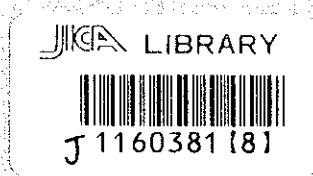


Japan International  
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THE FEASIBILITY STUDY  
ON  
THE LOWER MUNYATI RIVER BASIN  
AGRICULTURAL DEVELOPMENT PROJECT  
IN  
THE REPUBLIC OF ZIMBABWE

Volume - II  
APPENDIXES (1/2)



November 2000

Nippon Koei Co., Ltd.  
Kokusai Kogyo Co., Ltd.

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**Volume – II  
- APPENDIXES (1/2) -**

NOVEMBER 2000

Nippon Koei Co., Ltd.  
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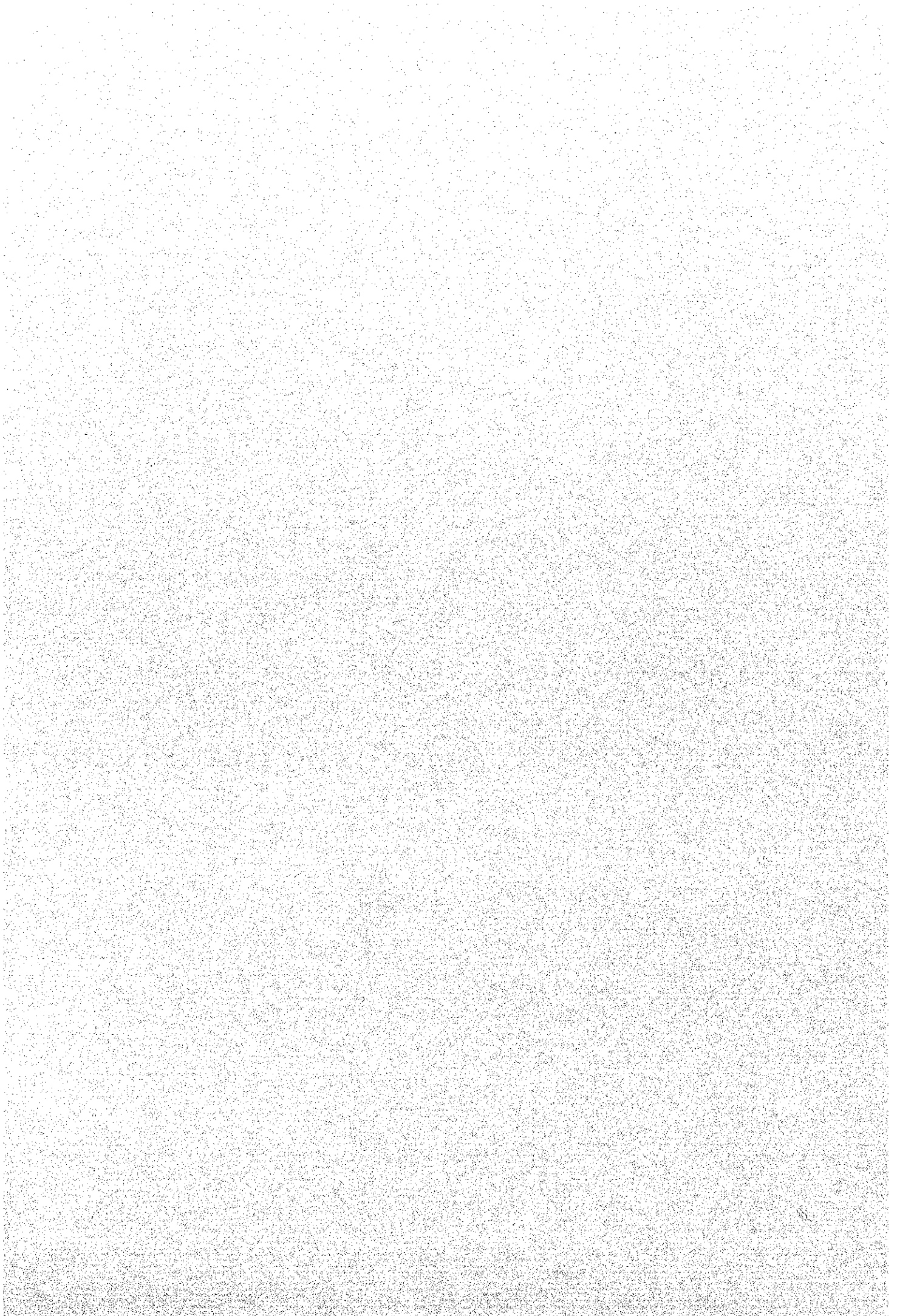
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**APPENDIX- I**  
**METEO – HYDROLOGY**

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## 1. Data Collection

Fig.1 shows the location of meteorological and hydrological stations in and around the study area.

### 1.1 Meteorological Data

Meteorological data were collected from the Meteorological Office in Harare as available for the Meteorological Stations of Kadoma and Gokwe, for the following years :

<b>Meteorological Data</b>		
<b>Data</b>	<b>Period for Kadoma</b>	<b>Period for Gokwe</b>
1. Daily rainfall	1952 - 97	1964 - 97
2. Monthly and annual maximum temperatures	1951 - 98	1963 - 98
3. Monthly and annual minimum temperatures	1951 - 98	1963 - 98
4. Monthly and annual wind speed	1959 - 98	1963 - 98
5. Monthly and annual cloud amount	1959 - 98	1963 - 98
6. Monthly and annual sunshine hours	1951 - 98	1966 - 98
7. Monthly and annual pan evaporation	1962 - 98	1963 - 98
8. Monthly and annual relative humidity	Not available	1983 - 98

### 1.2 River Runoff Data

There are eleven river runoff gauging stations in and around Munyati river basin, and the daily runoff data of these stations were collected from the data processing section of Department of Water Development (DWD) in Harare. The station number and data available period of respective stations are shown below.

<b>River Runoff Data</b>		
<b>Station No.</b>	<b>River</b>	<b>Data Available Period</b>
C8	Munyati	49/50 - 96/97
C9	KweKwe	68/69 - 93/94
C18	Munyati	62/63 - 96/97
C20	Ngesi	70/71 - 96/97
C30	Munyati	77/78 - 96/97
C36	Sebakwe	55/56 - 96/97
C48	Umsweswe	57/58 - 96/97
C59	Sanyati	61/62 - 96/97
C84	Mupfure	90/91 - 95/96
C87	Umswewe	76/77 - 96/97
C88	Munyati	76/77 - 94/95

### 1.3 Water Rights Data

Munyati river basin is divided by seven sub-hydrological zones, and the lists of water rights in sub-hydrological zones are prepared by the Water Right Section of DWD in Harare. The water rights list of Munyati river sub-hydrological zones, namely CUN1 to CUN6 and CUS were collected from DWD.

## 2. Climate and Rainfall

The mean monthly climate and rainfall records at Kadoma and Gokwe Stations are shown in Table 1 and summarized below.

Climate and Rainfall		
Max. Temperature	Kadoma	24.0 °C in July – 32.0 °C in October
	Gokwe	22.6 °C in July – 30.2 °C in October
Min. Temperature	Kadoma	8.5 °C in July – 17.8 °C in December
	Gokwe	8.9 °C in July – 18.0 °C in November
Relative Humidity	Kadoma	(not available)
	Gokwe	37.0 % in September – 74.0 % in January
Pan Evaporation	Kadoma	4.5 mm/day in June – 9.0 mm/day in October
	Gokwe	4.6 mm/day in June – 10.4 mm/day in September
Wind Speed	Kadoma	162.4 km/hr in February – 276.2 km/hr in October
	Gokwe	158.5 km/hr in January – 229.9 km/hr in October
Sunshine Hour	Kadoma	6.6 hours in December – 10.0 hours in August
	Gokwe	6.8 hours in December – 10.2 hours in August
Rainfall	Kadoma	0.3 mm in July – 184.7 mm in January
	Gokwe	0.2 mm in July – 182.1 mm in January

The mean annual rainfalls are recorded at 735.4 mm at Kadoma Station and 734.9 mm at Gokwe Station. The annual rainfall distribution is uneven showing that about 95% of annual rainfall is concentrated in the summer season from October to March and there is almost no rain in the winter season.

## 3. River Runoff

Among eleven hydrological gauging stations in and around the Munyati river basin, data of Station C8 at Munyati river, C9 at Kwekwe river, C36 at Sebakwe river and C48 at Umsweswe river are used for water resources development study with the Kudu Dam. Figs.2 to 5 show the availability of river runoff data at these four stations. As shown these figures, some data are intermittent and supplemented by using specific river runoff of the highest correlative station. The mean monthly discharges for the last 30 years are shown in Tables 2 to 5, and summarized below.

### Mean Monthly Discharges

( Unit : m<sup>3</sup>/sec )

Month	Station C8 (C.A=5,890km <sup>2</sup> )	Station C9 (C.A=1,250km <sup>2</sup> )	Station C36 (C.A=4,170km <sup>2</sup> )	Station C48 (C.A=2,480km <sup>2</sup> )
January	31.033	5.630	21.832	11.556
February	47.985	8.606	23.015	17.721
March	25.169	4.010	20.162	7.465
April	6.095	1.055	5.389	1.682
May	0.913	0.123	1.086	0.247
June	0.404	0.167	0.592	0.160
July	0.228	0.087	0.549	0.152
August	0.105	0.026	0.472	0.126
September	0.047	0.043	0.509	0.085
October	0.178	0.047	0.519	0.051
November	2.115	0.152	1.415	0.863
December	21.649	3.181	11.385	6.078
Annual	11.327	1.927	7.244	3.849

Fig.6 shows 10-days average river runoff, and Fig.7 presents the fluctuation of annual river runoff for the last 30 years. The annual river runoff shows wide fluctuation with the inclination to decrease in recent years.

#### 4. Water Rights

There are many water rights in the Muniyati river sub-hydrological zones. However, water rights at the upstream of the river runoff gauging stations are already abstracted in the measured river runoffs, and therefore only water rights of the downstream of gauging stations are considered for the water balance study. The annual total amounts of water rights in the downstream of river runoff gauging stations are shown in Tables 6 to 12, and summarized below.

### Water Rights

Section	Ref No. in Inflow Model	No. of Water Rights	Annual Total Amount (1,000m <sup>3</sup> )
Gauging Sta. C9 to KweKwe-Sebakwe CP	Q3	15	1,258.50
Gauging Sta. C36 to KweKwe-Sebakwe CP	Q7	9	5,901.00
KweKwe-Sebakwe CP to Sebakwe-Munyati CP	Q11	6	3,468.70
Gauging Sta. C8 to Munyati-Sebakwe CP	Q15	15	3,280.05
Munyati-Sebakwe CP to Munyati-Umsweswe CP	Q19	3	34.60
Gauging Sta. C48 to Umsweswe-Munyati CP	Q23	10	2,596.09
Kudu Dam Downstream to Munyati-Mupfure CP	Q26	12	20,858.42

Note : CP - Confluence Point

#### 5. Water Quality

The water quality survey was carried out so as to verify if the available water is suitable for the irrigation and domestic water use during the First Field Work. The following locations were selected and water was sampled at each site

##### (1) River water sampling locations

Site 1: Mazoe tributary, near Mari Mari Ranch

Site 2: Umsweswe river, 1-2 km downstream of Vic

Site 3: Upper Munyati river, 1 km upstream of Lucky Beanie

Site 4: Sebakwe river, 5-6 km upstream of confluence with Kwekwe river

Site 5: Kwekwe river, 1-2 km upstream of confluence with Sebakwe river

Site 6: Munyati river, causeway/bridge on the Empress Mine road

Site 7: Ngondoma tributary, 1-2 km downstream of Kudu dams site

Site 8: Munyati river, just downstream of confluence with the Mtanke river

Site 9: Munyati river, Renje bridge near Renji Camp

Site 10: Munyati river, downstream of Copper Queen (Cattle Fence)

(2) Well water sampling locations

Site 1: Kadoma district, Sanyati-K21, BH village 24

Site 2: Kadoma district, Sanyati-K22, BH village 9

Site 3: Kadoma district, Sanyati-K23, BH village 25

Site 4: Kadoma district, Sanyati-K24, BH village 32

Site 5: Kadoma district, Muzvezve I-K17, BH village 2

Site 6: Gokwe South district, Chisina I-GS 23 Vidco Batanai, BH Marundu

Site 7: Gokwe South district, Chisina I-GS 24 Vidco Murumemkuru, BH Nyamatshemi

Site 8: Gokwe South district, Chisina II-GS24 Vidco Mhungu, BH St. Cuthberts School

Site 9: Gokwe North district, Makore I-GN 11 Vidco Kushinga, BH Makore School

Site10: Gokwe North district, Ungwe State Land, Copper Queen Small Scale Commercial Farming Area, BH Ungwe School

20 samples (10 sites x 2 samples/site – December 1998 and February 1999) were collected from the river water sampling sites and 10 samples (10 sites x 1 sample/site) were taken from the existing wells. Water quality analysis was carried out on the following items for these 30 samples by the Government Analyst Laboratory on sub-contract basis.

- (a) Physical property Color, Turbidity, Water Temperature, Total Dissolved Solid (TDS), Suspended Solid (SS)
- (b) Chemical property Concentration (pH), Electric Conductivity (EC), Dissolved Oxygen (DO), Sodium (Na), Fluorine (F), Nitrogen (N), Phosphoric Acid (P), Magnesium (Mg), Calcium (Ca), Potassium (K), Mercury (Hg), Lead (Pb), Chromium (Cr), Cadmium (Cd), Copper (Cu)
- (c) Microorganism Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), COLIFORM (Plate count)

Laboratory analysis was completed and submitted to the JICA Study Team at the beginning of April 1999. The result of analysis is presented in Table 13 and it showed that Mercury, Lead and Coliforms concentrations were very high for both samples of rivers and the existing wells. The existing wells is being used for drinking by people in the area, and people's health is supposed to be severely affected if water has high concentrations of Mercury and Lead as shown in the result of analysis.

In order to confirm the reliability of the above result, additional analysis on Mercury and Lead was conducted during this Phase II Third Field Work. 10 samples from rivers and 10 samples from the existing wells were taken in January and February 2000 by JICA Study Team, and these samples were sent to Japan for analysis. The result of analysis in Japan showed low concentration of Mercury and Lead as presented in Table 14. All samples are under WHO standard, except for 2 samples from wells which show a little bit higher value of Lead. From this result, it can be said that water of rivers and wells in the area have no problem for domestic water use.



## ***TABLES***



**Table 1 Mean Monthly Climatological Data**

Name of Station : Kadoma

Description	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Average Rainfall (mm)	184.7	128.0	86.7	27.7	6.8	1.5	0.3	1.2	8.3	35.0	90.8	164.4	735.4
Air Temperature													
- Max. (°C)	28.6	28.4	28.9	28.1	26.4	24.1	24.0	26.7	30.4	32.0	30.7	29.0	28.1
- Min. (°C)	17.7	17.3	16.3	14.5	11.4	8.8	8.5	10.3	13.8	16.8	17.6	17.8	14.2
Relative Humidity (%)	-	-	-	-	-	-	-	-	-	-	-	-	-
Pan Evaporation (mm)	5.5	5.2	5.5	5.3	4.9	4.5	4.8	6.3	8.4	9.0	7.6	5.8	6.1
Wind Speed (km/hr)	176.6	162.4	172.0	193.5	194.2	212.5	226.9	246.2	264.9	276.2	244.2	204.0	214.5
Sunshine Hour (hrs)	7.2	7.3	8.3	8.9	9.2	9.2	9.4	10.0	9.9	9.1	7.5	6.6	8.6

Note : Data for relative humidity are not available.

Name of Station : Gokwe

Description	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Average Rainfall (mm)	182.1	158.7	76.3	34.4	5.9	1.1	0.2	0.7	3.5	26.3	85.2	160.4	734.8
Air Temperature													
- Max. (°C)	27.3	27.1	27.6	26.8	25.0	22.8	22.6	25.3	29.0	30.2	29.4	27.6	26.7
- Min. (°C)	17.7	17.4	17.0	15.1	12.0	9.3	8.9	11.4	15.2	17.6	18.0	17.6	14.8
Relative Humidity (%)	74.0	72.1	67.3	59.3	53.4	50.5	48.5	41.4	37.0	41.6	51.7	68.5	55.4
Pan Evaporation (mm)	5.5	5.5	5.8	5.6	5.1	4.6	4.9	6.3	10.4	8.9	7.5	5.7	6.3
Wind Speed (km/hr)	158.5	160.6	171.7	182.5	173.3	177.7	190.6	200.4	223.4	229.9	205.2	173.5	187.3
Sunshine Hour (hrs)	7.1	7.4	8.0	8.9	9.3	9.4	9.6	10.2	10.0	9.4	8.0	6.8	8.7





**Table 6 Summary of Water Right (Kwekwe River)**  
 <River runoff gauging station C9 to Kwekwe-Sebakwe confluence point>

Application No.	Property Name	River	Status	Priority (Y/M/D)	Abstract (m <sup>3</sup> /s)	Period (M/D)		Store (1000m <sup>3</sup> )	Abstract Total (1000m <sup>3</sup> )	Average Demand (m <sup>3</sup> /sec)
						From	To			
664	LOTS 27 & 28 CHICAGO	Kwekwe	FG	'45/5/3	0.00284	4/1	9/30	183	30.84	0.00195
1144	HUDSONS PLOT	Kwekwe	FG	'37/11/22	0.00142	10/1	9/30	365	15.42	0.00049
1274A	HAVEN ESTATE	Kwekwe	FG	'40/1/10	0.00284	4/1	9/30	183	30.84	0.00195
1274B	HAVEN ESTATE	Kwekwe	PR	'43/10/27	0.01000	4/1	9/30	183	10.00	0.00063
1568	STRATTON LOTS 27 & 28 CHICAGO	Kwekwe	FG	'45/5/3				365	45.46	0.00144
4687	S/D A GREENHAM	Kwekwe	FG	'60/1/9				365	81.83	0.00259
6568	S/D A RIVERLEA	Kwekwe	FG	'56/8/27				365	27.28	0.00086
6739	LOT 29 CHICAGO	Kwekwe	FG	'64/9/21	0.00057	10/1	9/30	365	8.00	0.00025
6756	LT29 CHICAGO FOR LT 1 RIVERLEA	Kwekwe	FG	'64/9/21	0.00057	12/15	3/31	106	56.00	0.00611
6914	EAST KWEKWE	Kwekwe	FG	'65/4/15				365	50.01	0.00159
8419	LOT 1 RIVERLEA	Kwekwe	FG	'65/4/20				365	50.01	0.00159
9174	AVALON OF GRAYDENE	Kwekwe	FG	'64/3/11	0.02841	12/15	3/31	106	185.02	0.02020
16002	GREENHAM	Kwekwe	FG	'68/7/26	0.01400	12/15	3/31	106	62.00	0.00677
M1349	GRAYDENE FOR TIGER REEF MINE	Kwekwe	PR	'70/11/18	0.02000	12/15	3/31	106	86.00	0.00939
M1398	CHESTERFIELD FR TIGERREEF MINE	Kwekwe	FG	'70/11/18				365	160.00	0.00507
	TOTAL				0.09865				556.58	0.07579

**Table 7 Summary of Water Right (Sebakwe River)**  
 <River runoff gauging station C36 to Kwekwe-Sebakwe confluence point>

Application No.	Property Name	River	Status	Priority (Y/M/D)	Abstract (m <sup>3</sup> /s)	Period (M/D)		Store (1000m <sup>3</sup> )	Abstract Total (1000m <sup>3</sup> )	Average Demand (1000m <sup>3</sup> /day)
						From	To			
6653	LOT 4A SHERWOOD	Sebakwe Lower	FG	'65/1/12	0.02200	4/1	9/30	183	93.00	0.00588
6653A	LOT 1 OF LOT4 SHERWOOD BLOCK	Sebakwe Lower	FG	'65/1/12	0.02131	12/15	3/31	106	92.51	0.01010
7629	LOT 4 A SHERWOOD BLOCK	Sebakwe Lower	FG	'66/9/5				365	264.00	0.00837
9314	LOT 7 OF SHERWOOD BLOCK	Sebakwe Lower	FG	'71/3/15				365	136.00	0.00431
11123	LOT 4A SHERWOOD BLOCK	Sebakwe Lower	FG	'76/4/20	0.04000	12/15	3/31	106	180.00	0.01965
11451	LOT 1 OF LOT 4 SHERWOOD BLOCK	Sebakwe Lower	PR	'78/1/18	0.05800	12/15	3/31	106	261.00	0.02850
12133	LOR 4A OF SHERWOOD BLOCK	Sebakwe Lower	FG	'81/4/22	0.07000	12/15	3/31	106	840.00	0.09172
14450	DELVILLE WOOD ESTATES	Sebakwe Lower	PR	'89/6/20				365	4000.00	0.12739
M1129	SEBAKWE MINE DUMPS	Sebakwe Lower	PR	'65/8/6	0.00055	10/1	9/30	365	17.27	0.00055
	TOTAL				0.2119				4400.00	1501.06

**Table 8 Summary of Water Right (Sebakwe River)**  
 <Kwekwe-Sebakwe confluence point to Sebakwe-Munyati confluence point>

Application No.	Property Name	River	Status	Priority (Y/M/D)	Abstract (m <sup>3</sup> /s)	Period (M/D)		Store (1000m <sup>3</sup> )	Abstract Total (1000m <sup>3</sup> )	Average Demand (1000m <sup>3</sup> /day)
						From	To			
2028	BROWNLANDS OF LINDALE	Sebakwe Lower	FG	'48/1/10	0.00139	4/1	9/30	183	25.00	0.00158
5835	BROWNLANDS OF LINDALE	Sebakwe Lower	FG	'61/1/30				365	120.00	0.00381
8636	LINDALE & DELVILLE WOOD	Sebakwe Lower	FG	'69/2/15	0.05660	12/15	3/31	106	246.70	0.02694
8781	IMPARA RANCH	Sebakwe Lower	FG	'71/3/29	0.25490	12/15	3/31	106	2220.00	0.24240
9440	DEVILLE WOOD & REM LINDALE	Sebakwe Lower	FG	'69/10/6	0.00500	10/1	9/30	365	49.00	0.00155
9441	BONSTED	Sebakwe Lower	FG	'71/7/14				365	68.00	0.00216
	TOTAL				0.17000	12/15	3/31	106	740.00	0.08080
					0.48789				188.00	3280.70

**Table 9 Summary of Water Right (Munyati River)**  
 <River runoff gauging station C8 to Munyati-Sebakwe confluence point>

Application No.	Property Name	River	Status	Priority (Y/M/D)	Abstract (m <sup>3</sup> /s)	Period (M/D)		Store (1000m <sup>3</sup> )	Abstract Total (1000m <sup>3</sup> )	Average Demand (1000m <sup>3</sup> /day)
						From	To			
1101	SELIMA	Munyati	FG	'42/6/16	0.01152	4/1	9/30	572.80	363.68	0.05923
1919	LORRAINE	Munyati	FG	'48/10/22	0.00284	10/1	9/30		30.84	0.00098
2187A	REM GLOVERS	Munyati	FG	'49/1/20	0.01133	10/1	9/30	159.11	123.35	0.00896
5193	RUNNIMEDE	Munyati	FG	'58/10/28	0.00426	10/1	9/30		46.26	0.00147
5608	RICHMOND FARM	Munyati	FG	'60/5/14	0.00284	10/1	9/30		30.84	0.00098
5949	KOPIES	Munyati	FG	'61/10/9				95.47		0.00303
7521	UMNIATI RANCH	Munyati	FG	'66/9/10				454.60		0.01442
8607	REM GLOVERS	Munyati	FG	'69/1/13				909.00		0.02882
M1080	JANET MINE	Munyati	FG	'71/1/26	0.07100	12/15	3/31		308.00	0.03363
M1166	RUNNIMEDE	Munyati	FG	'64/9/29	0.00126	10/1	9/30		39.80	0.00126
M1176	GLOVERS FOR OLYMPUS CONS	Munyati	FG	'68/1/2	0.00016	10/1	9/30		5.00	0.00016
M1177	GLOVERS FOR OLYMPUS CONS	Munyati	FG	'68/4/8	0.00005	10/1	9/30		1.82	0.00006
M1222	GLOVERS FARM FOR MID KENT	Munyati	FG	'68/4/8	0.00005	10/1	9/30		1.82	0.00006
R63	SELIMA	Munyati	FG	'70/9/14	0.00006	10/1	9/30		1.30	0.00004
R97	SELIMA	Munyati	FG	'39/4/12	0.00316	10/1	9/30		68.19	0.00216
	TOTAL			'56/5/5	0.00316	10/1	9/30	2190.97	1089.08	0.15741
					0.11169					



**Table 10 Summary of water Right (Munyati River)**  
 <Munyati-Sebakwe confluence point to Munyati-Umsweswe confluence point>

Application No.	Property Name	River	Status	Priority (Y/M/D)	Abstract (m <sup>3</sup> /s)	Period (M/D)		Store (1000m <sup>3</sup> )	Abstract Total (1000m <sup>3</sup> )	Average Demand (1000m <sup>3</sup> /day)
						From	To			
CR17	ROAD RESERVE	Munyati	FG	75/7/7	0.00002	4/1	9/30		0.60	0.00004
M1347	BULLER MINE	Munyati	PR	80/6/20	0.00079	10/1	9/30		17.00	0.00054
M1353	UMSWESWE RANDH FOR LINDA	Munyati	PR	80/7/14	0.00079	10/1	9/30		17.00	0.00054
	TOTAL				0.00159			0.00	34.60	0.00112

**Table 11 Summary of Water Right (Umsweswe River)**  
 <River runoff gauging station C48 to Umsweswe-Munyati confluence point>

Application No.	Property Name	River	Status	Priority (Y/M/D)	Abstract (m <sup>3</sup> /s)	Period (M/D)		Store (1000m <sup>3</sup> )	Abstract Total (1000m <sup>3</sup> )	Average Demand (1000m <sup>3</sup> /day)
						From	To			
4859	REM BENTLEY OF KANYEMBA ESTATE PF	Umsweswe	PF	'57/6/17		4/1	9/30	76.50		0.00484
				'69/11/8				38.50		0.00122
				90/10/15				94.50		0.00300
5021	REM KANYEMBA ESTATE	Umsweswe	PF	58/2/27				76.50		0.00243
				70/3/11				38.50		0.00122
6788	REM OF BENTLEY	Umsweswe	FG	'65/5/11	0.05683	10/1	3/31		370.04	0.02353
6863	REM OF KANYEMBA ESTATE	Umsweswe	FG	'65/7/22	0.05683	10/1	3/31		370.04	0.02353
9367	LOT 1 BENTLEY KENYEMBA ESTATE	Umsweswe	FG	71/5/12	0.00425	12/15	3/31		18.50	0.00202
				71/5/12	0.00000	4/1	12/14		2.00	0.00009
9887	LOT 6 BENTLEY, KENYEMBA ESTATE	Umsweswe	FG	72/9/6	0.00400	12/15	3/31		16.00	0.00175
10241	PAMENE & REM RAILWAT FARM 8	Umsweswe	FG	73/7/17	0.10000	12/15	5/31		500.00	0.03465
10242	LIDFORD AND CORYTON	Umsweswe	FG	73/7/17	0.10000	12/15	5/31		550.00	0.03812
10796	PTN A&B&REM S/D A KANYEMBA EST	Umsweswe	FG	74/11/15	0.04700	12/15	3/31		192.00	0.02096
				75/9/30				23.00		0.00073
14035	KENYEMBA ESTATE	Umsweswe	PR	'88/2/29				230.00		0.00729
	TOTAL				0.36890			577.50	2018.59	0.16538

**Table 12 Summary of Water Right (Munyati River)**  
 <Kudu Dam to Munyati-Mupfure confluence point>

Application No.	Property Name	River	Status	Priority (Y/M/D)	Abstract (m <sup>3</sup> /s)	Period (M/D)			Store (1000m <sup>3</sup> )	Abstract Total (1000m <sup>3</sup> )	Average Demand (1000m <sup>3</sup> /day)
						From	To	Days			
6011	SANYATI RANCH NO 3	Munyati	FG	'62/1/29	0.00568	10/1	9/30	365	61.67	0.00196	
6554	KUDU RIVER RANCH	Munyati	FG	'64/9/16	0.00500	12/15	3/31	106	28.00	0.00306	
6562	MURISON RANCH	Munyati	FG	'64/9/22				365	455.00	0.01443	
				'73/9/26				365	445.00	0.01411	
				'73/9/26		12/15	3/31	106	440.00	0.04804	
6695	KUDU RIVER RANCH	Munyati	FG	'65/2/23	0.00300	10/1	9/30	365	50.00	0.00159	
6894	SANYATI RANCH NO 3	Munyati	FG	'65/8/2	0.04700	10/1	9/30	365	567.00	0.01798	
6963	REM RHINO RANCH	Munyati	FG	'65/9/6	0.02200	11/15	3/31	137	130.00	0.01098	
				'65/9/6	0.00500	4/1	11/14	228	55.00	0.00279	
				'65/11/5	0.01500	4/1	12/14	258	442.00	0.01983	
7125	REM LODESTAR RANCH	Munyati	FG	'65/11/5	0.01500	12/15	3/31	106	45.00	0.00491	
				'74/12/23	0.01000	12/15	3/31	106	30.00	0.00328	
7779	SANYATI CL	Munyati	FG	'67/4/14	0.05660	10/1	9/30	365	616.74	0.01956	
8499	COPPER QUEEN 91	Munyati	FG	'68/10/16	0.00200	10/1	9/30	365	31.00	0.00098	
10578	GOKWE & SANYATI CL	Munyati	FG	'74/5/28	0.78000	10/1	9/30	365	6980.00	0.38844	
11299	CIRCLE K RANCH & GOKWE CL	Munyati	FG	'77/3/25				365	5200.00	0.16489	
13148	CHISINA CL	Munyati	FG	'85/4/24	0.00100	10/1	9/30	365	12.00	0.00038	
<b>TOTAL</b>									<b>11370.00</b>	<b>9488.42</b>	<b>0.71721</b>

**Table 13 Result of Water Analysis Undertaken during the Phase I First Field Work (1/3)**

Analysis Items	WHO Standard (1993)	Samples taken from Rivers on December 1998									
		Site 1 (Mazoe R.)	Site 2 (Umsweswe R.)	Site 3 (Upper M.R.)	Site 4 (Sebakwe R.)	Site 5 (Kwekwe R.)	Site 6 (Munyati R.)	Site 7 (Ngondoma R.)	Site 8 (Munyati R.)	Site 9 (Munyati R.)	Site 10 (Lower M.R.)
Color (TCU)	15.0	20.0	15.0	15.0	10.0	7.5	10.0	20.0	15.0	20.0	100.0
Turbidity (NTU)	5.0	163.2	92.1	148.0	57.7	6.1	90.3	275.0	185.0	202.0	1,605.0
Water Temperature (°C)		25.1	28.0	25.5	24.5	26.2	27.6	31.7	27.2	26.6	27.6
TDS (mg/l)	1,000.0	43.3	57.3	43.3	86.7	290.7	77.2	86.0	55.0	58.5	52.7
SS (mg/l)		0.04	0.03	0.06	0.006	0.003	0.03	0.04	0.03	0.04	1.46
pH	6.5 - 9.5	6.7	7.1	6.9	7.1	7.8	7.7	7.7	7.4	7.4	7.1
EC (mS <sup>m</sup> ⁻¹)		7.4	9.8	7.4	14.3	49.7	13.2	14.7	9.4	10.0	9.0
DO (mg/l)		19.1	11.2	9.0	11.7	12.4	9.7	9.3	9.6	9.4	7.3
Na (mg/l)	200.0	4.0	10.0	6.0	11.0	35.0	9.0	8.0	6.0	6.0	5.0
F (mg/l)	1.50	0.05	0.06	0.05	0.07	0.18	0.06	0.12	0.05	0.05	0.03
N (mg/l)	50.0	not detected	not detected	not detected	not detected	2.1	not detected	not detected	not detected	not detected	not detected
P (mg/l)		not detected	not detected	not detected	0.1	not detected	not detected	not detected	not detected	not detected	not detected
Mg (mg/l)		4.5	5.5	6.5	9.0	29.0	8.5	8.5	6.5	7.0	9.0
Ca (mg/l)		9.0	12.3	7.4	17.2	45.0	15.6	22.9	9.8	12.3	15.6
K (mg/l)		5.8	6.1	5.5	8.8	7.8	6.5	8.8	6.4	7.0	17.0
Hg (mg/l)	0.001	0.02	0.09	0.09	0.08	0.08	0.11	0.11	0.10	0.09	0.20
Pb (mg/l)	0.01	0.20	0.25	0.35	0.25	0.12	0.29	0.08	0.33	0.27	0.24
Cr (mg/l)	0.05	not detected	not detected	not detected	not detected	not detected	not detected	0.04	0.04	not detected	0.12
Cd (mg/l)	0.003	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected
Cu (mg/l)	1.00	not detected	0.06	0.04	0.08	0.08	0.16	0.21	0.20	0.22	0.23
BOD (mg/l)	5.0	3.4	2.8	2.9	2.5	2.4	2.6	1.5	2.7	2.5	2.8
COD (mg/l)	30.0	not detected	not detected	not detected	23.7	15.8	19.8	19.8	23.7	35.6	79.0
COLIFORM (MPN/100ml) (CFU/ml)	10	920 1 x 10 <sup>3</sup>	920 1 x 10 <sup>3</sup>	350 2 x 10 <sup>3</sup>	140 2 x 10 <sup>2</sup>	180 2 x 10 <sup>1</sup>	1,600 2 x 10 <sup>1</sup>	> 1,800 2 x 10 <sup>1</sup>	> 1,800 1 x 10 <sup>2</sup>	> 1,800 2 x 10 <sup>2</sup>	> 1,800 1 x 10 <sup>2</sup>

(Note) TDS : Total Dissolved Solid, SS : Suspended Solid, EC : Electric Conductivity, DO : Dissolved Oxygen, Na : Sodium, F : Fluorine,  
 N : Nitrogen, P : Phosphoric Acid, Mg : Magnesium, Ca : Calcium, K : Potassium, Hg : Mercury, Pb : Lead, Cr : Chromium,  
 Cd : Cadmium, Cu : Copper, BOD : Biological Oxygen Demand, COD : Chemical Oxygen Demand

**Table 13 Result of Water Analysis Undertaken during the Phase I First Fuel Work (2/3)**

Analysis Items	WHO Standard (1993)	Samples taken from Rivers on February 1999									
		Site 1 (Mazoe R.)	Site 2 (Umswesve R.)	Site 3 (Upper M.R.)	Site 4 (Sebakwe R.)	Site 5 (Kwekwe R.)	Site 6 (Munyangi R.)	Site 7 (Ngondoma R.)	Site 8 (Munyangi R.)	Site 9 (Munyangi R.)	Site 10 (Lower M.R.)
Color (TCU)	15.0	2.5	5.0	5.0	2.5	7.5	10.0	2.5	5.0	5.0	7.5
Turbidity (NTU)	5.0	41.2	75.1	37.7	51.0	68.1	83.4	117.0	58.8	78.7	83.7
Water Temperature (°C)		25.8	24.9	24.6	23.9	23.2	23.9	26.2	24.3	24.9	24.8
TDS (mg/l)	1,000.0	63.8	44.5	53.8	48.6	69.0	46.8	97.1	51.5	42.1	45.0
SS (mg/l)		0.001	0.001	0.001	0.006	0.003	0.002	0.004	0.003	0.002	0.005
pH	6.5 - 9.5	7.5	7.5	7.7	7.5	7.5	7.6	7.9	7.7	7.7	7.4
EC (mSm <sup>-1</sup> )		10.9	7.6	9.2	8.3	11.8	8.0	16.6	8.8	7.2	7.7
DO (mg/l)		17.7	17.4	20.2	18.3	18.9	20.9	20.6	19.5	21.1	20.3
Na (mg/l)	200.0	8.0	7.0	5.0	7.0	11.0	6.0	15.0	7.0	6.0	6.0
F (mg/l)	1.50	0.05	0.02	0.02	not detected	not detected	not detected	0.01	not detected	0.01	not detected
N (mg/l)	50.0	2.5	not detected	4.6	2.4	5.8	0.7	3.4	3.2	not detected	not detected
P (mg/l)		0.01	0.01	0.03	0.10	0.13	0.30	0.40	0.20	1.00	1.20
Mg (mg/l)		4.5	3.5	7.0	6.0	4.0	4.0	4.5	4.0	3.5	3.5
Ca (mg/l)		13.1	8.2	7.4	6.5	13.1	7.4	21.3	9.0	7.4	9.8
K (mg/l)		3.9	5.3	4.1	5.0	5.0	4.6	7.3	4.8	5.1	6.5
Hg (mg/l)	0.001	0.12	0.09	0.11	0.10	0.11	0.12	0.07	0.11	0.14	0.07
Pb (mg/l)	0.01	not detected	not detected	0.01	not detected	0.01	0.02	0.03	0.04	0.08	0.04
Cr (mg/l)	0.05	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected
Cd (mg/l)	0.003	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected
Cu (mg/l)	1.00	not detected	not detected	not detected	0.06	0.03	0.03	0.04	0.01	0.06	0.01
BOD (mg/l)	5.0	3.6	2.0	2.6	2.9	3.8	2.8	1.8	2.7	3.0	2.7
COD (mg/l)	30.0	15.8	7.9	11.9	11.9	35.6	35.6	27.7	27.7	11.9	27.7
COLIFORM (MPN/100ml) (CFU/ml)	10	> 1,800 3 x 10 <sup>2</sup>	920 9 x 10 <sup>2</sup>	> 1,800 9 x 10 <sup>4</sup>	> 1,800 8 x 10 <sup>2</sup>	920 7 x 10 <sup>3</sup>	1,600 2 x 10 <sup>2</sup>	1,600 1 x 10 <sup>2</sup>	> 1,800 7 x 10 <sup>2</sup>	1,600 2 x 10 <sup>2</sup>	1,600 1 x 10 <sup>4</sup>

(Note) TDS : Total Dissolved Solid, SS : Suspended Solid, EC : Electric Conductivity, DO : Dissolved Oxygen, Na : Sodium, F : Fluorine, N : Nitrogen, P : Phosphoric Acid, Mg : Magnesium, Ca : Calcium, K : Potassium, Hg : Mercury, Pb : Lead, Cr : Chromium, Cd : Cadmium, Cu : Copper, BOD : Biological Oxygen Demand, COD : Chemical Oxygen Demand

**Table 13 Result of Water Analysis Undertaken during the Phase I First Field Work (3/3)**

Analysis Items	WHO Standard (1993)	Samples taken from Wells on January 1999									
		Site 1 (Village 24)	Site 2 (Village 9)	Site 3 (Village 25)	Site 4 (Village 32)	Site 5 (Village 2)	Site 6 (Marundu)	Site 7 (Nyamatshem)	Site 8 (St.C.School)	Site 9 (Mak. School)	Site 10 (Ung. School)
Color (TCU)	15.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	10.0	
Turbidity (NTU)	5.0	5.4	36.4	20.5	55.5	2.2	16.5	6.0	4.7	570.0	
Water Temperature (°C)		28.6	27.4	27.8	27.7	25.1	28.5	26.2	27.5	26.2	
TDS (mg/l)	1,000.0	501.3	108.2	294.3	80.7	445.8	233.4	685.0	869.3	459.2	
SS (mg/l)		not detected	0.001	0.001	0.002	0.001	0.002	not detected	not detected	0.06	
pH	6.5 - 9.5	7.2	6.5	7.2	6.3	7.1	7.5	7.6	7.3	7.0	
EC (mSm <sup>-1</sup> )		85.7	18.5	50.3	13.8	76.2	39.9	117.1	143.6	78.5	
DO (mg/l)		3.0	7.1	3.2	3.9	2.8	2.6	4.1	4.6	5.3	
Na (mg/l)	200.0	11.0	8.0	49.0	12.0	52.0	245.0	175.0	62.0	21.0	
F (mg/l)	1.50	0.20	0.17	0.71	0.25	0.26	0.28	0.94	0.36	0.22	
N (mg/l)	50.0	7.2	8.2	0.2	0.6	8.7	0.6	1.3	14.5	1.2	
P (mg/l)		not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	
Mg (mg/l)		74.5	2.5	27.5	5.5	40.5	22.5	21.0	78.0	36.0	
Ca (mg/l)		97.4	29.5	50.7	17.2	100.7	80.2	67.1	125.2	103.9	
K (mg/l)		not detected	15.4	0.9	9.0	not detected	2.3	not detected	0.03	11.8	
Hg (mg/l)	0.001	0.10	0.08	0.10	0.09	0.09	0.10	0.11	0.11	0.11	
Pb (mg/l)	0.01	0.5	0.5	0.6	0.4	0.5	0.6	0.5	0.7	0.5	
Cr (mg/l)	0.05	2.9	3.2	3.2	3.5	3.0	2.9	2.4	2.4	2.8	
Cd (mg/l)	0.003	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	
Cu (mg/l)	1.00	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	not detected	
BOD (mg/l)	5.0	1.6	0.04	0.08	0.08	4.0	7.9	0.92	1.8	0.08	
COD (mg/l)	30.0	not detected	7.9	15.8	7.9	4.0	7.9	7.9	15.8	4.0	
COLIFORM (MPN/100ml) (CFU/ml)	10	> 1,800 3 x 10 <sup>5</sup>	920 9 x 10 <sup>2</sup>	> 1,800 9 x 10 <sup>4</sup>	> 1,800 8 x 10 <sup>3</sup>	920 7 x 10 <sup>3</sup>	1,600 2 x 10 <sup>2</sup>	1,600 1 x 10 <sup>2</sup>	> 1,800 7 x 10 <sup>2</sup>	1,600 2 x 10 <sup>3</sup>	

(Note) TDS : Total Dissolved Solid, SS : Suspended Solid, EC : Electric Conductivity, DO : Dissolved Oxygen, Na : Sodium, F : Fluorine,  
 N : Nitrogen, P : Phosphoric Acid, Mg : Magnesium, Ca : Calcium, K : Potassium, Hg : Mercury, Pb : Lead, Cr : Chromium,  
 Cd : Cadmium, Cu : Copper, BOD : Biological Oxygen Demand, COD : Chemical Oxygen Demand

**Table 14 Result of Water Quality Analysis of Mercury and Lead Undertaken during the Phase II Third Field Work**

( Unit : mg/l )

Sampling Locations	Analysis in Zimbabwe(GAL)				Analysis in Japan	
	Dec. 1998		Jan./Feb. 1999		Feb. 2000	
	Hg	Pb	Hg	Pb	Hg	Pb
(River)						
Site 1. Mazoe tributary, near Mari Mari Ranch	<b>0.02</b>	<b>0.20</b>	<b>0.12</b>	not detected	0.00005	0.0017
Site 2. Umsweswe river, 1-2 km downstream of Vic	<b>0.09</b>	<b>0.25</b>	<b>0.09</b>	not detected	<0.00003	0.0026
Site 3. Upper Munyati river, 1 km upstream of Lucky Beanie	<b>0.09</b>	<b>0.35</b>	<b>0.11</b>	0.01	0.00004	0.0025
Site 4. Sebakwe river, 5-6 km upstream of confluence with Kwekwe river	<b>0.08</b>	<b>0.25</b>	<b>0.10</b>	not detected	<0.00003	0.0035
Site 5. Kwekwe river, 1-2 km upstream of confluence with Sebakwe river	<b>0.08</b>	<b>0.12</b>	<b>0.11</b>	0.01		
Site 6. Munyati river, causeway/bridge on Empress Mine road	<b>0.11</b>	<b>0.29</b>	<b>0.12</b>	<b>0.02</b>	0.00008	0.0048
Site 7. Ngondoma tributary, 1-2 km downstream of Kudu damsite	<b>0.11</b>	<b>0.08</b>	<b>0.07</b>	<b>0.03</b>	0.00007	0.0082
Site 8. Munyati river, just downstream of confluence with Mtanke river	<b>0.10</b>	<b>0.33</b>	<b>0.11</b>	<b>0.04</b>	0.00003	0.0045
Site 9. Munyati river, Renji bridge near Renji Camp	<b>0.09</b>	<b>0.27</b>	<b>0.14</b>	<b>0.08</b>	<0.00003	0.0017
Site 10. Munyati river, downstream of Copper Queen	<b>0.20</b>	<b>0.24</b>	<b>0.07</b>	<b>0.04</b>	- under analysis -	
Site 11. Nyarupakwe Dam Site	-	-	-	-	- under analysis -	
(Well)						
Site 1. Sanyati-K21, BH village 24	-	-	<b>0.10</b>	<b>0.50</b>	<0.00003	0.0040
Site 2. Sanyati-K22, BH village 9	-	-	<b>0.08</b>	<b>0.50</b>	<0.00003	0.0072
Site 3. Sanyati-K23, BH village 25	-	-	<b>0.10</b>	<b>0.60</b>	<0.00003	<b>0.0116</b>
Site 4. Sanyati-K24, BH village 32	-	-	<b>0.09</b>	<b>0.40</b>	<0.00003	0.0057
Site 5. Muzvezve I-K17, BH village 2	-	-	<b>0.09</b>	<b>0.50</b>	<0.00003	0.0044
Site 6. Chisina I-GS 23 Vidco Batanai, BH Marundu	-	-	<b>0.10</b>	<b>0.60</b>	<0.00003	0.0021
Site 7. Chisina I-GS 24 Vidco Murumemkuru, BH Nyamatshemi	-	-	<b>0.11</b>	<b>0.50</b>	<0.00003	0.0014
Site 8. Chisina II-GS 24 Vidco Mhungu, BH St. Cuthberts School	-	-	<b>0.11</b>	<b>0.70</b>	0.00033	0.0029
Site 9. Makore I-GN 11 Vidco Kushinga, BH Makore School	-	-	<b>0.11</b>	<b>0.50</b>	<0.00003	0.0019
Site 10. Copper Queen Small Scale Commercial Farming Area, BH Ungwe School	-	-	not detected	<b>0.50</b>	<0.00003	<b>0.0496</b>

Note : (1) Hg - Mercury, Pb - Lead

(2) WHO Standard (1993) : Hg = 0.001 mg/l, Pb = 0.01 mg/l

(3) Bold figures show higher values than WHO Standard.

## ***FIGURES***





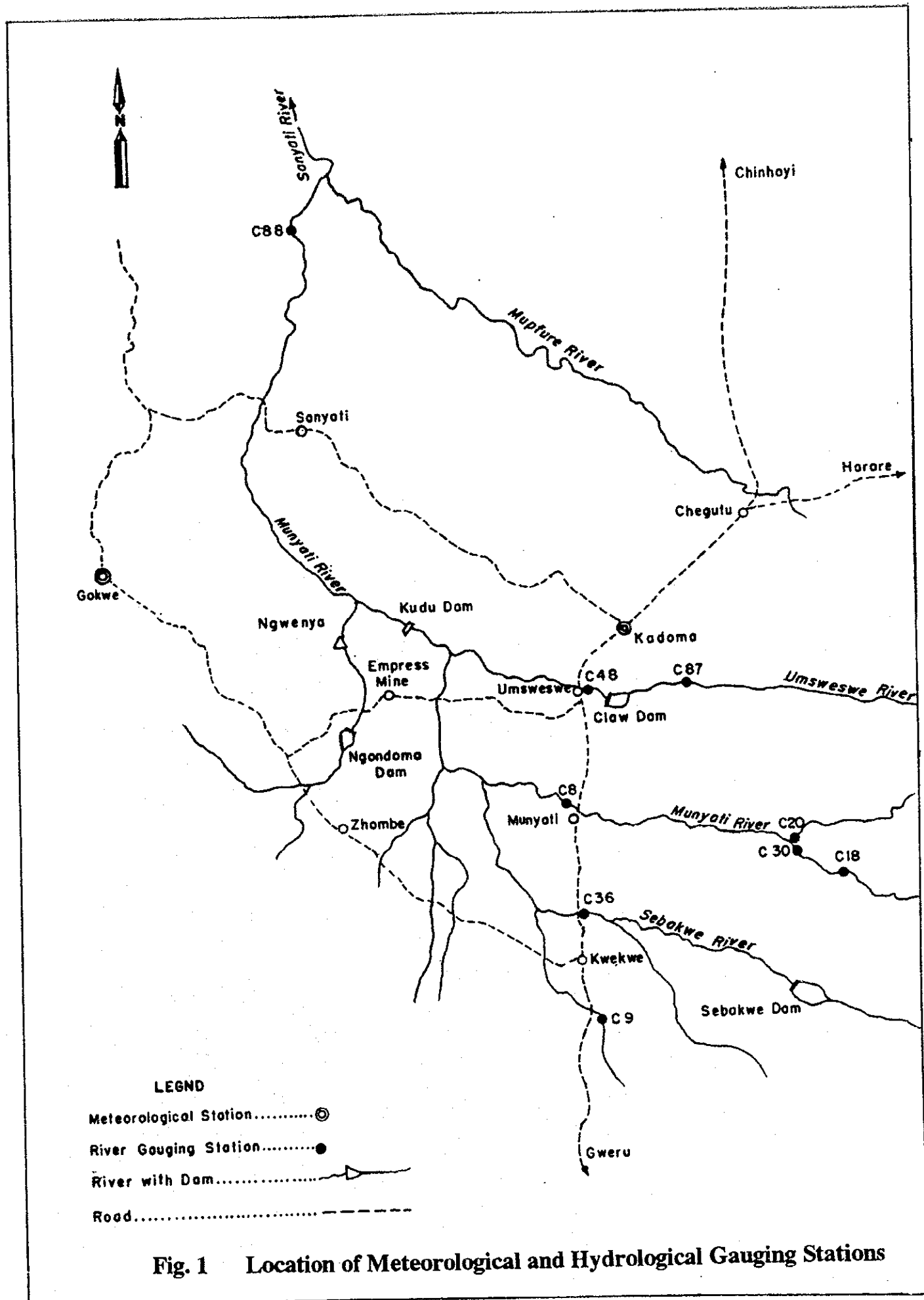






Fig. 3 Availability of River Runoff Data (Gauging Station C9)

C9	Oct			Nov			Dec			Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1966 to 1967	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
1967 to 1968	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
1968 to 1969																																				
1969 to 1970	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
1970 to 1971																																				
1971 to 1972	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
1972 to 1973																																				
1973 to 1974																																				
1974 to 1975	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
1975 to 1976	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
1976 to 1977	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
1977 to 1978	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
1978 to 1979	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		
1979 to 1980																																				
1980 to 1981																																				
1981 to 1982																																				
1982 to 1983	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
1983 to 1984																																				
1984 to 1985																																				
1985 to 1986																																				
1986 to 1987																																				
1987 to 1988																																				
1988 to 1989																																				
1989 to 1990																																				
1990 to 1991																																				
1991 to 1992																																				
1992 to 1993	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
1993 to 1994																																				
1994 to 1995	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
1995 to 1996	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
1996 to 1997	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2		

 Original Data (C9)
  Some of Data are Estimated from 2nd Priority Station (C18)





 Some of Data are Estimated from 1st Priority Station (C8)

Fig. 4 Availability of River Runoff Data (Gauging Station C36)

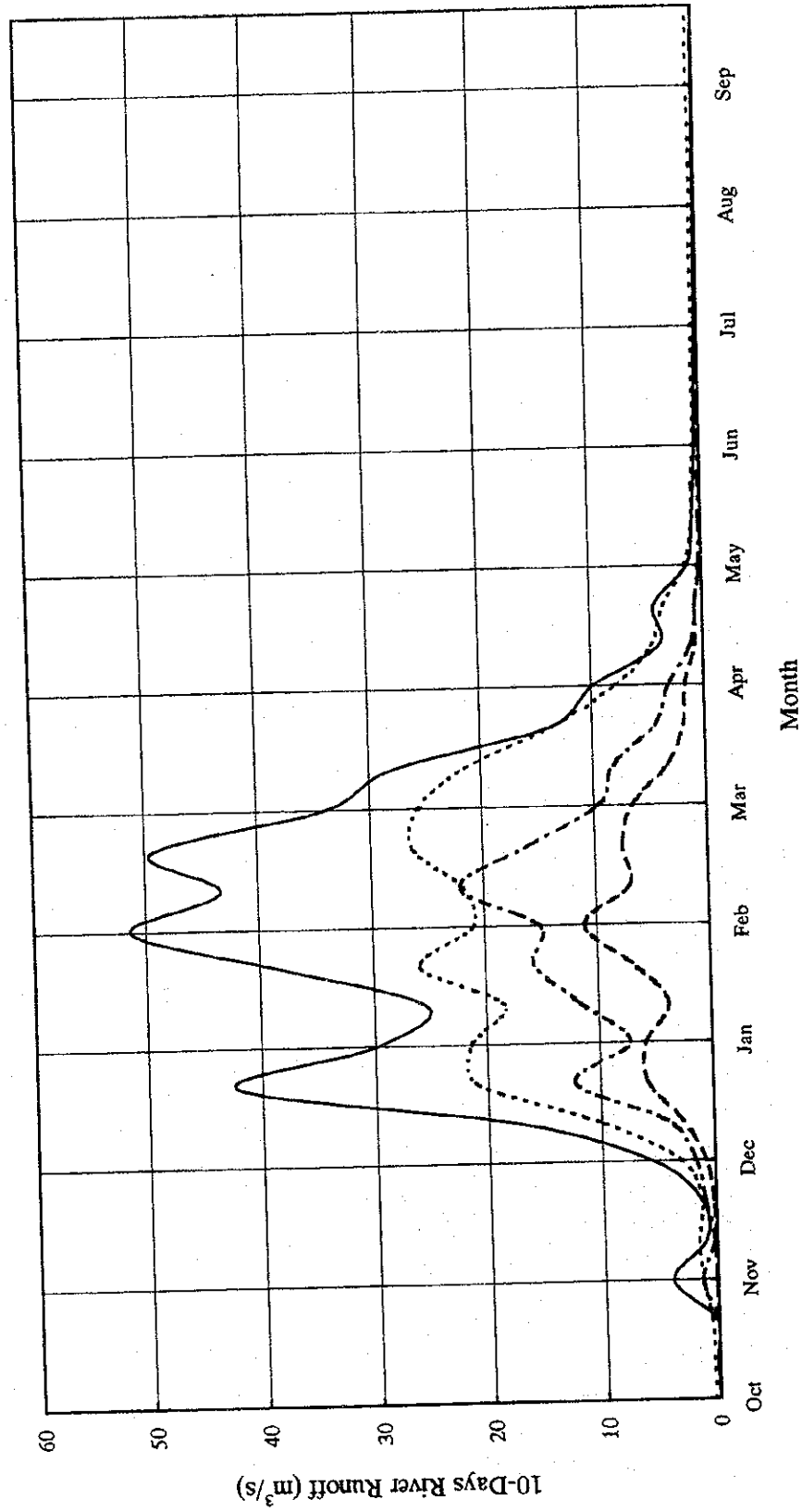
C36	Oct			Nov			Dec			Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1966 to 1967	Original Data (C36)																																			
1967 to 1968	Original Data (C36)																																			
1968 to 1969	Original Data (C36)																																			
1969 to 1970	Original Data (C36)																																			
1970 to 1971	Original Data (C36)																																			
1971 to 1972	Original Data (C36)																																			
1972 to 1973	Original Data (C36)																																			
1973 to 1974	Original Data (C36)																																			
1974 to 1975	Original Data (C36)																																			
1975 to 1976	Original Data (C36)																																			
1976 to 1977	Original Data (C36)																																			
1977 to 1978	Original Data (C36)																																			
1978 to 1979	Original Data (C36)																																			
1979 to 1980	Original Data (C36)																																			
1980 to 1981	Original Data (C36)																																			
1981 to 1982	Original Data (C36)																																			
1982 to 1983	Original Data (C36)																																			
1983 to 1984	Original Data (C36)																																			
1984 to 1985	Original Data (C36)																																			
1985 to 1986	Original Data (C36)																																			
1986 to 1987	Original Data (C36)																																			
1987 to 1988	Original Data (C36)																																			
1988 to 1989	Original Data (C36)																																			
1989 to 1990	Original Data (C36)																																			
1990 to 1991	Original Data (C36)																																			
1991 to 1992	Original Data (C36)																																			
1992 to 1993	Original Data (C36)																																			
1993 to 1994	Original Data (C36)																																			
1994 to 1995	Original Data (C36)																																			
1995 to 1996	Original Data (C36)																																			
1996 to 1997	Original Data (C36)																																			

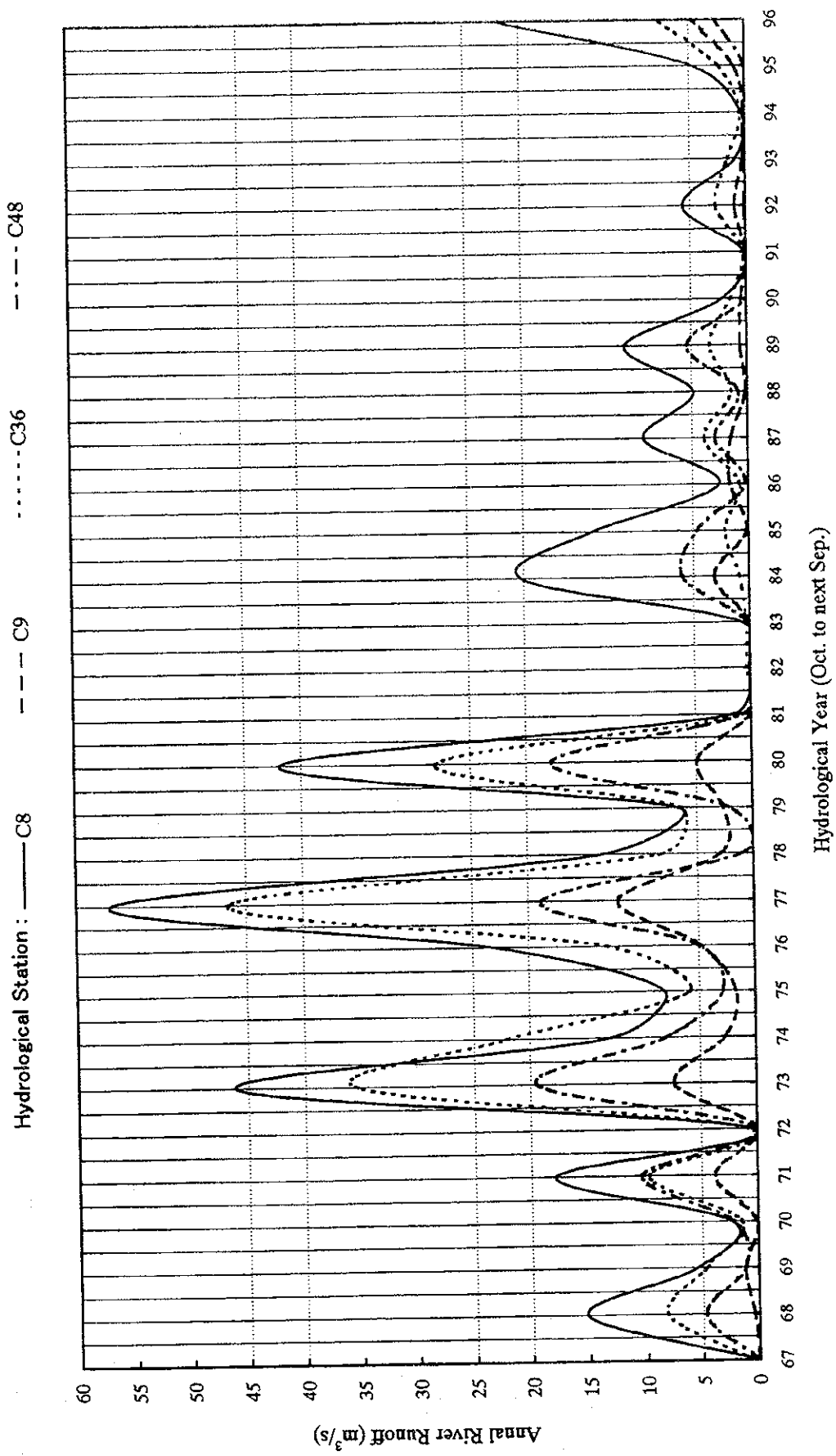
	Original Data (C36)		Some of Data are Estimated from 2nd Priority Station (C18)
	Some of Data are Estimated from 1st Priority Station (C8)		



Hydrological Station : ——— C8 — — — C9 ..... C36 - - - - C48



**Fig. 6 10-Days Average River Runoff**



**Fig. 7 Fluctuation of Annual River Runoff (Last 30 Years)**

