below Kingston

- discharge from both catchments are affected by significant abstractions for water supplies in the London area

Thames @ Kingston [gauged versus naturalized]

- ***Thames River records found in all available sources have been "naturalized" pseudo data***

- the table below shows reported differences between "naturalized" and "gauged" discharges given in m^3/s for 1996-1999, and long term means which are also given on NRFA annual data summary sheets

- in terms of annual volumes, the recent difference amounts to 0.75 km^3/a, versus the long term difference of 0.4 km^3/a
- much of the difference is likely due to withdrawals for domestic and industrial water supplies in the London area; some of this may return as effluent discharges below the Kingston gauge

	J	F	M	A	M	J	J	A	S	O	N	D	annual
1996-1999													
gauged	**115**	**68**	**58**	**60**	**29**	**23**	**11**	**14**	**16**	**26**	**50**	**76**	**45**
naturalized	**144**	**96**	**84**	**84**	**54**	**46**	**31**	**31**	**32**	**46**	**80**	**102**	**69**
difference	**29**	**28**	**26**	**24**	**24**	**23**	**20**	**17**	**17**	**20**	**30**	**26**	**24**
1883-1998													
gauged	**126**	**122**	**102**	**74**	**52**	**36**	**23**	**21**	**23**	**38**	**71**	**100**	**66**
naturalized	**138**	**134**	**114**	**87**	**65**	**48**	**35**	**32**	**34**	**50**	**83**	**112**	**78**
difference	**12**	**12**	**12**	**13**	**13**	**13**	**13**	**11**	**12**	**12**	**12**	**12**	**12**

Lee @ Feildes Weir [gauged versus naturalized]

- contrast of the available monthly records for 1996-1999 and the long term summary data show that the recent abstraction rate is essentially identical to the long term abstraction rate
- data below are in m^3/s

	J	F	M	A	M	J	J	A	S	O	N	D	annual
1996-1999													

gauged	**5.49**	**3.53**	**3.17**	**4.16**	**2.20**	**2.22**	**1.63**	**1.53**	**1.33**	**1.60**	**2.85**	**3.99**	**2.81**
naturalized	**6.65**	**4.70**	**4.33**	**5.02**	**2.99**	**3.10**	**2.45**	**2.37**	**2.25**	**2.59**	**3.88**	**5.04**	**3.78**
difference	**1.16**	**1.17**	**1.16**	**0.86**	**0.79**	**0.88**	**0.82**	**0.84**	**0.92**	**0.99**	**1.04**	**1.05**	**0.97**
1883-1998													
gauged	**7.43**	**7.57**	**6.40**	**4.96**	**3.82**	**2.80**	**2.15**	**1.94**	**1.84**	**2.99**	**4.48**	**6.10**	**4.37**
naturalized	**8.39**	**8.29**	**7.39**	**5.99**	**4.87**	**3.76**	**3.10**	**2.88**	**2.87**	**3.87**	**5.37**	**6.93**	**5.31**
difference	**0.95**	**0.73**	**0.99**	**1.02**	**1.05**	**0.96**	**0.95**	**0.95**	**1.03**	**0.88**	**0.89**	**0.83**	**0.94**

11.0 North America

Canada

- Canadian data in the present set are limited to
  - data submissions to UNESCO for about 80 gauges
  - 53 records for miscellaneous sites including:
    - gauges on the Canada-US border available from US sources
    - gauges in the Canadian Arctic available from Arctic studies of the early 1990s
    - scattered miscellaneous gauges

- gauge records in the Arctic, Hudson and Ungava Bay drainage basins were updated from R-Hydronet to the end of 1993

Data Availability

- in the early 1990s, Environment Canada adopted a hydrologic data policy that is roughly equivalent to licensing agreements issued for computer software
- the policy imposes severe restrictions on data use and reproduction
- previously, data had been published openly in paper year books
- the hard copy reports are still readily available in many libraries, and subsets of Canadian gauge data up to 1993 or so may still be found

- recently, historical monthly discharges to the end of 1993 for 2,000+ gauges in the Canadian Arctic drainage area were made available on R-Arcticnet (**www.R-arcticnet.sr.unh.edu/**)

- GRDC has data for almost 400 Canadian gauges that are updated sporadically, and another 450 records for gauges in Arctic drainage basins derived from R-Arcticnet with data extending to 1993

- because GRDC charges for data retrieval and imposes restrictions similar to those imposed by Environment Canada, obtaining the entire Canadian hydrologic data set on CD-ROM is likely more cost effective than obtaining data from GRDC

Grand R @ Dunnville — pseudo record

- record 10082 Grand R @ Dunnville is a pseudo record constructed by prorata extrapolation from upstream gauges in order to estimate discharges to Lake Erie
- the potential error in monthly mean discharges is <5%

USA

- the present set of US records has 110 records including:
  - 93 records in ds552.0
  - 16 records from Alaska
  - one border gauge re-assigned from Canada because US sources are updated regularly

- records in the present set have been updated to 1999 to the extent possible
- the present set includes some records not available in the two supplementary sources cited below

- Alaskan gauges were assigned a country code of “AK” to make them readily distinguishable from the main block of US gauges

- the notes that accompany ***ds552.0*** have a US section that discusses discharge routing in the lower Mississippi, certain border gauges, and some quirks of the US national archive

- a table in the companion spreadsheet lists the US gauge codes

Supplementary Sources of US data

- a large set of 1,700+ US records can be readily compiled from the following sources:

1. 1995 Russia-America exchange data set monthly discharges for about 455 US gauges to 1994/95 [available via NCAR **www.scd.ucar.edu/dss/datasets/ds550.1.html**]
2. the USGS HCDN [Hydro-Climatic Data Network] CD-ROM with data for about 1,659 US gauges to 1988 [**wwwrvares.er.usgs.gov/hcdn_cdrom/1st_page.html**]

Sources of current US data include:

a) for most sites, the USGS NWIS-W archive [**waterdata.usgs.gov/nwis-w/US/**]

b) the US–Mexico International Boundary Water Commission [IBWC] for selected sites in the Rio Grande and Colorado River basins [**www.ibwc.state.gov/**]

c) for two lower Mississippi sites, the US Army Corps of Engineers [**www.mvn.usace.army.mil/eng/edhd/Wcontrol/discharge.htm**]

12.0 South America — General

12.1 Naming Conventions

- river and gauge names in the present catalogue are an inconsistent mix of anglo, Hispanic and Portuguese names and spellings that reflects the inconsistencies in available catalogues and inventories

- it was practically impossible to follow consistent naming conventions
- beyond attempting to assure that the same river is named consistently, e.g., changing Parana to Paraná as necessary) all names are generally as found in the catalogues used for constructing the national gauge list in the present set

Multiple Names

- many streams have multiple names and multiple local reach names

- alternate names are given in round brackets
- sometimes a forward slash "***/***" is used to distinguish alternate names

- for most rivers, the name used in the downstream reach was given precedence, e.g., for the ***Uruguay (Uruguai, Pelotas)***, ***Uruguay*** is the name used in Uruguay, ***Uruguai*** is used in Brazil for the lower reach, and ***Pelotas*** is the name in Brazil for the upper reach

Article Conventions

Indefinite Articles

- Portuguese indefinites are "de", "do", "da", "dos", "das"

- Spanish indefinites are “de”, “del”, “de la”, “de los”, “de las”

- for river names with indefinite articles, the names were given with the indefinite articles in following parentheses, e.g.,
- “***Sangue [do]***” means ***Rio do Sangue*** [literally River of Blood, but most likely Blood River in English translation],

Definite Articles

- Hispanic river names with definite articles were generally left as is

- more often than not, a river name given with the definite article, e.g., ***Río El Durazno***, was different from ***Río Durazno*** located elsewhere in the same country

- in some cases, definite articles clipped in available catalogues were added back to river names to conform with what seemed to be the most common national usage

Stream Terminology Conventions

- Spanish and Portuguese have a host of words for surface water courses

- in the available gauge lists, stream terms were already mostly deleted or indicated in parentheses following the stream name; hence, the remaining instances were deleted for the sake of having rivers sort by proper name in the master catalogue stored in spreadsheet format

- if the watercourse name is followed by the indefinite article in square brackets or nothing at all, the watercourse is assumed by default to be a ***Río***, e.g., ***Salí Dulce*** means ***Río Salí Dulce***, and ***Vueltas [de las]*** means ***Río de las Vueltas***

Hispanic Stream Terms

- the most common Hispanic terms are: Río, Cañada, Caño, Quebrada, Arroyo; and for estuaries or river mouths: Estero
- Hispanic countries have numerous local terms including: Arroyito, Bocana, Cajon, Cañadon, Cañadote, Cañaote, Chorrillo, Crique, Riachuelo, Riachuello

Brazilian Portuguese Stream Terms

- the main Brazilian terms are: Rio, Ribeirão, Riacho, Córrego, Arroio, and Igarapé

- to keep catalogue entries manageable, the following abbreviations were used:
  - Rib Ribeirão
  - Cór Córrego
  - Arr Arroio
  - R Rio

- for streams called something other than Rio, the word for watercourse follows the watercourse name in square brackets including indefinite articles if present, e.g.,
- ***Areado [Rib]*** implies ***Ribeirão Areado***
- ***Cachoeira [Rib da]*** implies ***Ribeirão da Cachoeira***

- abbreviation ***R*** for ***Rio*** is only used when the watercourse is variably given as Rio and some other type, e.g.,
- ***Agudo [R/Rib do]*** means the stream is alternately known as ***Rio do Agudo*** or ***Ribeirão do Agudo***

13.0 South America — excluding Brazil

13.1 Argentina

- see ***Section 15.6*** for remarks on additional records obtained from the GHCDN compilation

- Argentina has much arid to semi-arid terrain; hence, numerous endorheic drainage systems

- metadata for this set have many questionable drainage areas

- many of the available gauges are clustered on headwater streams rising on the eastern slopes of the Andes
- amongst these sites there are several that yield anomalously high specific runoff relative to neighbouring gauges
- for the northern provinces of Salta and Jujuy, available information does indicate that localized zones of exceptionally high rainfall do occur; hence, occurrences of abnormally high specific runoff cannot automatically be attributed to under reported drainage areas

- the ***Lower Paraná*** reach below the confluence with Río Paraguay is a complex system with numerous gauge records that are generally not useful to anyone not armed with detailed knowledge of the local situation

- the two most crucial records are identified and the circumstances of the others are clarified somewhat in the section on the Lower Paraná

Warning: Confusing River Names

- in Argentina, there are numerous cases where two or more rivers have the same name, e.g., there are several rivers called ***Salado***

- there are numerous systems where different reaches have different names that are often not used consistently, and cases where the same reach has multiple names

- Río ***Pasaje*** and Río ***Juramento*** are generally the same river by different names
- further downstream, these become Río ***Salado*** (one of several in Argentina)
- some Argentine literature refers to the system as the "***Río Pasaje-Juramento-Salado***"

- the river identified as "***Dulce***" in UNESCO sources is known as Río ***Salí Dulce*** in some Argentinean sources; the upper reach may be known locally as the ***Salí*** and the lower reach known locally as the ***Dulce***

- Río ***Tercero*** becomes the Río ***Carcaraña*** in the lower reaches

General Remarks: R-Hydronet / INA data set

- a set of ca. 304 gauge records for Argentina was made available at R-Hydronet [**www.R-hydronet.sr.unh.edu/**] in early 2000

- **N.B.** to obtain the discharge data, the entire Argentine data collection including temperature, rainfall and discharge must be downloaded from R-Hydronet

- this compilation attributed to "***INA***" [*Instituto Nacional del Agua y del Ambiente* of the Environment Ministry]

- these data appear to be mostly derived from 1994 edition of the national compendium of hydrological data [*Estadística Hidrológica*] produced periodically by ***Subsecretaría de Recursos Hídricos*** [currently under the Ministry of Environment, formerly under other Ministries] — see **www.medioambiente.gov.ar/sian/subrechid/tapa1.htm** for the cover page of the 1997 edition

- GHCDN provided better versions of a few ***INA*** records and two records on Rio Uruguay not available in ***INA*** [see section **15.5 Argentina**]

- the gauges themselves seem to be operated by various national and provincial agencies

- at least 20 records are for outflows from reservoirs (reservoir = **embalse**)

- the ***Catálogo de Lagos y Embalses de la Argentina*** (Data Book of Lakes and Reservoirs in Argentina) [**www.mecon.gov.ar/lagos/ind.htm**] is a helpful source of additional information

- ***"(embalse ?)"*** was appended to the names of several gauges where it is known that a dam currently exists, but it is not clear when the dam was constructed or to what extent that the discharge record is affected by regulation

- at two sites, alternate versions of the respective discharge records exist containing record fragments that give either ***regulated*** or ***unregulated*** discharges

- the ***unregulated*** discharges may have been derived as ***regulated*** outflow adjusted by changes in reservoir storage; such records would approximate the net unregulated inflows to the reservoir

- Argentina seems to prefer "***dique***" for dam rather than usual spanish words represa or presa

- about 1/2 the records in the set extend to 1994
- about 1/3 end in 1979 or earlier

- the data set is skewed to small headwater drainage basins
- about 41% of sites have drainage areas < 1,000 km^2
- about 72% of sites have drainage areas <10,000 km^2

- scattered errata are present in the metadata and discharges

- metadata contained numerous questionable drainage areas
- the most flagrant cases are discussed below, but other discrepancies may remain as most gauge locations are too obscure to verify without high resolution maps

- cursory scans detected problems with discharge records at few sites

- for 15 of 18 gauges in UNESCO files, records were replaced with R-Hydronet data that generally are both more recent and historically longer
- some R-Hydronet data are suspect, e.g., the latter part of the ***Salí Dulce*** record (see below)

Composites

- there is at least one composite and likely several others in the data set

ID#	[a] RH#	River	Gauge
9451	5199	Salí Dulce	El Sauce (1967: Embalse Río Hondo)
35081	5053	Grande de Tarija	Algarrobito (1971: San Telmo)
35105	5077	Dorado	San Felipe/El Sombrero (1981: Barrealito)
35117	5089	Pasaje (Juramento)	Cabra Corral (1967: La Puerta)

[a] **RH#** = R-Hydronet ID code number.

- the 1st gauge in the list above is definitely a ***"dirty" composite*** that is discussed in a separate section below
- the other gauges in the list may also be composites where the original gauge was moved at the date indicated
- there may be other composite records in the set, e.g., gauges with hyphenated gauge names are suspect

Lower Río Paraná

- below the confluence with Río Paraguay, the Paraná appears to lose discharge in the lower reaches; however two confounding factors are at play:

  A) an order of magnitude increase in residence times leads to increased evapotranspiration losses
  B) the absence of well-defined control sections generally prevents gauging the entire discharge passing down the river

- the river meanders in braided channels through swampy alluvial valley bottom terrain
- in successive reaches, the greater channels are flanked usually on one side or the other by swampy terrain with a maze of minor channels that also receive inputs from local tributaries

- navigation and hydroelectric barrages increase water residence time
- a Río Paraná navigation study suggests that below the confluence of Río Paraguay and Río Paraná, average water velocities in the main channels decrease 10+ fold which increases water residence time 5–10+ fold by rough estimate; and thus, increases evaporation losses in the lower reach

- at the Corrientes–Barrenqueras transect about 30 km below the confluence of Río Paraguay and the Paraná, the total Paraná discharge could be monitored by gauges

on two channels; however, below this cross-section, there appear to be no locations where gauged channels capture all discharge passing down the Paraná

Available Discharge Records

- between R-Hydronet and UNESCO files, there are records for 15-16 distinct channels plus 1 cumulative sum of 3 records as listed below
- these are the gauged channels in the alluvial valley bottom that create most confusion
- except for Corrientes, the drainage areas are questionable
- the reported gauge elevations are in approximately correct topological order

ID#	RH#	Branch	Gauge	Lat	Lon	m	km^2
10113	2	Paraná	Corrientes	-27.46	-58.85	42	2,100,000
9368	4995	Paraná	Corrientes (MOSP)	-27.96	-58.85	42	2,119,505
35024	4996	Paraná - brazo principal	Isla Patí	-29.48	-59.58	31	-
35025	4997	Paraná - brazo secundario	Isla Patí	-29.48	-59.55	31	-
35040	5012	Paraná - San Javier	Helvecia	-31.10	-60.06	13	-
35028	5000	Paraná - Zapata	Chapetón	-31.55	-60.32	15	-
35029	5001	Paraná - Colorado	Chapetón	-31.55	-60.33	15	-
35026	4998	Paraná - brazo principal	Chapetón	-31.56	-60.31	12	-
35027	4999	Paraná - partial total	Chapetón	-31.55	-60.30	12	2,300,000
35020	4992	Paraná - Colastiné	Ruta Nac. 168	-31.65	-60.60	9	-
35030	5002	Paraná - Tunel (brazo principal)	Paraná city	-31.70	-60.50	9	2,302,000
35046	5018	Paraná - Santa Rita	Ruta Provincial 1	-31.48	-60.43	8	-
35066	5038	Paraná - Potrero	Ruta Provincial 1	-31.50	-60.45	8	-
35044	5016	Paraná - Leyes	Ruta Provincial 1	-31.50	-60.45	8	-
35042	5014	Paraná - Cierre Leyes	Ruta Provincial 1	-31.50	-60.45	8	-
35047	5019	Paraná - Sistema Setúbal	Santa Fe-La Guardia	-31.63	-60.66	8	-
35021	4993	Paraná - brazo principal	Timbues	-32.67	-60.71	4	2,346,000

- the main reaches are:
  - Corrientes — Isla Patí
  - Isla Patí — Chapetón
  - Chapetón — Paraná city
  - Paraná city — Timbues

- ***Chapetón*** is not far above ***Paraná city***
- there are navigation or hydroelectric barrages on the main channels at ***Chapetón***

- superficially, ***Río San Javier*** appears to be a independent tributary originating in the alluvial valley, but the discharge is so high that this likely receives water from the main channels
- ***Río San Javier*** discharges through some channels near or above ***Chapetón***, but is linked to side channels that continue down the west side of the valley that may contribute to the ***Laguna Setúbal*** system

- superficially, the ***Laguna Setúbal*** system appears to be a separate tributary system
- ***Ruta Provincial 1*** is a highway on a narrow strip of high ground that separates the ***Laguna Setúbal*** system from the main river; however, it is cross-cut by channels that link directly or indirectly to the main river channels
- hence, at least some tributary gauges along ***Ruta Provincial 1*** are likely cross-linked directly or indirectly to the main river channels

- discharge of the ***Setúbal*** should likely be added to ***Tunel*** and ***Colastiné*** discharges to approximate discharge at the ***Paraná city*** transect, and this may still not completely capture all discharge

Lower Paraná — Corrientes

		ID#	RH#	River	Gauge	Lat	Lon	El m	Area km^2	Discharge km^3
AR	SA	10113	2	Paraná	Corrientes	-27.46	-58.85	[a] 42	2,300,000	534
									[b] 2,096,907	
AR	SA	9368	4995	Paraná	Corrientes (MOSP)	-27.96	-58.85	[c] 42	1,950,000	498
									[d] 2,102,402	

[a] RH incorrectly gave this as 420 m; if the elevation for ***Corrientes*** is truely 42 m and ***Corrientes (MOSP)*** is in fact located downstream, the datum for ***Corrientes (MOSP)*** must be < 42 m.
[b] average of estimates due to GHCDN, OAS and Fekete et al. (1999)
[c] Some sources (e.g., WMO) incorrectly give this as 60 m; however, gage elevations upstream of Corrientes above the confluence with Río Paraguay are 46 m and higher, i.e., the elevation at Corrientes must be < 46 m. Other metadata inventories give elevations for both ***Corrientes*** and ***Corrientes (MOSP)*** as 42 m.
[d] Taken as the working estimate for ***Corrientes (MOSP)***. By rough estimate, the increase over ***Corrientes*** would likely be ca. 5,000–10,000 km^2, if ***Corrientes (MOSP)*** is actually located where the coordinates indicate, i.e., Empedrado.

- the most important records are these two, nominally labelled ***Corrientes***, that give estimates of water entering the lower reach
  A. ***Corrientes*** found in UNESCO sources has 1968–1979
  B. ***Corrientes (MOSP)*** found in R-Hydronet, GHCDN and other sources has 1904–1991

- the given coordinates locate ***Corrientes*** at ***Corrientes*** town on the east bank opposite ***Barrenqueras*** town which is the river port for the city of ***Resistencia***

- at the ***Corrientes–Barrenqueras*** transect, the total Paraná discharge could be monitored by gauges on two channels
  - the main channel
  - the secondary channel between Barrenqueras and the island that separates Barrenqueras from the main channel
  - in addition to water from the main channel, this secondary channel appears to capture input from a distributary channel that leads off Río Paraguay before it joins the Paraná

- all sources consistently place the record labelled ***Corrientes (MOSP)*** 56 km (straight line distance) downstream from Corrientes at the town of ***Empedrado***
- this record is mostly labelled ***Corrientes***; however, a Paraná basin wide gauge inventory identified this as ***Corrientes (MOSP)*** which is retained herein to facilitate distinction with the ***Corrientes*** record
- ***there appears to be no other instance in the INA set where a gauge is named for a town 50-60 km upstream; hence, there is good reason to believe that the geographic coordinates are incorrect***

- the Paraná basin gauge inventory, in addition to ***Corrientes (MOSP)***, lists a gauge called ***Barrenqueras*** that might be the same entity as ***Corrientes***

Dubious Drainage Areas

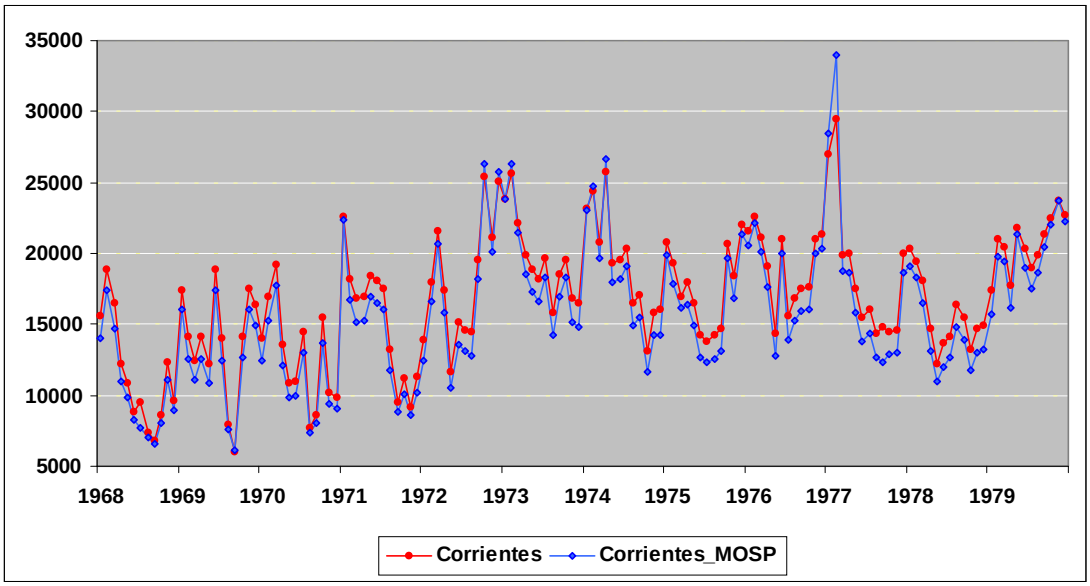
- **the drainage areas assigned to both gauges are wrong !!**

- ***Corrientes*** is ca. 30 km below the confluence of Río Paraguay with Río Paraná
- at the confluence, the combined drainage area is consistently estimated at 2.0–2.1 million km^2
- hence, the drainage area at ***Corrientes*** is at least 2 million km^2, and likely greater
- other drainage area estimates for ***Corrientes*** are 2,051,720 [Dettinger & Diaz GHCDN metadata]; 2,067,000 km^2 [OAS]; and 2,172,000 km^2 (Fekete et al., 1999)
- the average of these, 2,096,907 km^2 is accepted herein

- if the specified location coordinates are correct, ***Corrientes (MOSP)*** has a somewhat larger drainage area than ***Corrientes***, but the difference cannot be determined reliably without delineating the basin via high resolution maps or DEMs
- a rough working estimate of ***Corrientes (MOSP)*** drainage area is taken as 2,102,402 km^2

Discharge Discrepancy

- on the concurrent 12 yrs data, mean annual discharge of ***Corrientes*** is 7% higher than ***Corrientes (MOSP)*** — see figure below



- if ***Corrientes (MOSP)*** has been mislocated, the ***Corrientes*** record may be an early version of the ***Corrientes (MOSP)*** record

- without direct recourse to the source agency, the validity of the ***Corrientes*** record and the correct location of ***Corrientes (MOSP)*** cannot be verified

Warning: R-Hydronet Drainage Areas 1000-fold Too Low

- ***R-Hydronet metadata give drainage areas are too low by 1000-fold for ca. 155 of 300+ sites***
- these are likely due to processing problems by R-Hydronet
- multiplying the given areas by 1,000 gives drainage areas on the correct order of magnitude within ±500 km^2 of the "true" value

- all but one of these cases were "corrected" to nominal "true" drainage areas by cross-referencing against other Argentine gauge inventories or data summaries
- however, some "corrected" drainage areas are almost surely wrong, i.e., there are probable errata in R-Hydronet and other inventories that likely descend from errata in the original source of the metadata

- scattered errata are also present in drainage areas of sites not affected by the R-Hydronet processing problems

Other Drainage Areas & Metadata Discrepancies

- after the previous corrections to drainage areas, and excluding gauges of the Lower Paraná basin that are discussed separately below, scattered cases of questionable drainage areas remain in the metadata
- most of these latter errata also appear in other Argentine inventories; hence, these errata mostly originated in INA metadata

- for sensitive work, the gauge names, locations and drainage areas should be confirmed independently as best as possible

- some obvious cases are listed below:

Atuel @ Loma Negra and Atuel @ La Angostura

ID#	RH#	River	Gauge	m	km^2	km^2
35155	5127	Atuel	Pte Sosneado	1,580	2,380	
35156	5128	Atuel	Loma Negra	1,340	3,860	3,700
35153	5125	Atuel	La Angostura	1,200	3,800	

- Río Atuel rises in the Andes at ca. 3,500 m altitude or higher
- between **Sosneado** and **Loma Negra**, Río Atuel and the Río Salado tributary discharge onto an arid plain forming an inner delta known as "**Las Juntas**"
- **Loma Negra** is located not far downstream of the point where the inner delta distributaries reunite into a single channel

- ***Atuel @ La Angostura*** is located just upstream of ***Embalse El Nihuil***, the reservoir behind the ***El Nihuil 1*** dam

- the elevation of La Angostura cannot be confirmed; the mean level of the reservoir pool has been alternately cited as 1,025 m and 1,325 m in different sources

- ***Atuel @ Loma Negra*** must have smaller drainage area than ***Atuel @ La Angostura***
- for the present, the drainage area for Loma Negra has been reduced to a working estimate of 3,700 km^2

- the drainage areas should be recalculated
- fact sheets give the drainage area of the **dam** as 3,800 km^2 and the maximum surface area of the reservoir as 96 km^2

- the reservoir receives direct input from sizable areas of ephemeral drainage that would not be included in the La Angostura drainage area; however, much of the time, the areas of ephemeral drainage to the north of Río Atuel proper may function as an independent endorheic system
- because of the arid terrain, these drainage area discrepancies should not induce appreciable difference between discharges observed at La Angostura and the outflow of the reservoir beyond evaporation losses from the reservoir surface

Barrancas @ Alpa Corral

ID#	RH#	River	Gauge	km^2	mm
35050	5022	Barrancas	Alpa Corral	215	602
				160	810

- two drainage areas have been reported
- the larger area yields specific runoff more consistent with a nearest neighbour
- take your pick

Carapari @ Pte Carretera

ID#	RH-ID#	River	Gauge	km^2	km^2
35069	5041	Carapari	Pte Carretera	850	125

- inventories give two drainage areas for this gauge: 850 km^2 (R-Hydronet), and 125 km^2 (another Argentine gauge summary)
- respectively, these areas give specific runoff that is 2-3 fold lower and 2+ fold higher than nearest neighbours
- for the present, the area of 850 km^2 is retained

Río Carrenleufú (Corcovado) gauges

ID#	RH#	River	Gauge	m	km^2	km^2
35265	5237	Carrenleufú (Corcovado)	Lago Vintter (Palena) outflow	850	790	
35264	5236	Carrenleufú (Corcovado)	Elena	802	1,500	
35270	5242	Carrenleufú (Corcovado)	Poncho Moro	463	2,290	1,680
35269	5241	Carrenleufú (Corcovado)	Pte de Hierro	439	2,160	2,160
35263	5235	Carrenleufú (Corcovado)	Carrenleufú (Corcovado)	435	1,680	2,290

- Río Carrenleufú, also known as Río Corcovado, begins as the outflow of bi-national Lago Vintter (Lago Palena in Chile); circles to the north and enters Chile near Carrenleufú town, Argentina
- in Chile, it becomes Río Palena

- the drainage areas are clearly wrong for the three lower gauges and possibly the other two; however, the location coordinates, gauge names (except Puente de Hierro which is too obscure to appear on maps) and elevations are consistent
- as a provisional solution, the drainage areas of the lower three gauges were sorted into ascending order and substituted for the given drainage areas
- these may be wrong, but the errors should be relatively small

Chuscha @ Cafayate

ID#	RH#	River	Gauge	km^2	mm
35116	5088	Chuscha	Cafayate	49	320
				488	32

- the drainage area given for this gauge yields specific runoff that exceeds reported rainfall for the area (ca. 145 mm/a for Cafayate town) and is perceptibly higher than specific runoff for other gauges in the area (ca. 20 mm/a)
- as a working estimate, the drainage area was increased by 10-fold which gives specific runoff of about the correct order

Ñorquinco @ Ñorquinco

ID#	RH-ID#	River	Gauge	km^2	km^3	mm
35186	5158	Ñorquinco	Fita Timen	117	0.059	507
35193	5165	Ñorquinco	Ñorquinco	2,590	0.057	22

- the drainage area of the downstream site is likely wrong
- an available, somewhat crude scale map suggests that the drainage area of the downstream gauge cannot be much more than 2-fold larger than the upstream gauge [assuming that the specified coordinates are correct]
- an area of 259 km^2 is accepted for the present

Salí Dulce @ El Sauce (1967: Embalse Río Hondo) — Warning: probable composite

ID#	RH-ID#	River	Gauge	km^2	km^2

9451	**5199**	**Salí Dulce**	**El Sauce (1967: Embalse Río Hondo)**	**20,200**	**18,250**
35228	**5200**	**Salí Dulce**	**La Escuela**	**19,680**	**19,680**

- ***this record is almost surely a dirty composite of records from pre- and post-reservoir construction that should be used with the utmost caution***

- pre-construction records may have come from a gauge on the Salí Dulce located upstream of tributaries that drain directly to the reservoir; and thus, have perceptibly lower discharge than would have been observed by a gauge at the current reservoir outlet

- there are two versions of post-construction data that differ primarily on the final record fragment from late 1972–1980
- INA appears to give ***regulated*** discharges for 1972–1980
- UNESCO records appear to give ***unregulated*** discharges for 1972–1980
- the two versions balance within 3%
- the ***unregulated*** discharges may have been calculated from reservoir outflows and changes in storage, or by the sum of discharges gauges above the reservoir on the Salí Dulce and several tributaries that currently drain directly to the reservoir

- Embalse Río Hondo (Río Hondo reservoir) is located just upstream of the town ***Termas de Río Hondo*** at the base of the Andes
- the reservoir receives discharges of the Salí Dulce and 3 sizable tributaries from the southwest that would have previously joined the Salí Dulce somewhere within the current lake formed by the reservoir
- the completion date is unavailable, but 1967 is suggested by the gauge name "***El Sauce (1967: Embalse Río Hondo)***" and discharges appear to be regulated from about that time

- metadata in alternate sources are somewhat contradictory

- metadata for gauge "***El Sauce (1967: Embalse Río Hondo)***" from alternate sources place this gauge both upstream and downstream of the old "***La Escuela***" gauge [see below] with greater or lesser drainage areas and gauge elevations

- drainage areas specified for "***El Sauce (1967: Embalse Río Hondo)***" range up to 22,070 km^2
- the selected value of 18,250 km^2, given by the reservoir fact sheet, is consistent with the drainage area reported for "***La Escuela***"

- there is reason to believe that record "***El Sauce (1967: Embalse Río Hondo)***" is a composite record of:

  A) a gauge that existed before construction of the Río Hondo reservoir (embalse) likely at a place called "***El Sauce***", and

B) reservoir discharges since then

- "***La Escuela***" gauge records span 1926–1959
- coordinates consistently place this not far downstream of ***Termas de Río Honda***; specifically, about 10 km downstream of the ***Embalse Río Hondo*** outlet

- if location coordinates for "***La Escuela***" are correct, the difference in discharge between "***La Escuela***" and a gauge located at the point of the reservoir outflow should be negligible

- concurrent 1926–1959 records with "***El Sauce (1967: Embalse Río Hondo)***" have consistently higher discharges that could only come from the tributary streams now captured by ***Embalse Río Hondo***, and perhaps further upstream of the reservoir

- for 32 years of concurrent data, "***La Escuela***" averages discharge of 19 m^3/s or 0.6 km^3/a (24%) greater than "***El Sauce (1967: Embalse Río Hondo)***"
- if "***La Escuela***" discharges and metadata are correct, drainage area of "***El Sauce***" would have to have been about 15,900 km^2 to account for the difference in discharges between the two gauges

- hence, it seems likely that from 1926–1959 the "***El Sauce (1967: Embalse Río Hondo)***" record does not include tributary discharges that are included from 1967 onward
- this in turn implies that the composite record "***El Sauce (1967: Embalse Río Hondo)***" should have a perceptible jump in mean level ca. 1967
- however, further analysis is confounded by climatological trends as post-1967 mean discharges are perceptibly higher than 1926–1959 means for both "***El Sauce***" and "***La Escuela***" because 1973–1980 were abnormally wet years with mean discharge almost 60% greater than the 1926–1959 mean for "***La Escuela***"

Data Retained

- presently, the UNESCO versions of "***El Sauce (1967: Embalse Río Hondo)***" which is missing fewer months and has ***unregulated*** discharges from Sep 1972 is retained

- ***the entire record should be viewed as poor quality data that should be replaced with data and metadata directly from the source agency if the opportunity arises***

- R-Hydronet ***regulated*** discharges for 1968–1980 are listed below for anyone who wants to substitute them — the red-shaded entry may be an erratum
- a spliced record of "***La Escuela***" and the data below will give a higher, perhaps better estimate of long term specific runoff

	J	F	M	A	M	J	J	A	S	O	N	D
1968	52.6	127.0	68.8	-	-	67.3	49.5	71.2	61.0	62.4	95.3	170.0
1969	42.1	-	-	-	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-	74.0	58.7	53.7	62.6
1971	36.6	20.5	139.0	160.0	121.0	61.9	68.3	81.5	70.6	65.2	58.7	55.5
1972	62.9	6.8	35.4	39.1	39.9	7.4	45.8	69.9	32.3	18.2	26.7	10.7
1973	11.8	5.7	123.0	147.0	124.0	67.1	39.0	58.9	23.6	-	-	-
1974	152.0	264.0	457.0	229.0	109.0	68.6	52.0	73.4	62.5	56.4	65.3	77.7
1975	68.1	51.4	227.0	273.0	69.5	70.4	77.2	96.5	97.8	96.7	131.0	217.0
1976	183.0	282.0	370.0	160.0	99.0	93.2	74.6	59.0	93.4	134.0	98.0	61.1
1977	134.0	301.0	473.0	397.0	199.0	97.2	76.6	87.1	115.0	125.0	130.0	200.0
1978	530.0	434.0	245.0	328.0	106.0	129.0	-	96.9	132.0	97.4	65.5	59.5
1979	262.0	-	443.0	409.0	-	81.3	129.0	128.0	127.0	-	-	-
1980	192.0	-	-	160.0	140.0	103.0	105.0	125.0	-	-	-	-

Salí Dulce and Embalse Río Hondo tributaries

- data area available for 16 headwater tributary streams of the 3-4 larger rivers draining to Embalse Río Hondo or Río Salí Dulce just above the reservoir
- these are listed below in order of descending latitude:

ID#	RH#	River	Gauge	Lat	Lon	El m	Area km^2	Area km^2	Runoff mm
35202	5174	Angostura	Tafi del Valle-km 52	-26.91	-65.68	1,820	500		82
35212	5184	Reales	Casa de Piedra	-27.08	-65.76	1,150	100		769
35209	5181	Los Sosa	Ruta 307 km 19	-27.10	-65.60	1,500	620		252
35206	5178	Horqueta	La Junta-Los Ahujones	-27.11	-65.78	1,000	115		555
35225	5197	Pueblo Viejo	Los Ahujones	-27.13	-65.76	1,000	310		604
35215	5187	Solco	La Higuera	-27.28	-65.70	460	138		1,241
35205	5177	Conventillo	La Angostura	-27.28	-65.71	350	251		920
35226	5198	Acequia Trinidad	La Angostura	-27.28	-65.71	350	60	6	745
35218	5190	Membrillo	La Higuera	-27.29	-65.70	450	40		846
35204	5176	Cochuna	Los Hornitos	-27.33	-65.91	1,000	157		825
35207	5179	Las Cañas	Las Hachas	-27.35	-65.85	600	1,100		151
35208	5180	Las Cañas	Potrero del Clavillo	-27.38	-65.98	1,300	836	1,000	130
35200	5172	Campo (del)	Cabo San Miguel	-27.40	-65.98	1,300	701		58
35211	5183	Marapa	Embalse Escaba	-27.67	-65.77	565	900		212
35219	5191	Singuil	Escaba	-27.68	-65.78	600	600		92

35201	5173	San Ignacio	Barro Negro (La Cocha ?)	-27.82	-65.65	600	238	129

- these streams rise in the mountains to the west and drain a narrow 1° latitude band
- the gauges are located in the foothills (roughly □ 1,000 m) or at the base of mountains

- the gauges of the north-central basin exhibit anomalously high specific runoff relative to gauges in all directions
- this may be attributable to a local climatic anomaly

- caution is advised using these data

- ***Solco @ La Higuera*** yields the highest mean annual runoff of 1,241 mm
- the only rain gauge in the area, ***Santa Ana***, has mean annual rainfall of 1,123 mm for an unspecified reporting period
- because the Solco runoff exceeds rainfall depth, the Solco drainage area may be under reported

- ***Acequia @ Trinidad La Angostura*** is one of the gauges for which drainage areas were truncated in R-Hydronet metadata
- the reported value of 6 km^2 yields implausibly high specific runoff of 7.5 m, while the "corrected" value of 6,000 km^2 yields implausibly low runoff of 7 mm
- to be consistent with neighbouring gauges, the drainage area must be on the order of 60 km^2 which is accepted herein

- two drainage areas have been reported for ***Las Cañas @ Potrero del Clavillo***
- the smaller estimate, 836 km^2, seems more reasonable

- ***San Ignacio @ Barro Negro (La Cocha ?)*** may be a composite of records from two gauges

San Juan @ km 47.3 and San Juan @ La Puntilla (Dique I. de la Rosa)

ID#	RH-ID#	River	Gauge	km^2	km^2
35134	5106	San Juan	km 47.3	26,000	25,670
9447	5107	San Juan	La Puntilla (Dique I. de la Rosa)	25,000	26,356

- the drainage areas given for these two decrease from upstream to downstream
- the replacement values from other sources may not be correct either, but force the sites to sort in correct topological order

- R-Hydronet calls the downstream gauge “Dique I. de la Rosa”, but all other available sources identify this record as “La Puntilla”
- ***San Juan @ La Puntilla (Dique I. de la Rosa)*** appears to be the outflow of the ***Quebrada de Ullum*** reservoir so ***Dique I. de la Rosa*** may be the name of the dam
- the initial 33 m dam was completed in 1969
- the current 60 m dam was completed in 1981

Seco @ San Fernando and Dorado @ San Felipe/El Sombrero (1981: Barrealito)

ID#	RH-ID#	River	Gauge	km^2	km^3	mm
35106	5078	Seco	San Fernando	32	0.077	2,421
				320		242
35105	5077	Dorado	San Felipe/El Sombrero (1981: Barrealito)	85	0.145	1,708
				850		171
35104	5076	Dorado	Apolinario Saravia	1,399	0.149	106

- the drainage areas reported for the first two streams are almost surely too low by up to an order of magnitude
- in general, the catchments receive <1,000 mm precipitation annually; hence, mean annual specific runoff depths >1,000 mm are physically implausible
- replacement drainage areas of 320 and 850 km^2 respectively give plausible specific estimates for streams descending into the arid Chaco region
- these replacement areas may be not be correct, but they far superior to the reported drainage areas

- ***Seco @ San Fernando*** is a tributary of the Dorado, and may join the Dorado upstream of ***Dorado @ San Felipe/El Sombrero (1981: Barrealito)***

- the gauge name for ***Dorado @ San Felipe/El Sombrero (1981: Barrealito)*** has been identified variably in different sources as:
  - San Felipe
  - San Felipe/El Sombrero
  - El Sombrero (1981: Barrealito)
- otherwise, location coordinates, drainage area and discharge data are identical
- all the place names are too obscure to confirm other than that the gauge is located in a greater township or municipal district named Barrealito which may have a town of the same name
- ***the variable names suggest that this record is a composite of 2 and maybe 3 different gauge records***

Quebrada del Toro / Río Arias

ID#	RH#	River	Gauge	m	km^2	mm
35119	5091	Toro (Rosario)	Campo Quijano	1,565	4,400	48
35112	5084	Blanco	Dique Nivelador	1,573	63	1,617
35115	5087	Corralito	Peñas Bayas	1,590	103	443
35110	5082	Arias (Arenales)	Salamanca	2,000	152	562
35109	5081	Arias (Arenales)	Potrero de Diaz	1,249	230	965
35111	5083	Arias (Arenales)	San Gabriel	1,150	7,100	108

- these tributaries of Pasaje-Juramento-Salado system have confusing names, yield apparently anomalous specific runoff, and were assigned somewhat inaccurate gauge coordinates

- ***Quebrada del Toro***, variably known as ***Río del Toro***, ***Río Rosario*** and **Río El Tunal**, is a tributary of ***Río Arias*** which is also known as ***Río Arenales*** in its upper reaches
- above the ***Campo Quijano*** gauge, ***Quebrada del Toro*** drains a high desert valley of the same name that extends up to 4,000+ m altitude
- below the ***Campo Quijano*** gauge, the ***Blanco*** and ***Corralito*** are the only tributaries of note to ***Quebrada del Toro*** before it joins ***Río Arias*** in the ***Lerma Valley***

- ***Río Arias*** rises just north of ***Campo Quijano*** town as the ***Río Arenales***, but downstream of ***Potrero de Diaz*** veers eastward to the city of ***Salta*** where it turns due south to become ***Río Arias*** and discharge into ***Embalse General Belgrano*** also known as ***Embalse Cabra Corral***

- ***Salta*** and ***Embalse General Belgrano*** / ***Cabra Corral*** occupy the bottom of the ***Lerma Valley***
- Salta has an altitude of ca. 1,180 m, and the mean elevation of the reservoir surface is about 1,025 m

Anomalous Specific Runoff

- there is a significant discrepancy between the specific runoff of the ***Quebrada del Toro @ Campo Quijano*** gauge, and nearby gauges on the ***Blanco***, ***Corralito*** and ***Arenales***
- the only readily available rain gauge data are for ***Salta*** which has long term mean annual precipitation of 700 mm which is not enough to explain the runoff observed at stream gauges near ***Campo Quijano***

- however, information from the government of Salta Province indicates that on the western slopes of the ***Lerma Valley*** annual rainfall increases to as much as 1,400 mm in a narrow elevation band from the valley bottom up to 2,500 m or so, and then declines abruptly to 120 mm as altitude increases past 3,000 m
- the gauges reporting anomalously high specific runoff have catchments located within the elevation zone of high annual rainfall

Location of Arias (Arenales) @ San Gabriel

- this gauge has records only to 1967
- the coordinates given in INA metadata place it too far south and east
- regrettably, ***San Gabriel*** is too obscure to locate
- the gauge elevation of 1,150 m suggests that the site was located not too far south of Salta city; and the drainage area of 7,100 km^2 implies that the location was below the confluence with ***Quebrada del Toro***
- if the gauge elevation of 1,150 m is ***not*** correct, the gauge may even have been located on a river reach now submerged by the reservoir

- for the present, the gauge location was moved to just below the confluence with ***Quebrada del Toro***

Urugua-í @ Pte Viejo Ruta 12

ID#	RH-ID#	River	Gauge	km^2
35015	**4987**	**Urugua-í**	**Pte Viejo Ruta 12**	**2,294**

- Arroyo **Urugua-í** is given correctly in R-Hydronet, but this record has been mis-identified occasionally in other sources as a mis-located gauge of distinctly different Río Uruguay [the GRDC catalogue] or some variant such as “Uruguay 1”
- the record pre-dates construction of the **Urugua-í** reservoir completed in the 1980s
- the drainage area may be low; the catchment of the reservoir is cited as 2,533 km^2; new Ruta 12 crosses directly over the dam wall and spillway

13.2 Bolivia

- the following gauges were updated or added to the limited Bolivian data available in UNESCO files

ID#	River	Gauge	km2	m
9372	**Beni**	**Angosto del Bala**	**69,000**	**284**
9377	**Grande**	**Abapó**	**59,000**	**500**

36001	Beni trib ?	Sirupaya	-	1640
36002	Beni trib (Coroico ?)	Santa Rita	-	4350
36003	Beni trib (Unduavi/Taquesi)	Puente Villa	-	1185
36004	Beni trib ?	Humapalca	-	1980
36005	Beni trib ?	Chorocona	-	2075
36006	Beni trib ?	Cajetillas	-	762
36007	Beni trib ?	Angosto Quercano	-	600
36008	Beni	Angosto Inicua	-	400
36009	Beni trib (Choqueyapu ?)	Achachicala	-	3960
36010	Beni	Cachuela Esperanza	-	124
36011	Mamoré	Guayaramerín	589,500	120
36012	Mamoré	Puerto Siles	-	136
36013	Grande trib ?	Puerto Pailas	-	614
36014	Misicuni ?	Angosto Sivingani	350	3950
36015	Beni	Cotacajes	-	2710
36016	Ichilo	Puerto Villarroel	-	173
36017	Chapare	Villa Tunari	4,377	-

- for the first two sites, 1976-1979 data in UNESCO files were updated with data from LBA-Hydronet
- see **ds552.1** notes for details
- sites 36001–360016 were added from LBA-Hydronet
- site 36017 data were taken from an old OAS development report

- all sites are in the Amazon basin
- most sites are in the upper Beni [Alto Beni] sub-basin

Data Quality — warning

- Bolivian data available in LBA-Hydronet are of lower quality [generally because Bolivian technical capability remains minimal]
- these data are included because Bolivia is poorly covered

- river names were not given; only gauge names were available
- at 9 of 16 sites river names are unknown
- no drainage areas were given
- records have many missing entries
- some records are suspect

Beni trib (Unduavi/Taquesi) @ Puente Villa

ID#	River	Gauge	km2	m
36003	Beni trib (Unduavi/Taquesi)	Puente Villa	-	1185

- the ***Unduavi*** and ***Taquesi*** rivers join just below the town of Puente Villa to form ***Río Tamampaya***
- it is unclear whether the gauge is upstream or downstream of the confluence
- if the gauge is upstream of the confluence, it is unclear which river it monitors
- a hydroelectric dam is being constructed on ***Río Taquesi*** just upstream of ***Puente Villa*** — the project may impact ***Río Unduavi*** discharges above ***Puente Villa***

Misicuni ? @ Angosto Sivingani

ID#	River	Gauge	km^2	m
36014	Misicuni ?	Angosto Sivingani	350	3950

- LBA-Hydronet coordinates place this gauge near the Chile-Peru border
- the location almost surely just north of the city of ***Cochabamba*** on ***Río Misicuni*** in the ***Cordillera del Tunari***

- ca. 20-25 km north of ***Cochabamba***, a hydroelectric / water supply scheme has been under development since the mid 1990s on the ***Río Misicuni @ Angosto Sivingani***
- the project also involves water diversion from other small watersheds adjacent to the Misicuni

- the dam has a catchment area of ca. 350 km^2
- applying this drainage area to the available discharge data gives a specific runoff of 355 mm which seems reasonable considering that the south side of the ***Cordillera del Tunari*** is much drier than the north side

13.3 Bolivia / Brazil

Mamoré @ Guayaramerín / Guajara-Mirim — Warning: discrepancies

		ID#	River	Gauge	km^2	km^3	mm
BO	SA	36011	Mamoré	Guayaramerín	589,500	232.3	394
BR	SA	81106	Mamoré	Guajara-Mirim	589,500	266.4	452

- these gauges are nominally the same location; however, there are significant discrepancies between these records
- from 1971-1977, Bolivian discharges are higher than, but near, Brazilian data
- from 1984-1995, Bolivian discharges are significantly lower than Brazilian data, enough so that they might be from a gauge further upstream

13.4 Chile

- Chilean records herein are a collation of data from PACRIM, SHI and UNESCO
- PACRIM has the most recent data
- SHI has older data including some that pre-date data in PACRIM at common sites
- where they overlap, PACRIM records have generally been revised from the version available in SHI
- the degree of revision indicates that older SHI records may be somewhat inaccurate but not enough so to preclude pre-pending old SHI records that are unavailable in PACRIM and UNESCO

Warning: Chilean Metadata

- in both PACRIM and SHI, most gauges are located by coordinates in apparent decimal format that are actually in dd.mm format, i.e., degrees and minutes separated by a decimal point
- after conversion to decimal format, some further corrections were required

13.5 Venezuela

- available data derive from UNESCO and SHI
- most gauges in SHI were located by coordinates in apparent decimal format that are actually in dd.mm format, i.e., degrees and minutes separated by a decimal
- after conversion to decimal format, some further corrections were required

Warning: Orinoco-Amazon Link / Casiquiare Bifurcation

ID#	River	Gauge	km^2	km^3	mm
9911	Orinoco	Tama-Tama	37,870	39.5	1,042

- the Orinoco forks just below Tama-Tama
- the main branch continues with roughly 2/3 the discharge as the Orinoco
- the minor branch, known as the Casiquiare, descends to join Rio Negro and ultimately the Amazon

14.0 South America: Brazil

- see ***Section 12.1*** for remarks on naming conventions

- see ***Sections 15.6*** and ***15.7*** for remarks on additional records obtained from the GHCDN compilation

14.1 ANEEL data now On-line

- the Brazilian agency ANEEL [Agência Nacional de Energia Elétrica] now makes it's hydrometric data base [rainfall (***chuvas***), water levels (***cotas***) and stream discharges (***vazões***)] openly available at ***hidroweb.aneel.gov.br/***
- this site has occasionally gone off-line for extended periods, and is frequently down for short periods (1-2 hrs)

- ANEEL has data collected by ANEEL and at many gauges operated by other federal and state agencies, but is not a complete archive of all stream discharge data collected in Brazil

- the ANEEL inventory lists over 7,000 gauges; but most do not have discharge data
- many of these may be water level and water quality monitoring sites
- at least 2,000 sites had discharge data in mid-2001

- ANEEL documents suggest that there may be 2,900+ Brazilian gauge records with data; however, other remarks suggest that the number of gauge records with data may exceed 4,000

- the main difficulties with the ANEEL archive are:
  1. there is nothing to indicate which sites have data; i.e., finding sites with data is a trial and error process without knowing ID codes of gauges that have data
  2. even when ID codes are known, metadata do not indicate what records are currently available, i.e., it can only be determined if a gauge record has been updated by directly retrieving the data for that gauge

- ID codes and summary data for gauges known to have data in the ANEEL archive are given in sheet ***BR*** of spreadsheet ***code_tables.xls***

- ***ANEEL now appears to be regularly updating the data archive and metadata***; hence, records obtained directly from the archive may supersede the present data

14.2 São Paulo state data now On-line

www.sigrh.sp.gov.br/sigrh/basecon/bancodedados/index.html

- daily river discharges for ca. 240 state operated gauges can be downloaded
- click on **Dados Fluviométricos**

- 197 gauge records for São Paulo state were added to the present set
- these gauges currently have no data in the ANEEL archive, but are listed in the ANEEL catalogue
- data are available for about 43 other gauges which mostly represent small (<100 km^2) catchments or have very short records (<10 yrs)

- state gauge codes are of the form ***5B-004***
- after ANEEL practice, SIGRH ID #s have been appended to gauge names in the catalogue files

14.3 Brazilian Basin Coding Scheme

- descriptions [*in Portuguese*] of the major Brazilian basins can be found at
  - **www.ana.gov.br/Bacias/bacias.htm**
  - **hidroweb.aneel.gov.br/doc/atlas/atlas.htm**

- 8-digit Brazilian gauge codes [listed in sheet ***BR*** of spreadsheet ***Code_tables.xls***] indicate major basin and sub-basins
- the 8 major (first order) basins [Table 1 and Figure 1] are identified by the first digit of the code

Table 1. Brazilian major basins

basin	code	area km^2
Amazon	**1**	**3,900,000**
Tocantins	**2**	**757,000**
Atlantic - North/Northeast	**3**	**1,029,000**
Sao Francisco	**4**	**634,000**
Atlantic - East	**5**	**545,000**
Paraná	**6**	**1,245,000**
Uruguai	**7**	**178,000**
Atlantic - Southeast	**8**	**224,000**

Figure 1. Major hydrologic basins of Brazil [Figure courtesy of ANEEL]

- second order basins [sub-basins] are identified by the 1st 2 digits of the Brazilian codes, i.e., major basin in the 1st digit, and the second order basin by the 2nd digit
- tertiary basins indicated by the first 3 digits of the Brazilian codes likely have some hydrogeographic significance that it is not obvious without detailed mapping
- coastal basins [3,5,8] are operational aggregates comprising independent coastal drainage systems

14.4 Gauge ID code revision — Warning

- the large number of Brazilian records forced revision of the 5-digit gauge codes used in the present compilation
- all Brazilian records were sorted into order of the 8-digit Brazilian codes which locate gauges to the national sub-basins
- then 5-digit codes were re-assigned from **81001** through **82946**

- the new scheme places all Brazilian gauge records at the end of the data file which facilitates separating the Brazilian records from other data

- the new scheme also facilitates sorting gauge lists and data summaries in spreadsheets or database software
- many Brazilian streams have common names, e.g., Pardo, Peixe, Grande, etc.
- when sorted by the new codes, the gauges will be grouped by basin and approximately ordered by drainage area
- maintaining this order implies that codes must be revised each time new sites are added

- in v1.3, two new records were added; however, because revising all codes is onerous, the new sites were assigned codes **82946** and **82947**
- codes will be revised if more more Brazilian gauges are added in future

14.4.1 Code translation table — spreadsheet *Code_tables.xls*

- sheet ***BR*** of companion spreadsheet ***Code_tables.xls*** gives a code translation table with cross-referenced lists of codes used in the present set [v1.3], the previous versions [v1.0/1.1], the ANEEL catalogue, and LBA-Hydronet

- Brazilian ID codes are given for all sites known to have data in the ANEEL archive and the Sao Paulo state archive
- these include records from ANEEL, LBA-Hydronet, and Sao Paulo state that are not included in the present collection

- if working **only** with Brazilian gauges, using the 8-digit Brazilian codes is preferable

- the river names [not gauge site names] ***Code_tables.xls*** mostly have correct Brazilian spelling with Portuguese accent marks
- there may be some errors as the Brazilian river name data base from which these came had scattered errata
- fully anglicized names are also given for accented Brazilian names

14.4.2 UNESCO sites

- due to the code revision, there may be potential confusion when referring to Brazilian UNESCO sites in ***ds552.0***

- the table below gives the necessary code translations

ds552.0	v1.2	ANEEL	River	Gauge
9385	81113	15400000	Madeira	Porto Velho
9379	81168	17050000	Amazon	Obidos (Pcd)
9386	81217	18850000	Xingu	Altamira
9387	81258	22350000	Tocantins	Porto Nacional (Pcd)
9389	81318	27500000	Araguaia	Conceição do Araguaia (Pcd)
9390	81328	29200000	Tocantins	Itupiranga
9388	81428	34879500	Parnaiba	Porto Formoso / Luzilandia composite
9381	81729	48020000	Sao Francisco	Juazeiro (Pcd)
9391	81748	49660000	Sao Francisco	Traipu
9378	81873	54780000	Jequitinhonha	Jacinto
9382	82110	58974000	Paraiba do Sul	Campos-Ponte Municipal
9380	82518	64843000	Paraná	Guaíra (Porto Guaíra)
9383	82542	65895002	Iguazu (Iguaçu)	Salto Osorio-jusante Uhe
9384	82622	67050000	Paraguay (Paraguai)	Fecho dos Morros

- in Dec 2000, ANEEL archives had data for all sites **except** ***Paraguay (Paraguai) @ Fecho dos Morros***

- in mid-2001, ANEEL has data for ***Paraguay (Paraguai) @ Fecho dos Morros***, but the record for ***Xingu @ Altamira*** had mysteriously disappeared

- the original record for ***Parnaiba @ Porto Formoso*** has been collated with the record ***Parnaiba @ Luzilandia*** into a single operational composite as discussed further below

14.4.3 SHI sites

- the SHI data set has records for 18 Brazilian gauges
- 6 are of no consequence as ANEEL has superior records

- the table below lists 12 SHI records currently have no data in the ANEEL archive or other readily available sources
- 4 are not listed in the ANEEL catalogue
- these records give some useful old data
- in sub-basin 53 [Rio Pardo] these are the only data available

v1.2 ID#	ANEEL #	sb	River	Gauge	km^2	mm	yrs	Y1	YL
81789		50	Itapicuru	Cajueiro	35,123	15	9.2	1934	1943
81814	51680000	51	Jequirica	Laje-Pimenteira	5,700	67	11.9	1932	1943
81838		52	Contas [de]	Itapira	52,227	51	8.3	1935	1943
81839	53182000	53	Cachoeira	Itabuna	3,964	207	8.3	1935	1943
81840	53460000	53	Pardo	Rio Pardo	3,043	114	6.6	1937	1943
81841	53605000	53	Pardo	Porto de Santa Cruz	12,227	48	8.0	1936	1943
81842	53650000	53	Pardo	Itambe (Pcd)	18,603	37	7.8	1936	1943
81843	53950000	53	Pardo	Mascote	29,138	70	7.7	1936	1943
81877		54	Jequitinhonha	Itamarati	61,907	278	7.7	1936	1943
81876		54	Jequitinhonha	Pontal	21,065	275	13.0	1931	1943
81879	55690000	55	Mucuri	Mairinque	13,310	202	6.0	1938	1943
82305	61941000	61	Grande	Porto Jose Americo (Caeeb)	116,700	561	2.0	1939	1940

sb = sub-basin code

14.5 Present Compilation v1.3

- this collection comprises records for 1,948 Brazilian gauges
  - ANEEL — 1,742 ANEEL only
  - UNESCO — 14
  - SHI — 12 not in ANEEL
  - SIGRH — 197 not in other sources
  - GHCDN — 2 not in other sources

- there is a net gain of 917 records over v1.0/1.1 after accounting for deletion of one redundant record and the creation of two composite records

- few users may want or need all the available records; however, thinning gauge records invariably leads to arbitrary deletions of records that some will find useful
- even if interest focuses on larger catchments, data for smaller catchments are often of qualitative, if not quantitative, use for assessing local runoff patterns, assisting in

the identification of records representing regulated discharges (i.e., dam outflows — Brazil has 1000s of dams of all sizes), constructing operational composites, etc.

- as per the table below, about 75% of the available records represent catchments of 1,000 km^2 or greater

drainage area km^2	sites	%
A < 100	10	0
100 ≤ A < 1,000	490	25
1,000 ≤ A < 10,000	860	44
10,000 ≤ A < 100,000	446	23
100,000 ≤ A < 1,000,000	101	5
1,000,000 ≤ A	6	0
unknown	33	2

- there are many clusters of 2–3 gauges located at identical or nearly identical coordinates with identical or nearly identical catchment areas that could be composited into long operational records

- often these sites are identified by the Portuguese terms ***montante*** / ***jusante*** [sometimes ***acima*** / ***abaixo***] which correspond generally to ***upstream / downstream*** or ***above / below***

- crude ***runs*** statistics obtained during work-up of daily discharges indicate that many records have frequent extended runs of identical or nearly identical daily discharges
- this suggests that many records may represent regulated discharges, i.e., dam outflows

- comparison of ANEEL records with concurrent SHI/UNESCO data at 16 sites revealed that some records have seen significant retrospective revision from the SHI/UNESCO versions
- most of the 16 records had not been revised appreciably, but SHI/UNESCO versions did contain scattered errata
- hence, all concurrent SHI/UNESCO records were replaced with ANEEL data

- some SHI/UNESCO records had old data not available in ANEEL
- these were pre-pended to ANEEL records

- this set includes ca. 560 gauge records not in the LBA-Hydronet collection [see below]

14.5.1 Spatial distribution of gauges

- on mapping, it should be obvious that most gauges are concentrated in heavily populated southeastern Brazil, particularly the states of Sao Paulo and Rio de Janeiro where gauge density exceeds 1,000 / 10^6 km^2

- the Amazon basin has the lowest gauge density with about 60 / 10^6 km^2
- the ***Paraguai*** catchment [sub-basins 66/67] of the ***Paraná*** basin [6] is also sparsely represented with about 85 / 10^6 km^2 — this area represents roughly the western 2/3 of basin 6 and comprises mostly the ***Pantanal*** wetlands

14.5.2 Data work up

- for data derived directly and indirectly via ANEEL, monthly discharges were estimated from daily discharges
- two issues that required clarification are discussed below:

14.5.2.1 Months with missing days

- ANEEL daily records have many missing days
- monthly mean discharges were estimated by the same algorithm used for Australian daily data with some extensions

- monthly means were estimated for months missing no more than 10 days if mean annual discharge at the site was <100 m^3/s which holds generally for all but a few Australian gauges

- Brazil has many gauges on very large rivers with mean annual discharges ranging up to 160,000 m^3/s
- generally, as mean discharge exceeds 100 m^3/s, discharge patterns exhibit increasing inertia [resistance to rapid change]; hence, more liberal estimation rules can be used
- from mean discharge of 100 up to 500 m^3/s, the permissible number of missing days was increased gradually to 14 subject to certain additional conditions

- as a result, numerous gauges on large rivers acquired from 1–6 additional months

- the extended rules are still rather conservative

14.5.2.2 ANEEL Data Status Codes — Code 4: 0 or missing value ?

- ANEEL daily discharges each have a numerical “status” code from amongst the alternatives listed below

Table xx. ANEEL data status codes

Meaning	code	mid 2001	code	Dec 2000
no data / missing value	**0**	**branco**	**7** **9**	**ausência de dado** **sem observação**
genuine discharge	**1**	**real**	**0**	**dado real**
estimate	**2**	**estimado**	**1**	**estimado**
doubtful	**3**	**duvidoso**	**2**	**duvidoso**
discharge below lower limit of rating curve	**4**	**régua seca**	**8**	**régua seca ou caída**

- between Dec 2000 and mid 2001, ANEEL changed the codes; however, the system remains essentially the same

- for the present data set, estimates and doubtful entries were accepted as legitimate discharges in calculating monthly means

- though the verbal description has changed, all ***code 8*** entries became ***code 4*** entries in the more recent version

Code 4/8 — Régua seca

- in ANEEL data files, discharges corresponding to these codes appear as the alpha entry “–” which is also used for missing values [current ***code 0***]

- technically, ***code 4*** [previously ***code 8***] means discharge had fallen below the lower limit of the stage-discharge rating relationship [***régua seca***]

- practically, this implies that the missing discharge has value <***X*** where ***X*** is the lower limit of the stage-discharge relation; and usually ***X*** declines over time as primary stream metering data improve
- for ephemeral streams in arid regions, limit ***X*** is often virtually 0

- however, there is reason to suspect that these codes were also used to indicate missing records due to equipment failure [***régua caída***]
- in this case, the potential missing values are unknown and not limited to values less than some numerical constant

- 273 sites in the present set had some ***code 4/8*** entries in the daily discharge data

- for high discharge rivers, e.g., in the Amazon basin, the occurrence of ***code 4/8*** entries should indicate when discharges have fallen below the operational limit of the stage-discharge rating relationship in effect at the time

- for numerous low discharge ephemeral rivers, most ***code 4/8*** entries are likely *de facto* 0s which if recognized as 0s would yield more reliable results in certain hydrological analyses than assuming missing values

- scans for the occurrence of ***code 4/8*** entries suggest that this code has not always been used consistently
- at some high discharge sites, records contain appreciably lower discharges than occur immediately before and after ***code 4/8*** occurrences
- this supports the notion that ***code 4/8*** was used for missing observations due to gauge malfunction

- ***for present purposes, all code 4/8 data were regarded as missing values***

- at about 38 sites, mostly in the arid northeast, it may be preferable to assign 0s to ***code 4/8*** entries rather than missing values
- for ephemeral low discharge streams, assuming that ***code 4/8*** entries are ***missing values*** can induce certain biases and distortions into in statistical summaries and modelling efforts

- these 38 gauges are identified in sheet ***BR*** of companion spreadsheet ***code_tables.xls***
- anyone particularly concerned with drought and low flow conditions may wish to avoid these gauges; or obtain the daily discharge files from ANEEL and substitute 0s or other values for ***code 4/8*** entries

14.5.3 Metadata Quality

- ANEEL metadata have scattered errors in gauge coordinates, drainage areas and elevations
- gauge coordinates are mostly reasonable in coastal and southern regions
- ANEEL has corrected coordinates for some previously mis-located Amazon basin gauges
- some ANEEL coordinates disagree with coordinates given in other inventory lists
- some plot far enough from rivers to be obviously in error
- ANEEL plans to visit each site and obtain correct location data with GPS units

- a cursory scan was run against a somewhat crude digital map and river DLG (digital line graph) that lacks most small river channels
- coordinates for a few egregiously mis-located sites were corrected
- many sites were somewhat off-river, but river channels on an accurate high resolution DLG likely meander appreciably more than the available map, and most gauge locations are too obscure to verify without high resolution maps; hence, most sites were left as is for the present

- gauge elevations, if available at all, are often dubious

- drainage areas are mostly reasonable but should be recalculated for sensitive work
- some drainage area discrepancies are listed in **section 14.9**

14.5.4 Updated records

- ANEEL now appears to be regularly updating the data base as new information becomes available from the contributing agencies

- in mid-2001, data were obtained for about 700 of 1,024 records v1.0/1.1
- of the 700 records, ANEEL has updated about 500 since Dec 2000

- updates involve:
  - additions of recent data, most often 1-4 years
  - addition of historical data that pre-dates existing records — some records in the v1.0/1.1 gained 25-50 years of historical data between Dec 2000 and mid-2001
  - revisions and replacements of some discharge data and metadata

- in 45 cases, updates significantly affected basic mean annual summary statistics
- cases of significant change involved :
  - mostly significant increases in available record length
  - some cases of retrospective revision of historical data
  - some replacements of apparently mis-located data with nominally correct data
  - two cases resulting from deletion of 0s and other spurious entries from ANEEL data as described in ***section 14.11***

- 3 records replaced by ANEEL between Dec 2000 and mid-2001 [***Acre @ Assis Brasil***, ***Itambacuri @ Campanario*** and ***Tijucas @ São João Batista***] are cases of suspicious revisions and updates by ANEEL discussed in ***section 14.10***

- updates were not evenly distributed
- the most significant gains were in basin 6 [***Paraná*** and ***Paraguai***] where many gauges previously had either no data or had short records ending in the mid-1980s

- there have been few updates in the Amazon and Tocantins basins between Dec 2000 and mid-2001, though some sites that previously had no data now have discharge records

- amongst the new stations added in v1.2, many had no data in Dec 2000, e.g., sites in sub-basin 54 [***Jequitinhonha***]

14.5.5 Lost records

v1.0 ID	v1.2 ID	ANEEL #	River	Gauge
81046	**81049**	**13750000**	**Purus**	**Seringal Fortaleza**
9386	**81217**	**18850000**	**Xingu**	**Altamira**

- between Dec 2000 and mid-2001, the two records above have been deleted from the ANEEL archive

- Dec 2000 data for these appear to be valid
- ***Xingu @ Altamira*** is consistent with the concurrent part of the old UNESCO record
- ***Purus @ Seringal Fortaleza*** is consistent with other Purus gauge records

- there may be other records that have disappeared from the archive since Dec 2000

14.6 LBA-Hydronet Collection

- as of mid-2001, LBA-Hydronet has monthly records for 1,636 Brazilian gauges from ANEEL

- despite some problems, LBA-Hydronet has additional records that may be helpful if used with appropriate caution
- ***LBA has ca. 250 gauge records not in the present collection***

- most of these additional gauges represent drainage areas < 500 km^2 or have < 3 yrs record

- ID #s used by LBA-Hydronet, ANEEL and the present collection are cross-listed for gauges known to have data in sheet ***BR*** of spreadsheet ***code_tables.xls***

- the present collection has 550+ gauge records not in ***LBA-Hydronet***

14.6.1 LBA-Hydronet Collection — caution advisory

- LBA-Hydronet has not given the ANEEL gauge identification codes
- gauge ID #s used by LBA-Hydronet are cross-referenced to ID #s of Brazil and the present collection in sheet ***BR*** of spreadsheet ***code_tables.xls***

- LBA-Hydronet has records that generally match the versions available in the earlier v1.0/1.1 releases of this collection
- ANEEL has since updated many records

- LBA-Hydronet appears to have calculated mean discharges using rather liberal rules for months with missing days

- contrast of 900 common records from v1.0 and LBA-Hydronet shows that LBA monthly time series average ca. 4.2 months longer than records in v1.0
- informal sampling found that the observed differences in time series length were almost solely attributable to LBA-Hydronet having estimated mean discharges for months missing more than 10 days of daily discharges

- differences in mean annual discharge estimates for 20 of 900 common sites were large enough to warrant serious concern — differences in estimated mean discharges exceed 25%
- 30 other cases were marginally significant — differences in estimated mean discharges exceed 10% but are <25%
- the mean annual discharge is the most elementary and resistant summary statistic
- if used for monthly time series modelling, the impacts of the liberal estimation rules employed by LBA-Hydronet may be more significant

14.7 Araguaia Bifurcation — Warning

ID#	ANEEL #	River	Gauge	km^2
81301	26030000	Araguaia (main branch)	Fazenda Telesforo	131,600
81308	26350000	Araguaia (main branch)	Sao Felix do Araguaia (Pcd)	193,923
81309	26400000	Araguaia (main branch)	Luciara	232,000
81310	26700000	Araguaia (main branch)	jusante Crisostomo	217,840
81314	26800000	Araguaia (Javaes branch)	Barreira da Cruz	40,327

- the Araguaia is the major tributary of the Tocantins
- in its mid reaches, the Araguaia forks around ***Ilha do Bananal*** (ca. 20,000 km^2) which is touted as the "world's largest river island"

- drainage areas for gauges **81258** and **81259** are plainly inconsistent
- generally, the drainage areas listed above are of dubious merit, and at best of limited use

14.8 Composites Records

- three composite records were formed by splicing records from nearly co-located discontinued and active records
- many similar composites could be constructed, as many similar situations exist

Parnaiba @ Porto Formoso / Luzilandia — composite

ID#	ANEEL #	River	Gauge
81428	34879500	Parnaiba	Porto Formoso

- the record herein is a composite of gauge records for Porto Formoso and Luzilandia
- the gauge was evidently moved from Porto Formoso to Luzilandia at the end of 1981
- ***these records were composited to a single record because the two gauge sites are virtually co-located and the distinct records can be easily separated if desired***

- ANEEL metadata are given below

ANEEL #	River	Gauge	Lat	Lon	el m	area km^2	discharge km^3	1st yr	last yr
34880000	Parnaiba	Porto Formoso	-3.45	-42.37	20	282,000	25.1	1963	1981
34879500	Parnaiba	Luzilandia	-3.45	-42.37	26	322,800	24.0	1982	1998

- Luzilandia is a few km downstream of Porto Formoso
- ANEEL coordinates place the two gauges at virtually the same location between the two towns
- mean annual discharge volume is almost identical for the two gauges

- gauge elevations should be nearly identical
- Luzilandia elevation should be slightly lower than Porto Formoso
- the average of ANEEL metadata (23 m) is accepted for the present

- ***the ANEEL drainage area for Luzilandia is wrong*** — elsewhere ANEEL also gives the total Parnaiba watershed area at the river mouth as 325,000 km^2
- the drainage area for Luzilandia should be slightly (<1%) greater than Porto Formoso
- for the present, the gauge area for Porto Formoso (282,000 km^2) is accepted
- drainage area should be determined from a high resolution DEM if available

Pomba @ Guarani - composite

ID#	ANEEL #	River	Gauge	km^2	m
81699	58730000	Pomba	Guarani Rv	1,642	393
	58730001	Pomba	Guarani	1,642	612
82086	58730001	Pomba	Guarani - composite	1,642	393

- ***Pomba @ Guarani Rv*** has data for 1934-1944 and 1971-1972
- 1971-1972 are identical to ***Pomba @ Guarani***, and likely belong to this record

- metadata for other gauges on the Pomba suggest that the elevation given for ***Guarani*** [612 m] is wrong

- because the two sites are nearly co-located, the two records are composited into the new operational record ***82086 Pomba @ Guarani - composite***
- in future, data for ANEEL site ***58730001*** can be appended to this record

- record ***81699 Pomba @ Guarani Rv*** given in v1.1 is deleted

Salitre @ Junco - composite

ID#	ANEEL #	River	Gauge	km^2	m
	47960000	Salitre	Junco-montante	12,500	381
	47961000	Salitre	Junco	12,500	380

81728	47961000	Salitre	Junco – composite	12,500	380.5

- the two ANEEL records give identical data for 1973 — the last yr of ***Junco-montante*** and the first yr of ***Junco***

- because both records are short and the sites are virtually co-located, the two records were composited into record 81728 of the present set

14.9 Drainage Area Discrepancies

ID#	ANEEL #	River	Gauge	km^2	km^2
82076	58578000	Flores [das]	Travessao do Meio	6,300	630

- the drainage area for ***Flores [das]*** @ ***Travessao do Meio*** is most likely 630 not 6,300 km^2 as given by ANEEL

- the 4 sites below have different drainage areas in the current ANEEL catalogue than given in Dec 2000
- the old areas are retained for all 4 sites
- the old area [405 km^2] for ***Pirapama*** @ ***Pirapama*** makes more physical sense — the specific runoff with the smaller area seems too high
- the old area [274 km^2] for ***Pirapetinga*** @ ***Bom Sucesso*** yields specific runoff closer to that observed at neighbouring sites
- the new area [15,395 km^2] for ***Grande*** @ ***Macaia (Pcd)*** is larger than given for the next downstream gauge; hence the old area [14,854 km^2] is retained

ID#	ANEEL #	River	Gauge	km^2	km^2
81518	39200000	Pirapama	Pirapama	274	405
82217	61140000	Pirapetinga	Bom Sucesso	331	274
82403	63001000	Sucuriu	proximo Costa Rica	1,280	1,338
82218	61145000	Grande	Macaia (Pcd)	15,395	14,854

- the area for ***66072000 Jauru*** @ ***Porto Esperidião*** changed; however, a second site with one year of data only [***66072001 Jauru*** @ ***Porto Esperidião***] retained the same area in both versions of the catalogue
- both gauges are listed with identical coordinates
- analysis of the discharges for the concurrent year suggests that the difference in drainage area between the two gauges should be only about 150 km^2
- the new area is retained for the present for ***66072000 Jauru*** @ ***Porto Esperidião***

ID#	ANEEL #	River	Gauge	km^2	km^2
82563	66072000	Jauru	Porto Esperidião	5,759	4,970
	66072001	Jauru	Porto Esperidião	4,970	4,970

14.10 Questionable Revisions by ANEEL — Warning

- the 3 cases described in this section involve suspicious revisions by ANEEL

Acre @ Assis Brasil & Brasileia — corrupted revision / drainage area ?

v1.0 ID	v1.2 ID	ANEEL #	River	Gauge	km^2	km^3	mm	yrs	Y1	YL
81038	81040	13450000	Acre	Assis Brasil	3,016	1.37	454	10.2	1983	1997
			as revised by ANEEL			3.76	1,245	16.6	1980	2000
			excluding 1980–1981			1.62	539	14.3	1983	2000
81039	81041	13470000	Acre	Brasileia (Pcd)	3,299	4.09	1,238	14.1	1982	1997
						4.03	1,222	14.3	1982	2000
	81042	13550000	Acre	Xapuri	11,765	6.92	588	23.7	1968	1997
	81043	13600002	Acre	Rio Branco	22,670	10.74	474	28.1	1967	1997
	81044	13650000	Acre	Floriano Peixoto	33,468	18.51	553	28.8	1967	1997

- drainage areas and discharges are potentially fouled at two upper Rio Acre gauges

- between Dec 2000 and mid-2001, discharges given at ***Assis Brasil*** were updated
- revised discharges included data for Aug 1980 – Nov 1981 that appear to be an order of magnitude too high — these discharges likely belong to another gauge
- Aug 1980 – Nov 1981 were deleted

- ANEEL also revised discharges from 1983 to 1997
- discharges during high discharge months are perceptibly higher than given in Dec 2000, but plausible

- the drainage area for ***Brasileia*** should be 2.5-3.0 fold higher than at ***Assis Brasil***, say 7,500–10,000 km^2, if the ***Assis Brasil*** drainage area is correct
- this would make the specific runoff at ***Brasileia*** approximately consistent with gauges further down the Acre
- drainage area between ***Brasileia*** and ***Xapuri*** is perceptibly smaller than the drainage area at ***Assis Brasil***

Itambacuri @ Campanario

v1.0 ID #	v1.2 ID #	ANEEL #	River	Gauge	km^2	km^3	mm	yrs	Y1	YL
81644	81943	56900000	Itambacuri	Campanario	732	0.14	190	53.0	1938	1998
						0.16	219	57.6	1938	1998

- between Dec 2000 and mid-2001, this site acquired 4.6 yrs of data almost exclusively during the period 1938–1962
- in addition to previously unavailable data, discharges for numerous months were revised perceptibly upwards

- this gauge is somewhat isolated from other discharge gauges, but there is a rain gauge at Campanario [ANEEL ID# 1841003] with data from about 1940

- while the additional and revised data have the general seasonal characteristics expected for the site, they often disagree with the rain gauge data

- the new record is retained
- the old record can be obtained from the archived copies of v1.0/v1.1 at NCAR under site ID# 81644

Tijucas @ São João Batista — corrupted revision ?

v1.0 ID #	v1.2 ID #	ANEEL #	River	Gauge	km^2	km^3	mm	yrs	Y1	YL
81960	82846	84095500	Tijucas	São João Batista	1,964	1.39	707	12.3	1983	1995
						2.00	1,021	16.2	1983	1999
81959	82844	84071000	Tijucas	Major	1,042	0.77	739	50.8	1945	1995
						0.73	697	55.2	1944	1999

- historical records on this system were retrospectively revised and recent data were added between Dec 2000 and mid-2001

- **the revision of *Tijucas @ São João Batista* may have been corrupted**

- the new record averages almost 50% higher specific runoff than previously
- mostly this is due to discharges from 1989 onward

- from 1983–1988, revised discharges are ca. 20% higher than the Dec 2000 version

- from 1989–1995, revised discharges are ca. 82% higher than the Dec 2000 version

- for the concurrent months, the new version of the ***São João Batista*** correlates more strongly with neighbouring gauges, particularly with the upstream gauge at ***Major***
- however, increased runoff at ***São João Batista*** is inconsistent with ***Major***

- the contradictory indications are reason to be suspicious about the data revisions after 1989

- nevertheless, the new version of the ***São João Batista*** is retained

- the old record can be obtained from the archived copies of v1.0/v1.1 at NCAR under site ID# 81960

14.11 Replicates and Other Fixes

- some daily records from ANEEL had:
  - spurious 0s that were set to missing values before estimating the respective monthly series herein
  - entries of 0.999 m^3/s for extended periods of up to one year; these were almost surely missing values that been miscoded; these entries were discarded
  - entries of other implausible constant discharges for extended periods; these were set to missing values

Acungui @ abaixo Capela

ID#	ANEEL #	River	Gauge
82784	**81525000**	**Acungui**	**abaixo Capela**

- Jan 1 – Feb 25 1953 daily discharges are all 0.999 m^3/s
- these were set to missing values

Atibaia @ Itatiba

ID#	ANEEL #	River	Gauge
82369	**62675100**	**Atibaia**	**Itatiba**

- Jan 1 – Dec 14 1945 daily discharges are all 0.999 m^3/s

- these were set to missing values

Claro @ Montes Claros de Goias

ID#	ANEEL #	River	Gauge
81290	24950000	Claro	Montes Claros de Goias

- Jun 1979 had a spurious discharge of 1426 m^3/s — an order too high; all daily discharges had the same value
- Jun 1979 was set to missing

Contas [de] @ Ipiau

ID#	ANEEL #	River	Gauge
81832	52680000	Contas [de]	Ipiau

- spurious entries for Mar 18–19 and Apr 2-3 1973 and Jan 1 1980 were set to missing in the daily discharges before estimating monthly averages

Corrente Grande @ Fazenda Corrente

ID#	ANEEL #	River	Gauge	Lat	Lon	km^2
81934	56845000	Corrente Grande	Fazenda Corrente	-18.89	-42.71	1,064

- Jan–Nov 1988 and 1989 are identical except that 1988 was a leap year
- nearest neighbours suggest that 1988 and 1989 were similar but not identical
- existing data were retained “as is” for the present

Dourados [dos] @ Professor Jamil

ID#	ANEEL #	River	Gauge	Lat	Lon	km^2
82166	60665000	Dourados [dos]	Professor Jamil	-17.25	-49.28	1,198

- May–Dec 1992 and 1993 are identical
- it is unclear which year has the correct data
- existing data were retained “as is” for the present

Jacupiranga @ Jacupiranga

ID#	ANEEL #	River	Gauge
82810	81710000	Jacupiranga	Jacupiranga

- Jan 1 – Dec 4 1951 daily discharges are all 0.999 m^3/s
- these were set to missing values

Juquia @ Barra do Acungui

ID#	ANEEL #	River	Gauge
82785	81530000	Juquia	Barra do Acungui

- daily discharges of 0.999 given from Jan 1 – Dec 15 1951 are missing values

Juquia @ Juquitiba 1

ID#	ANEEL #	River	Gauge
82780	81470000	Juquia	Juquitiba 1

- daily discharges of 0.999 given from Jan 1 – Oct 26 1951 are missing values

Juquia @ Juquia 1

ID#	ANEEL #	River	Gauge
82801	81680000	Juquia	Juquia 1

- daily discharges of 0.999 given from Jan 1 – Jul 26 1930 are missing values
- daily discharges of 0 given from Mar 17 – Dec 31 1940 are missing values

Lava Tudo @ Fazenda Mineira / Pelotinhas @ Coxilha Rica

ID#	ANEEL #	River	Gauge	Lat	Lon	km^2
82629	70300000	Lava Tudo	Fazenda Mineira	-28.09	-50.06	1,119
82631	70500000	Pelotinhas	Coxilha Rica	-28.15	-50.44	548

- May–Oct 1990 are identical
- Nov 1993 – Aug 1994 are identical

- these data seem more likely to belong to ***Lava Tudo @ Fazenda Mineira*** which typically averages up to 50% greater annual discharge; however, the magnitude of these data remain within the plausible range for ***Pelotinhas @ Coxilha Rica***

- existing data were retained “as is” for the present

Moji-Guacu @ Ponte Guatapara

ID#	ANEEL #	River	Gauge
82295	61912000	Moji-Guacu	Ponte Guatapara

- in 1964, daily discharges from Aug 26 to Oct 15 are 0s
- nearby gauges suggest that these data should be missing values
- daily discharges from Aug 26 to Oct 15 1964 were set to missing

Mucuri @ Nanuque

ID#	ANEEL #	River	Gauge
81880	55700000	Mucuri	Nanuque

- spurious 0s from Jan 1 – Jan 11 1966 were set to missing values

Muqui do Sul @ Mimoso do Sul

ID#	ANEEL #	River	Gauge
82006	57880000	Muqui do Sul	Mimoso do Sul

- spurious 0s in Mar 8–9 1994 were set to missing before estimating monthly discharge

Muzambo @ Estacao do Areado

ID#	ANEEL #	River	Gauge
82255	61615000	Muzambo	Estacao do Areado

- 1964 and 1965 are identical except for 2 days
- data are assumed to belong to 1964

Paraiba do Sul @ Campos-Ponte Municipal / Guarus

ID#	ANEEL #	River	Gauge	Lat	Lon	km^2	m
81716	58972000	Paraiba do Sul	Guarus	-21.73	-41.33	55,083	13
82110	58974000	Paraiba do Sul	Campos-Ponte Municipal	-21.75	-41.31	55,500	14

- ***Paraiba do Sul @ Guarus*** has data for 1955-1973 that are identical to 1955-1973 data in the longer [1934-1995] ***Paraiba do Sul @ Campos-Ponte Municipal*** record

- it is possible that ***Guarus*** data were copied to fill missing entries in the ***Campos-Ponte Municipal*** record or vice versa
- although this may be wrong, the ***Campos-Ponte Municipal*** record is assumed to be the correct location for these data
- the ***Guarus*** record given in v1.1 is deleted

- data from Jan 1928 – Feb 1934 given in UNESCO files have been pre-pended to the ANEEL record ***Paraiba do Sul @ Campos-Ponte Municipal***

Paranaiba @ Porto da Barra

ID#	ANEEL #	River	Gauge
82121	60015000	Paranaiba	Porto da Barra

- Jan 1 – May 13 daily discharges given as 0s are almost surely missing values
- nearby sites show discharge peaked in February
- Jan 1 – May 13 daily discharges were set to missing

- Aug 1 – Dec 31 for 1951 and 1952
- the data belong to 1951
- Aug 1 – Dec 31 1952 were set to missing

Paranapanema @ Porto Jau

ID#	ANEEL #	River	Gauge
82454	64335100	Paranapanema	Porto Jau

- for Jan – Mar 1952, the 1st 4 months of this record, discharges are all 3 m^3/s
- this is physically implausible
- Jan – Mar 1952 are set to missing values

Parauna @ Usina Parauna

ID#	ANEEL #	River	Gauge
81620	41700001	Parauna	Usina Parauna

- Feb 1 – Sep 12 of 1951 daily data are garbage that should be deleted

Peixe [do] @ Chacara Santana

ID#	ANEEL #	River	Gauge
82247	61520000	Peixe [do]	Chacara Santana

- 1987 and 1989 have identical data
- it is unclear which year is correct; nearest neighbours have similar discharges for both years

Piracicaba @ Piracicaba

ID#	ANEEL #	River	Gauge
82374	62707000	Piracicaba	Piracicaba

- 0s given for Jan 1 – Jul 5 1930 almost surely should be missing values
- 0.999 given for Feb 2 – Jul 1931 should be missing values
- these discharges were set to missing values

Quixeramobim @ Quixeramobim

ID#	ANEEL #	River	Gauge	Lat	Lon	km^2
81463	36520000	Quixeramobim	Quixeramobim	-5.20	-39.29	7,100

- Jul–Dec 1933; Aug–Dec 1934; Sep–Dec 1935 discharges are all 2 m^3/s
- these are the only years before 1990 when dry season discharges did not go to 0
- neighbouring gauges dried up during these months

- these discharges were set to missing; the true values were likely 0 for most of these months

Santo Antonio [do] @ Brumado

ID#	ANEEL #	River	Gauge
81825	52250000	Santo Antonio [do]	Brumado
81824	52090000	Contas [de]	Cristalandia

- daily discharges of 0 from Mar 1 – Nov 4 1971 are likely false
- discharges a neighbouring site of the same order [***Contas [de] @ Cristalandia***] do not go to zero
- the zeros were set to missing values

São Bento @ Davinopolis

ID#	ANEEL #	River	Gauge	Lat	Lon	km^2
82126	60050000	São Bento	Davinopolis	-18.12	-47.62	902

- Feb–Sep 1989 and 1991 are identical except that March differs slightly
- it is unclear which year has the correct data
- existing data were retained “as is” for the present

São Lourenço @ Pedro Barros

ID#	ANEEL #	River	Gauge
82794	81600000	São Lourenço	Pedro Barros

- daily discharges of 0.999 given for Jan 1 – Jul 28 1937 were set to missing values

São Lourenço @ Miracatu

ID#	ANEEL #	River	Gauge
82797	81630000	São Lourenço	Miracatu

- daily discharges of 0.999 given for Jan 1 – Dec 8 1951 were set to missing values

Sapucaí @ Pontalete

ID#	ANEEL #	River	Gauge
82251	61550000	Sapucaí	Pontalete

- Jan–Oct are essentially identical for 1931 and 1933
- data from nearest neighbours suggest than 1933 is the correct year

Toropi @ Cachoeira 5 Veados

ID#	ANEEL #	River	Gauge
82729	76085000	Toropi	Cachoeira 5 Veados

- May 1987 daily discharges are constant at 78.2 m^3/s
- the stream shows no signs of regulation and the discharge of 78.2 is inconsistent with the last and first days of Apr and Jun respectively
- May 1987 is deleted
- July 1996 daily discharges are similarly constant and were deleted

Toropi @ Vila Clara

ID#	ANEEL #	River	Gauge
82730	76100000	Toropi	Vila Clara

- the available discharges for Dec 1992 and Dec 1994 are constants
- Dec 1992 and Dec 1994 were set to missing

Trombetas gauges

ID#	ANEEL #	River	Gauge	km^2
81161	16430000	Trombetas	Garganta	37,910
81162	16460000	Trombetas	Caramujo	50,650
81164	16500000	Mapuera (Urucurina)	Estirao da Angelica	26,040
81165	16650000	Trombetas	Cachoeira da Porteira-Conj 1	76,782

- ANEEL geographic coordinates virtually co-locate these four gauges

- coordinates were adjusted to make the sites visible on maps

- the location of ***Trombetas @ Garganta*** is not known, but the gauge must be perceptibly upstream of Caramujo
- the replacement coordinates supplied for this site are likely inaccurate, the gauge may be further upstream

- ***Trombetas @ Caramujo*** and ***Trombetas @ Cachoeira da Porteira*** must be not far upstream and downstream respectively of the Mapuera tributary

Una [de] @ Fazenda Iguacu

ID#	ANEEL #	River	Gauge
81798	51230000	Una [de]	Fazenda Iguacu

- as of mid-2001, ANEEL records contain data for 1940 that belong to a river with much larger discharge
- the proper record begins in Jun 1952

Uatumã @ Balbina P-8

ID#	ANEEL #	River	Gauge
81154	16080000	Uatumã	Balbina P-8

- this is the site of the notorious Balbina dam
- discharges went to 0 over Oct 1-3 1987 as gates were closed to fill the reservoir
- discharges had resumed by 1989 when the dam / powerplant were commissioned

- ANEEL records give the 0s for Oct-Dec 1987, but lack data for 1988–1990
- because records are incomplete, Oct-Dec 1987 data were omitted in the present set
- available data to Sep 1987 give pre-dam discharges, while 1991-1996 data give post-dam conditions

- Balbina dam gained notoriety because the designers significantly underestimated the area flooded by the reservoir, and the builders did not clear vegetation prior to flooding
- consequently, the reservoir releases substantially greater carbon equivalent in CH_4 from rotting vegetation than an equivalent coal-fired thermal electric generating station, and dissolved oxygen levels are so depleted that fish stocks were annihilated downstream

15.0 GHCDN — Notes

- the Global Hydroclimatic Data Network [GHCDN] comprises a set of 1,345 global discharge records compiled by Dettinger and Diaz (2000)

- most GHCDN records within the geographic purview of ds552.1 are already available in the present set

- 84 “new” records were found from the following countries and territories: Mexico (57), China (10), Sudan (4), Namibia (3), Brazil (2), Antarctica (2), Argentina (2), Paraguay (1), Uganda (1), Zambia (1), Zimbabwe (1)

- 15 records previously available in v1.0–v1.2 were updated with more recent or more complete data from GHCDN

15.1 Antarctica

- GHCDN gives data for two sites on the Onyx River apparently operated by New Zealand and the USA
- all non-positive discharges are reported as missing values
- positive discharges occur only during the few months of the Antarctic summer
- the “missing values” are almost surely 0s during months when the stream is frozen solid

- in the present set, all missing values have been changed to 0s
- some of these may actually be missing values, but this a better assumption for most practical and statistical purposes
- the 0s can readily be reset to missing values if desired

15.2 Asia: China — Ganjiang tributaries

- GHCDN has 10 records labelled ***GUO-PRC 1*** through ***10*** which are for small tributaries of the Ganjiang, a sizable tributary of the Changjiang (Yangtze) that flows from south to north into Poyang Lake before joining the Chang

- despite being labelled as “Gangjiang”, the proper name for the main river appears to be ***Gan*** [Ganjiang = Gan River]

- the names assigned to the 10 tributaries appear to be gauging station names rather than stream names; hence, the streams are generically named “***unknown Ganjiang tributary***” for ds552.1

- the 10 tributaries nominally drain catchments of 1,935–5,257 km^2

- 9 of 10 tributaries yield mean annual specific runoff of 785–965 mm
- this is consistent with 2 sites the Gan main branch which yield 831 and 936 mm/a

15.2.1 unknown Ganjiang tributary @ Shaitang — dubious drainage area

- 1 tributary [gauge name: ***Shaitang***, nominal area: **3,073 km^2**] yields only ***66*** mm/a
- the record strongly correlates with the others and unequivocally belongs in this region
- specific runoff of 66 mm is generally implausible for the region; hence, ***the drainage area is almost surely wrong***
- the specific yields of the other Gan gauges, suggest that the true drainage area is about 209–257 km^2

15.3 North America: Mexico

- nominally, there are 66 records for northern Mexico from two sources:
  - 22 records with identifier prefix CICESE
  - 44 records with identifier prefix SIAS

- after rejecting some data as per remarks below, 57 new records were added and records for 4 existing sites in ds552.1 were updated

- there are 4 rivers named “***Principal*** ....”
- these should likely be interpreted as “***Brazo Principal*** ...” [main branch ...]
- these and many streams in these arid regions often bifurcate into 2 or more channels [that sometimes later reunite]

15.3.1 Replicated / Junk Records

- CICESE–14 and SIAS-3 [***Sonora @ El Orégano***] are essentially identical; the SIAS version has an extra digit
- SIAS-4, SIAS-5 & SIAS-6 have identical data to SIAS-3

- ***Sonora @ El Orégano*** was retained [SIAS-3] because it is present in both Mexican data sets; hence, it seems more likely to be the correct source of these data

- SIAS-2 is 50% identical to SIAS-3 and has identical geographic coordinates
- SIAS-2 was discarded

15.3.2 Spurious Entries

- there are 13 egregiously large entries scattered through the SIAS records
- these are all >9000; hence, easily detected & removed
- these are so large that a single occurrence in a record may appreciably distort summary statistics

15.3.3 San Lorenzo @ Santa Cruz — Warning: regime shift / potential data corruption

- ***San Lorenzo @ Santa Cruz*** experiences a profound shift in regime roughly from 1984 onwards
- the mean annual discharge for 1984-94 is 72 m^3/s versus 52 m^3/s before 1984
- the seasonal distribution of discharges changes radically
- the 95 months of 1984–1994 data do not correlate with any other data in the set

- possible explanations include hydroclimatic trends, anthropogenic alterations [dams and water transfers from adjacent basins], and data corruption or muddled records
- without other information, it is impossible to ascertain what is responsible
- for the time being, the data are accepted as is

15.4 South America

- GHCDN has South American records of potential interest from three sources
    - CDC — 2 records for Columbia
    - EVARSA — 15 records for Argentina
    - UNL — 10 records for Argentina, Brazil and Paraguay

- as discussed below, some records are “new”, some that already existed in ds552.1 have previously unavailable data, and others already existing in ds552.1 required examination to determine that they offered nothing new

- there are considerable inconsistencies amongst data available for the 3 records listed below relative to neighbouring gauges
- these discrepancies likely reflect data quality problems with primary gauging data
- except for the ***Uruguay*** @ ***Santo Tome*** record, it is impossible to ascertain which records, these or others on the same river reaches, have the most reliable data
- the cases are discussed in more detail in subsequent sections

River	Gauge		km^2
Paraná	**Guaíra**	**PY**	**830,580**
Iguazu (Iguaçu)	**Capanema**	**BR**	**64,630**
Uruguay (Uruguai, Pelotas)	**Santo Tome (Dncpvn-580)**	**AR**	**127,500**

15.5 South America — Argentina

- GHCDN has 24 Argentine records of potential interest from two sources:
  - EVARSA — 15 records
  - UNL — 7 records

15.5.1 EVARSA

- EVARSA is an acronym for a national compilation of hydrological data [*Estadística Hidrológica*] produced periodically by ***Subsecretaría de Recursos Hídricos*** [currently under the Ministry of Environment, formerly under other Ministries] — see **www.medioambiente.gov.ar/sian/subrechid/tapa1.htm** for the cover page of the 1997 edition

- the 15 EVARSA records originate from the 1994 edition

- the 1994 edition of the national compilation also appears to be the basis of the "***INA***" [*Instituto Nacional del Agua y del Ambiente* of the Environment Ministry] set of 314 discharge records available via R-Hydronet
- the ***INA*** set includes versions of the 15 EVARSA records already incorporated into ds552.1

- there are differences between the EVARSA and INA versions of some records

- contrast of EVARSA and INA versions of the 15 records reveals:
  - scattered trivial discrepancies and a few significant errata
  - most discrepancies appear to be data entry typos by D&D

- 1 significant typo in each of 3 INA records which were replaced by concurrent EVARSA / D&D data

- at one low discharge site [***Portozuelo @ Dique Malanzan***], D&D give a superior record with 3 significant digits to the right of the decimal
- R-Hydronet gave truncated [not rounded] data to 2 digits to the right of the decimal which practically means that only 1 significant digit is reported for most months
- in some years, truncation reduces estimated mean annual discharge by 25%
- the D&D version is accepted

15.5.2 UNL

- UNL records are from a personal compilation by a member of the Civil Engineering Faculty, Universidad Nacional del Littoral, Santa Fe, Argentina

- there are 8 Argentine records
- 6 are also in the EVARSA / INA compilations, but only 3 have some data not previously available in ds552.1
- 2 records on Rio Uruguay are entirely "new" and not listed in the greater EVARSA / INA compilations

15.5.2.1 Existing Records in ds552.1

- UNL records for the three gauges listed below have some data not previously available in ds552.1

River	Gauge		km^2	km^2	Y1
Paraná	**Posadas**	**AR**	**99,360**	**975,375**	**1901**
Paraguay (Paraguai)	**Pto Bermejo**	**AR**	**1,095,000**	**1,095,000**	**1910**
Paraná	**Corrientes (MOSP)**	**AR**	**2,051,720**	**2,102,402**	**1904**

Drainage Areas

- the GHCDN drainage area for ***Paraná*** @ ***Posadas*** [99,360 km^2] is clearly wrong
- the GHCDN drainage area for ***Paraná*** @ ***Corrientes (MOSP)*** is replaced by [2,102,402 km^2] — see **Lower Río Paraná** subsection of **13.1 Argentina**

First Year — Y1

- all other available versions of these three records begin in Sep of the year (**Y1**) indicated in the table
- UNL versions of these records all begin in Jan of **Y1**
- as there is nothing unusual about Jan–Aug of **Y1** data at any of these sites, the records are accepted as is
- it is possible that Jan–Aug of **Y1** are pseudo data created for the convenience of engineering hydrologic and hydraulic calculations
- these records should be verifiable by anyone with access to the *Estadística Hidrológica* compendium

Paraguay @ Pto Bermejo — Warning: Bad UNL data

- the UNL has corrupted entries for Nov-Dec 1984; Dec 1989 — Dec 1990; and Nov–Dec 1991
- the existing ds552.1 / INA record is one year longer and generally of superior quality

Paraná @ Posadas / Paraná @ Corrientes (MOSP) — good UNL data

- both UNL records have better and more complete data for 1984–1991 than in the existing INA / ds552.1 record

15.5.2.2 Uruguay @ Santo Tome / Uruguay @ Monte Caseros

- UNL has 2 “new” records listed below

River	Gauge		km^2
Uruguay (Uruguai, Pelotas)	**Santo Tome (Dncpvn-580)**	**AR**	**127,500**
Uruguay (Uruguai, Pelotas)	**Monte Caseros (MOSP)**	**AR**	**217,360**

- these two gauges are on the reach of Rio Uruguay that forms the border between Argentina and Brazil

- ***Uruguay @ Monte Caseros (MOSP)*** has no obvious discrepancies or inconsistencies with other records

Rio Uruguay gauges — general remarks

- there are a series of Argentine and Brazilian gauges on this reach, some in close proximity
- evidently, each nation operates its gauges independently
- discharges are broadly consistent amongst gauges; however, there are instances when particular gauge records behave inconsistently
- ***neither drainage areas nor gauge elevations cited by the two countries for gauges on this reach are consistent***
- if sorted by drainage area or gauge datum, the gauges are not listed in correct topological order
- ***drainage areas should be re-delineated and re-calculated for all Rio Uruguay gauges from high resolution data***

Uruguay @ Santo Tome — Warning: Low Data / Bad 1989 data

- ***Uruguay @ Santo Tome*** is exceptional in ***that data are mostly lower than*** both downstream and ***upstream gauges*** including the next ***upstream*** gauge operated by Argentina [***Uruguay @ Garibi***]

- ***Uruguay @ Santo Tome*** data are retained because statistical relations might be developed to adjust this record to approximate consistency with other gauges on the reach

- ***most months of 1989, the final year of available record, are flagrantly inconsistent with the records of 7 other u/s and d/s gauges on the Uruguay***
- 1989 was deleted

15.6 South America — Brazil

- GHCDN has 2 Brazilian records currently unavailable from ANEEL or other sources

River	Gauge		km^2
Paranapanema	**Rosana**	**BR**	**100,120**
Iguazu (Iguaçu)	**Capanema**	**BR**	**64,630**

15.6.1 Paranapanema @ Rosana

- the GHCDN record ***Paranapanema @ Rosana*** is the most downstream and historically longest time series currently available for Rio Paranapanema

- see NE corner of the map at **www.itaipu.gov.br/hidrolport/** for the general location of Rosana

- the Rosana hydroelectric dam [barragem] was completed in 1984

Bad Data Sep 1975 — Dec 1977

- as below, there is a sequence of replicated records from Sep 1975 – Dec 1977

	J	F	M	A	M	J	J	A	S	O	N	D
1974	2644	1682	2404	1394	990	1471	1154	961	913	1057	1048	1509
1975	1634	1538	1250	865	702	721	817	856	820	1024	942	1015
1976	1264	1379	1206	845	865	988	904	735	820	1024	942	1015
1977	1264	1379	1206	845	865	988	904	735	820	1020	942	1015
1978	677	585	600	622	549	567	1040	840	1254	1003	896	724

- as best as can be determined from upstream gauges, the entire Sep 1975 – Dec 1977 sequence should be set to missing values

- ANEEL offers several upstream gauge records, but these typically end between 1958 and 1979
- the GHCDN record may be one of the two entities listed in the ANEEL site catalogue and below:

ANEEL ID	River	Gauge	Lat	Lon	km^2
64571080	Paranapanema	UHE Rosana-Barragem	-22.60	-52.87	99,000
64571200	Paranapanema	Rosana jusante-Roj	-22.58	-52.88	-
			-22.59	-52.88	99,573

- for the present the GHCDN record is retained with the average geographic coordinates and the average drainage area [99,000, 99,600 and 100,120 km^2]

15.6.2 Iguazu (Iguaçu) @ Capanema

- ***Iguazu (Iguaçu) @ Capanema*** was mis-identified as an Argentine gauge

- Capanema city is about 5-10 km inside the Brazilian border, and about 10 km due south of Rio Iguaçu where there is a gauge labelled ***Porto Capanema***

- see map at **www.itaipu.gov.br/hidrolport/**
- [the Capanema gauge on the map is owned by the Itaipu power corporation and may not be among the several Capanema gauges listed further below]

- ***GHCDN coordinates are clearly wrong*** as they place the site much further inside Brazil and south of Rio Iguaçu

- ***Puerto Andresito*** is the first Argentine gauge on Rio Iguazu where it exits purely Brazilian territory to briefly become the Brazilian-Argentine border

- Brazilian and Argentine discharge records along the Iguazu/Iguaçu are inconsistent with the topologic ordering of gauging sites
- discharge does not rise from site-to-site from upstream-to-downstream likely due to the variable quality of the measurements

- metadata for the GHCDN / UNL gauge and 4 Capanema stations listed by ANEEL area listed below

ANEEL ID	River	Gauge		Lat	Lon	km^2
	Iguazu (Iguaçu)	Puerto Andresito	AR	-25.59	-53.98	67,290
	Iguazu (Iguaçu)	Capanema	BR	-25.00	-53.00	64,630
65987000	Iguazu (Iguaçu)	Porto Capanema (Pcd)	BR	-25.57	-53.93	65,680
65987001	Iguazu (Iguaçu)	Porto Capanema-Simepar	BR	-25.57	-53.93	65,680
65985200	Iguazu (Iguaçu)	UHE Inv Capanema	BR	-25.58	-53.83	62,500
65985190	Iguazu (Iguaçu)	Capanema Eletrosul	BR	-25.58	-53.82	-

- ANEEL currently (Sep 2001) has no data for the 4 listed sites
- GRDC gives partial summary data for ***Porto Capanema*** (likely gauge 65987000, but possibly 65987001)

- for 14 concurrent years, the partial GRDC series has mean discharge 5 km^3 (10%) higher than the GHCDN record

- GHCDN Capanema may be the record of the station labelled ***Capanema Eletrosul***, but this is only speculation

15.7 South America — Paraguay / Brazil ???

- UNL has 1 record listed below that is, for the present, assumed to be Paraguayan

River	Gauge	km^2

Paraná **Guaíra** **PY 830,580**

- GHCDN incorrectly lists ***Paraná @ Guaíra*** as an Argentine gauge
- the Guaíra cataracts are located at the point where Rio Paraná emerges from Brazil and forms the border between Brazil and Paraguay
- on the Brazilian side is the town of ***Guaíra***
- on the Paraguayan side is the town of ***Saltos del Guaíra***
- these are the last gauges above the backwater influence of the huge ***Itaipu*** reservoir
- see map at **www.itaipu.gov.br/hidrolport/**

- Brazil operates gauge ***Paraná @ Guaíra*** [#**82518** in ds552.1] for which data are available from ANEEL

- the GHCDN record labelled ***Paraná @ Guaíra*** is **distinctly different** from the Brazilian ***Paraná @ Guaíra (Porto Guaíra)*** record except for the two final years 1991–1992 which appear to have been copied from the Brazilian record
- both records begin identically in Aug 1920
- there are scattered discrepancies of up to 100% on concurrent months until about 1980 when differences between the two versions become consistently small
- long term mean annual discharge of the GHCDN record is ca. 2.5% less than the Brazilian record

- a Paraná basin catalogue lists a Paraguayan gauge ***Paraná @ Saltos del Guaíra*** with almost identical coordinates as the Brazilian gauge
- because the GHCDN record is **distinctly different** than the Brazilian record for all but the two final years, it is assumed for the time being to be the Paraguayan gauge record and re-labelled as ***Paraná @ Saltos del Guaíra***
- data are retained except for 1991–1992
- this may not be correct, but it assures that the two records are not confused

- the drainage area cited by GHCDN [830,580 km^2] seems too large
- the catchment of Itaipu dam is variably cited as 820,000–830,000 km^2
- a drainage area of 802,150 km^2 is assigned for ***Paraná @ Saltos del Guaíra***, identical to the Brazilian gauge

15.8 South America — Colombia

- GHCDN has records for 2 sites already in ds552.1

15.8.1 Cauca @ La Virginia

ID#	River	Gauge
9406	Cauca	La Virginia

- ds552.1 has 1971–1974 data for nominally the same location given in UNESCO files and other sources
- the GHCDN record spans 1947–1994

- ***the competing versions of 1971–74 data are clearly from different gauges***; however, they are strongly correlated
- the UNESCO version has mean annual discharge 15.7 km^3
- the GHCDN version has mean annual discharge 22.0 km^3

- Colombia has many gauges on Rio Cauca
- as judged relative to data at several Cauca gauges, the GHCDN record seems correctly located while the UNESCO data likely come from a gauge upstream of La Virginia with a drainage area of 15,000–18,000 km^2

- the four year record fragment from UNESCO files is preserved below as it may be useful in future corroboration of additional records that may become available

	J	F	M	A	M	J	J	A	S	O	N	D
1971	584	741	859	940	919	525	356	339	346	475	833	470
1972	528	537	411	455	620	439	276	189	182	187	443	394
1973	195	124	122	161	319	353	270	330	660	629	881	1003
1974	771	956	792	650	551	435	349	188	235	523	759	-

15.8.2 Magdalena @ Pto Berrio

ID#	River	Gauge
9398	Magdalena	Pto Berrio

- ds552.1 has 1969–1984 data given by UNESCO, SHI and other sources
- the GHCDN record spans 1936–1993

- 13 years of concurrent data derived from ds552.1 agree with the GHCDN version with a few exceptions:
  - Mar 1971 should likely be 2699 m^3/s as given by UNESCO rather than 3699 m^3/s given by GHCDN according to patterns observed at other gauges

- 1976 UNESCO data are about 4% lower than GHCDN, but from available information, it is impossible to judge which version is correct, nor will it make much practical difference which data are accepted
- 1979 UNESCO data are about 28% higher than GHCDN, and appear likely to be from another gauge

- the GHCDN record is accepted with Mar 1971 taken from the UNESCO version

15.9 Africa: Nile Basin

- GHCDN has 12 records for the Nile basin labelled ***Nile 1***, ***Nile 2***, ...
- these are listed below in order from downstream to upstream

GHCDN	ds552.1	GRDC	River	Gauge		[a] area km^2
Nile 5	9953		Nile	Aswan Dam	EG	2,846,409
Nile 6	9155		Nile	Dongola (Dunqulah)	SD	2,694,242
Nile 1	9975		Atbara	Kilo 3	SD	178,709
Nile 7			Nile	Hudeiba (Hassanab)	SD	2,007,678
Nile 8			Nile	Thamaniyat (Tamaniat)	SD	1,999,750
Nile 2	9154		Blue Nile (Abbay)	Khartoum	SD	311,870
Nile 4			Blue Nile (Abbay)	Sennar (dam outflow ?)	SD	227,940
Nile 3		1663800	Blue Nile (Abbay)	Roseires Dam	SD	210,000
Nile 11	9156		White Nile (el Jabel)	Malakal	SD	1,084,140
Nile 12		1468050	Semliki	Bweramule	UG	20,720
Nile 9	80371		Victoria Nile	Paraa	UG	340,000
Nile 10	9158		Victoria Nile	Jinja / Owen Falls dam	UG	257,794

[a] **drainage areas given here are considered crude estimates; drainage areas given for most of these sites in other sources often disagree perceptibly**

- GHCDN Nile records are composites of data given in Appendix D of Shahin (1985) and more recent data obtained from the US-NOAA Nile forecasting system

- 5 records were unavailable in earlier versions of ds552.1
- two these have partial monthly series from GRDC summaries that permit general corroboration of concurrent GHCDN time series

- the yellow-shaded records are problematic
- the GHCDN ***Victoria Nile @ Jinja / Owen Falls*** record is identical to ***Victoria Nile @ Paraa*** to 1969 as given in other sources, and it is not known precisely what the fragment from 1970–1995 represents; this is discussed in greater detail below

- the recent monograph by Sutcliffe and Parks (1999) is likely a helpful source of information

15.9.1 Nile @ Aswan

- ***GHCDN data for 1974–1985 are definitely not from Aswan !!!!***
- these data originate from another gauge — most likely from a point below the confluence of the Nile and the Atbara, and above Dongola
- the 1974–1985 GHCDN record fragment has strongly seasonal (unregulated) discharges that are implausible for Aswan
- these are also greater than discharges at Dongola [Nile discharges generally decline with distance below Atbara due to evapotranspiration losses]

- the existing ds552.1 record is retained as is

15.9.2 Nile @ Dongola

- GHCDN data are essentially identical to ds552.1 for 1912–1972 period

- there are perceptible differences between concurrent monthly discharges from 1973–1984 —— up 10% on low discharge months, <5% on peak flow months and <5% in annual mean discharges
- discrepancies are apparently random as neither version is consistently higher or lower than the other

- 1985–1995 GHCDN data are consistent with historical ranges

- the existing 1912–1972 ds552.1 record is retained with 1985–1995 GHCDN data appended

15.9.3 Atbara @ Kilo 3

- GHCDN data are identical to the available ds552.1 record except for 1973
- GHCDN specifies 0 discharges for Jan–Jun which are listed as missing in ds552.1
- GHCDN incorrectly gives 0 discharges for Jul 1973; discharge should be 698 m^3/s

- the ds552.1 record is retained as is except for Jan–Jun 1973 which are set to 0

15.9.4 Nile @ Hudeiba (Hassanab)

- this site is just above the Atbara confluence
- other sources list the gauge name as Hudeiba
- if available information is correct, ***Hassanab*** is the district name, and ***Hudeiba*** is the name of the town nearest the gauge site

- GHCDN Hudeiba data are consistent with records upstream and downstream

15.9.5 Nile @ Thamaniyat (Tamaniat)

- this gauge is just below the confluence of the Blue and White Nile at Khartoum
- records seem consistent with the limited information available

- GHCDN Tamaniat data are retained as is

15.9.6 Blue Nile

GHCDN	ds552.1	GRDC	River	Gauge		area km^2
Nile 3		1663800	Blue Nile (Abbay)	Roseires Dam	SD	208,322
Nile 4			Blue Nile (Abbay)	Sennar (dam ?)	SD	227,940
Nile 2	9154		Blue Nile (Abbay)	Khartoum	SD	311,870

- Roseires dam was completed about 1966
- Sennar dam was originally completed in 1927 and raised in the 1950s
- Sennar dam is relatively small and does not appreciably affect Blue Nile discharges
- both dams have lost significant capacity (25-50%) due to sedimentation

- between available ds552.1 records for Khartoum and the GRDC partial monthly series for Roseires, records for Roseires and Sennar can be largely corroborated

Roseires

- the GHCDN Roseires record spans 1912–1995 with a few missing years
- the GRDC Roseires partial monthly record spans 1912–1982
- the two versions are essentially identical to 1972
- from 1973–1982, the two versions differ perceptibly
- for 6 years with complete data, the GHCDN version averages 2.2 km^3 [4.8%] higher mean annual discharge
- a calibration for 22 concurrent annual minima, maxima and means from 1973–1982, indicates GHCDN data are about 2.9% higher

- the GHCDN record is retained with 4 missing months added from GRDC without adjustment

Sennar

- from 1912–1982, Sennar records concur generally with Roseires and Khartoum
- there is a typo in Dec 1937 — GHCDN gives 0 when the discharge must be between about 375–475 m^3/s
- Dec 1937 was set to missing

Khartoum

- GHCDN data are essentially identical to ds552.1 for the concurrent 1912–1982 period
- ds552.1 has 1900-1911

- GHCDN has a typo in Jul 1981 — discharge should be 1,377 m^3/s not 470 m^3/s

- the ds552.1 record is retained as is

15.9.7 Nile @ Malakal

- GHCDN data are essentially identical to ds552.1 for 1912–1972 period
- there are perceptible differences between concurrent monthly discharges from 1973–1984, but neither version is consistently higher or lower than the other
- 1985–1995 GHCDN data are consistent with historical ranges
- the existing 1912–1972 ds552.1 record is retained with 1985–1995 GHCDN data appended

15.9.8 Uganda Nile

- from the Lake Albert outlet to the Sudan border, the river is called ***Albert Nile***
- as it crosses into Sudan, in the ***Albert Nile*** becomes the ***White Nile (el Jabel)***

- from Lake Victoria to Lake Albert, the river is called ***Victoria Nile***
- less often, the reach from Lake Kyoga mid-way between Lakes Victoria and Albert, is called the ***Kyoga Nile***

15.9.9 Semliki @ Bweramule

- the Semliki flows about 210 km from Lake Edward to Lake Albert
- about 2/3 of the course is through Congo DR, and the rest forms the border between Congo DR and Uganda

- ***Bweramule*** is not far above Lake Albert

- the GHCDN record spans 1948–1970
- GRDC gives a partial monthly series for the identical period

Bweramule Drainage Area Discrepancy

- ***the widely reported drainage area of 8,000 km2 for the Bweramule gauge is wrong***
- [GHCDN gives no drainage area, but this estimate is reported in most references to this gauge]

- Lake Edward has combined lake surface and influent drainage area of about 14,300 km^2 according to ILEC [International Lake Environment Committee, **www.ilec.or.jp/**]
- an FAO source reports the catchment area of Lake Albert, excluding the Victoria Nile drainage area, to be 65,000 km^2
- neither source is necessarily correct; however, the drainage area at ***Bweramule*** is almost surely > 14,300 km^2 and < 65,000 km^2

- if the 8,000 km^2 were really square miles, the area would be 20,720 km^2
- 20,720 km^2 seems low, but is taken as a provisional estimate for the time being

Mis-scaled GHCDN data

- GHCDN data are mis-scaled by approximately the same systematic linear relation as the ***Victoria Nile @ Paraa*** records [see below] which amounts to a scaling factor of roughly 2.63

- as given, GHCDN records yield a mean annual discharge of 1.8 km^3/a versus 4.65 km^3 from the partial GRDC series
- as given, the GHCDN discharges are too small to support the discharge gained by the Nile from above the inlet to below the outlet of Lake Albert

- contrast between GHCDN data against concurrent months from GRDC summary statistics [annual minimum/maximum/mean] for the monthly time series yields 86 concurrent values that demonstrate the discrepancy and establish the calibration
- unlike the Paraa calibration given further below, there is virtually no scatter except for 3 obvious typos in the GRDC data

- after accounting for 3 errata, the following calibration relation obtains:

$$Q = 2.671 \bullet Q\_g - 2.451$$

  where ***Q_g*** is the monthly discharge given by GHCDN

- by this equation, the GHCDN ***Semliki @ Bweramule*** record was scaled to the correct magnitude

- the ***Semliki @ Bweramule*** record retained is a composite created by filling missing entries of the partial GRDC monthly time series with the scaled up entries from the GHCDN series

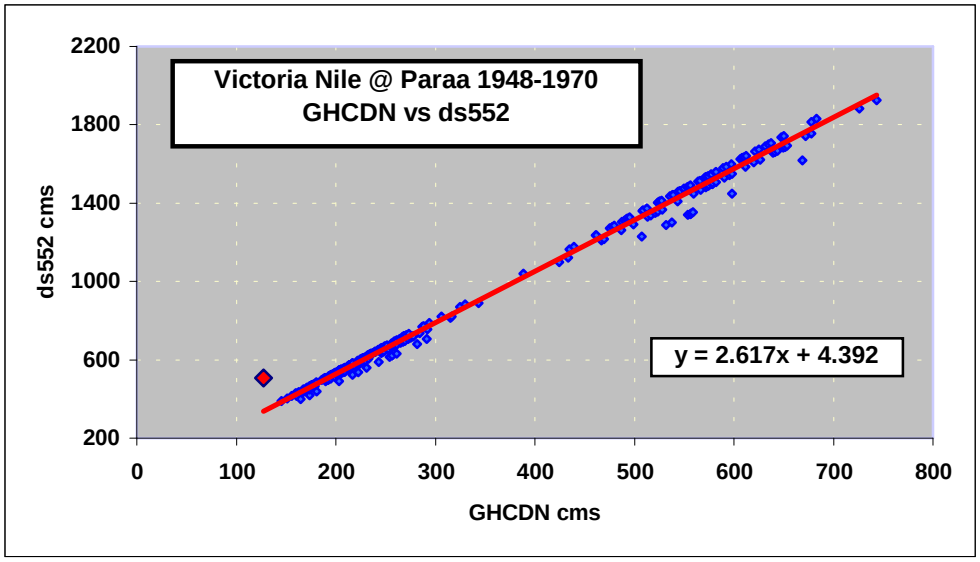
- this hybrid series is undoubtedly imprecise but sufficient for most general purposes

15.9.10 Victoria Nile @ Paraa

- ds552.1 and GHCDN give records for 1948–1970

- GHCDN data are mis-scaled
- these require multiplication by ca. 2.63 to be brought to correct magnitude
- as given, GHCDN data yield mean annual discharge at Paraa of only 11 km^3 versus 29.9 km^3 of the ds552.1 record [source SHI, corroborated by partial GRDC series]
- GHCDN data imply loss of 18-20 km^3 / yr water between Lake Victoria and Paraa

- the intercalibration plot [below] of concurrent monthly discharges for 1948–1970 reveals some deviation at higher discharges
- barring one typo in GHCDN [the red point in the lower left], it appears that at least 3 linear relations with slightly different slopes govern the calibration between GHCDN and ds552.1 records
- in any case, the relations between the two versions of the record are unequivocally systematic



15.9.11 Victoria Nile @ unknown [Jinja / Owen Falls ????]

- Jinja is a town at the outlet of Lake Victoria to the Victoria Nile

- in the 1950s, the Owen Falls hydroelectric dam complex was constructed there
- Lake Victoria essentially functions as the Owen Falls reservoir

- the Owen Falls complex was extended in 1999 with an additional dam
- a major expansion is underway at Bujagali Falls a few km further downstream
- it is not known how these will affect Victoria Nile discharges
- except in the short (< 1 yr) term, the current Owen Falls Dam does not alter mean discharges down the Victoria Nile, but does reduce their variability

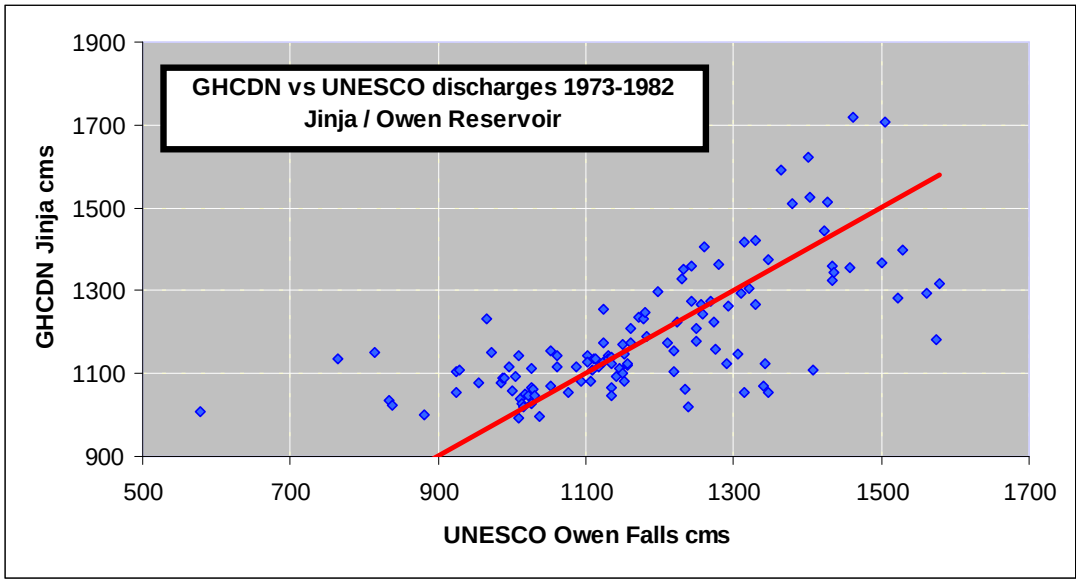
- GHCDN gives a record for 1948–1995
- ds552.1 has the UNESCO records for 1973–1982

- ***for 1948–1969, the nominal GHCDN records for Jinja are exactly identical to Victoria Nile @ Paraa data given in ds552.1*** [from source ***SHI***, corroborated by partial ***GRDC*** monthly data]

- in 1970, GHCDN–Jinja data are perceptibly lower than ***Victoria Nile @ Paraa***

- ***after 1970, it is impossible to establish from readily available information precisely what the nominal GHCDN–Jinja data represent***
- these could be discharges at Owen Falls, Paraa or other gauges between the two

- after 1970, GHCDN–Jinja data can only be compared with the nominal Owen Reservoir outflows for 1973–1982 as shown below
- for the 10 year period, GHCDN–Jinja records yield 0.4 km^3/a greater discharge than the Owen Reservoir record given by UNESCO



- the scatter seems reasonable for measurements that might have been made above and below the passage through swampy Lake Kyoga mid-way between Owen Reservoir and Paraa

- a difference of 0.4 km^3/a is plausible between the Lake Victoria outlet and Paraa for typical years, though during wet years as in the 1960s, the difference was 2.5 km^3/a [reported in an FAO source]
- this difference is also within typical margins of gauging error

- given the potential for abuse, this record is not included in the present compilation; however, the 1970–1995 fragment of the GHCDN ***Victoria Nile @ Jinja*** record could be helpful for elaborating the general patterns of Victoria Nile discharges even if the correct location of the source gauge cannot be determined

15.10 Africa: Okavango and Zambezi

- GHCDN offers 5 sites of considerable interest in southern Africa
  - 2 on the lower Okavango above the interior delta
  - 3 on the upper Zambezi

- the Okavango records appear to be of good quality

15.10.1 Zambezi @ Victoria Falls

- GHCDN has records for two gauges operated by Zimbabwe (Bigtree) and Zambia (Livingstone) as listed below
- from an old report, summary data are given for a gauge listed as Victoria Falls, Zimbabwe [blue shading]

River	Gauge		Lat	Lon	km^2	km^3
Zambezi	Bigtree	ZW	-17.92	25.83	316,000	35.17
Zambezi	Livingstone	ZM	-17.88	25.83	360,600	39.04
Zambezi	Victoria Falls	ZW	-18.00	25.85	517,050	40.12

- coordinates specified by GHCDN place the two gauges north and south of the same point on the river, apparently just above Victoria Falls

- while the reported drainage area for the Zimbabwean gauge [Bigtree] is about 14% lower than the Zambian gauge [Livingstone], discharge is only about 4% lower than discharges for 292 concurrent months of record

- coordinates supplied for old summary data [the gauge labelled Victoria Falls] would place the gauge below Victoria Falls
- the old summary data [1924-1975] are consistent with the Livingstone gauge record which also begins in 1924; these may be the same entity

- drainage areas should be re-delineated and re-calculated for Bigtree and Livingstone from high resolution digital elevation data

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