A GENERIC WATER BALANCE FOR THE SOUTH AFRICAN COAL MINING INDUSTRY

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Water Research Commission

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by

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"A generic water balance for the South African coal mining industry"

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The Steering Committee responsible for this project, consisted of the following persons:

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Mr AC Fritz	Water Research Commission (Secretary)
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February 2001

EXECUTIVE SUMMARY

1. INTRODUCTION

In order to be able to plan research initiatives and to have benchmarks against which mine water management on coal mines could be measured, a need was identified to develop a generic water balance for the coal mining industry. When the research project was undertaken, there were sixty-five operating coal mines of various sizes in South Africa. A total of forty-one mines have been included in the database used in this investigation, which represents 66% of the total number of operating coal mines in South Africa. In terms of the run-of-mine total production, this investigation included mines that represented 88% of the total coal production in South Africa.

The development of an industry-wide water balance enables the mines, authorities and other role players to set some benchmarks that can be used to evaluate the water management performance of individual mines. It was also felt that the development of such an industry-wide water balance would assist in informing future research priorities.

2. RESEARCH METHODOLOGY

A generic water balance was developed for the following types of coal mining operations:

- Open cast with beneficiation plant.
- Open cast without beneficiation plant.
- Underground bord and pillar with beneficiation plant.
- Underground bord and pillar mine without beneficiation plant.
- Underground total extraction mine with beneficiation plant.
- Open cast and underground bord and pillar mining with beneficiation plants.
- Open cast and underground bord and pillar mining without beneficiation plants.

The prepared water balances have been devised to be both sufficiently generic to be of use for a wide range of mines and sufficiently detailed to show useful information. In a generic sense, the overall balance has been constructed on the basis of a 4-stage process as shown schematically below.

WATER SOURCES → WATER USERS → WATER STORAGE → WATER SINKS

The various water sources that are considered are:

- Board water
- River water
- Ground water (either through boreholes or ingress into mine workings)
- Rain water
- Unspecified sources (unspecified combination of the above)

Water users that are considered in the generic balance are:
- Potable water treatment plant (treating river or ground water)
- Domestic water users (drinking and ablution water in houses, hostels, offices, plant and mine, but excluding industrial users of potable water)
- Sewage treatment plant
- Irrigation of treated sewage
- Mine workings (underground or open pit)
- Beneficiation plant
- Slurry dam
- Road wetting for dust suppression

Provision is made for intermediate storage of the following types of water:
- Potable water
- Treated sewage
- Dirty water (including water pumped from mine workings, plant process water, slurry dam return water, contaminated stormwater, etc.)

Sinks for discharged water are:
- Human consumption
- Surface water on coal product and coarse discard
- Discharge to rivers
- Evaporation
- Discharge to unspecified sinks (unspecified combination of all of the above plus ground water)

This project was severely hampered by the following:

1. Reluctance of mines to provide data, resulting in repeated requests for information.
2. Generally inadequate water balances provided by mines, requiring extensive manipulation of data by the project team and resulting in large percentages of unspecified water sources and sinks.

3. DISCUSSION OF RESULTS

The overall summary water balance for the coal mining industry (based on the survey mines) is shown in Figure I below, with a more detailed generic water balance shown in Figure II. Summary data is shown in Tables I and II. Similar water balances have been prepared for all the following categories of mining:

- Open cast mines with beneficiation plant.
- Open cast mines without beneficiation plant.
- Underground bord and pillar mines with beneficiation plant.
- Underground bord and pillar mines without beneficiation plant.
- Underground total extraction mines with beneficiation plant.
- Open cast and underground bord and pillar mines with beneficiation plants.
- Open cast and underground bord and pillar mines without beneficiation plants.
- All mines located in the Olifants River catchment.
- All mines located in the Vaal River catchment.

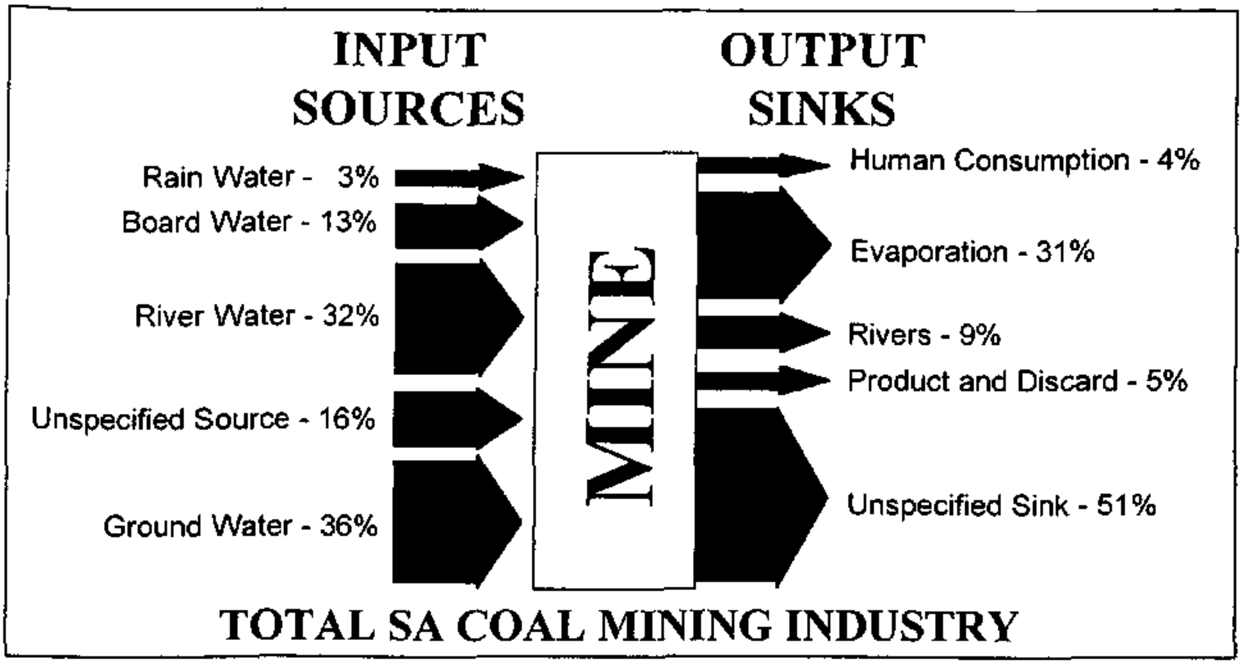


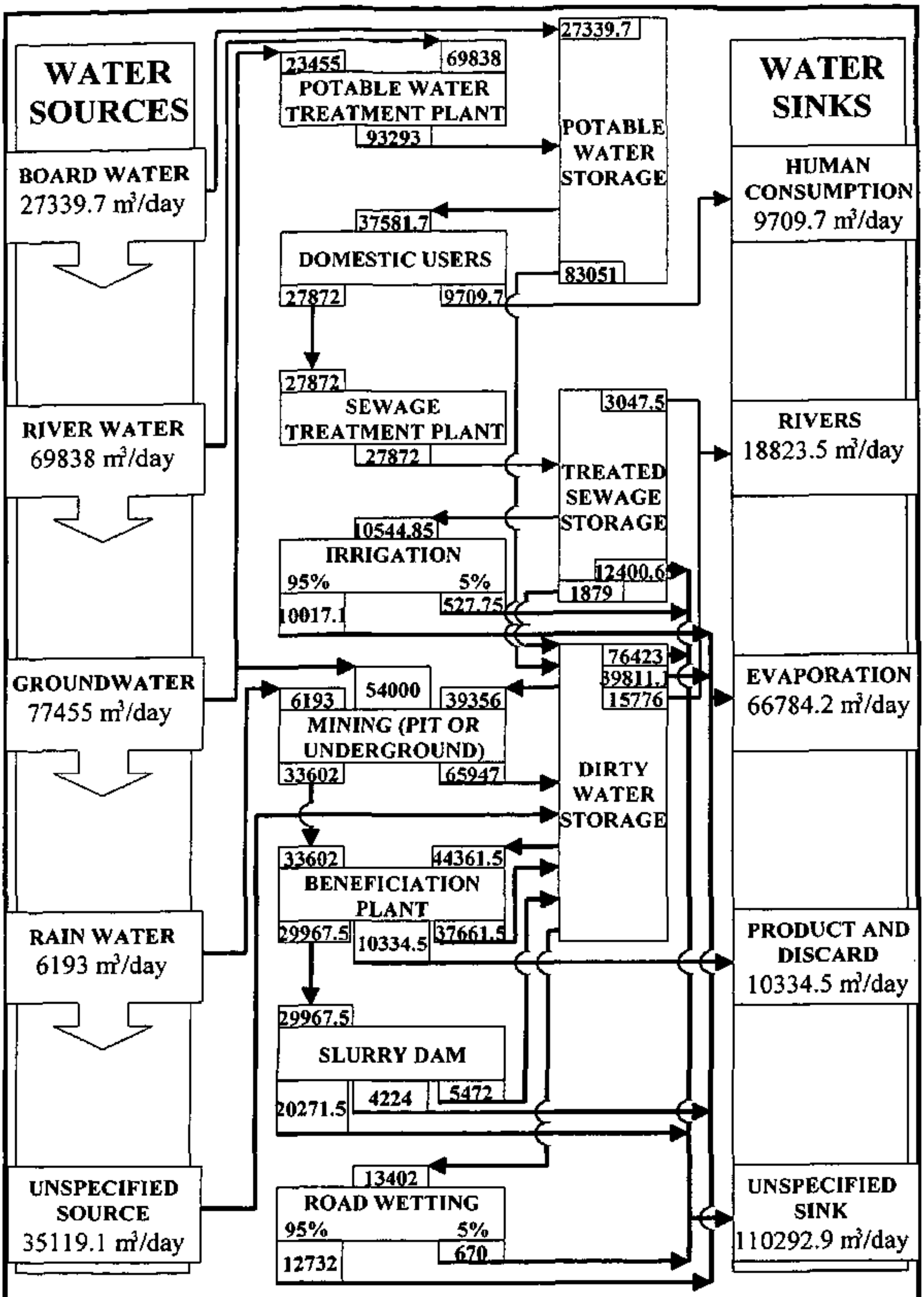
Figure I: Summary water balance for the South African coal mining industry

The overall water balance for the South African coal mining industry indicates that on average, 133 l of water is used for each ton of coal that is mined. A large percentage, approximately 85%, use underground or pit water as a water source compared to some 57% that extract board water as a water source. Volumetrically, the primary source of water came from ground water and river water, contributing 35.9% and 32.3% respectively. Board water as a primary source, contributed 12.7% of the total water source.

Beneficiation plants consumed the largest portion, *i.e.* 36.1%, of the water used by the industry, compared to mining operations that used 25% of the available water. Six percent of the total water consumed by the coal mining industry was used for road wetting. Approximately 31% of the available potable water is used for domestic purposes, with 18.8% of the latter volume of water actually being consumed.

Only ten mines, *i.e.* 25% of the total number of mines, have included seepage as a parameter in water balance calculations, creating the erroneous perception that seepage from coal mines is not a problem. This omission reflects, among others, the lack of detail contained in water balances produced by the majority of mines. In general, the water balances provided by the mines suffer from a lack of detail, *e.g.* 40% have not included evaporation in their water balance.

The incompleteness of water balances on South African coal mines is reflected in the large percentage, i.e. 51.1%, of effluent being discharged into unspecified sinks. These unspecified sinks could include loss of water that is difficult to quantify, such as ground water, but could also indicate a lack of good water balance information for each individual mine. In general, water is lost in the following manners: human consumption – 4.5%; rivers – 8.7%; evaporation – 30.9%; and water lost as moisture with the coal and discard material – 4.8%.



All values in m³/day

Figure II: Overall generic water balance for the South African coal mining industry

Table I: Summary of water sources data for all survey mines

Stream	Opencast with beneficiation plant	Opencast without beneficiation plant	Underground bord&pillar with beneficiation plant	Underground bord&pillar without beneficiation plant	Total extraction with beneficiation plant	Opencast and bord&pillar with beneficiation plant	Opencast and bord&pillar without beneficiation plant	TOTAL SURVEY MINES
Coal production (t/d)	*159056*	*1168333*	*130650*	*6167*	*833*	*137693*	*26052*	*1628784*
No of mines	*8*	*2*	*13*	*3*	*1*	*11*	*3*	*41*
BOARD WATER								
Volume (m^3)	2537	1205	18336	0	0	3576	1686	27340
% of budget	4	8	25	0	0	7	48	13
Specific usage (l/t)	15.95	1.03	140.34	0	0	25.97	64.72	16.79
RAIN WATER								
Volume (m^3)	2106	1377	0	0	0	2710	0	6193
% of budget	3	9	0	0	0	6	0	3
Specific usage (l/t)	13.24	1.18	0	0	0	19.68	0	3.80
RIVER WATER								
Volume (m^3)	18824	10822	15427	90	3500	20673	502	69838
% of budget	31	68	21	10	31	42	14	32
Specific usage (l/t)	118.35	9.26	118.08	14.59	4201.68	150.14	19.27	42.88
GROUND WATER								
Volume (m^3)	26726	2442	30004	828	1300	15914	241	77455
% of budget	45	15	40	88	11	33	7	36
Specific usage (l/t)	168.03	2.09	229.65	134.26	1560.60	115.58	9.25	47.55
UNSPECIFIED SOURCES								
Volume (m^3)	10495	0	10838	25	6540	6146	1075	35119
% of budget	17	0	14	2	58	12	31	16
Specific usage (l/t)	65.98	0	82.95	4.05	7851.14	44.64	41.26	21.56
TOTAL WATER SOURCES								
Volume (m^3)	60688	15846	74605	943	11340	49019	3504	215945
% of budget	100	100	100	100	100	100	100	100
Specific usage (l/t)	381.55	13.56	571.03	152.91	13613.45	356.00	134.50	132.58

An evaluation of the different components of the water balance is presented in the following sections of this chapter. The data shown in Tables I and II clearly indicate that there are two categories of mine that deviate substantially from the average values. The 2 mines classed as opencast without a beneficiation plant account for a large percentage (71.7%) of the overall coal production but exhibit an extremely low water usage based on supplied data. On the other hand, the single total extraction mine with a beneficiation plant has a very small coal production but an extremely high water usage. If the data for these three mines are excluded then the average data for all the survey mines changes substantially as shown below:

- Average specific board water usage changes from 16.79 l/t to 56.86 l/t
- Average specific rain water usage changes from 3.80 l/t to 10.48 l/t
- Average specific river water usage changes from 42.88 l/t to 120.79 l/t
- Average specific ground water usage changes from 47.55 l/t to 160.38 l/t
- Average water usage from unspecified sources changes from 21.56 l/t to 62.18 l/t
- Average human consumption of water changes from 5.96 l/t to 18.94 l/t
- Average water discharge to river changes from 11.56 l/t to 40.96 l/t
- Average water loss to product and discard moisture changes from 6.34 l/t to 22.48 l/t

- Average evaporative water loss changes from 41.00 l/t to 144.76 l/t
- Average water discharge to unspecified sinks changes from 67.71 l/t to 183.56 l/t
- Average total water usage changes from 132.58 l/t to 410.69 l/t

Table II: Summary of water sinks data for all survey mines

Stream	Opencast with beneficiation plant	Opencast without beneficiation plant	Underground bord&pillar with beneficiation plant	Underground bord&pillar without beneficiation plant	Total extraction with beneficiation plant	Opencast and bord&pillar with beneficiation plant	Opencast and bord&pillar without beneficiation plant	TOTAL SURVEY MINES
Coal production (t/d)	*159056*	*1168333*	*130650*	*6167*	*833*	*137693*	*26052*	*1628784*
No of mines	*8*	*2*	*13*	*3*	*1*	*11*	*3*	*41*
HUMAN CONSUMPTION								
Volume (m^3)	1005	132	5081	29	875	2297	291	9710
% of budget	2	1	7	3	8	5	8	4
Specific usage (l/t)	6.32	0.11	38.89	4.70	1050.42	16.68	11.17	5.96
DISCHARGE TO RIVERS								
Volume (m^3)	1101	0	6193	61	0	11468	0	18824
% of budget	2	0	8	6	0	23	0	9
Specific usage (l/t)	6.92	0	47.40	9.89	0	83.29	0	11.56
PRODUCT & DISCARD MOISTURE								
Volume (m^3)	6005	0	2219	0	4	2111	0	10334
% of budget	10	0	3	0	0	4	0	5
Specific usage (l/t)	37.75	0	16.98	0	4.81	15.33	0	6.34
EVAPORATION								
Volume (m^3)	36200	153	15295	815	95	11611	2615	66784
% of budget	59	1	21	87	1	24	75	31
Specific usage (l/t)	227.59	0.13	117.07	132.16	114.05	84.33	100.38	41.00
DISCHARGE TO UNSPECIFIED SINKS								
Volume (m^3)	16377	15561	45817	38	10366	21532	598	110293
% of budget	27	98	61	4	91	44	17	51
Specific usage (l/t)	102.96	13.32	350.69	6.16	12444.18	156.38	22.95	67.71
TOTAL SINKS								
Volume (m^3)	60688	15846	74605	943	11340	49019	3504	215945
% of budget	100	100	100	100	100	100	100	100
Specific usage (l/t)	381.55	13.56	571.03	152.91	13613.45	356.00	134.50	132.58

4. CONCLUSIONS AND RECOMMENDATIONS

The lack of good water balance data for the survey coal mines makes it impossible to make meaningful conclusions about water usage patterns on the coal mines. The primary conclusions that must be drawn however are the following:

1. In general terms, the state of water balances at coal mines is poor with insufficient detail being provided to enable a proper assessment of the status of water management at these mines. It must, therefore, be concluded (on the basis that one cannot manage what you cannot measure) that there is an equivalent problem with the status of water management on coal mines.

2. The primary problems with the water balances are an inadequate consideration of the effects of seepage and evaporation losses and the effect of rainwater as an input to the water balance.
3. The inadequacy of the water balances is most pronounced with regard to the losses of water from the mine water reticulation systems with 51% of all water losses being unaccounted for.
4. There are a few exceptions to the above generalisations where mines, although not perfect, have made significant effort to develop detailed water balances that are being refined and improved upon on an ongoing basis.
5. The lack of appropriate water balances is believed to be a serious hindrance to effective mine water management that needs to be addressed and remedied as a matter of priority.

No recommendations are made for further studies on water balances at coal mines although the discussion contained in this report should clearly motivate for the mines and authorities to expend considerable more effort in ensuring that proper water (and salt) balances are developed for the mines. A special need can be identified to ensure that the effects of seepage, evaporation and rainwater are included in the water balance Upgrading of mine water balances is not a research topic and must be undertaken as an operational issue by the mines themselves.

It is believed, however, that mines will benefit greatly from the ready availability of a user-friendly computerised water and salt balance model that is capable of being easily updated as and when mine water reticulation systems change.

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1. INTRODUCTION

1.1 Introduction to the Project

In order to be able to plan research initiatives and to have benchmarks against which mine water management on coal mines could be measured, a need was identified to develop a generic water balance for the coal mining industry. When the research project was undertaken, there were sixty-five operating coal mines of various sizes in South Africa. A total of forty-one mines have been included in the database used in this investigation, which represents 66% of the total number of operating coal mines in South Africa. In terms of the run-of-mine total production, this investigation included mines that represented 88% of the total coal production in South Africa.

The development of an industry-wide water balance enables the mines, authorities and other role players to set some benchmarks that can be used to evaluate the water management performance of individual mines. It was also felt that the development of such an industry-wide water balance would assist in informing future research priorities.

1.2 Research Objectives

This study was undertaken to provide a holistic view of the water use in the South African coal mining industry and to place the water use from coal mining in a regional context where possible. Furthermore, this project was aimed at quantifying and characterizing the use of water, as well as the discharge under various conditions in different catchment areas for the different mining methods. Such an understanding would provide an input to the proper management of water quality, as well as the assessment of hydrological impacts associated with coal mining activities.

A generic water balance was developed for the following types of coal mining operations:

- Open cast with beneficiation plant.
- Open cast without beneficiation plant.
- Underground bord and pillar with beneficiation plant.
- Underground bord and pillar mine without beneficiation plant.
- Underground total extraction mine with beneficiation plant.
- Open cast and underground bord and pillar mining with beneficiation plants.
- Open cast and underground bord and pillar mining without beneficiation plants.

1.3 Research Method

A generic water balance has been prepared for the South African coal mining industry to reflect the industry-wide patterns with regard to water sources, water usage and water disposal. The prepared water balance has been devised to be both sufficiently generic to be of use for a wide range of mines and sufficiently detailed to show useful information. In a generic sense, the overall balance has been constructed on the basis of a 4-stage process as shown schematically in Figure 1 below.

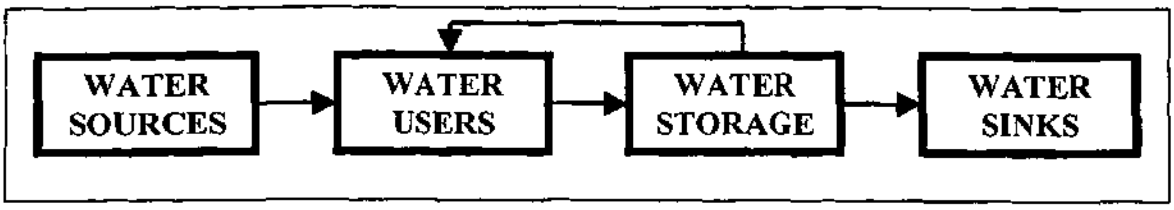


Figure 1: Process for water balance construction

The various water sources that are considered are:

- Board water
- River water
- Ground water (either through boreholes or ingress into mine workings)
- Rain water
- Unspecified sources (unspecified combination of the above)

Water users that are considered in the generic balance are:

- Potable water treatment plant (treating river or ground water)
- Domestic water users (drinking and ablution water in houses, hostels, offices, plant and mine, but excluding industrial users of potable water)
- Sewage treatment plant
- Irrigation of treated sewage
- Mine workings (underground or open pit)
- Beneficiation plant
- Slurry dam
- Road wetting for dust suppression

Provision is made for intermediate storage of the following types of water:

- Potable water
- Treated sewage
- Dirty water (including water pumped from mine workings, plant process water, slurry dam return water, contaminated stormwater, etc.)

Sinks for discharged water are:

- Human consumption
- Surface water on coal product and coarse discard
- Discharge to rivers
- Evaporation
- Discharge to unspecified sinks (unspecified combination of all of the above plus ground water)

The way in which these different components have been arranged into a generic balance diagram is shown in Figure 2 below.

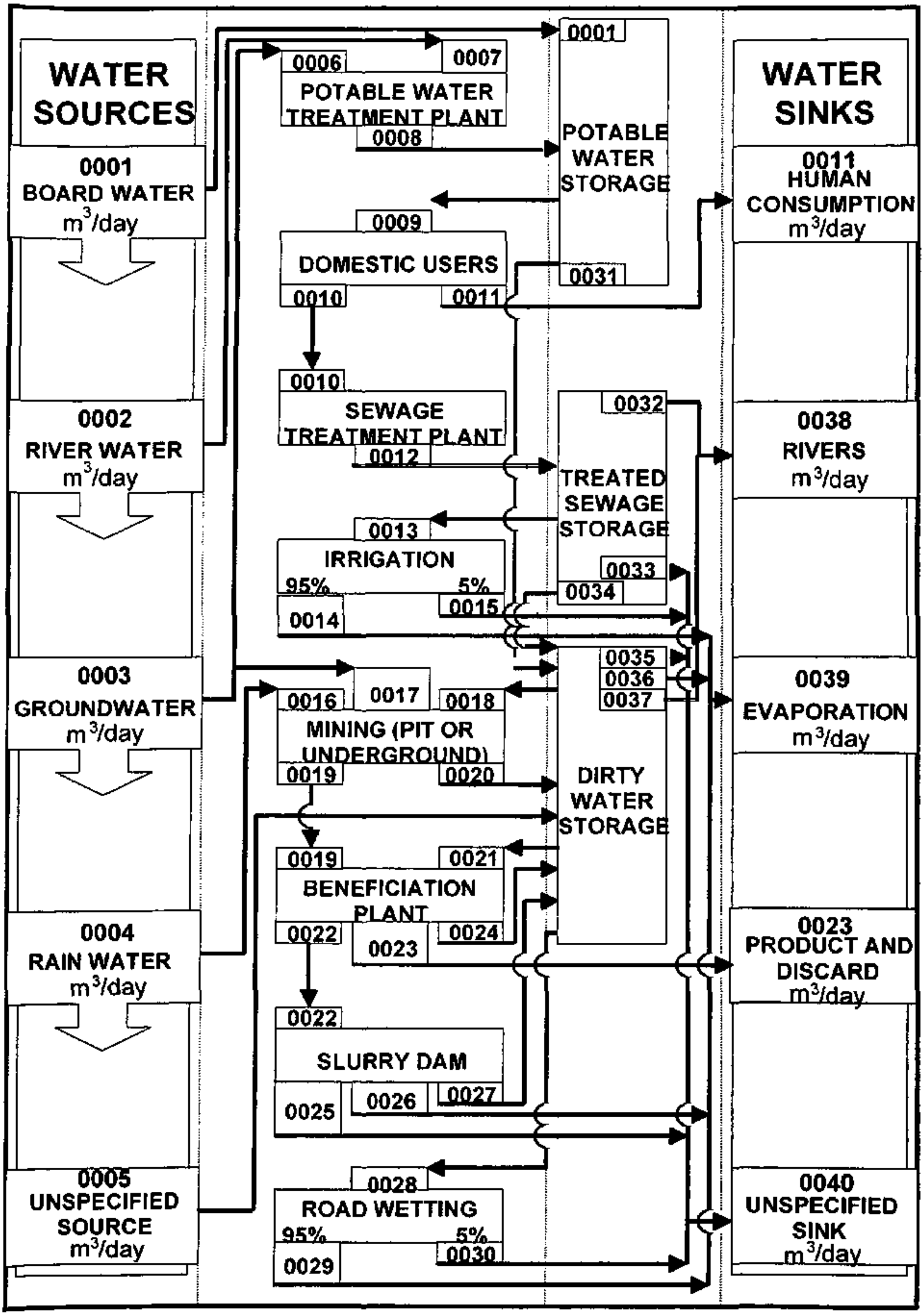


Figure 2: Generic Water Balance Diagram

The individual streams in the generic water balance are described in Table 1.

Table 1: Description of generic water balance streams

STREAM	DESCRIPTION
0001	Total volume of Board and/or potable water taken in by the mine for all uses
0002	Total volume of river water taken in by the mine for all uses
0003	Total volume of ground water taken in by the mine for all uses, including boreholes and ground water entering the mine workings
0004	Total rain water taken in by the mine for all uses, including rain into pits, storage dams and stormwater runoff
0005	Calculated volume of water from unspecified sources required to balance the overall water circuit
0006	Total volume of ground water abstracted for use as potable water – presumed to first require treatment in a potable water treatment plant
0007	Total volume of river water abstracted for use as potable water – presumed to first require treatment in a potable water treatment plant
0008	Total volume of potable water produced by mine's own treatment plants
0009	Total volume of water supplied to domestic water users (drinking and ablution water in houses, hostels, offices, plant and mine, but excluding industrial users of potable water)
0010	Total volume of water treated by the mine's sewage treatment plants (if this is not specified, it is assumed to be equal to 75% of stream 0009)
0011	Total volume of domestic water consumed by users (drinking, garden irrigation, car washing, etc.) – calculated as 0009 – 0010 or if these are not specified, calculated as 25% of stream 0009
0012	Total volume of treated sewage produced by the mine's sewage treatment plants (if this is not specified, it is assumed to be equal to 95% of stream 0010
0013	Volume of treated sewage used for irrigation of gardens, sports fields, rehabilitated areas, etc.
0014	Calculated as 95% of stream 0013 that is evaporated and evapotranspirated
0015	Calculated as 5% of stream 0013 that is discharged to rivers or ground water through runoff
0016	Total amount of rain water reported to flow into open pits
0017	Total amount of ground water reported to flow into open pits or underground workings
0018	Total amount of process water sent to mine workings for mining purposes (includes potable water and other water used for mining machines and dust suppression purposes)
0019	Surface moisture associated with ROM coal produced by mine – calculated as 6% of ROM coal
0020	Total water pumped from mine workings (underground or pit) for reuse or discharge
0021	Total amount of water used by beneficiation plant for process purposes (includes potable water used for process, cooling, gland purposes etc.)
0022	Total volume of water in fine discard slurry pumped from plant to slurry dams
0023	Surface moisture associated with washed product and coarse discard produced by plant – calculated as 6% of mass of washed product and discard
0024	Total amount of contaminated water returned from beneficiation plant to dirty water storage for reuse or discharge (includes contaminate stormwater)
0025	Total volume of water from slurry dam which discharges directly into unspecified sinks such as river or ground water (calculated to be equal to stream 0022 – streams (0026 + 0027)
0026	Total volume of water from slurry dam which evaporates (this stream is assumed to be zero if not specified by the mine and will then be included in stream 0025)
0027	Total volume of slurry water recovered as penstock decant and returned to the process water circuits
0028	Volume of water used for road wetting for dust suppression
0029	Calculated as 95% of stream 0028 that is evaporated and evapotranspirated
0030	Calculated as 5% of stream 0028 that is discharged to rivers or ground water through runoff
0031	Total volume of potable quality water used for industrial purposes in mine workings or plant
0032	Total volume of treated sewage discharged directly to rivers
0033	Total volume of treated sewage sent to unspecified sinks – calculated as stream 0012 – streams (0013 + 0034)
0034	Total volume of treated sewage water used for industrial purposes in mine workings or plant
0035	Total volume of dirty water discharged to unspecified sinks – calculated as streams (0005 + 0020 + 0024 + 0027 + 0031 + 0034) – streams (0018 + 0021 + 0028 + 0036 + 0037) if not specified by mine
0036	Total volume of dirty water evaporated (this stream is assumed to be zero if not specified by the mine and will then be included in stream 0035)
0037	Total volume of dirty water discharged directly to rivers (this stream is assumed to be zero if not specified by the mine and will then be included in stream 0035)
0038	Total amount of water discharged directly to rivers (calculated as streams 0032 + 0037) – additional water may be discharged to rivers as part of stream 0040
0039	Total amount of water lost to evaporation (calculated as streams 0014 + 0026 + 0029 + 0036) – additional water may be lost to evaporation as part of stream 0040
0040	Total amount of water discharged to unspecified sources (calculated as streams 0015 + 0025 + 0030 + 0033 + 0035) + any other water which is required to balance the circuit

It needs to be emphasized that due to the generally poor water balances provided by the coal mining industry, many of the streams indicated in the above table and the generic water balance are missing from the mine's water balances and have had to be calculated by PHD. A database has been developed where values for streams 0001 to 0041 have been entered for each survey mine.

In order to be able to combine and compare water balance data from large and small mines, the data has been normalised by dividing total volumes of water by ROM (run of mine) coal production (product + discard) to give m^3 water / ton mined. Total volumes of water (in m^3/day) for the whole coal mining industry are also shown.

1.3.1 Collection and use of existing data from water permits and EMPRs

Data for coal mine water use and balances were obtained from EMPRs and water permits from the Departments of Mineral and Energy Affairs and Water Affairs and Forestry.

Data that was obtained from the EMPR's was found to be more useful than that derived from water permits as the water permits did not contain the relevant data required, *i.e.* tonnages produced by the mine, type of mining or the water balance detail required for the database input.

The limited success rate of the data obtained from the Departments of Mineral and Energy Affairs and Water Affairs and Forestry necessitated that the head offices of the various mining groups be contacted to obtain the data that was required for the database.

A coal mine survey questionnaire, as shown in Appendix 1, was sent to the individual mines to obtain data. A very limited response to the questionnaire was obtained from the mines. After a period of delay the questionnaire was resent to the mines, and follow up phone calls were made to the responsible persons on the mines to make sure that the data obtained would be the most up to date data that was available. This approach also yielded a limited response.

A total of forty-one mines' data was eventually obtained by use of a combination of EMPR's and questionnaires. This data was inserted into the database. The number of mines in the database totals forty-one out of a possible sixty-five mines (Department of Mineral and Energy Affairs). This represents 66% of the total number of mines. In terms of run-of-mine production, the survey mines accounted for 88% of the total South African coal production.

1.3.2 Set up of database from the collected data

The data received from the mines were used to develop a water balance per mine by using the generic water balance model described above. Water inputs were characterised and quantified as water from water boards, pumped from rivers / aquifers, fissure influx, *etc.* The uses (*e.g.* cooling, coal washing *etc.*) were categorised and quantified for the various mines, and lastly, the water discharges and losses (evaporation, seepage, *etc.*) were identified, characterised and quantified. No characterisation and quantification exceeds levels of detail provided in the EMPR's.

The database was constructed in a Microsoft Excel workbook where the water inputs could easily be manipulated so that they could be characterised and quantified as water from water boards, pumped from rivers / aquifers, fissure influx, *etc.* The uses (*e.g.* cooling, coal washing *etc.*) have been categorised and quantified for the various mines, and lastly the water discharges and losses (evaporation, seepage, *etc.*) have been identified, characterised and quantified. Flow data were entered in S.I. (Standard International) units of m^3/d.

1.3.3 Generation of water balances for each mine

The data was entered as supplied from the collieries and converted to m^3/t run-of-mine produced. This normalisation of data enabled the comparison of collieries producing large tonnage's with smaller collieries as the volume of water usage is dependant on the tonnage mined. The collieries were separated with respect to the type of mining and water catchment areas. The type of mining refers to the mining methods employed and is discussed in 1.3.5.

1.3.4 Identification of problems regarding quality of the data

Data entered into the database was assessed using the descriptive statistics analyses tool pack, a feature in Microsoft Excel. It was not possible to statistically determine the accuracy of the data neither the precision, as the water balance data forwarded provided no indication of the period of monitoring. The data was analysed using the variance to determine statistical accuracy and was found to be questionable. Rainfall and river data both had a large variance. This is mainly due to the fact that a large proportion of the collieries failed to report rainfall and or river data. Similar inconsistencies are present for water influents, water users and effluent sinks.

In situations where underground mining activities formed part of the water balance, the component associated with underground mining was considered to be recirculated water. The motivation for this assumption emanated from the experience gained from manipulation of a few of the more complete water balances.

1.3.5 Categories of mining activities

Water balances were performed on the following categories of mines:

- Open cast with beneficiation plant,
- Open cast without beneficiation plant;
- Underground bord and pillar with beneficiation plant;
- Underground bord and pillar mine without beneficiation plant;
- Underground total extraction mine with beneficiation plant;
- Open cast and underground bord and pillar mining with beneficiation plants.
- Open cast and underground bord and pillar mining without beneficiation plants.

The number of participating mines in each category, as well as the proportional percentage of the total number of mines that participated in the survey are listed in Table 2 and presented in Figure 3.

Table 2: Summary of data collected

Mine Type	No. of Mines	% of total
Open cast with beneficiation plant	8	20
Open cast without beneficiation plant	2	5
Underground bord and pillar with beneficiation plant	13	32
Underground bord and pillar mine without beneficiation plant	3	7
Underground total extraction mine with beneficiation plant	1	2
Open cast and underground bord and pillar mining with beneficiation plants	11	27
Open cast and underground bord and pillar mining without beneficiation plants	3	7
	41	**100**

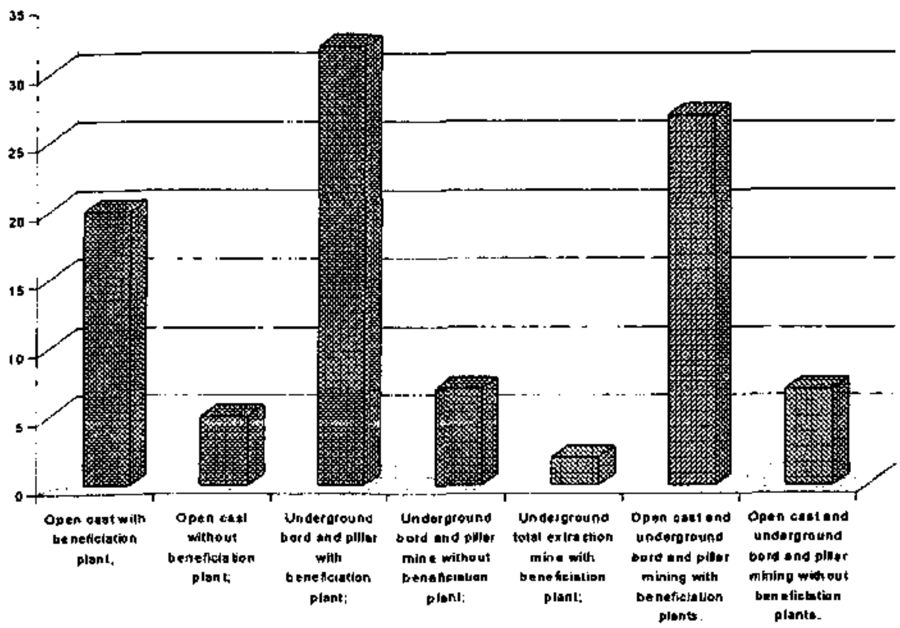


Figure 3: Number of survey mines per category

1.4 Report Structure

Following the introductory chapter in which the motivation for the project is presented, the data input to the database and manipulation of the data for the various scenarios for the generic water balances for the different types of coal mining operations are discussed in Chapters 2 to 8. A summary discussion of differences between the different types of mining is given in Chapter 9. Chapter 10 compares the data for mines in the Olifants River catchment with those in the Vaal River catchment. The construction of a generic water balance for all the survey mines is presented in Chapter 11, together with a more detailed comparison of water use and discharge patterns between the different types of mining. The conclusions and recommendations are presented in Chapter 12.

2. WATER BALANCE FOR OPEN CAST MINES WITH BENEFICIATION PLANTS

A summary of the overall volumes of water associated with open cast mining operations that include a beneficiation plant are shown in Figure 4 while a more detailed generic water balance is shown in Figure 5. The number of mines present in this category forms 20% of the mines in the total database. The total production of the eight mines that form part of this category amounts to 159 056 t/d. A total of 381 l of water is required for each ton of coal mined and is derived as follows:

- 16 l/t board water
- 118 l/t river water
- 168 l/t ground water
- 13 l/t rain water
- 66 l/t of water derived from an unspecified source

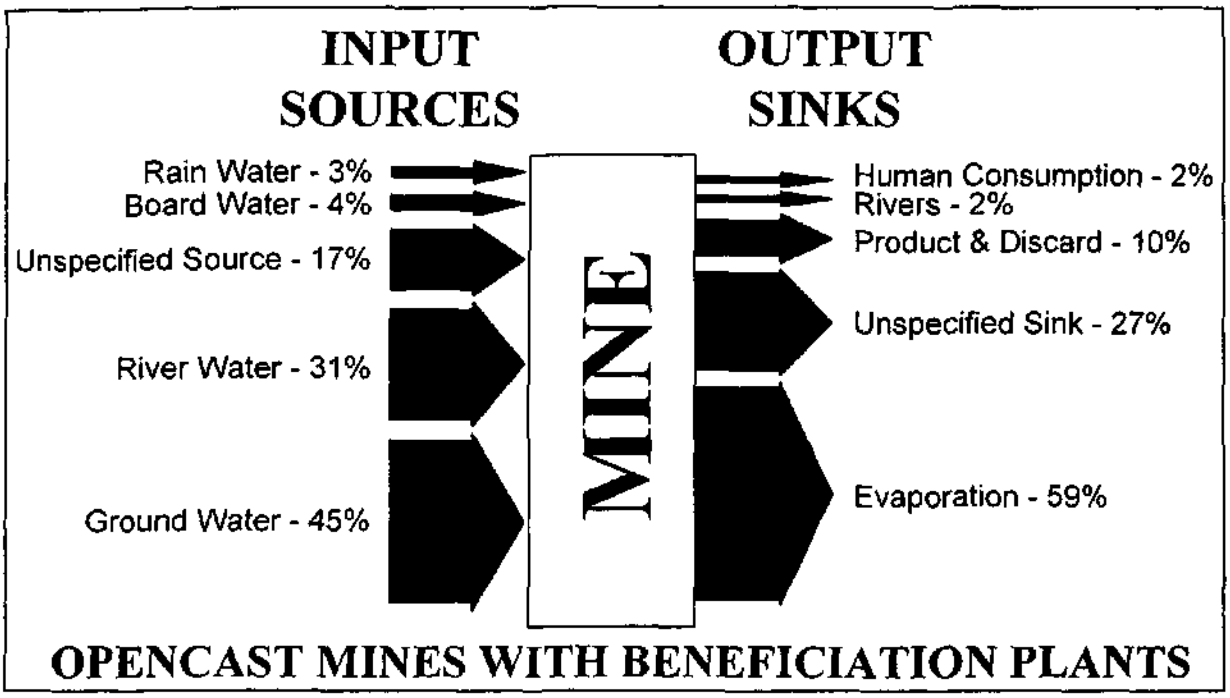
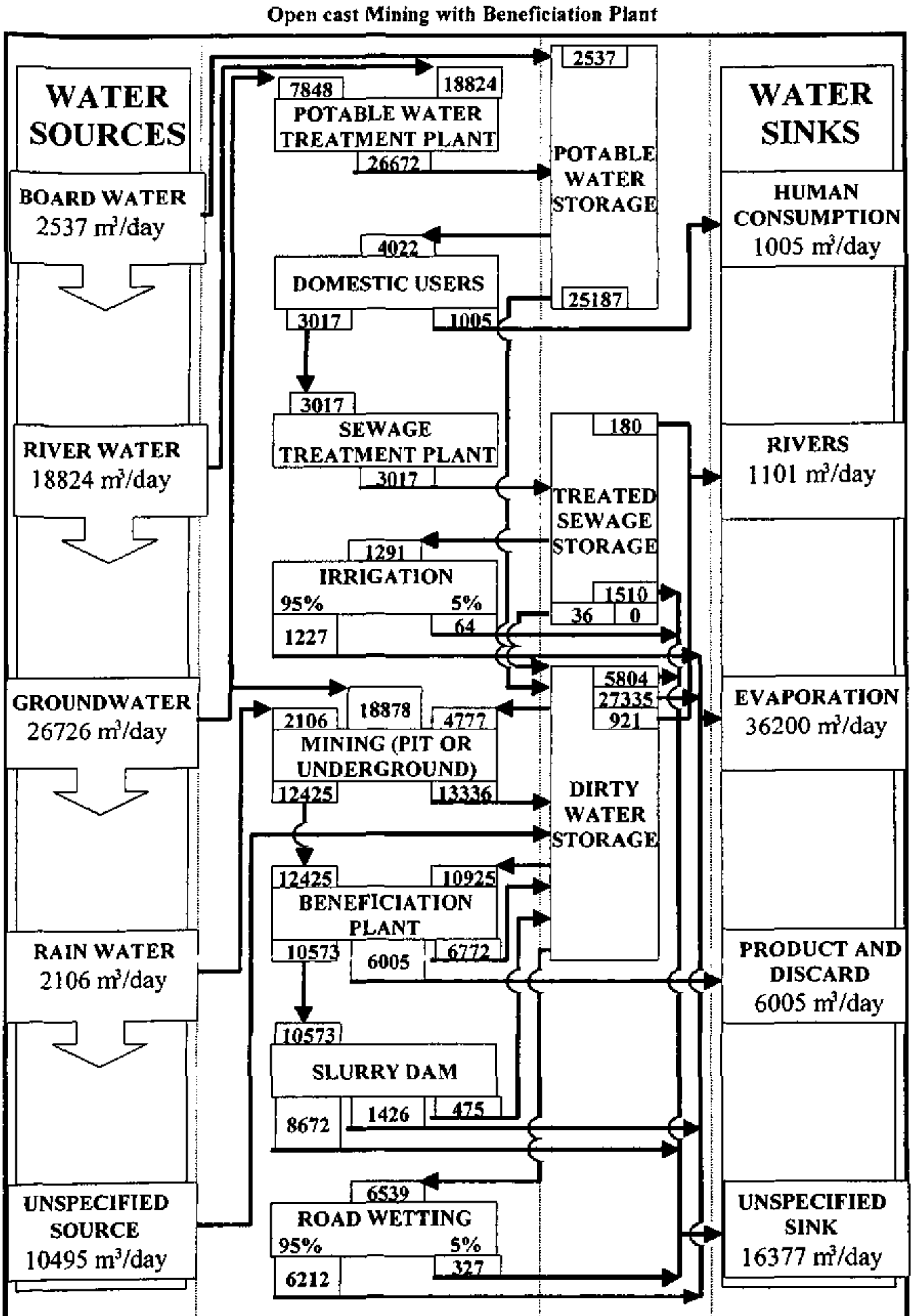


Figure 4: Summary water balance for open cast mines with beneficiation plants

The total volume of water associated with this particular type of mining operation is 60 688 m^3/d. These figures indicate that the dominant sources of water for the eight mines included in this category are ground water (45%), river water (31%), and board water (4%).

Domestic users consume 1.7% of the total water budget. The treated sewage effluent is mainly used for irrigation (42.8%), whereas only 1.2% is recycled back into the system. Six percent of the treated sewage effluent is released into the river system. In total 1.8% of the total water budget is released into the river systems, i.e. 7 l/t, whereas the bulk of the water evaporates (59%). Water lost to evaporation amounts to 229 l/t of coal mined. Approximately 10% of the water is lost as surface moisture with the product and discard material from the beneficiation plant. Water required for the open cast mining operations amount to 42% of the



All values in m³/day

Figure 5: Overall generic water balance for open cast mines with beneficiation plants

total water budget. Mining operations and the beneficiation plant recycle approximately 26% of the total water balance.

Eleven percent of the water available is used for road wetting and dust suppression. No account could be given for 17% of the water sources. Furthermore, 27% of the water is being discharged into unspecified sinks, which may include any of those sinks shown in Figure 4. These large percentages of unspecified water sources and water sinks raise concerns regarding the completeness of the water balances provided by the individual mines. Data for the 8 individual mines that form part of this category are presented in Appendix 2.

Table 3: Summary of the statistics for open cast mines with beneficiation plants

Water Sources, Uses & Sinks	Stream	Average (m^3/day)	Minimum (m^3/day)	Maximum (m^3/day)	Ave. %	Min. %	Max. %
Board water source	001	634	53	1544	25	2	61
River water source	002	3137	408	5170	17	2	27
Groundwater source	003	3341	127	7870	13	0	29
Rain water source	004	702	565	877	33	27	42
Unspecified source	005	2624	1060	4935	25	10	47
Potable Treatment Plant	006	3924	3000	4848	50	38	62
Potable Treatment Plant	007	3137	408	5170	17	2	27
Potable Treatment Plant	008	3810	623	5256	14	2	20
Domestic Users	009	575	30	1544	14	1	38
Domestic Users	010	431	23	1158	14	1	38
Human Consumption Sink	011	144	7	386	14	1	38
Sewage Treatment Plant (users)	012	431	23	1158	14	1	38
Irrigation (users)	013	323	23	623	25	2	48
Irrigation (users)	014	307	22	592	25	2	48
Irrigation (users)	015	16	1	31	25	2	48
Mining (Pit or Underground)	016	702	565	877	33	27	42
Mining (Pit or Underground)	017	2360	127	7870	13	1	42
Mining (Pit or Underground)	018	955	23	1930	20	0	40
Mining (Pit or Underground)	019	1553	168	3450	13	1	28
Mining (Pit or Underground)	020	1667	23	5045	13	0	38
Beneficiation Plant (users)	021	3642	1764	5031	33	16	46
Beneficiation Plant (users)	022	1322	160	2565	13	2	24
Product & Discard Sink	023	751	8	2943	13	0	49
Beneficiation Plant (users)	024	1693	1220	2217	25	18	33
Slurry Dam (users)	025	1239	160	2565	14	2	30
Slurry Dam (users)	026	1426	1426	1426	100	100	100
Slurry Dam (users)	027	475	475	475	100	100	100
Road Wetting (users)	028	1090	360	2976	17	6	46
Road Wetting (users)	029	1035	342	2827	17	6	46
Road Wetting (users)	030	55	18	149	17	6	46
Potable Water Storage (users)	031	3598	623	5208	14	2	21
Treated Sewage Storage (users)	032	180	180	180	100	100	100
Treated Sewage Storage (users)	033	378	60	540	25	4	36
Treated Sewage Storage (users)	034	36	36	36	100	100	100
Dirty Water Storage (users)	035	2902	1887	3917	50	33	67
Dirty Water Storage (users)	036	3417	360	8805	13	1	32
Dirty Water Storage (users)	037	921	921	921	100	100	100
Rivers Sink	038	1101	1101	1101	100	100	100
Evaporation Sink	039	4525	360	9575	13	1	26
Unspecified Sink	040	2047	26	4687	13	0	29

Descriptions of the various Streams are summarised in Table 1.
Percentages are expressed relative to the total water budget

3. WATER BALANCE FOR OPEN CAST MINES WITHOUT BENEFICIATION PLANTS

Figure 6 depicts the summary water balance associated with open cast mines operating without a beneficiation plant. A more detailed generic water balance is shown in Figure 7. A total volume of 15 846 m^3/d is required by this type of coal mining activity. Given a total production of 1 168 333 t/d, the amount of water required per ton of coal produced is 13.6 l/t. River water is the main source of water, contributing 68% of the total water budget. The river water contributes 9.2 l/t of coal mined, compared to the 2.1 l/t (15%) derived from ground water, 1.1 l/t (9%) from rain water, and 1 l/t (8%) board water.

A total volume of 13 510 m^3/d is available as potable water. The percentage that is used for domestic purposes amounts to 3.7% of the potable water budget. Twenty five percent of the domestic water is actually being consumed, i.e. 132 m^3/d. Treated sewage is directly dissipated into unspecified sinks, which exclude rivers. No treated sewage is being used for irrigation purposes. The water being used for mining operations in the open pits account for 14.7% of the total water budget.

Less than two percent of the water is lost due to human consumption and evaporation, leaving the largest portion to be discharged into the environment in an unspecified manner. Detailed data for the individual mines that comprise this category are presented in Appendix 2.

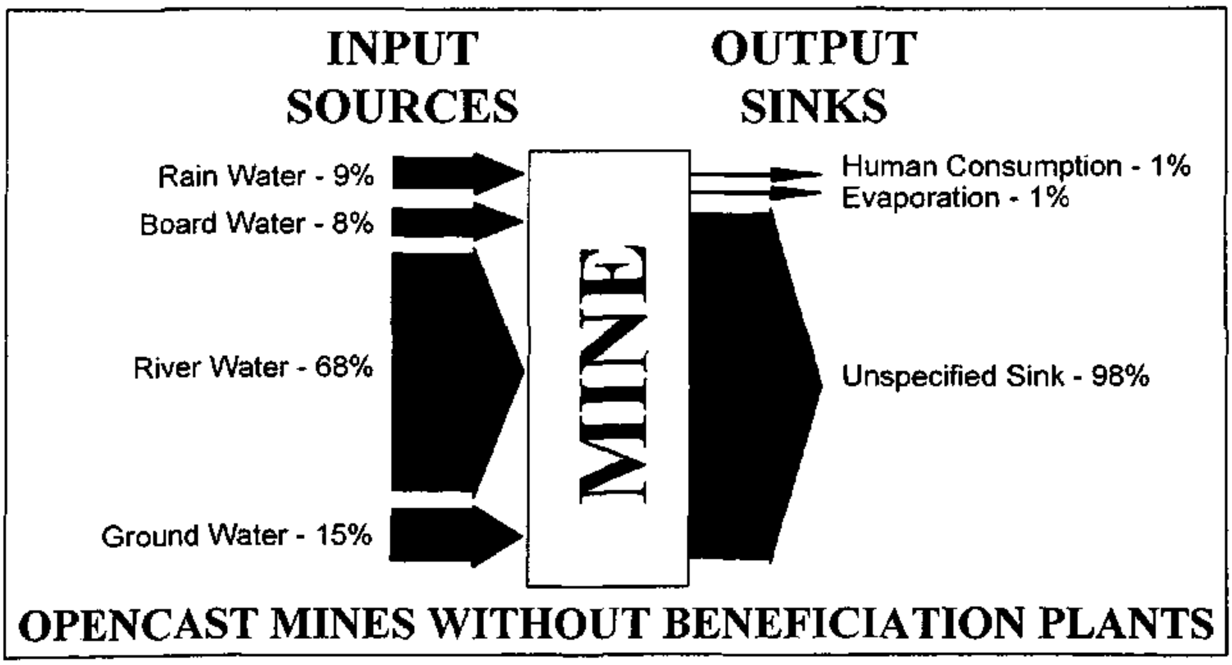
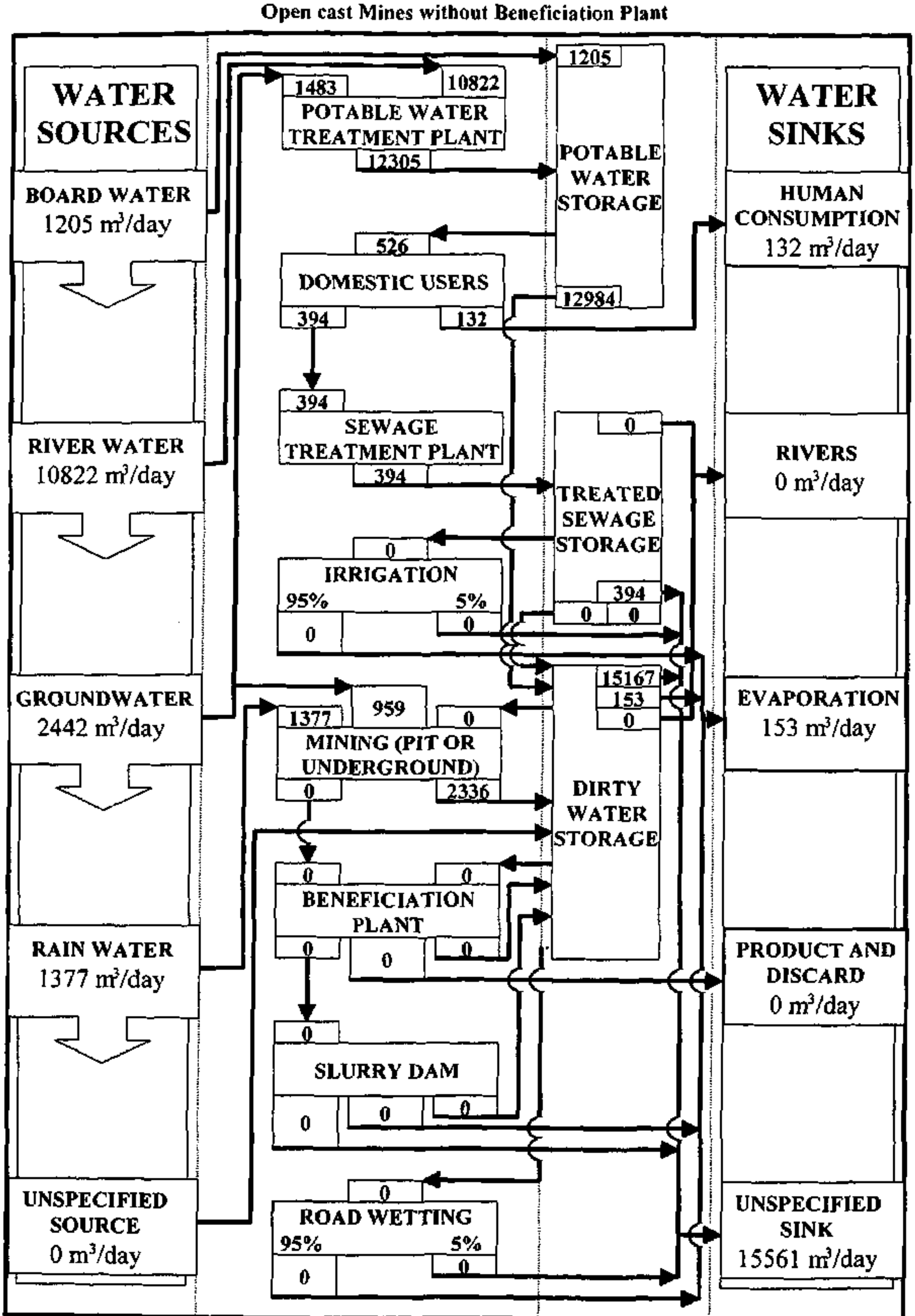


Figure 6: Summary water balance for open cast mines without beneficiation plants

As only two mines were in this category, no table of statistics such as shown in Table 3 has been prepared.



All values in m³/day

Figure 7: Overall generic water balance for open cast mines without beneficiation plants

4. WATER BALANCE FOR UNDERGROUND BORD & PILLAR MINES WITH BENEFICIATION PLANTS

The summarised water balance for underground mining operations that include beneficiation plants is shown in Figure 8 while a more detailed generic water balance is shown in Figure 9. A total of 13 mines made up this category, producing 130 650 t/d of coal. The total volume of water required amounts to 571 l/t, i.e. 74 605 m^3/d. Domestic users require 42.7% of the available potable water, with 25% of the domestic water being consumed. Of the treated sewage, 45.7% is used for irrigation, 6% is being recycled, and 13% is released into the river systems. The remainder of the treated sewage is discharged into unspecified sinks.

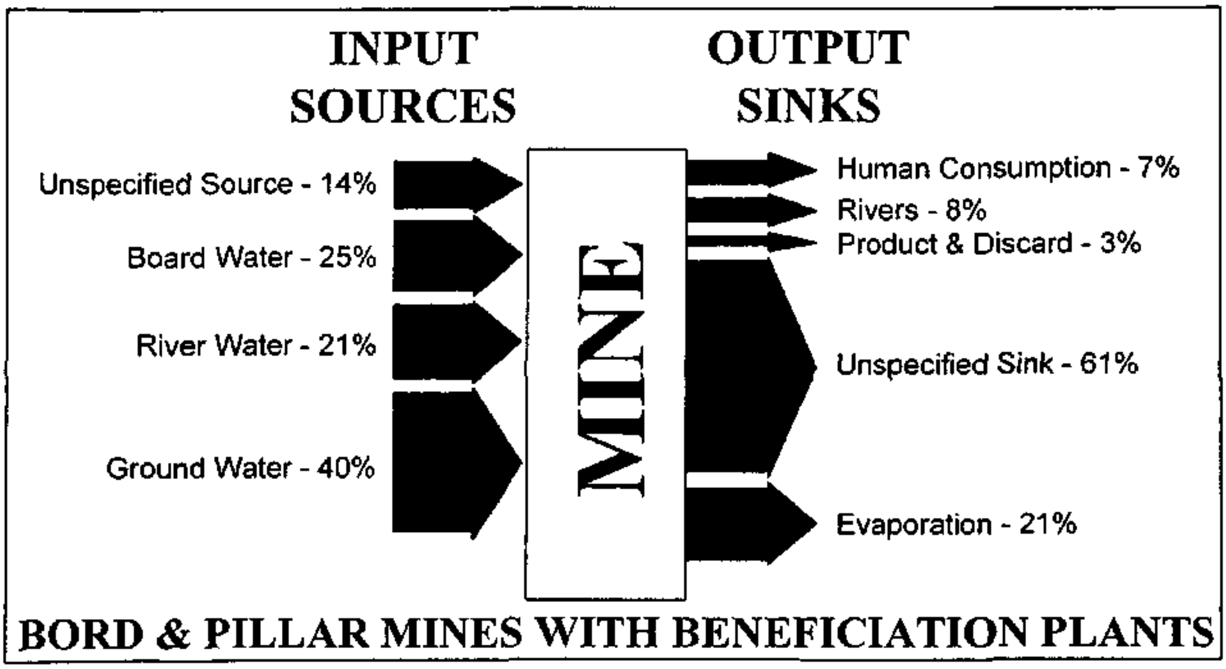
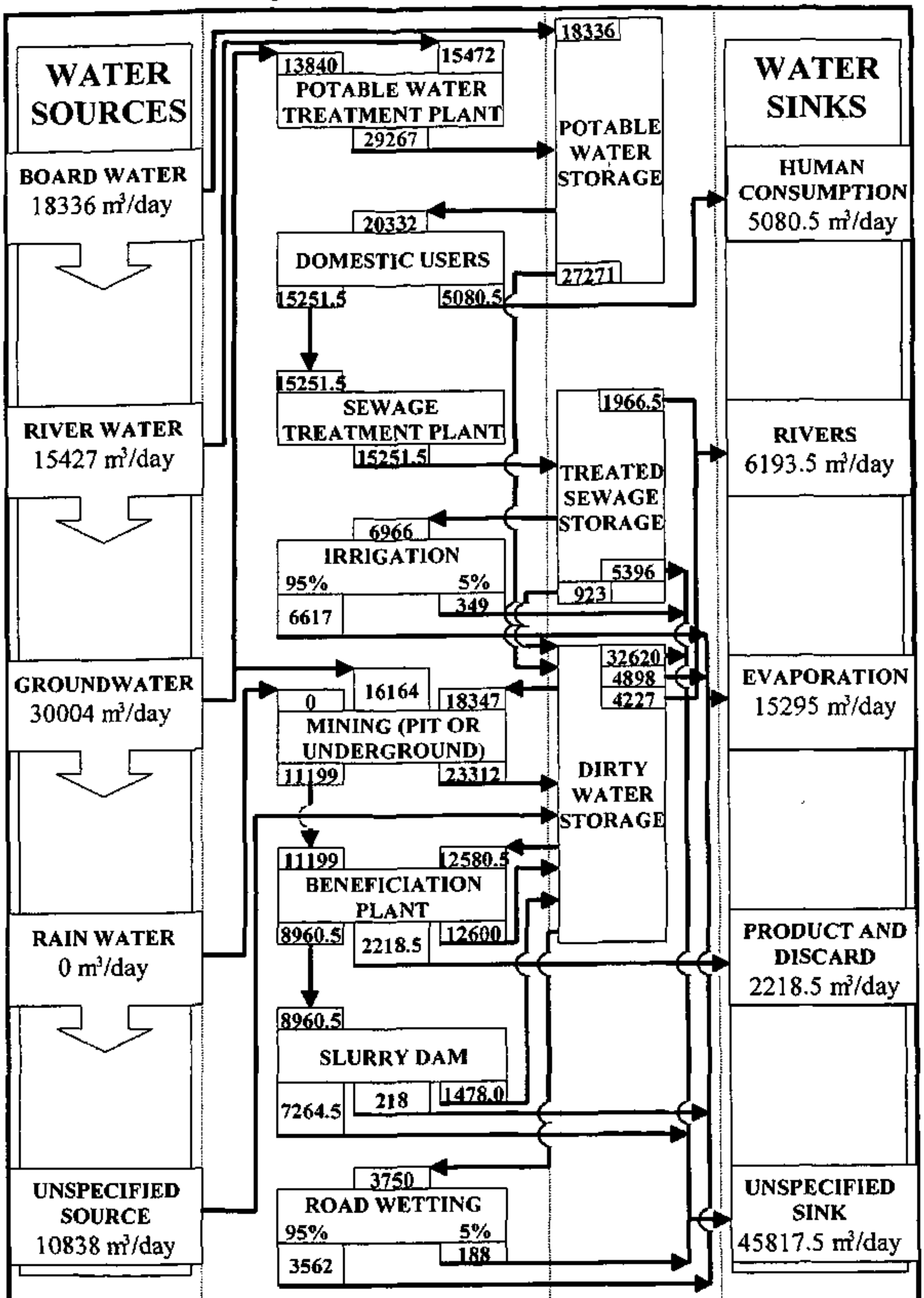


Figure 8: Summary water balance for underground bord & pillar mines with beneficiation plants

Underground mining activities require 34 511 m^3/d. Approximately 68% of the water required for underground mining is being recycled. The total volume of water required for the operation of the beneficiation plant amounts to 23 779 m^3/d, with 54% being recycled. A total percentage of 8.8% is lost as moisture, together with the product and discard material. A total of 37.7% is being discharged into slurry dams. The volume of decanted water from the slurry dams that is recycled forms 16.4% of the slurry dams water budget. Five per cent of the total water budget is used for road wetting and dust suppression.

The largest portion of water (61.4%) is discharged into unspecified sinks, which could include the ground water system. Twenty per cent of the water evaporates, whereas a total of approximately 8% of the total water budget is being discharged into the river systems. Detailed breakdowns for the 13 individual mines that form part of this category are given in Appendix 2. Variations for the data between the different mines are shown in Table 4.

Underground Bord and Pillar with Beneficiation Plant



All values in m³/day

Figure 9: Overall generic water balance for underground bord & pillar mines with beneficiation plants

Table 4: Summary of the statistics for underground bord & pillar mines with beneficiation plants

	Average	Minimum	Maximum	Average %	Minimum %	Maximum %
Stream 001	2619	5	7500	14	0	41
Stream 002	1543	68	3697	10	0	24
Stream 003	2728	432	7754	9	1	26
Stream 004	0	0	0	0	0	0
Stream 005	2710	1016	6440	25	9	59
Stream 006	2307	8	6696	17	0	48
Stream 007	1543	68	3697	10	0	24
Stream 008	2439	11	6950	8	0	24
Stream 009	1564	5	7495	8	0	37
Stream 010	1173	4	5621	8	0	37
Stream 011	391	1	1874	8	0	37
Stream 012	1173	4	5621	8	0	37
Stream 013	2322	10	5621	33	0	81
Stream 014	2206	9	5340	33	0	81
Stream 015	116	1	281	33	0	81
Stream 016	0	0	0	0	0	0
Stream 017	1469	432	3868	9	3	24
Stream 018	1529	68	6440	8	0	35
Stream 019	861	100	4300	8	1	38
Stream 020	1943	50	6440	8	0	28
Stream 021	1573	1	5018	13	0	40
Stream 022	689	43	2203	8	0	25
Stream 023	185	2	886	8	0	40
Stream 024	1800	117	4114	14	1	33
Stream 025	605	25	1615	8	0	22
Stream 026	218	218	218	100	100	100
Stream 027	370	100	778	25	7	53
Stream 028	750	30	3500	20	1	93
Stream 029	712	28	3325	20	1	93
Stream 030	38	2	175	20	1	93
Stream 031	3030	68	6955	11	0	26
Stream 032	492	4	1325	25	0	67
Stream 033	675	9	2625	13	0	49
Stream 034	462	75	848	50	8	92
Stream 035	3262	587	6340	10	2	19
Stream 036	700	34	2709	14	1	55
Stream 037	1057	402	1782	25	10	42
Stream 038	1239	440	3107	20	7	50
Stream 039	1390	34	8665	9	0	57
Stream 040	3524	46	10205	8	0	22

5. WATER BALANCE FOR UNDERGROUND BORD & PILLAR MINES WITHOUT BENEFICIATION PLANTS

A total of three of the survey mines that applied the bord and pillar mining method operated without a beneficiation plant. These data are summarized in Figure 10 while a more detailed water balance is shown in Figure 11. A total volume of 943 m^3/d of water is required to produce 6167 t/d, to give a specific water usage of 153 l/t. Ground water is the main water source of water, accounting for 87.8% of the total available water budget. River water contributes only 9.5% as a source of water. No board water is being consumed.

The potable water produced by the treatment plant is mainly used for domestic purposes, i.e. 71%, of which 31.8% is actually consumed. Treated sewage effluent is mainly being discharged into rivers, i.e. 80.6%, whereas no treated sewage is used for irrigation. The volume of water used for underground mining operations amounts to 825 m^3/d.

In terms of water sinks, the largest volume of water is lost through evaporation, i.e. 86.4%. The remainder of the water is discharged into rivers (6.5%) and lost through domestic consumption (3.1%). Four per cent of effluent is discharged into unspecified sinks.

Detailed water balance data of the three mines in this category are summarized in Appendix 2.

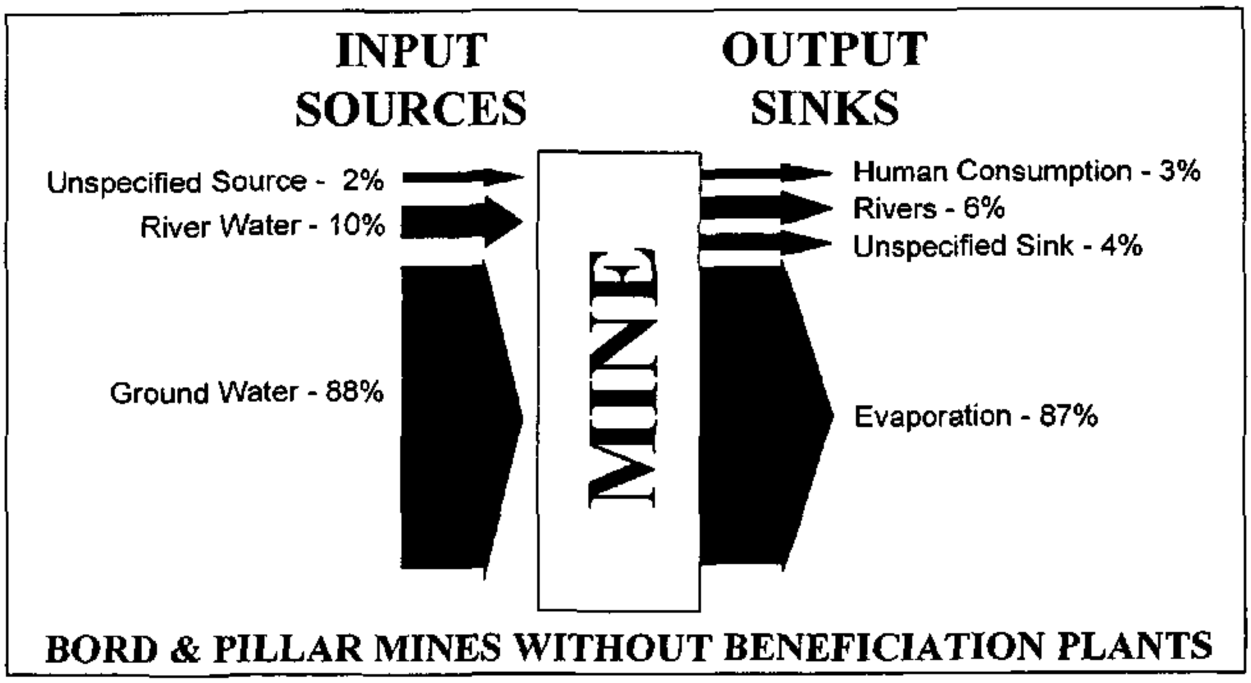
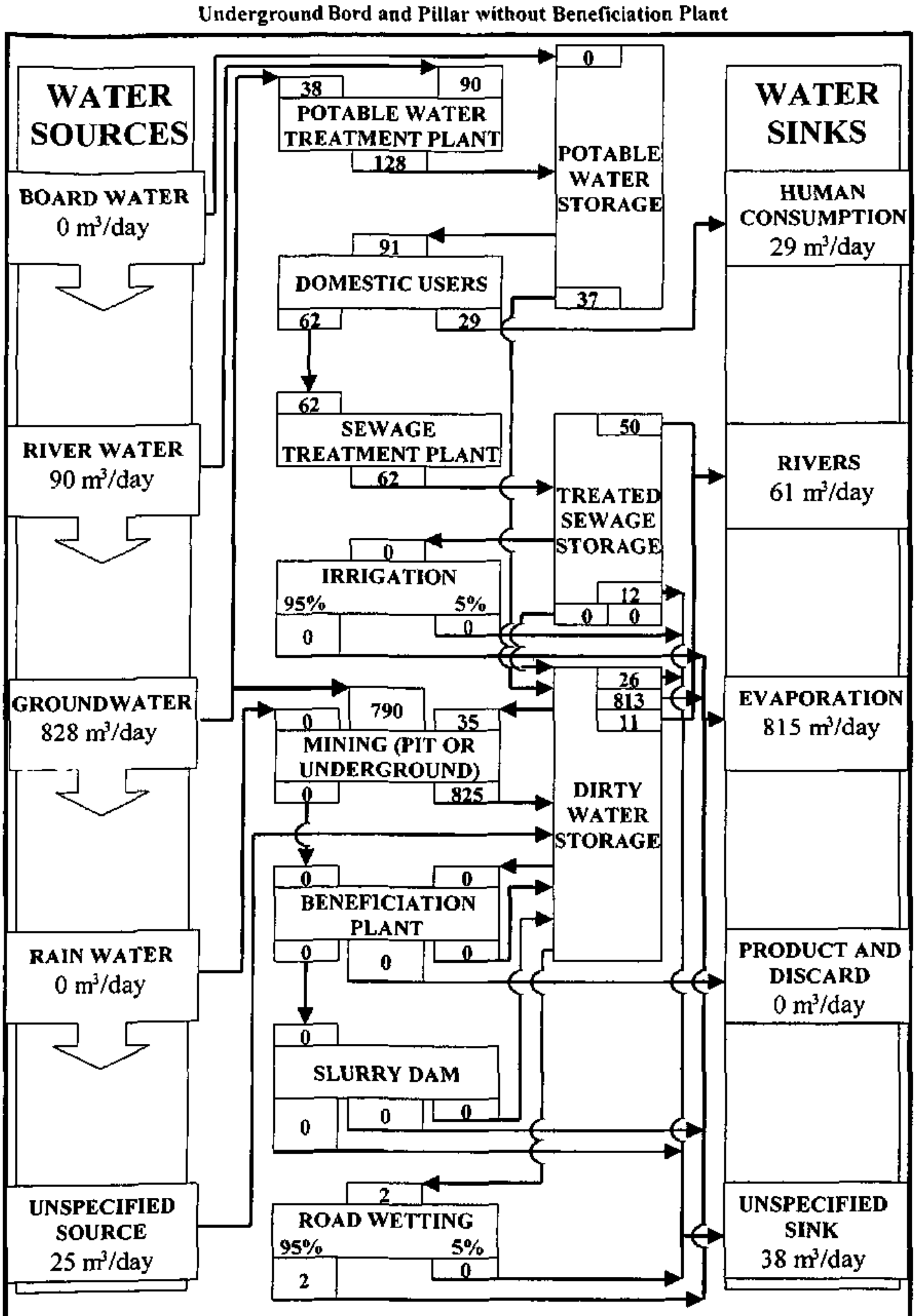


Figure 10: Summary water balance for underground bord & pillar mines without beneficiation plants



All values in m³/day

Figure 11: Overall generic water balance for underground bord & pillar mines without beneficiation plants

6. WATER BALANCE FOR TOTAL EXTRACTION MINES WITH BENEFICIATION PLANTS

Figure 12 summarizes the water balance information for underground operations that apply total extraction mining techniques, and which include a beneficiation plant. A more detailed water balance is shown in Figure 13. Only one mine is reflected in this category, producing 833 t/d. The total volume of water required by this mine to operate amounts to 11 340 m^3/d. Thus, the volume of water required per ton of coal produced is 13 613 l/t.

The total amount of available potable water is used for domestic purposes. Exactly one quarter of this volume of domestic water is actually consumed. The total volume of treated sewage is discharged into unspecified sinks, no treated sewage is used for irrigation. Underground mining operations require 1 300 m^3/d. Of the water processed by the beneficiation plant, 94% is being recycled. Two per cent of the total water budget is being used for road wetting and dust suppression.

Eighty per cent of the effluent is discharged into unspecified sink, which in this particular case would probably be the local river system. Less than 2% of the effluent actually evaporates.

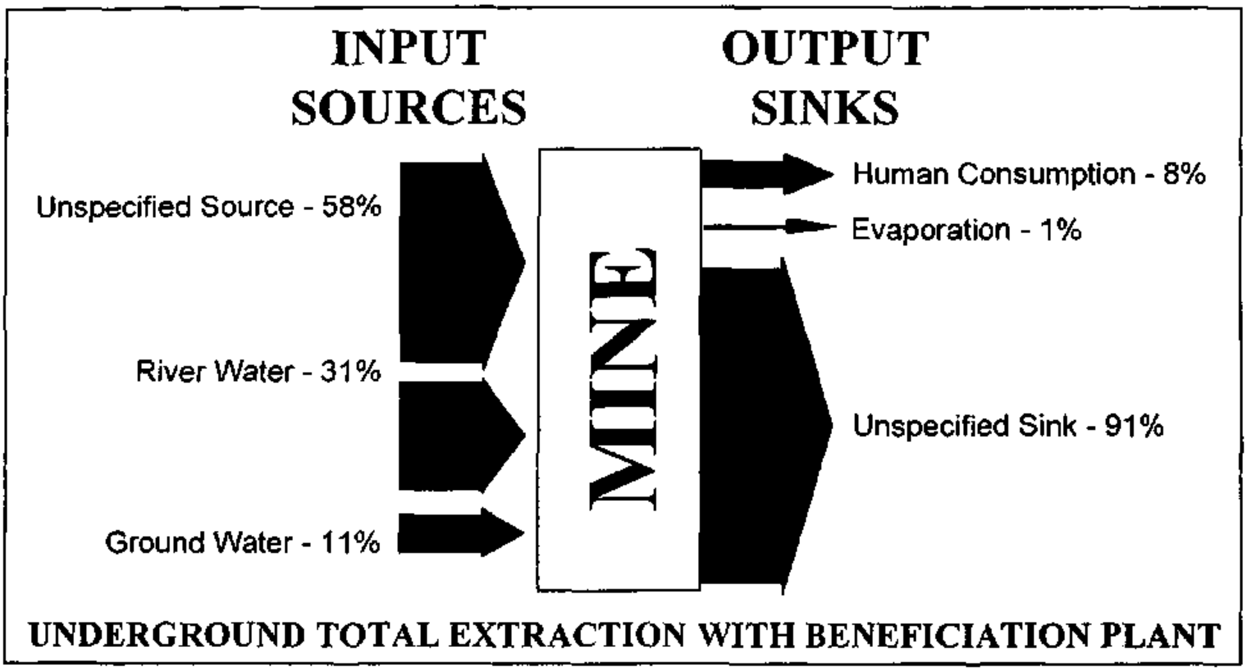
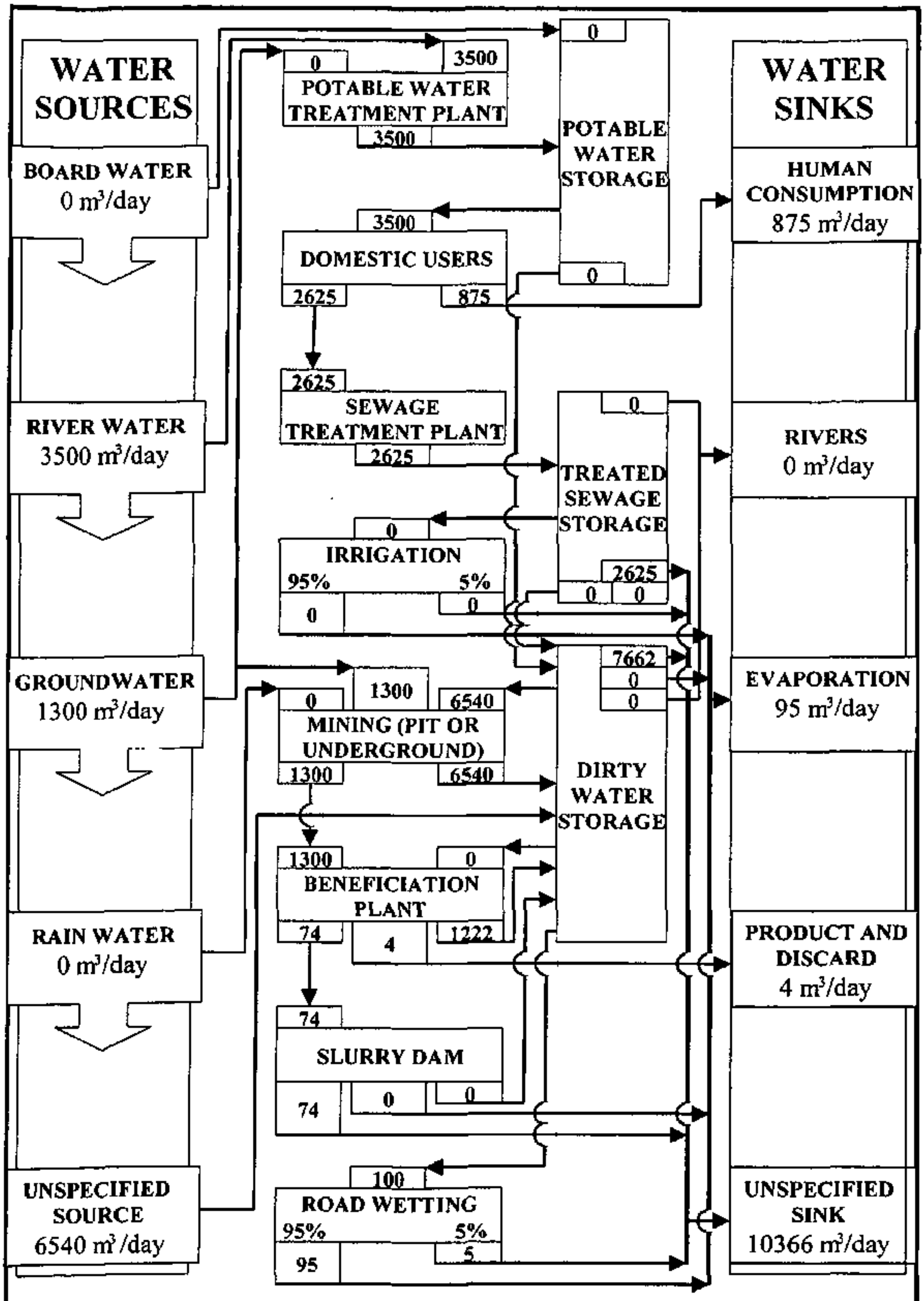


Figure 12: Summary water balance for total extraction mines with beneficiation plants

The details of the one mine that constitute this category are presented in Appendix 2.

Underground Total Extraction with Beneficiation Plant



All values in m³/day

Figure 13: Overall generic water balance for total extraction mines with beneficiation plants

7. WATER BALANCE FOR COMBINED OPENCAST AND UNDERGROUND BORD & PILLAR MINES WITH BENEFICIATION PLANTS

Figure 14 summarizes the water balance for the eleven mines that constitute the category of combine open cast and underground bord and pillar mines with beneficiation plants. A more detailed generic water balance for these mines is shown in Figure 15.

In order to produce 137 693 t/d of coal, the total volume of water required by these mines amounts to 49 019 m^3/d. Thus, 356 liters of water is required to produce one ton of coal. The main sources of water are as follows:

- river water - 42.2%
- ground water - 32.5%
- board water - 7.3%
- rain water - 5.5%)
- water from unspecified sources - 12.5%

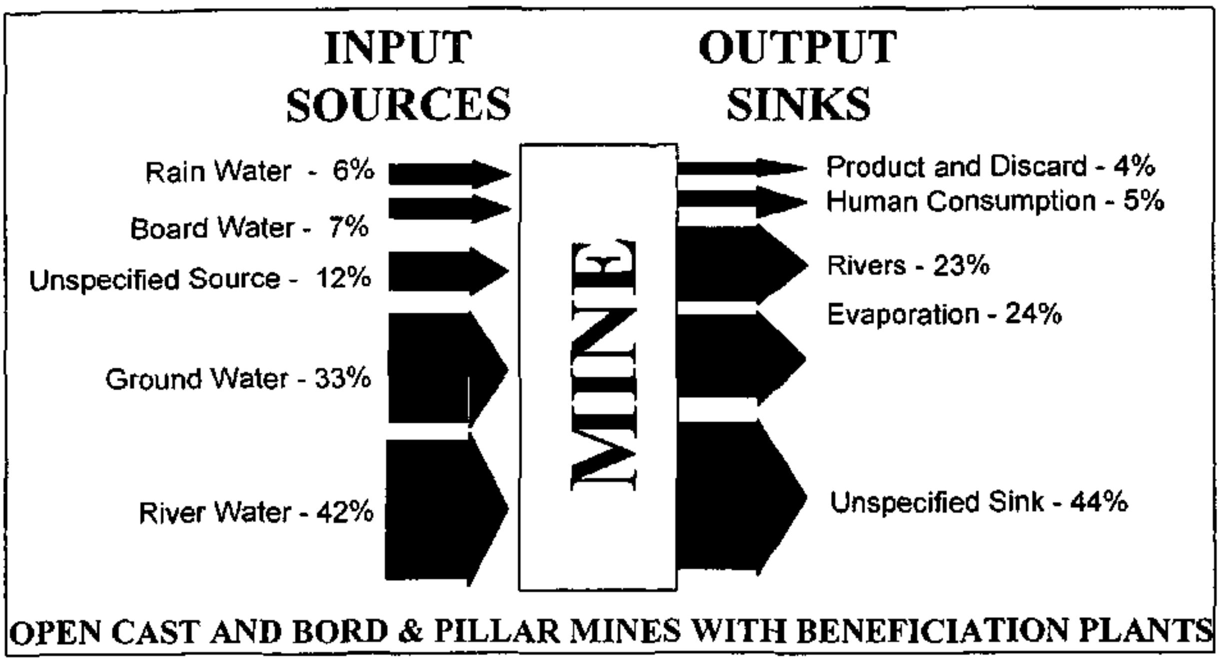
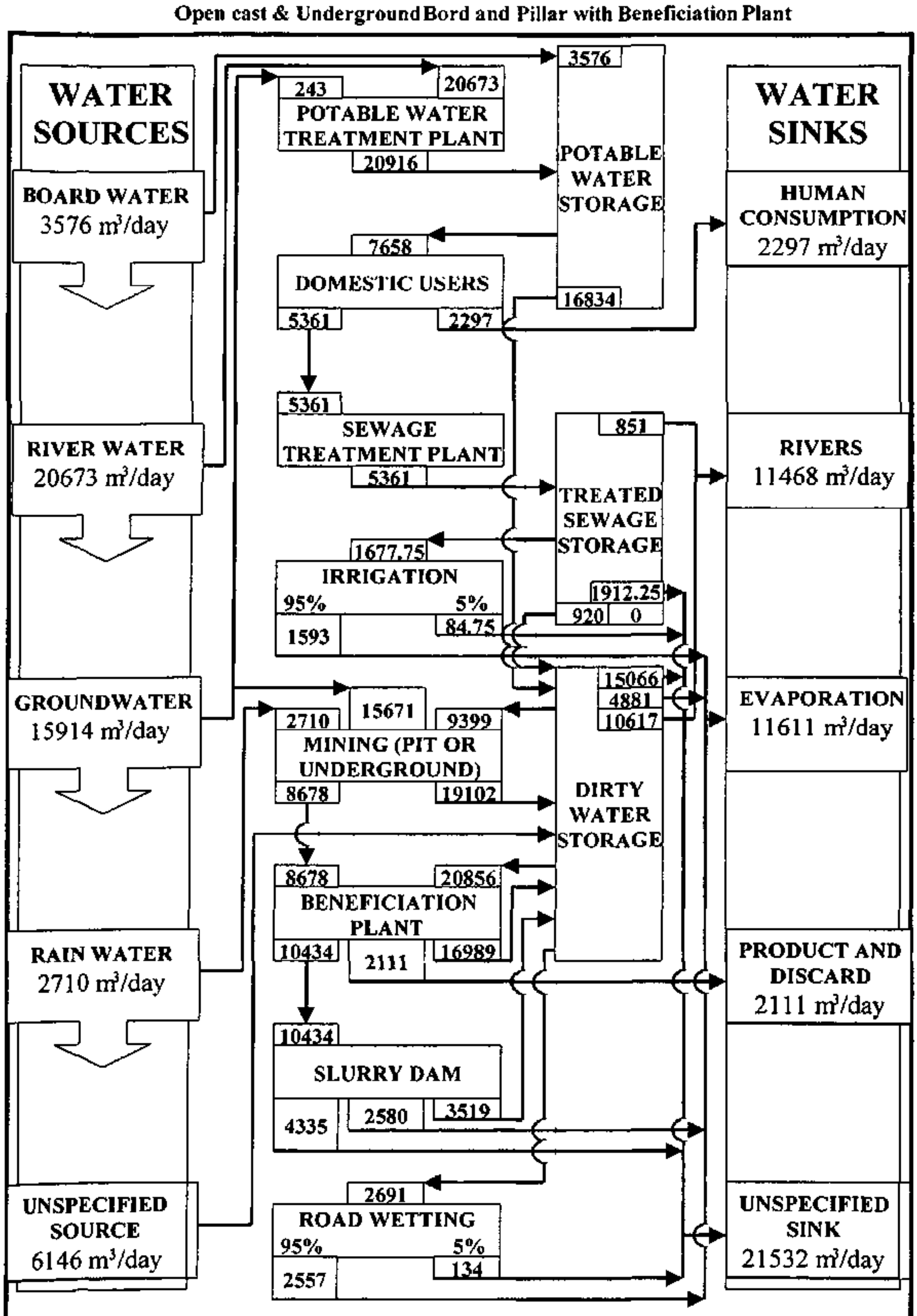


Figure 14: Summary water balance for combined opencast and underground bord & pillar mines with beneficiation plants

Thirty-one per cent of the available potable water is used for domestic purposes, whereas 30% of the domestic water is consumed. Approximately 31.3% of the treated sewage is being used for irrigation and 15.9% is being discharged into the river systems. Approximately 17% of the treated sewage is being recirculated.

The total volume of water required for mining activities amounts to 56.7% of the total water budget, i.e. 27 780 m^3/d. Of this volume of water, 68.8% is being recirculated. The beneficiation plant receives 29 534 m^3/d, of which 35.3% is passed on to the slurry dam, 57.5% is being recirculated, and the remainder is lost as moisture with the product and discard material. Road wetting and dust suppression accounts for 5.5% of the total water budget.



All values in m³/day

Figure 15: Overall generic water balance for combined opencast and underground bord & pillar mines with beneficiation plants

The largest specified portion of the effluent, i.e. 23.7%, is lost through evaporation, whereas 23.4% of the effluent is discharged into the river systems. Approximately 4.3% is lost as moisture together with the product and discard material. Human consumption accounts for 4.7% of water lost. The remaining portion of effluent, i.e. 43.9%, is discharged into unspecified sinks. Detailed water balances for the eleven mines in this particular group are presented in Appendix 2. Variations for the data between the different mines are shown in Table 5.

Table 5: Summary of the statistics for combined opencast and underground bord & pillar mines with beneficiation plants

	Average	Minimum	Maximum	Average %	Minimum %	Maximum %
Stream 001	48	45	50	50	47	53
Stream 002	3778	333	9945	20	2	65
Stream 003	773	30	2430	17	0	47
Stream 004	0	0	0	0	0	0
Stream 005	1649	340	3606	33	7	73
Stream 006	79	10	203	25	0	85
Stream 007	3778	333	9945	20	2	65
Stream 008	2558	10	9945	14	0	64
Stream 009	559	24	2189	14	1	61
Stream 010	419	18	1642	14	1	61
Stream 011	140	6	547	14	1	61
Stream 012	419	18	1642	14	1	61
Stream 013	143	16	400	25	3	70
Stream 014	136	15	380	25	3	70
Stream 015	7	1	20	25	3	70
Stream 016	0	0	0	0	0	0
Stream 017	725	20	2430	17	0	48
Stream 018	1718	123	3606	33	2	70
Stream 019	985	123	3969	14	2	64
Stream 020	719	20	1430	20	0	52
Stream 021	1321	160	2949	20	2	37
Stream 022	937	82	2850	13	1	42
Stream 023	251	4	1269	13	0	72
Stream 024	959	687	1340	25	11	53
Stream 025	391	82	1433	13	3	49
Stream 026	2580	2580	2580	100	100	100
Stream 027	1247	1247	1247	100	100	100
Stream 028	460	48	1340	20	2	61
Stream 029	437	46	1273	20	2	61
Stream 030	23	2	67	20	2	61
Stream 031	2418	10	9083	20	0	75
Stream 032	0	0	0	100	100	100
Stream 033	471	34	1242	33	2	88
Stream 034	265	23	507	50	4	96
Stream 035	1610	248	5296	17	2	49
Stream 036	905	23	3506	25	1	97
Stream 037	617	617	617	100	100	100
Stream 038	617	617	617	50	23	77
Stream 039	1213	17	3685	13	0	42
Stream 040	1759	149	5422	13	1	35

8. WATER BALANCE FOR COMBINED OPENCAST AND UNDERGROUND BORD & PILLAR MINES WITHOUT BENEFICIATION PLANTS

Water balance data for combined open cast and underground operations without beneficiation plants are summarized in Figure 16 while a more detailed generic water balance is shown in Figure 17. The total production of the three mines in this category amounts to 26 052 t/d. The volume of water associated with these mining activities is 3 503.8 m^3/d. Thus, the volume of water required to mine a ton of coal in this particular category is 134 l/t.

Of the available potable water, 66.3% is available for domestic users. Twenty per cent of the volume of domestic water is consumed. A major portion of the treated sewage, i.e. 52.5%, is used for irrigation, whereas the remainder is discharged into unspecified sinks. Approximately 14 per cent of the total water budget is used for the mining operations, whereas 9.1% is used for road wetting and dust control.

The largest portion of the water is reported as being lost due to evaporation, i.e. 74.6%. Apart from the 8.3% lost due to human consumption, the rest of the effluent is being discharged into unspecified sinks. Detailed water balances for the mines in this particular group are presented in Appendix 2. Variations for the data between the different mines are shown in Table 6.

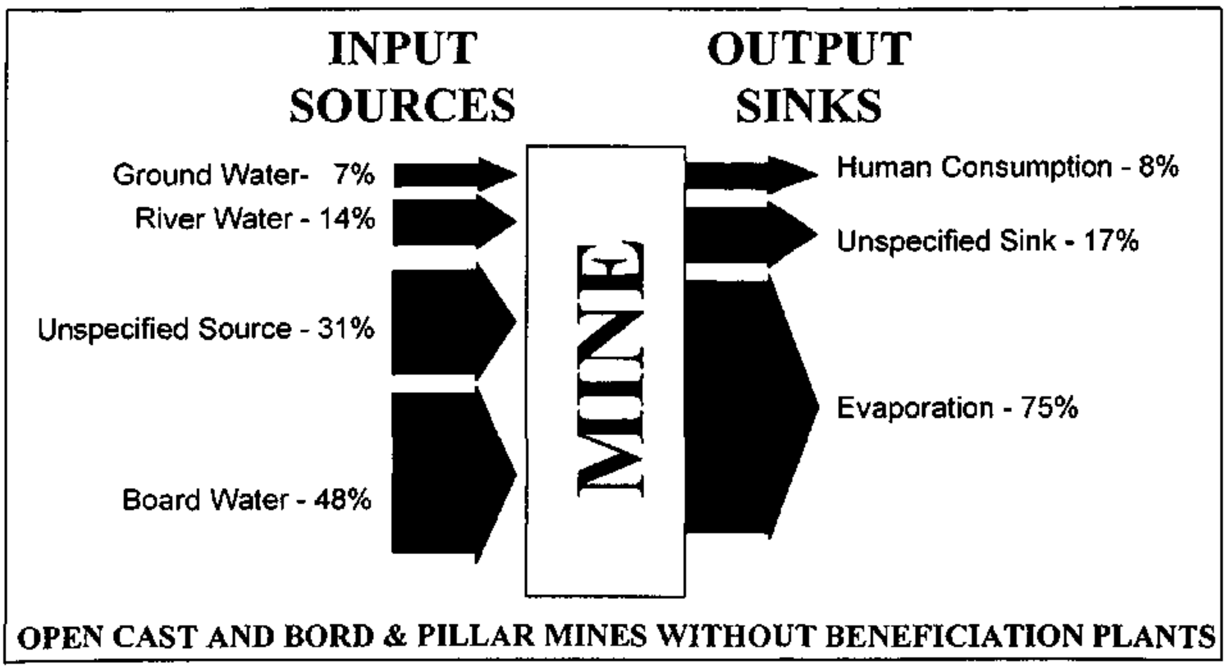
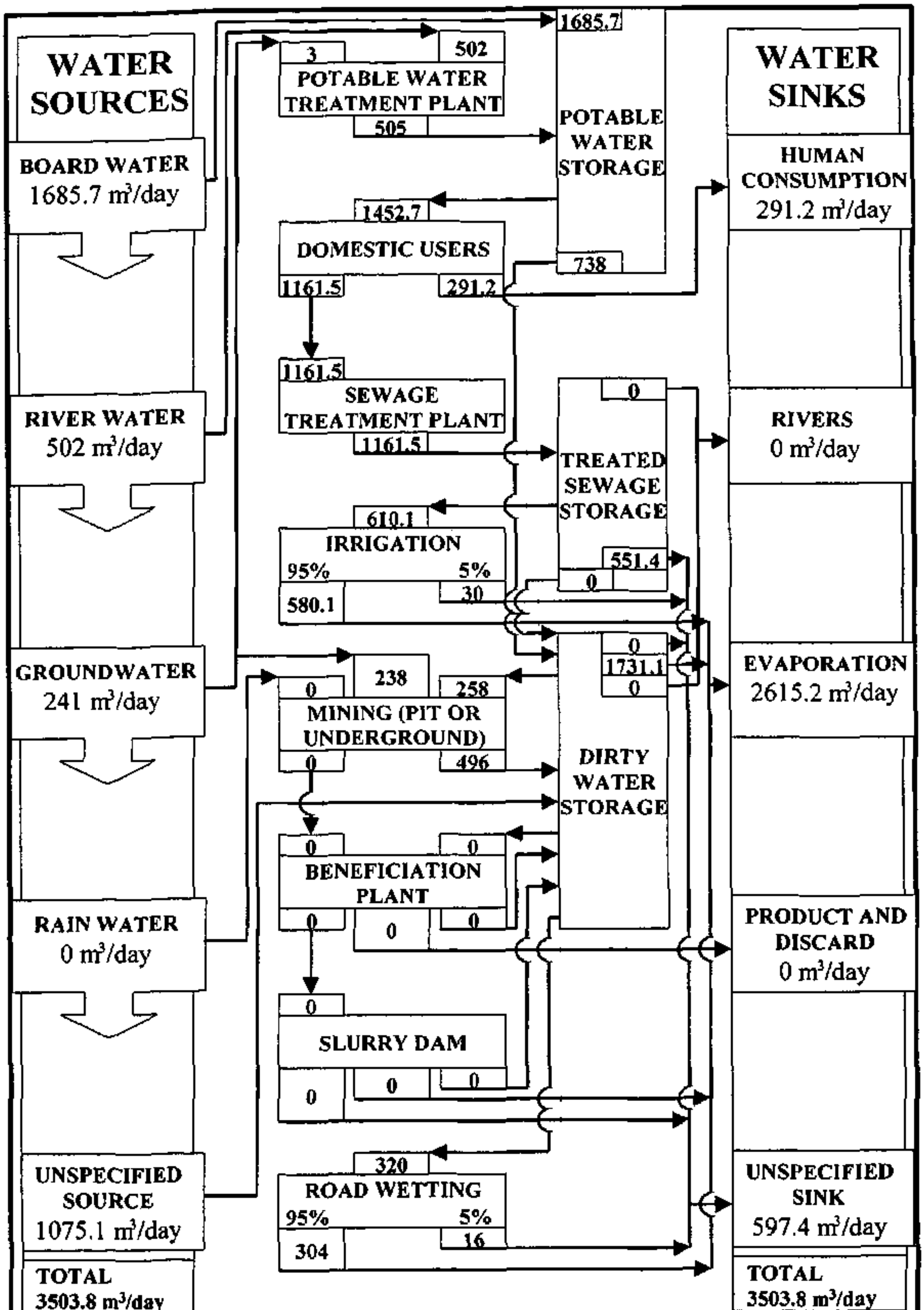


Figure 16: Summary water balance for combined opencast and underground bord & pillar mines without beneficiation plants

Open cast & Underground Bord and Pillar without Beneficiation Plant



All values in m³/day

Figure 17: Overall generic water balance for combined opencast and underground bord & pillar mines without beneficiation plants

Table 6: Summary of the statistics for combined opencast and underground bord & pillar mines without beneficiation plants

	Average	Minimum	Maximum	Average %	Minimum %	Maximum %
Stream 001	843	7	1679	50	0	100
Stream 002	502	502	502	100	100	100
Stream 003	121	40	201	50	17	83
Stream 004	0	0	0	0	0	0
Stream 005	538	225	850	50	21	79
Stream 006	2	1	2	50	33	67
Stream 007	502	502	502	100	100	100
Stream 008	253	1	504	50	0	100
Stream 009	484	8	1085	33	1	75
Stream 010	387	6	886	33	0	76
Stream 011	97	2	199	33	1	68
Stream 012	387	6	886	33	0	76
Stream 013	305	270	340	50	44	56
Stream 014	290	257	323	50	44	56
Stream 015	15	13	17	50	43	57
Stream 016	0	0	0	0	0	0
Stream 017	119	38	200	50	16	84
Stream 018	258	258	258	100	100	100
Stream 019	0	0	0	0	0	0
Stream 020	165	38	258	33	8	52
Stream 021	0	0	0	0	0	0
Stream 022	0	0	0	0	0	0
Stream 023	0	0	0	0	0	0
Stream 024	0	0	0	0	0	0
Stream 025	0	0	0	0	0	0
Stream 026	0	0	0	0	0	0
Stream 027	0	0	0	0	0	0
Stream 028	160	120	200	50	38	63
Stream 029	152	114	190	50	38	63
Stream 030	8	6	10	50	38	63
Stream 031	369	144	594	50	20	80
Stream 032	0	0	0	0	0	0
Stream 033	276	6	546	50	1	99
Stream 034	0	0	0	0	0	0
Stream 035	0	0	0	0	0	0
Stream 036	577	182	850	33	11	49
Stream 037	0	0	0	0	0	0
Stream 038	0	0	0	0	0	0
Stream 039	872	439	1136	33	17	43
Stream 040	199	13	569	33	2	95

9. EVALUATION OF EFFECT OF BENEFICIATION PLANTS ON WATER BALANCES FOR DIFFERENT TYPES OF MINING

The data presented in Chapters 2 to 8 clearly indicate significant anomalies, the most important of which are;

- Large percentages of water derived from unspecified sources (up to 58%) and discharged to unspecified sinks (up to 98%).
- Major variations in evaporation data, ranging from 1 to 87%.
- Major variations in water losses reported with product and discard, ranging from 0 to 10%.

These anomalies, together with the general poor state of water balances found within the industry, make it very difficult to extract meaningful information from the data. It also makes it impossible to determine whether calculated differences in water usage between different types of mining are real or whether they are artifacts of poor data. The discussion presented in this chapter should, therefore, not be considered definitive.

9.1 Open Cast Mines With Beneficiation Plants Vs Open Cast Mines Without Beneficiation Plants

Open cast mines with beneficiation plants represent approximately 20% of the total number of mines surveyed, whereas 5% are open cast mines without beneficiation plants.

The largest source of water for open cast mining operations "with beneficiation plants" is ground water, whereas mines in the category "open cast mines without beneficiation plants" reported river water as the main source of water. The significant effect of a beneficiation plant on water demand is clearly illustrated - mines without a beneficiation plant require 13.6 l/t of coal produced, while mines with a beneficiation plant require 381 l/t of coal produced.

Mines without beneficiation plants consume 25% of the potable water, as opposed to approximately 14% fo0r mines with beneficiation plants, presumably due to the presence of additional users within the plant. The proportion of the total water budget required for the actual mining operations is 14.7% for mining operations without beneficiation plants and 42% for mining operations with beneficiation plants. Those operations with beneficiation plants recycle approximately 26% of the total water budget.

Discharge of effluent in operations associated with beneficiation plants is predominantly claimed to be through evaporation, whereas those operations without beneficiation plants discharge effluent mainly into unspecified sinks, which could include ground water seepage. The apportionment of 98% of "lost" water to unspecified sinks in mines without beneficiation plants is unacceptable and may indicate a higher level of water management on those mines that use more water.

Water usage for domestic and underground mining purposes was only reported by one mine. The usage of water by a single mine, forming 17 % of the total sample set, cannot be validly extrapolated to all open cast mines with beneficiation plants.

A single mine reported data for the effluent water being discharged into rivers, resulting in a value of 0.12 m^3/t. Again this is not a true reflection of the industry, and detracts from the quality and validity of the conclusions in this report.

It needs to be emphasised that the lack of data for the open cast mines with beneficiation plants with regard to borehole, rainfall, river effluent and seepage would definitely lead to inconclusive water balances for this particular category of mines. The lack of domestic water usage data for open cast mines without beneficiation plants would also lead to inconclusive water balances.

9.2 Underground Bord And Pillar Mines With Beneficiation Plants Vs Underground Bord And Pillar Mines Without Beneficiation Plants

The total number of underground bord and pillar mines with beneficiation plants represented 31.7% of the total sample set. The total number of underground bord and pillar mines without beneficiation plants, represented 7.3% of the total sample set. A total of thirteen mines in the survey database employ bord and pillar mining, with or without beneficiation plants. The volume of water required for the underground operations with and without beneficiation plants is 571 l/t and 153 l/t, respectively. This again shows a significant increase in the mine's water usage when a beneficiation plant is present.

The ground water contributed a mean value of 30 004 m^3/d, i.e. 40%, to the total water budget in the category "underground bord and pillar mines with beneficiation plants". In the category "underground bord and pillar mines without beneficiation plants", ground water also provided the bulk of the water budget, i.e. 88% (828 m^3/d).

Mines without beneficiation plants use 87% of the water budget for the underground mining activities, whereas mines with plants use 46.3% of the total water budget for mining. The relatively low proportion of water budget required by underground mining operations is probably due to the high percentage of recycled water being used on these mines, i.e. 68% of the water is being recycled.

Thirteen percent (n=5) of the total number of underground bord and pillar mines with and without beneficiation plants reported data for seepage. It is widely accepted that seepage from coal mining operations is a major issue of concern. It is therefore imperative that such information should be monitored and included in future water and salt balances.

If the data for evaporation and unspecified sinks are added together then it can be seen that approximately 80 - 90 % of discharged water can reportedly be ascribed thereto. These values are unacceptably high and it is difficult to conceive of a water reticulation system that loses 87% to evaporation.

In order to calculate a representative and useful water and salt balance, it is important that a proper inventory of the contributing parameters should be formulated. The limited number of mines that actually provided data for rainfall, seepage and evaporation creates the perception that the contribution of these parameter are being regarded as insignificant, whereas they actually form an important and integral part of an accurate water and salt balance.

9.3 Underground Total Extraction With Beneficiation Plants Vs Underground Total Extraction Without Beneficiation Plants

Only one underground total extraction mine was included in the survey and it included a beneficiation plant. No assessment can therefore be made of the effect of a beneficiation plant on the water balance.

9.4 Open Cast And Underground Bord And Pillar Mines With Beneficiation Plants Vs Open Cast And Underground Bord And Pillar Mines Without Beneficiation Plants

The data from eleven mines that use open cast and underground bord and pillar mining and that have beneficiation plants was acquired, i.e. 26.8% of the mines in the database, compared to the data from three open cast and underground bord and pillar mines without beneficiation plants. The volume of water required per ton of coal mined is 134 l/t for operation without beneficiation plants and 356 l/t for mines with beneficiation plants.

River water is the main water source (42.2%) for operations with beneficiation plants, whereas mines operating without beneficiation plant are mainly dependant on board water, which forms 48.1% of their water budget. Ground water is a major source of water for mines with beneficiation plants, forming 32.5% of the total water budget, as opposed to the 6.9% contribution to the total water budget in operations without a beneficiation plant.

In the case of mining operations without beneficiation plants, the majority of effluent is apportioned to evaporation, i.e. 74.6%. In case of operations with beneficiation plants the discharge is distributed more evenly among the various effluent sinks, i.e. evaporation – 23.7%, river systems – 23.4%, human consumption – 4.7%, and moisture associated with product and discard – 4.3%. The remaining 44% of effluent is discharged into unspecified sinks.

No mines reported any seepage information. This would negatively influence the calculation of a water balance of mines in this category. Five mines reported evaporation data, representing 50% of the mines with and without beneficiation plants.

9.5 General Comments

Although it can generally be stated that the majority of mines suffer from poor water balance information, it would appear that the mines with beneficiation plants have somewhat better water balances. This may be linked to the fact that they use considerably more water than mines without beneficiation plants and are therefore required to apply better water management. The large flows apportioned to evaporation and unspecified sinks clearly hamper the development of meaningful water balances and make interpretation difficult.

10. WATER BALANCE COMPARISONS FOR MINES LOCATED IN THE OLIFANTS RIVER AND VAAL RIVER CATCHMENTS

10.1 Olifants River Catchment

The number of mines located in the Olifants River catchment area formed 51% (n = 21) of the mines in the database. The average volume of water required per ton of coal mined for mines within the Olifants River catchment area is 347 l/t, given a total production of 332 017 t/d and a water requirement of 115 059 m^3/d.

River water and ground water constituted the main sources of water in this catchment area, contributing 36.9% and 37.7%, respectively, to the total water budget. Only 13.1% of the water was sourced as board water. Rainwater supplied only 4.2% of the total water budget. A summary water balance is shown in Figure 18 below while a more detailed generic water balance is shown in Figure 19.

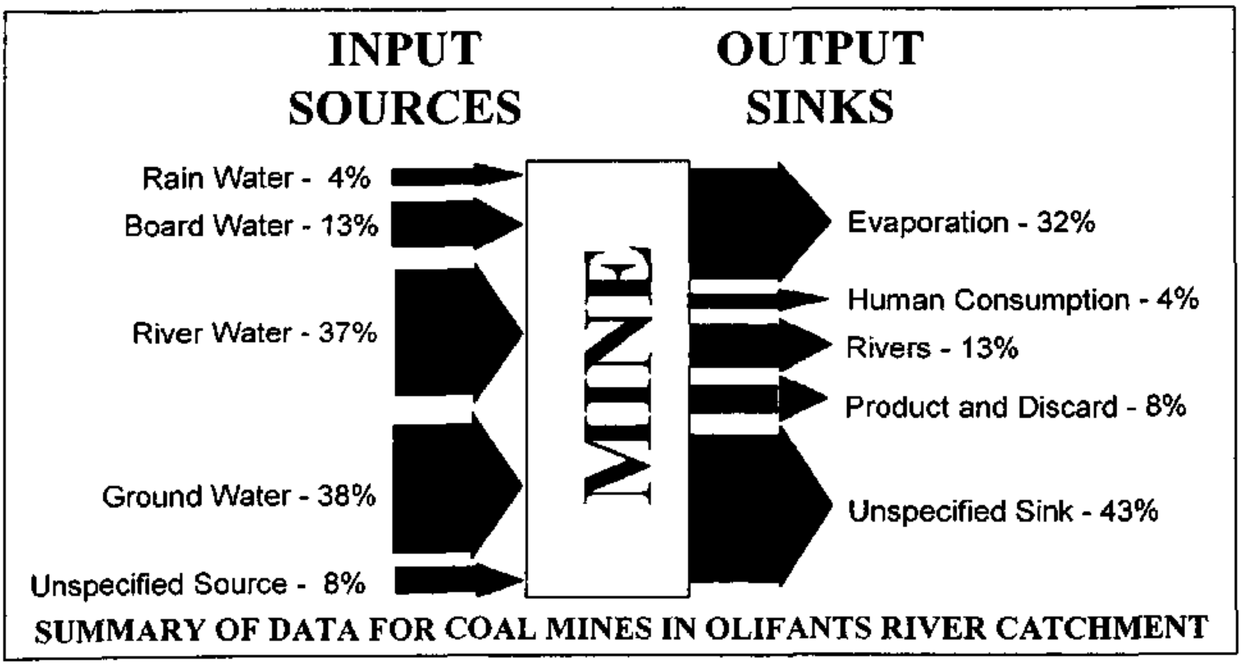
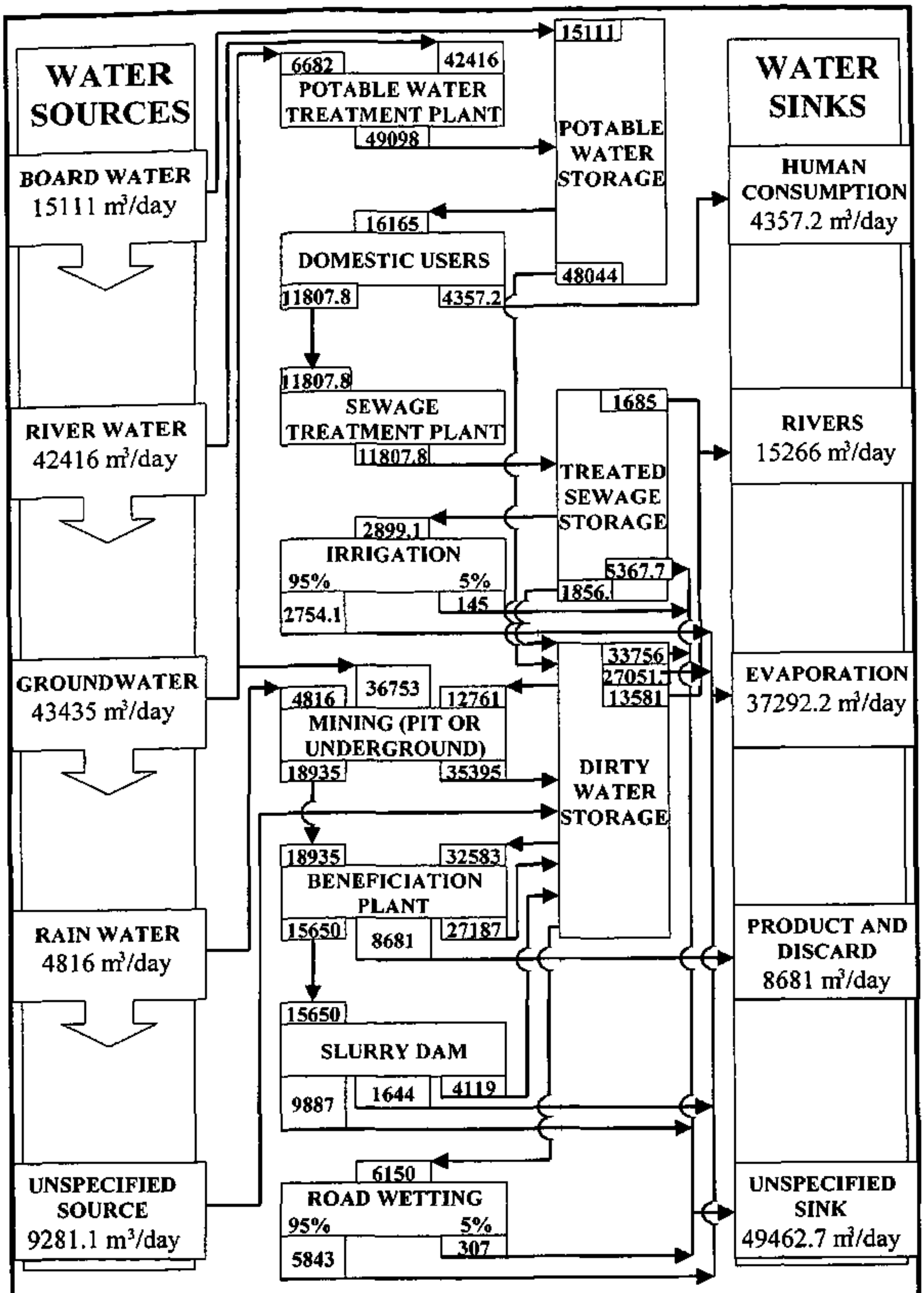


Figure 18: Summary water balance for coal mines in the Olifants River catchment

One quarter of the potable water is allocated for domestic use while domestic users consume 13.4% of the domestic water. Furthermore, one quarter of the treated sewage is used for irrigation purposes. Of the treated sewage effluent, 14.3% is discharged into the river systems. The actual mining operations in the catchment area consume 47.2% of the total water budget. Sixty-five per cent of the water required by the mining operations is recycled.

The volume of water that enters the beneficiation plant is 44.8% of the total water budget, whereas 52.8% of the beneficiation plant water budget is recycled. Approximately 5% of the total water budget is used for dust suppression and road wetting purposes. Only 13.3% of the effluent is discharged into the river systems, whereas the largest volume of effluent is lost to unspecified sinks. Evaporation reportedly accounts for 32.4% of water leaving the systems, with 7.5% of the water being lost as moisture associated with product and discard material.



All values in m³/day

Figure 19: Overall generic water balance for coal mines in the Olifants River catchment

All the mines in the Olifants River catchment drew water from water boards, rivers, boreholes and underground mining or pit water as a primary water source. Combinations of these water sources were used for the mines in this particular catchment. River water was used by 64% of the mines as a water source, resulting in a mean value of 0.32 m^3/t of coal produced. Mines that used underground or pit water as a primary water source totalled some 86%. Only four mines reported rainfall as a source of water.

Approximately 68% of the mines reported using water for beneficiation plants. This indicates that not all the mines in the Olifants River catchment have beneficiation plants. Only 55% reported usage of water for underground mining. Water that is released back to the rivers was only reported by four of the twenty-two mines. This indicates that it is possible that mines are either storing their water and have closed systems, or are not measuring the volume of water that is returned to the rivers.

Seepage losses were only reported by 18% of the mines. This raises a serious question with regard to the adequacy of the water balances. Evaporation was reported by 50% of the mines. The information supplied by the mines did not always indicated whether the evaporation figures were measured or used as a convenient way to balance the calculations. A similar argument applies to the ten mines that reported irrigation figures in the water balances. Twelve mines reported that they recirculated their water. These mines reported closed loop systems for their mines.

10.2 Vaal River Catchment

A total of seven mines that were located in the Vaal River catchment area were included in the database, i.e. 17.1% of the mines in the total database. The total production of these mines amounts to 99 833 t/d, and the volume of water required per ton of coal mined is 472 l/t. The largest source of water is ground water, i.e. 45.4%, whereas 23.2% board water and 8.1% river water makes up the rest of the balance. Approximately one quarter of the water used for coal mining activities in the Vaal River catchment area come from unspecified sources. A summary water balance is shown in Figure 20 below while a more detailed generic water balance is shown in Figure 21.

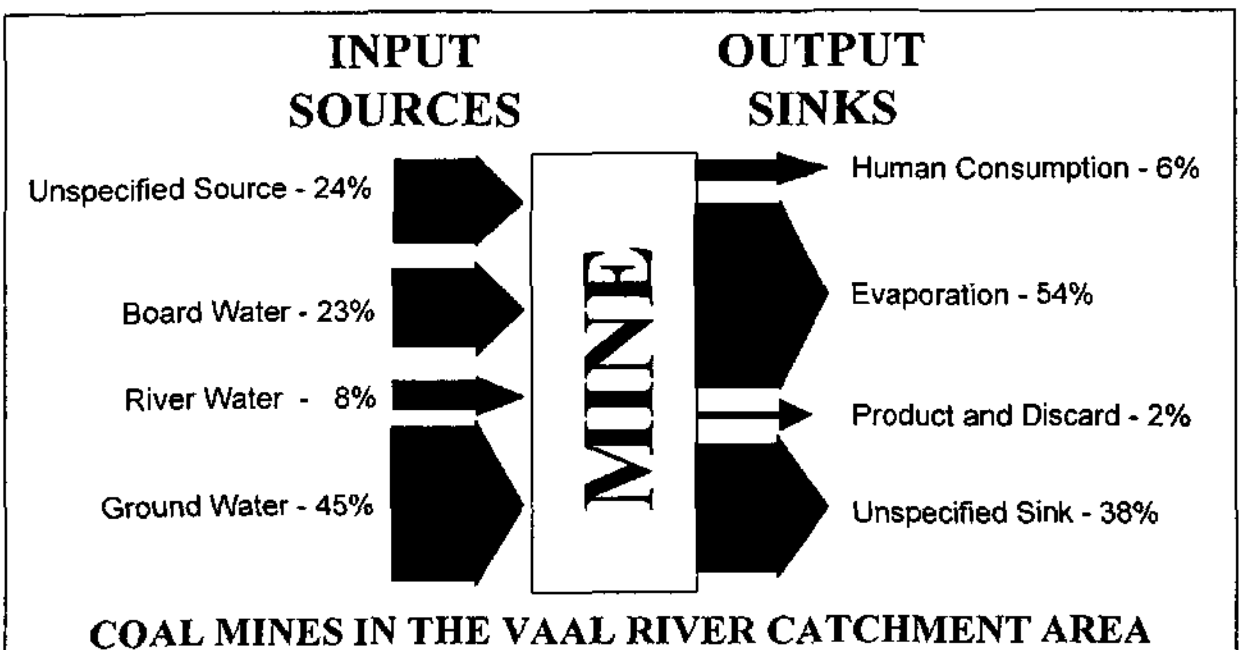
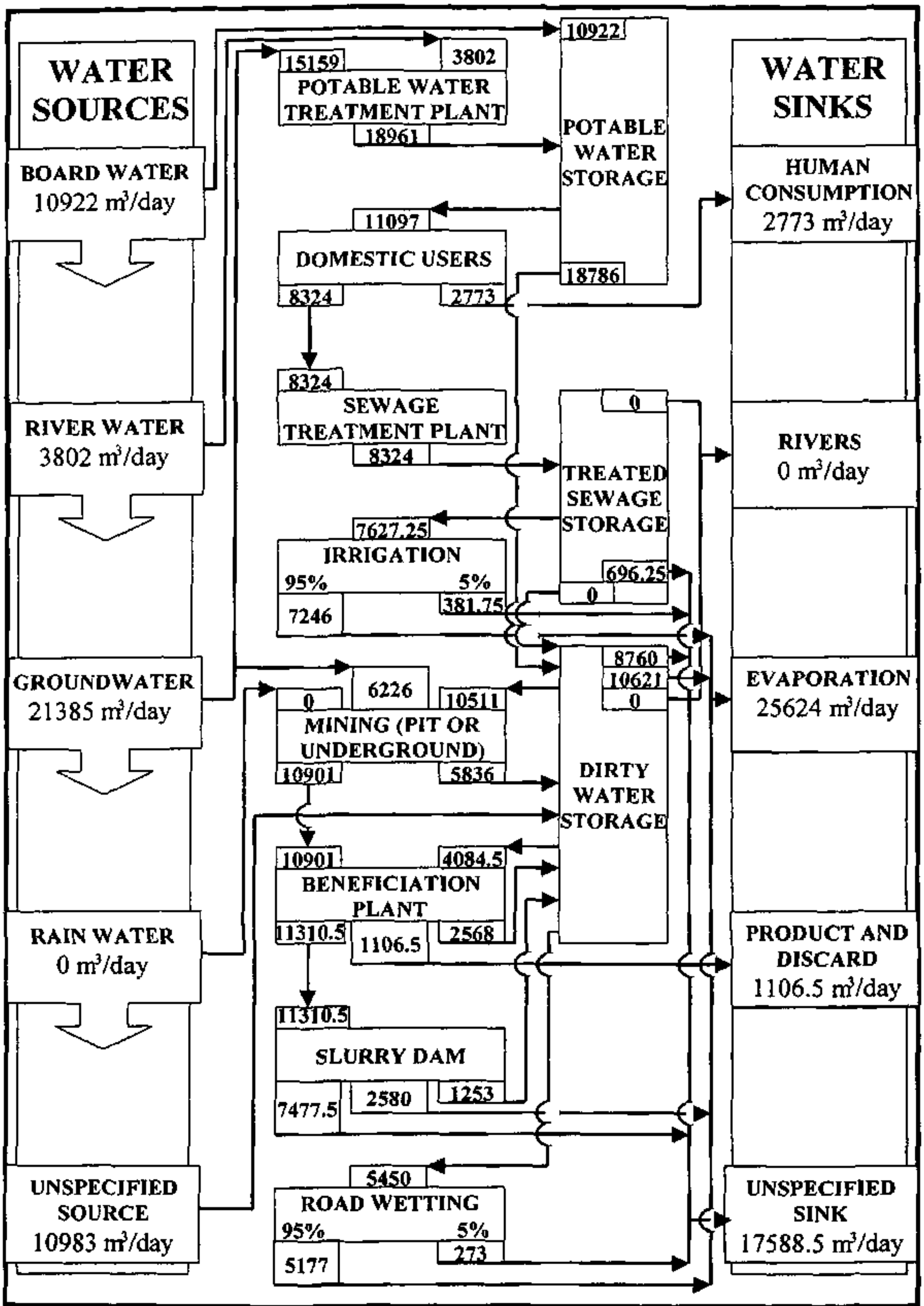


Figure 20: Summary water balance for coal mines in the Vaal River catchment



All values in m³/day

Figure 21: Overall generic water balance for coal mines in the Vaal River catchment

Domestic users consume 5.9% of the total water budget. More than 90% of the treated sewage effluent is used for irrigation. The data obtained in the survey show that no water is released into the rivers in the Vaal River catchment area.

Approximately 30% of the ground water is being used in mining operations. The total water budget required for mining operations forms 35.5% of the available water. Almost 35% of the water used in mining operations is being recycled. Seventeen per cent of the water used in beneficiation plants is being recycled and 7.4% is lost together with the product and discard. A small portion of the slurry pond water is recycled, i.e. 11.1%. Water used for dust suppression and road wetting makes-up 11.6% of the total water budget. The bulk of the water is reportedly lost through evaporation, i.e. 54.4%. Only 2.3% is lost as moisture associated with coal product and discard. The remaining effluent is discharged into unspecified sinks.

All of the mines in the Vaal River catchment drew water from water boards, rivers, boreholes and underground mining or pit water. All the mines used underground or pit water as a water source. Two mines reported rainfall as a source of water. The water users for plant water totalled 86%. Some 50% reported a usage of water for underground mining.

No seepage was reported by any of the mines, which raises questions regarding the accuracy of the mine water balances. Evaporation was reported by 43% of the mines.

11. OVERALL WATER BALANCE FOR THE SOUTH AFRICAN COAL MINING INDUSTRY

The overall water balance for the South African coal mining industry indicates that on average, 133 l of water is used for each ton of coal that is mined. A large percentage, approximately 85%, use underground or pit water as a water source compared to some 57% that extract board water as a water source. Volumetrically, the primary source of water came from ground water and river water, contributing 35.9% and 32.3% respectively. Board water as a primary source, contributed 12.7% of the total water source. A summary of the water balance is shown in Figure 22 while a more detailed generic water balance is shown in Figure 23. Summary data on water sources and sinks are shown in Tables 7 and 8 respectively.

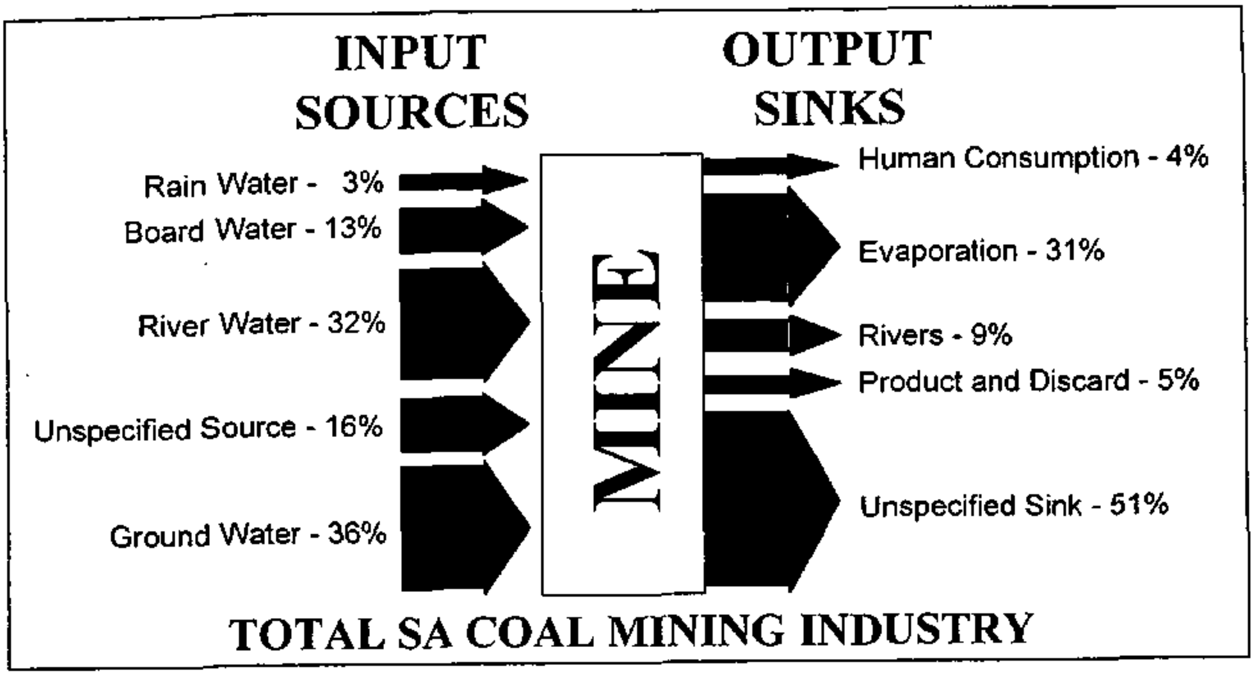
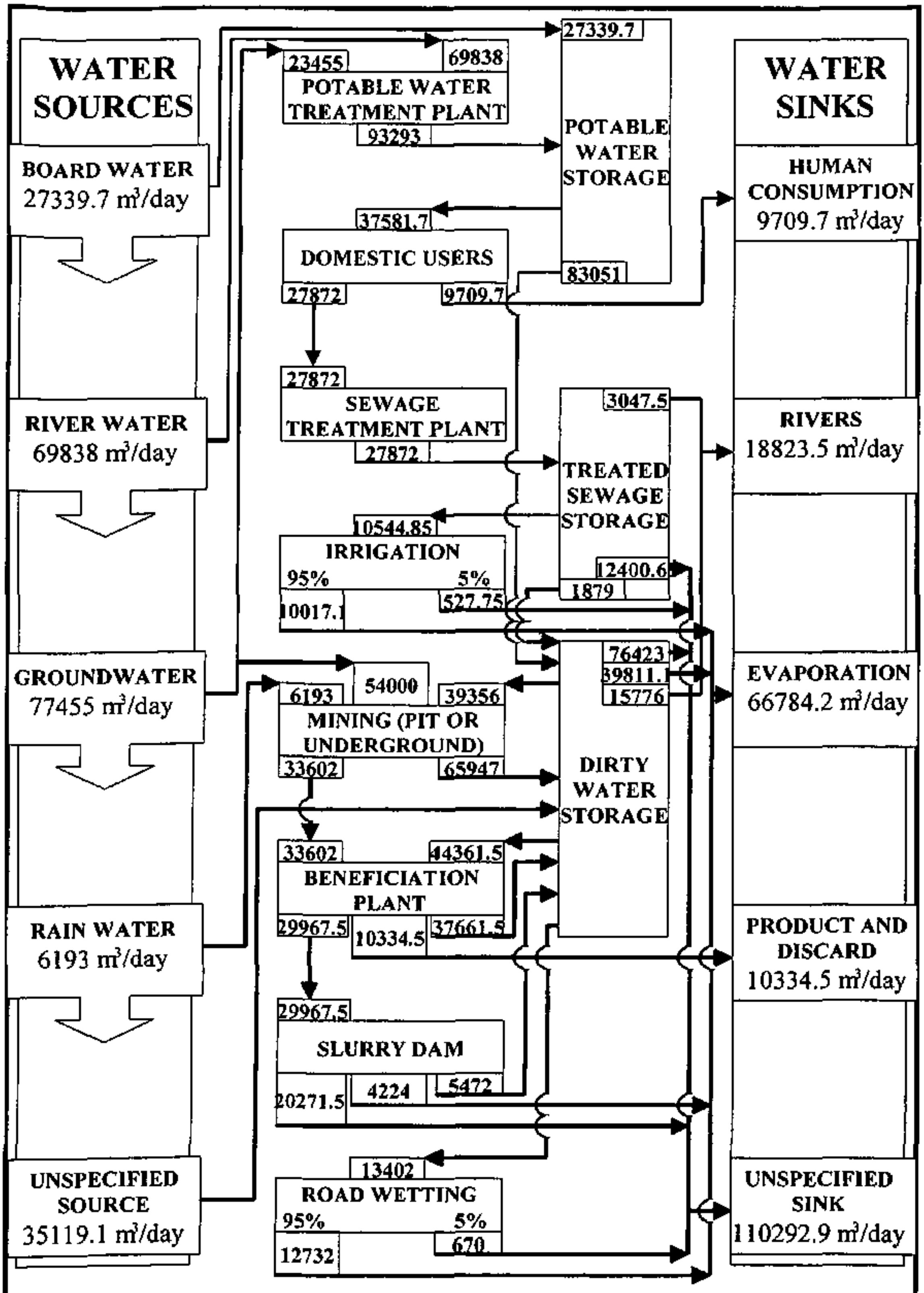


Figure 22: Summary water balance for the South African coal mining industry

Beneficiation plants consumed the largest portion, *i.e.* 36.1%, of the water used by the industry, compared to mining operations that used 25% of the available water. Six percent of the total water consumed by the coal mining industry was used for road wetting. Approximately 31% of the available potable water is used for domestic purposes, with 18.8% of the latter volume of water actually being consumed.

Only ten mines, *i.e.* 25% of the total number of mines, have included seepage as a parameter in water balance calculations, creating the erroneous perception that seepage from coal mines is not a problem. This omission reflects, among others, the lack of detail contained in water balances produced by the majority of mines.

In general, the water balances provided by the mines suffers from a lack of detail, *e.g.* 40% have not included evaporation in their water balance. In order to develop a thorough understanding of the water and salt balance in the coal mining industry, it is imperative that sufficient detail should be included in the mine's balances.



All values in m³/day

Figure 23: Overall generic water balance for the South African coal mining industry

The incompleteness of water balances on South African coal mines is reflected in the large percentage, i.e. 51.1%, of effluent being discharged into unspecified sinks. These unspecified sinks could include loss of water that is difficult to quantify, such as ground water, but could also indicate a lack of good water balance information for each individual mine. In general, water is lost in the following manners: human consumption – 4.5%; rivers – 8.7%; evaporation – 30.9%; and water lost as moisture with the coal and discard material – 4.8%.

Table 7: Summary of water sources data for all survey mines

Stream	Opencast with beneficiation plant	Opencast without beneficiation plant	Underground bord&pillar with beneficiation plant	Underground bord&pillar without beneficiation plant	Total extraction with beneficiation plant	Opencast and bord&pillar with beneficiation plant	Opencast and bord&pillar without beneficiation plant	TOTAL SURVEY MINES
Coal production (t/d)	*159056*	*1168333*	*130650*	*6167*	*833*	*137693*	*26052*	*1628784*
No of mines	*8*	*2*	*13*	*3*	*1*	*11*	*3*	*41*
BOARD WATER								
Volume (m^3)	2537	1205	18336	0	0	3576	1686	27340
% of budget	4	8	25	0	0	7	48	13
Specific usage (l/t)	15.95	1.03	140.34	0	0	25.97	64.72	16.79
RAIN WATER								
Volume (m^3)	2106	1377	0	0	0	2710	0	6193
% of budget	3	9	0	0	0	6	0	3
Specific usage (l/t)	13.24	1.18	0	0	0	19.68	0	3.80
RIVER WATER								
Volume (m^3)	18824	10822	15427	90	3500	20673	502	69838
% of budget	31	68	21	10	31	42	14	32
Specific usage (l/t)	118.35	9.26	118.08	14.59	4201.68	150.14	19.27	42.88
GROUND WATER								
Volume (m^3)	26726	2442	30004	828	1300	15914	241	77455
% of budget	45	15	40	88	11	33	7	36
Specific usage (l/t)	168.03	2.09	229.65	134.26	1560.60	115.58	9.25	47.55
UNSPECIFIED SOURCES								
Volume (m^3)	10495	0	10838	25	6540	6146	1075	35119
% of budget	17	0	14	2	58	12	31	16
Specific usage (l/t)	65.98	0	82.95	4.05	7851.14	44.64	41.26	21.56
TOTAL WATER SOURCES								
Volume (m^3)	60688	15846	74605	943	11340	49019	3504	215945
% of budget	100	100	100	100	100	100	100	100
Specific usage (l/t)	381.55	13.56	571.03	152.91	13613.45	356.00	134.50	132.58

Table 8: Summary of water sinks data for all survey mines

Stream	Opencast with beneficiation plant	Opencast without beneficiation plant	Underground bord&pillar with beneficiation plant	Underground bord&pillar without beneficiation plant	Total extraction with beneficiation plant	Opencast and bord&pillar with beneficiation plant	Opencast and bord&pillar without beneficiation plant	TOTAL SURVEY MINES
Coal production (t/d)	*159056*	*1168333*	*130650*	*6167*	*833*	*137693*	*26052*	*1628784*
No of mines	*8*	*2*	*13*	*3*	*1*	*11*	*3*	*41*
HUMAN CONSUMPTION								
Volume (m^3)	1005	132	5081	29	875	2297	291	9710
% of budget	2	1	7	3	8	5	8	4
Specific usage (l/t)	6.32	0.11	38.89	4.70	1050.42	16.68	11.17	5.96
DISCHARGE TO RIVERS								
Volume (m^3)	1101	0	6193	61	0	11468	0	18824
% of budget	2	0	8	6	0	23	0	9
Specific usage (l/t)	6.92	0	47.40	9.89	0	83.29	0	11.56
PRODUCT & DISCARD MOISTURE								
Volume (m^3)	6005	0	2219	0	4	2111	0	10334
% of budget	10	0	3	0	0	4	0	5
Specific usage (l/t)	37.75	0	16.98	0	4.81	15.33	0	6.34
EVAPORATION								
Volume (m^3)	36200	153	15295	815	95	11611	2615	66784
% of budget	59	1	21	87	1	24	75	31
Specific usage (l/t)	227.59	0.13	117.07	132.16	114.05	84.33	100.38	41.00
DISCHARGE TO UNSPECIFIED SINKS								
Volume (m^3)	16377	15561	45817	38	10366	21532	598	110293
% of budget	27	98	61	4	91	44	17	51
Specific usage (l/t)	102.96	13.32	350.69	6.16	12444.18	156.38	22.95	67.71
TOTAL SINKS								
Volume (m^3)	60688	15846	74605	943	11340	49019	3504	215945
% of budget	100	100	100	100	100	100	100	100
Specific usage (l/t)	381.55	13.56	571.03	152.91	13613.45	356.00	134.50	132.58

An evaluation of the different components of the water balance is presented in the following sections of this chapter. The data shown in Tables 7 and 8 clearly indicate that there are two categories of mine that deviate substantially from the average values. The 2 mines classed as opencast without a beneficiation plant account for a large percentage (71.7%) of the overall coal production but exhibit an extremely low water usage based on supplied data. On the other hand, the single total extraction mine with a beneficiation plant has a very small coal production but an extremely high water usage. If the data for these three mines are excluded then the average data for all the survey mines changes substantially as shown below:

- Average specific board water usage changes from 16.79 l/t to 56.86 l/t
- Average specific rain water usage changes from 3.80 l/t to 10.48 l/t
- Average specific river water usage changes from 42.88 l/t to 120.79 l/t
- Average specific ground water usage changes from 47.55 l/t to 160.38 l/t
- Average water usage from unspecified sources changes from 21.56 l/t to 62.18 l/t
- Average human consumption of water changes from 5.96 l/t to 18.94 l/t
- Average water discharge to river changes from 11.56 l/t to 40.96 l/t
- Average water loss to product and discard moisture changes from 6.34 l/t to 22.48 l/t

- Average evaporative water loss changes from 41.00 l/t to 144.76 l/t
- Average water discharge to unspecified sinks changes from 67.71 l/t to 183.56 l/t
- Average total water usage changes from 132.58 l/t to 410.69 l/t

11.1 Usage of Board Water

The reported usage of Board water varied significantly between the different types of mining activities as shown in Figure 24 below.

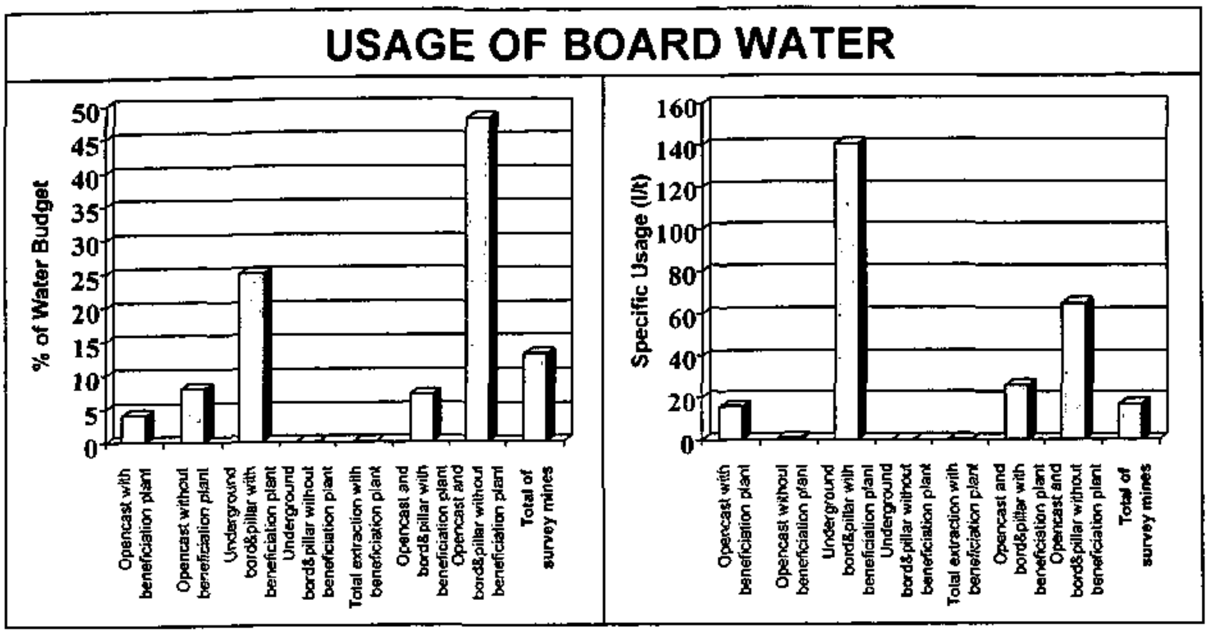


Figure 24: Usage of board water

The average usage of Board water within the survey coal mines is 16.79 l/ton of coal mined, although this increases to 56.86 l/ton when the data for opencast mines without beneficiation plants and total extraction mines with beneficiation plant are excluded. It is interesting to note that two of the mining categories (underground bord & pillar with beneficiation plant and combined opencast and bord & pillar mines without beneficiation plant) have a major requirement for Board water in terms of their overall water budget. There is no clear explanation for this and it may be a co-incidence of the physical locality of the mines.

11.2 Usage of Rain Water

The reported usage of rain water varied significantly between the different types of mining activities as shown in Figure 25 below.

It is believed that the fact that so many mines did not include rainwater in the overall water budget is indicative of inadequate water balances. Coal mines include significant areas of contaminated land, particularly for opencast mines and all mines with beneficiation plants. Good practice with regard to pollution control requires that rain runoff from these contaminated areas be collected and reused or treated and discharged. Mines in these categories that do not include rain water in their water balance either have an inadequate balance or are not applying appropriate water management measures.

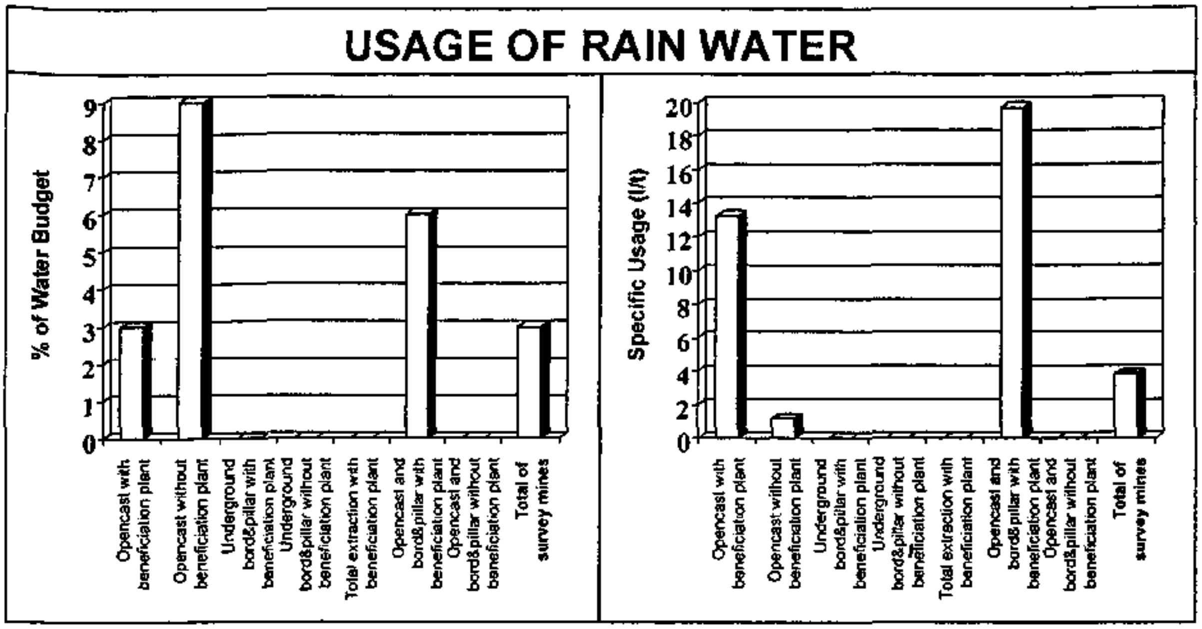


Figure 25: Usage of rain water

11.3 Usage of River Water

The reported usage of river water varied between the different types of mining activities as shown in Figure 26 below.

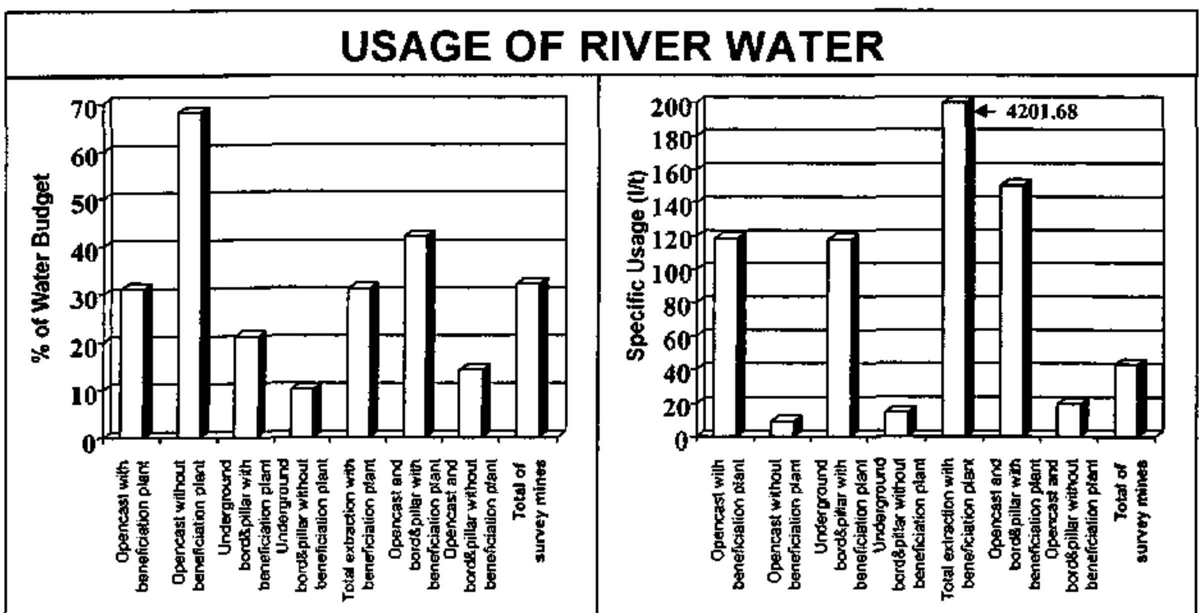


Figure 26: Usage of river water

While the actual importance of river water as a contributor to the overall water budget varied substantially from 10 to 68%, all the categories of mining included river water as a primary water source with an average contribution of 32% of water budget. The specific usage of river water varied from less than 10l/ton of coal to 150 l/ton of coal with a single mine reporting a usage of 4200 l/ton of coal. The average specific usage of river water increases from 42.88 to

120.79 l/ton of coal mined when the data for opencast mines without beneficiation plants and total extraction mines with beneficiation plant are excluded.

It is also interesting to note (see Figure 26 and Table 7) that specific river water usage ranged from 10-20 l/ton for mines without beneficiation plants and was an order of magnitude higher at 120-150 l/ton for mines with beneficiation plants.

11.4 Usage of Ground Water

The reported usage of ground water varied significantly between the different types of mining activities as shown in Figure 27 below.

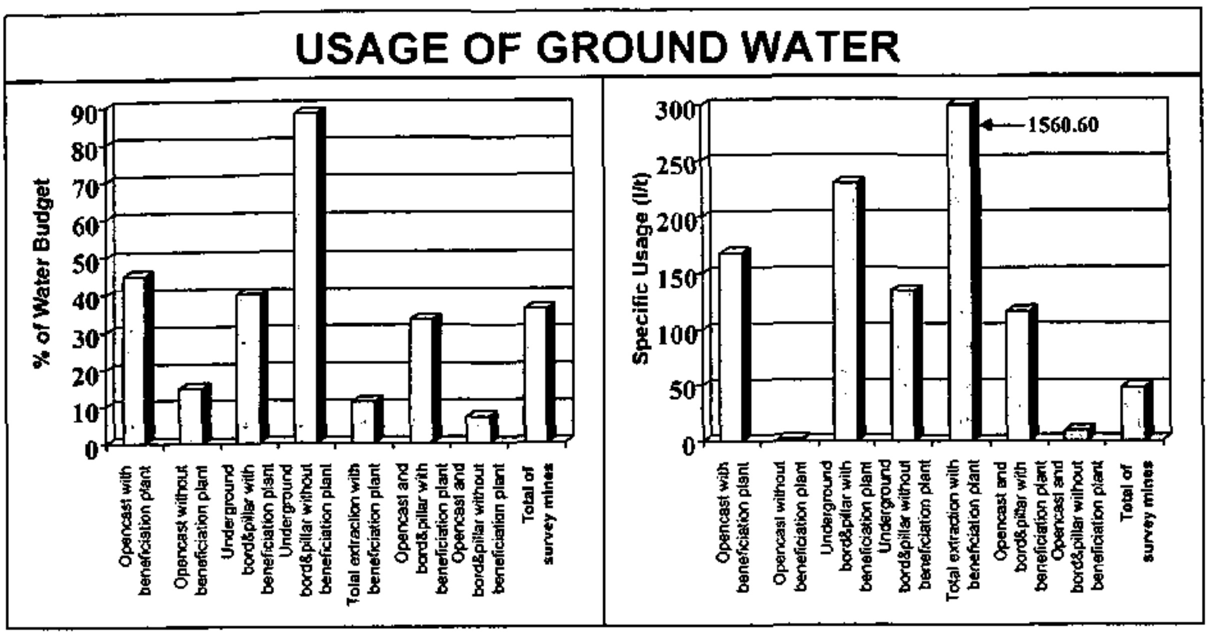


Figure 27: Usage of ground water

The importance of the ground water as a contributor to the overall water budget varied from 7 to 88 percent while the specific ground water usage varied from 2 to 230 l/ton of coal mined. As with the other categories of water usage, when the data for opencast mines without beneficiation plants and total extraction mines with beneficiation plant are excluded, the average industry specific usage of ground water increases from 47.55 to 160.38 l/ton of coal mined. There are no correlations between ground water usage and type of mining or presence of beneficiation plant.

11.5 Usage of Water from Unspecified Sources

The reported usage of water from unspecified sources for the different types of mining activities are shown in Figure 28 below.

An accurate water balance should have no apportionment of water to unspecified sources. Data obtained during the survey and subsequently manipulated by the research team indicated that on average, for all the survey mines, 16 % of the incoming water budget was unallocated. The average specific water usage from unspecified sources also increases from 21.56 to 62.18 l/ton of coal mined when the data for opencast mines without beneficiation plants and total extraction mines with beneficiation plant are excluded.

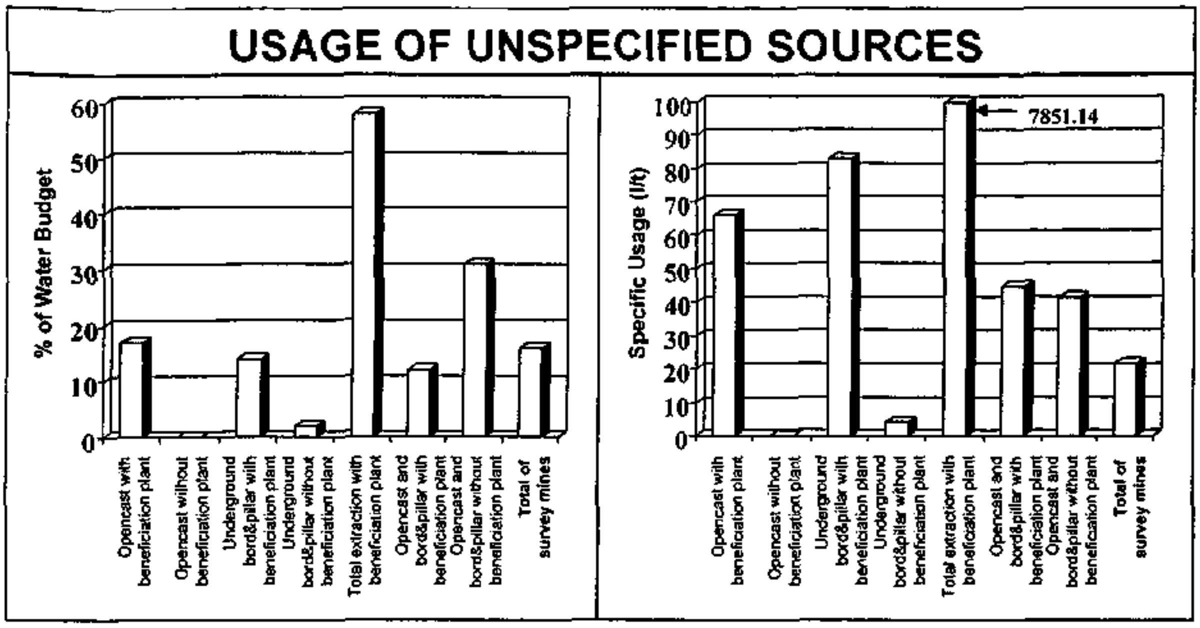


Figure 28: Usage of water from unspecified sources

11.6 Human Consumption of Water

The reported human consumption of water varied between 1 and 8 percent of the total water budget for the different types of mining activities as shown in Figure 29 below.

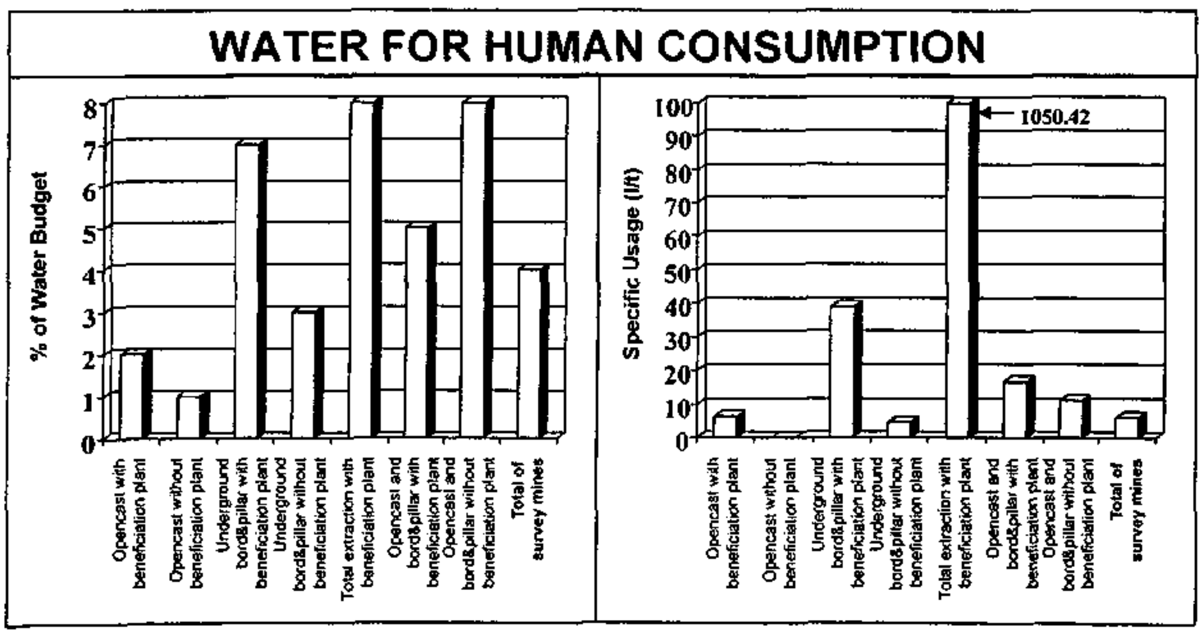


Figure 29: Human consumption of water

The average specific water usage for human consumption is 5.96 l/ton of coal, increasing to 18.94 l/ton of coal when the data for opencast mines without beneficiation plants and total extraction mines with beneficiation plant are excluded. As discussed previously, the single mine within the category "total extraction with beneficiation plant" clearly has a major problem with its reported water balance with a specific human consumption value of 1050 l/ton of coal mined.

11.7 Water Discharge to Rivers

The reported water discharge to rivers varied substantially between the different types of mining activities as shown in Figure 30 below.

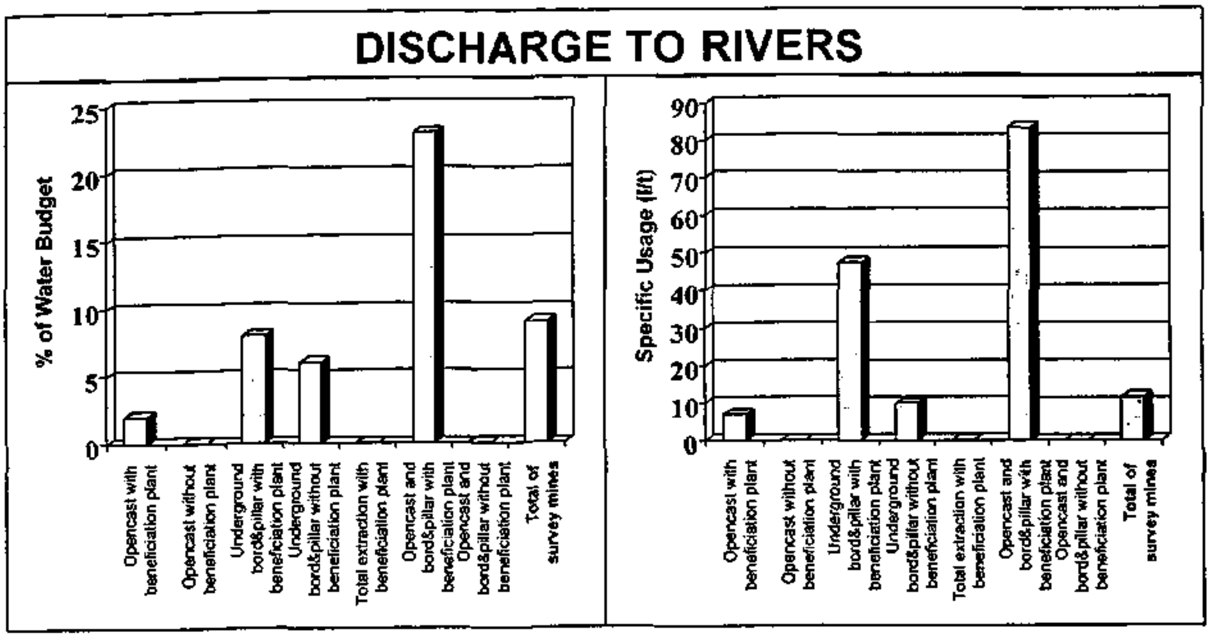


Figure 30: Discharge of water to rivers

While many mines reported no discharge of water to rivers, others used the rivers as a major sink of water. A study of the water balances in Appendix B will indicate that 28 of the 41 survey mines reported zero discharge to rivers in their water balances. Those mines that did discharge to rivers generally tended to use the river as the major sink for discharged water. On average, the survey mines discharged 11.56 l/ton of coal mined to receiving surface watercourses which increases to 40.96 l/ton when the data for opencast mines without beneficiation plants and total extraction mines with beneficiation plant are excluded.

11.8 Moisture on Product and Discard

The reported/calculated losses of water to surface moisture on coal and coarse varied substantially between the different types of mining activities as shown in Figure 31 below.

It must be pointed out that it is an artifact of the way the water balances were constructed for this project that all mines without beneficiation plants show a zero allocation to moisture on the coal. For these mines, this portion of the water budget will be allocated to unspecified sinks. For the mines with beneficiation plants, this component of the water balance was generally omitted by the mines themselves and the reported values are based on calculations by the research team who assumed a surface moisture equivalent to 6% of the dry weight of washed coal and coarse discard. This suggests that the calculated average specific water usage of 6.34 l/ton of coal mined should increase to around 60/lton when data for the mines without beneficiation plants are included.

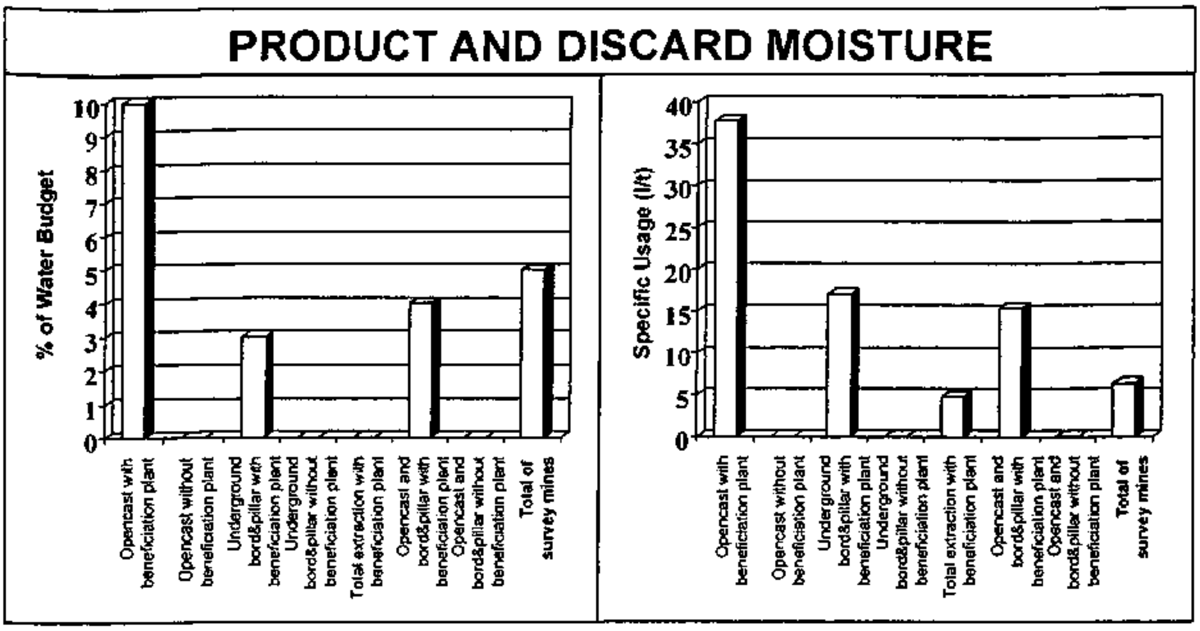


Figure 31: Product and discard moisture

11.9 Water Lost to Evaporation

The reported losses of water to evaporation varied substantially between the different types of mining activities as shown in Figure 32 below.

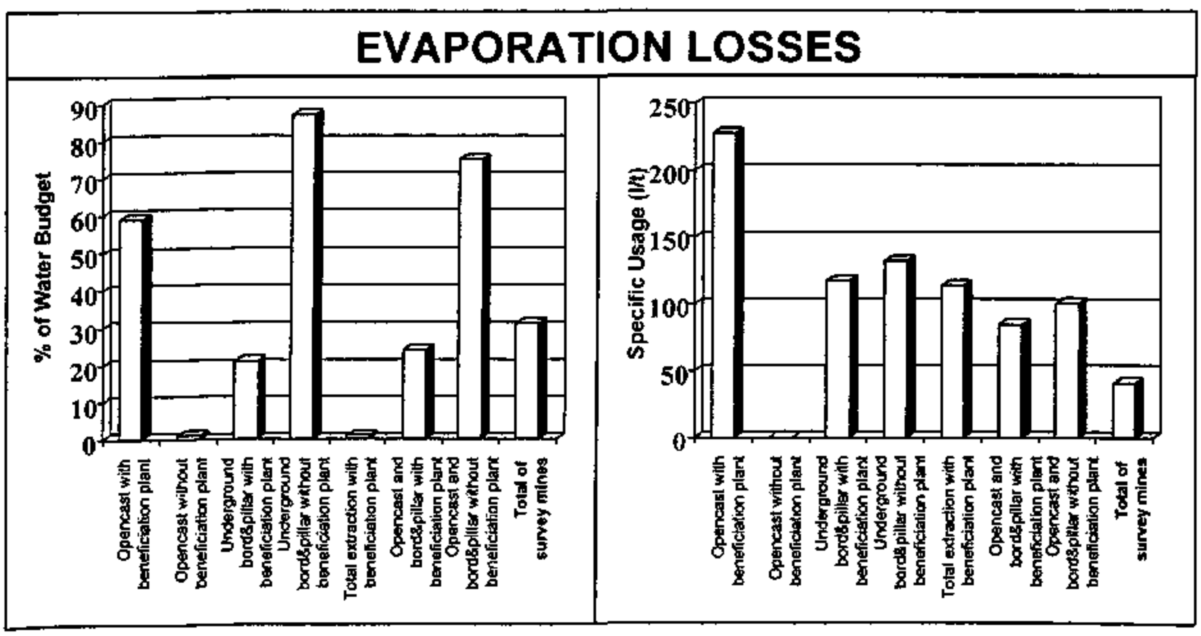


Figure 32: Evaporation losses

Reported evaporation varied between the different types of mines from an unrealistically low 1 % of water budget to a very optimistic 87%. It has been observed that many mines ignore the effect of seepage losses from water storage facilities, slurry dams and discard dumps and readily ascribe the missing water to evaporation. A review of the balances shown in Appendix B indicates that individual mines report evaporation as accounting for anywhere between 0 and 95 % of their water sinks, with both extremes being unrealistic. The average specific water loss to evaporation for all the survey mines is 41 l/ton of coal mined, increasing to 144.76 l/ton of coal mined when the data for opencast mines without beneficiation plants and total extraction mines with beneficiation plant are excluded.

Generally speaking, most of the coal mines did not calculate evaporation in any scientifically defensible manner and unexplained or unaccounted for losses were often simply allocated to evaporation.

11.10 Water Discharged to Unspecified Sinks

The reported losses of water to unspecified sinks is unacceptably high and was found to vary between 4 and 98% of the total water budget as shown in Figure 33 below.

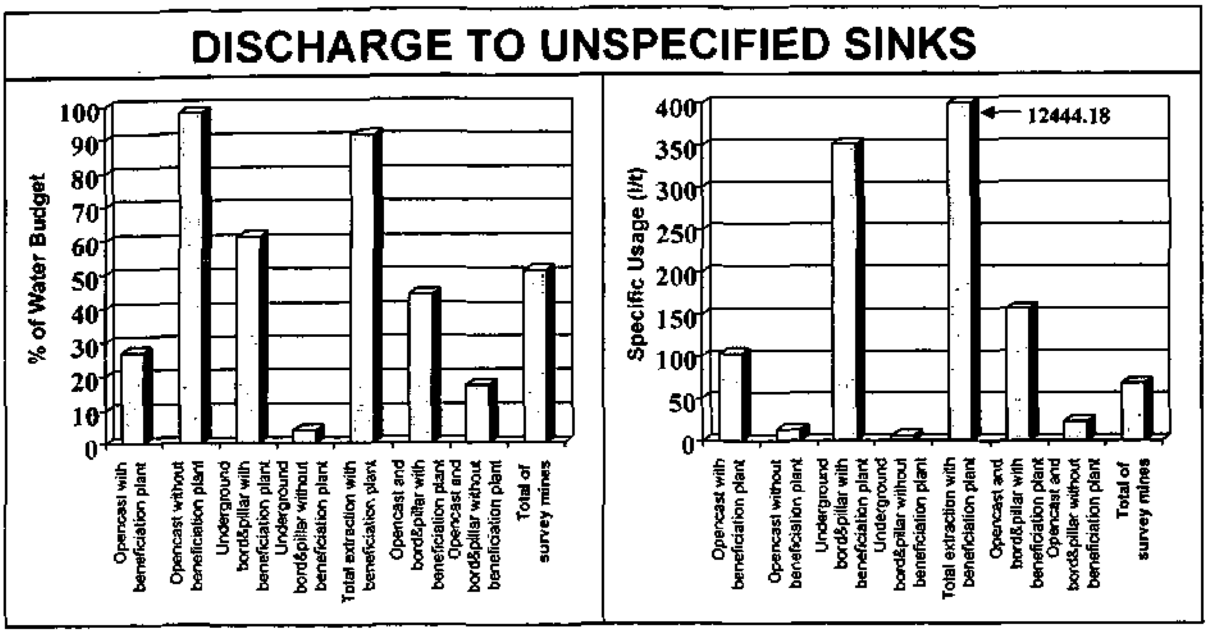


Figure 33: Discharge to unspecified sinks

On average, for all the survey mines, 51% of the water discharged by the mines was unallocated - indicating serious problems with water balances and water management on these mines. It is not possible for a mine to control and manage its water impacts if it is not known where the water is being discharged. The apportionment to unspecified sinks is also almost four times higher than the unspecified sources, suggesting that management of water intake (which often costs money) is considered more important than management of water discharge.

11.11 Total Water Sources and Sinks

The variations in specific total water usage between the different types of mines, with and without beneficiation plants is shown in Figure 34 below.

The average total specific water usage across all the survey mines was 132.58 l of water per ton of coal mined. When the data for opencast mines without beneficiation plants and total extraction mines with beneficiation plant are excluded, the average total specific water usage increases more than threefold to 410.69 l/ton of coal mined. The one total extraction mine with a beneficiation plant reported an unrealistic specific water usage of 13613 l/ton of coal mined - suggesting either a very poor water balance and/or very poor water management.

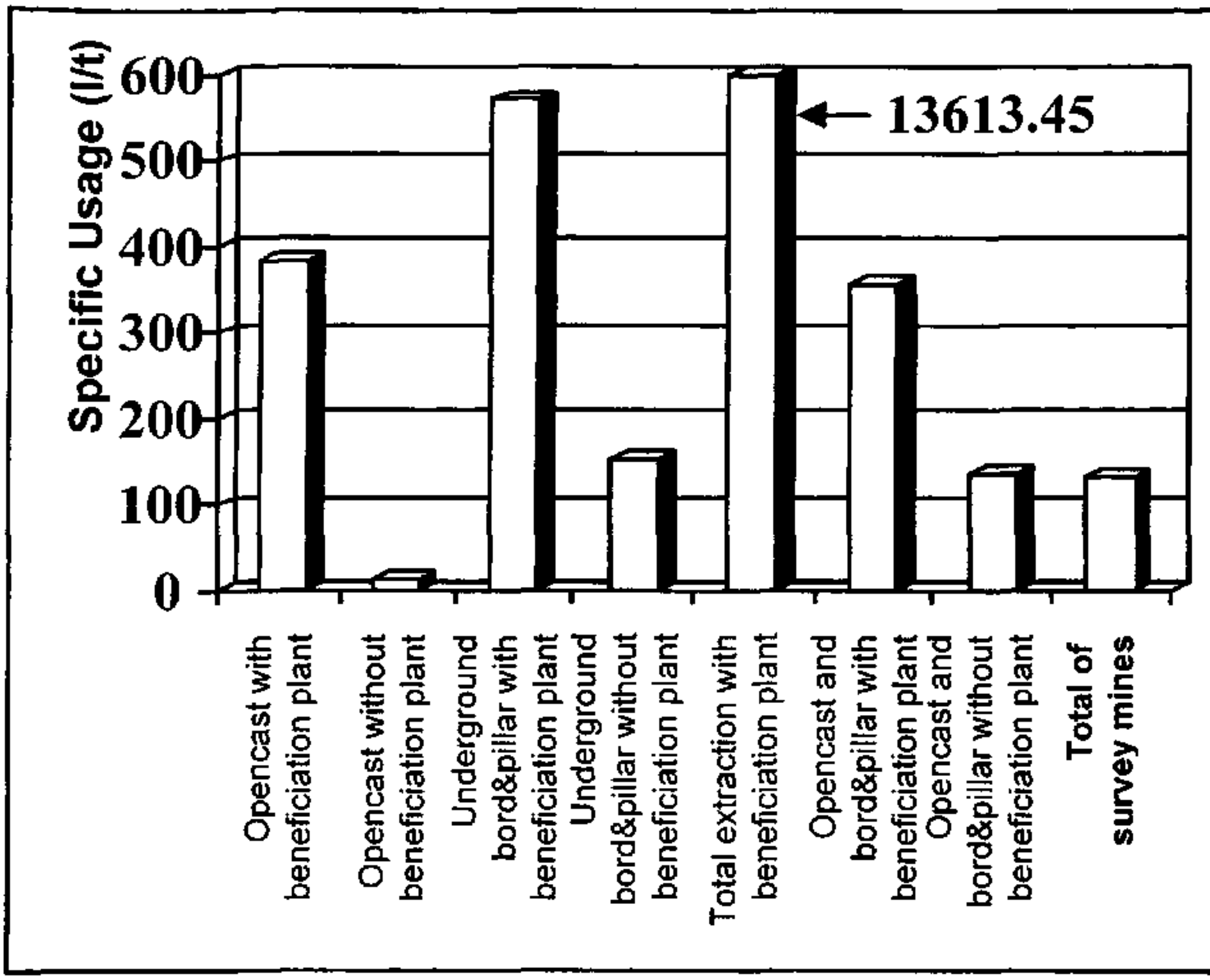


Figure 34: Total water sources and sinks

12. CONCLUSIONS AND RECOMMENDATIONS

Data have been acquired from forty-one mines out of a total of sixty-five operating coal mines, representing 66%. However, the mines incorporated in the database accounts for 88% of the total South African coal production. The results emanating from this investigation are therefore considered to be statistically representative of the South African coal mining industry. However, the constitution of a proper generic database for the South African coal mining industry was hampered by the omission of crucial data in the mine water balances. For example, only 25% of the mines included rainfall and seepage when calculating their water balance. Furthermore, evaporation was reported by 60% of the mines in the database.

The lack of good water balance data for the survey coal mines makes it impossible to make meaningful conclusions about water usage patterns on the coal mines. The primary conclusions that must be drawn however are the following:

1. In general terms, the state of water balances at coal mines is poor with insufficient detail being provided to enable a proper assessment of the status of water management at these mines. It must, therefore, be concluded (on the basis that one cannot manage what you cannot measure) that there is an equivalent problem with the status of water management on coal mines.
2. The primary problems with the water balances are an inadequate consideration of the effects of seepage and evaporation losses and the effect of rainwater as an input to the water balance.
3. The inadequacy of the water balances is most pronounced with regard to the losses of water from the mine water reticulation systems with 51% of all water losses being unaccounted for.
4. There are a few exceptions to the above generalisations where mines, although not perfect, have made significant effort to develop detailed water balances that are being refined and improved upon on an ongoing basis.
5. The lack of appropriate water balances is believed to be a serious hindrance to effective mine water management that needs to be addressed and remedied as a matter of priority.

No recommendations are made for further studies on water balances at coal mines although the discussion contained in this report should clearly motivate for the mines and authorities to expend considerable more effort in ensuring that proper water (and salt) balances are developed for the mines. A special need can be identified to ensure that the effects of seepage, evaporation and rainwater are included in the water balance Upgrading of mine water balances is not a research topic and must be undertaken as an operational issue by the mines themselves.

It is believed, however, that mines will benefit greatly from the ready availability of a user-friendly computerised water and salt balance model that is capable of being easily updated as and when mine water reticulation systems change.

APPENDIX 1:
COAL MINE SURVEY QUESTIONNAIRE

COAL MINE SURVEY QUESTIONNAIRE

1. GENERAL INFORMATION

Name of mine……………………………………………………………………………………………

Name of person completing questionnaire……………………………………………………………

Nearest town……………………………………………………………………………………………

Name of catchment……………………………………………………………………………………

Monthly production……………………………………………………………………………………

Monthly discard production……………………………………………………………………………

Monthly slurry production………………………………………………………………………………

Current age of mine……………………………………………………………………………………

Expected remaining life of mine………………………………………………………………………

Type of mining carried out (u/g, o/cast, etc.)…………………………………………………………

EMPR / water permit available?………………………………………………………………………

2. MINE WATER BALANCE

Please complete the following conceptual mine water balance, indicating flow rates of the different streams and treatment applied.

WATER SOURCES	TREATMENT	WATER USERS	TREATMENT	EFFLUENT SINKS
1.BOARD WATER				A) RIVER/STREAM
		a) DOMESTIC, HOUSES,OFFICES		
2.RIVER WATER				B) SEEPAGE, GROUNDWATER
		b) PLANT WATER		
3.BOREHOLE WATER				C) EVAPORATION
		c) UNDERGROUND MINING WATER		
4.UNDERGROUND OR PIT WATER				D) IRRIGATION
		d) ROAD WETTING		
5.RAINFALL				E)
		e)		

*TREATMENT

(C) Floc/ clarification
(P) pH adjustment
(T) Sewage plant

(F) Filtration
(D) Disinfection
(S) Softening

3. WATER SOURCES

Water sources for all consumers (e.g. drinking, mining, plant process water) based on flow balance shown on page 1

No	Source description	Quality**	Flow
1			
2			
3			
4			
5			
6			

****TDS or Sodium**

4. WATER USERS

No	User description	Source**	Flow
a			
b			
c			
d			
e			
f			

** Refer to numbers 1-6 used in Question 3.1 and water balance in Question 2.1

Describe internal water treatment systems for the different users (e.g. pH, settling) as shown in the water balance in Question 2.1

No	Description of system
a	
b	
c	
d	
e	
f	

5. EFFLUENT SYSTEMS

Effluent sources (including diffuse sources) as shown in the water balance of Question 2.1

No	Effluent source description	Sink	Flow
A			
B			
C			
D			
E			
F			

6. MONITORING SYSTEMS

Which water sources, users and effluents are being monitored in terms of flow and quality?

Monitoring	Stream
Flow only	Sources
	Users
	Effluents
	Other
Quality only	Sources
	Users
	Effluents
	Other
Flow & Quality	Sources
	Users
	Effluents
	Other

How frequently are these streams being monitored (grab samples or continuous?)

....

....

....

Is the monitoring programme sufficient to enable the mine to define adequate water and salt balances?

....

....

....

7. MANAGEMENT TOOLS

Can the mine produce a total mine water balance? (ground water, surface hydrology, point sources and users, diffuse sources)

Can the mine produce a total salt balance?

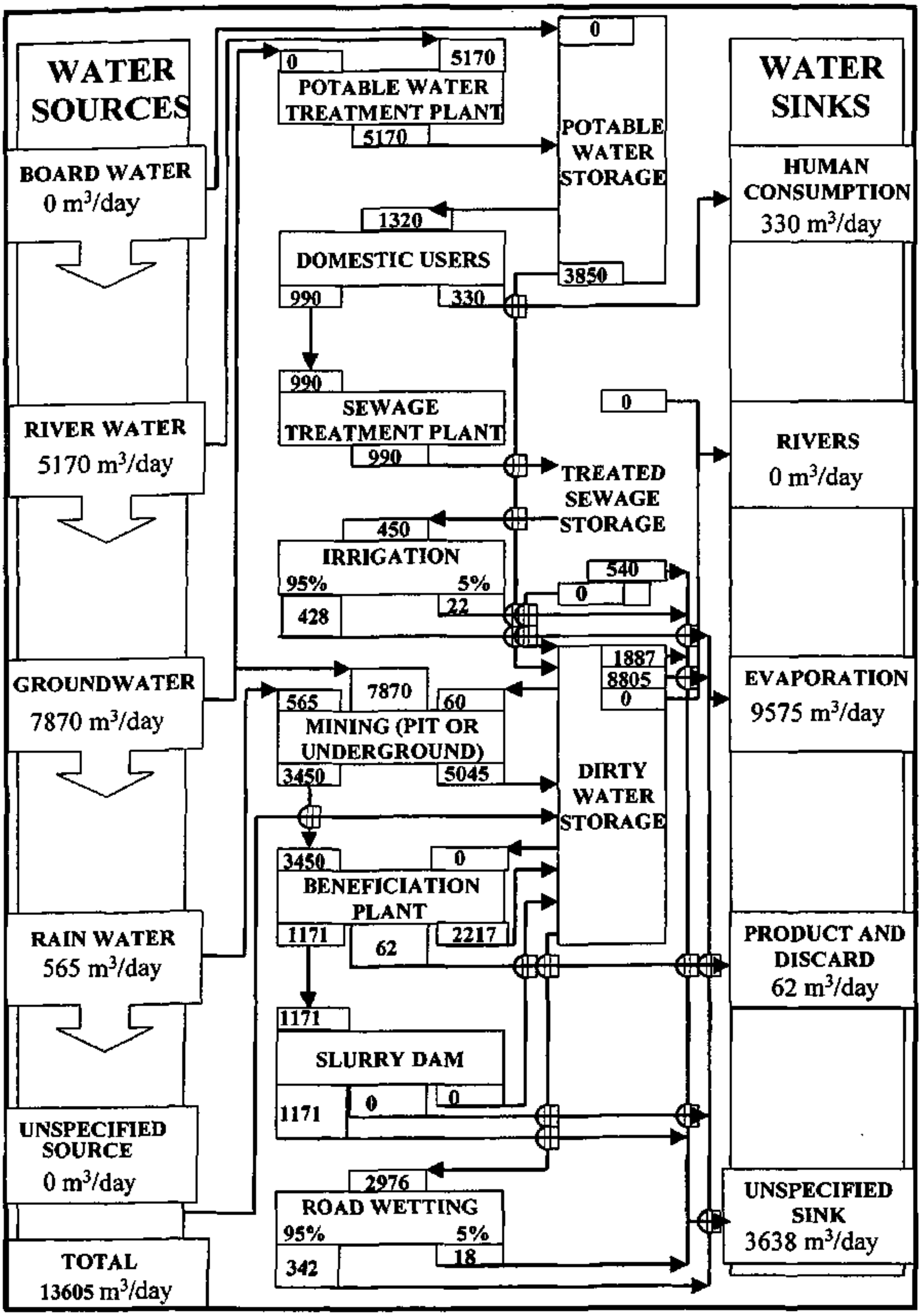
8 GENERAL

List any issues, problems, needs, solutions etc. not discussed above in relation to Water and Salt balance

APPENDIX 2: INDIVIDUAL MINE WATER BALANCES

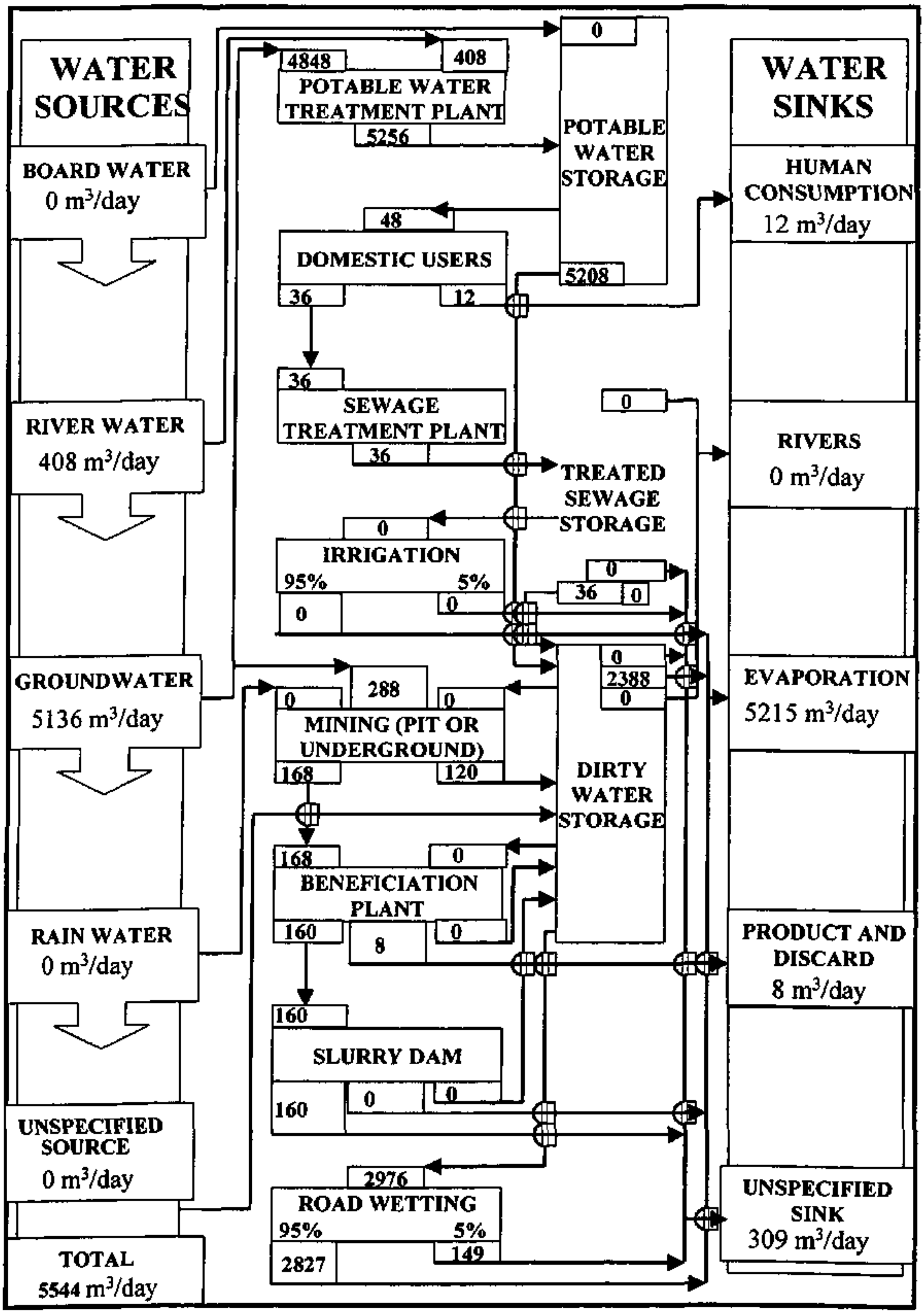
A1-8: OPEN CAST MINES WITH BENEFICIATION PLANT.
B1-2: OPEN CAST MINES WITHOUT BENEFICIATION PLANT.
C1-13: UNDERGROUND BORD AND PILLAR MINES WITH BENEFICIATION PLANT.
D1-3: UNDERGROUND BORD AND PILLAR MINES WITHOUT BENEFICIATION PLANT.
E1: UNDERGROUND TOTAL EXTRACTION MINES WITH BENEFICIATION PLANT.
F1-11: OPEN CAST AND UNDERGROUND BORD AND PILLAR MINES WITH BENEFICIATION PLANTS.
G1-3: OPEN CAST AND UNDERGROUND BORD AND PILLAR MINES WITHOUT BENEFICIATION PLANTS.

A1

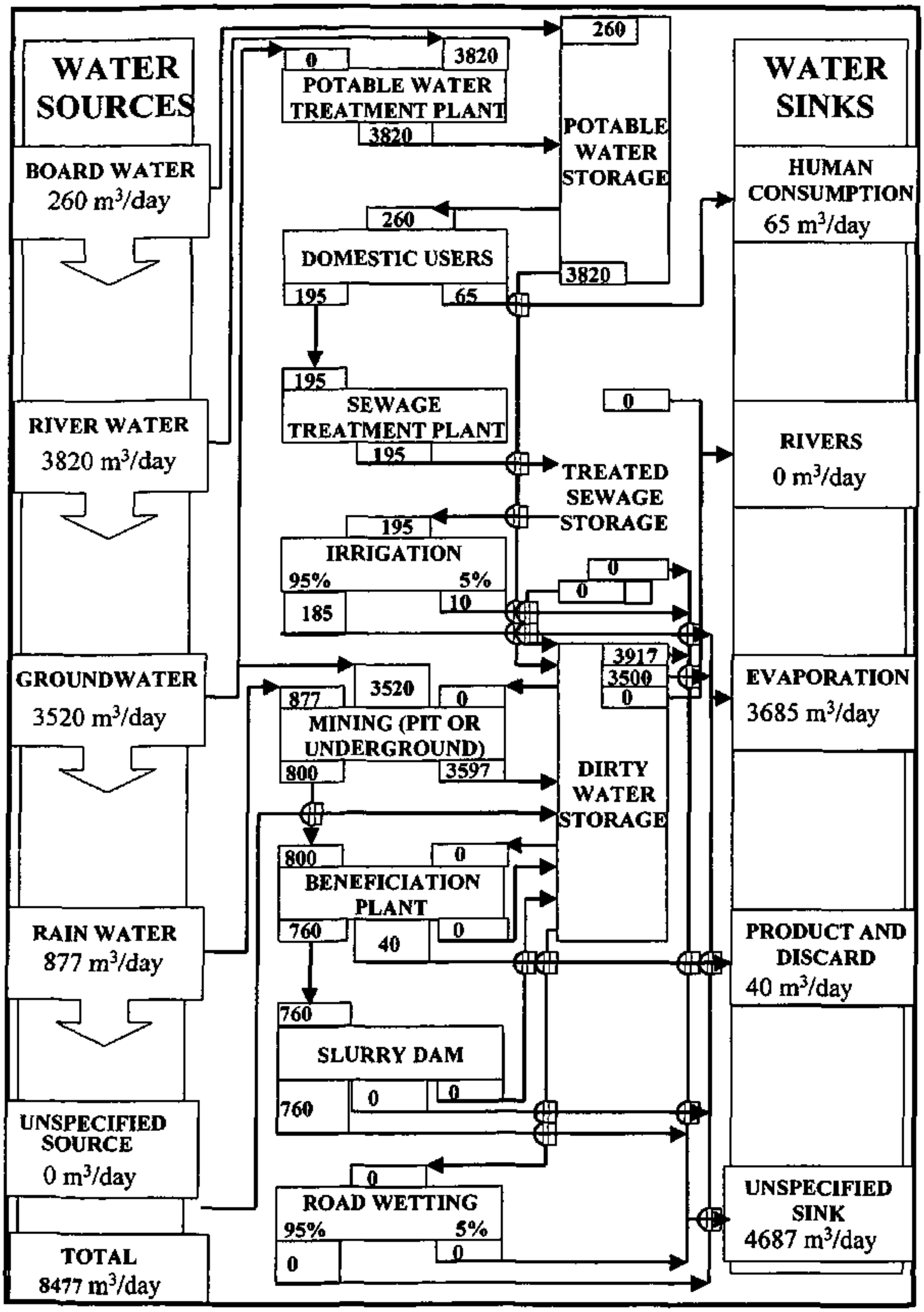


WATER SOURCES
BOARD WATER 0 m³/day
RIVER WATER 5170 m³/day
GROUNDWATER 7870 m³/day
RAIN WATER 565 m³/day
UNSPECIFIED SOURCE 0 m³/day
TOTAL 13605 m³/day
POTABLE WATER TREATMENT PLANT
0
5170
5170
POTABLE WATER STORAGE
0
3850
DOMESTIC USERS
1320
990
330
SEWAGE TREATMENT PLANT
990
990
TREATED SEWAGE STORAGE
0
IRRIGATION
450
95%
5%
428
22
540
0
1887
8805
0
MINING (PIT OR UNDERGROUND)
565
7870
60
3450
5045
DIRTY WATER STORAGE
BENEFICIATION PLANT
3450
0
1171
62
2217
SLURRY DAM
1171
1171
0
0
ROAD WETTING
2976
95%
5%
342
18
WATER SINKS
HUMAN CONSUMPTION 330 m³/day
RIVERS 0 m³/day
EVAPORATION 9575 m³/day
PRODUCT AND DISCARD 62 m³/day
UNSPECIFIED SINK 3638 m³/day

A2

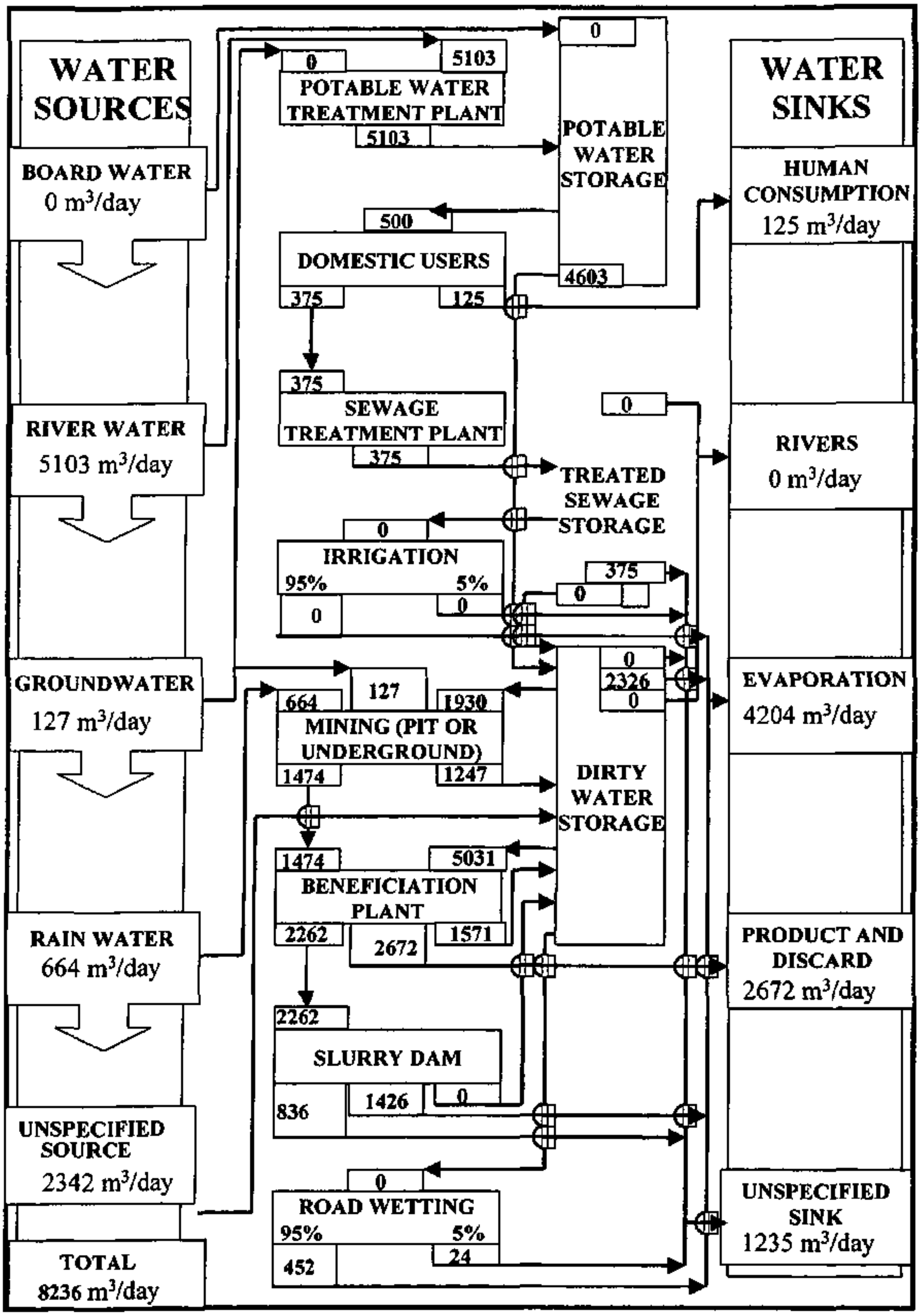

WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
408 m³/day
GROUNDWATER
5136 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
5544 m³/day
4848
408
POTABLE WATER TREATMENT PLANT
5256
0
POTABLE WATER STORAGE
5208
48
DOMESTIC USERS
36
12
36
SEWAGE TREATMENT PLANT
36
0
TREATED SEWAGE STORAGE
0
IRRIGATION
95%
5%
0
0
0
36
0
288
0
0
MINING (PIT OR UNDERGROUND)
168
120
0
2388
0
DIRTY WATER STORAGE
168
0
BENEFICIATION PLANT
160
8
0
160
SLURRY DAM
160
0
0
2976
ROAD WETTING
95%
5%
2827
149
WATER SINKS
HUMAN CONSUMPTION
12 m³/day
RIVERS
0 m³/day
EVAPORATION
5215 m³/day
PRODUCT AND DISCARD
8 m³/day
UNSPECIFIED SINK
309 m³/day

A3

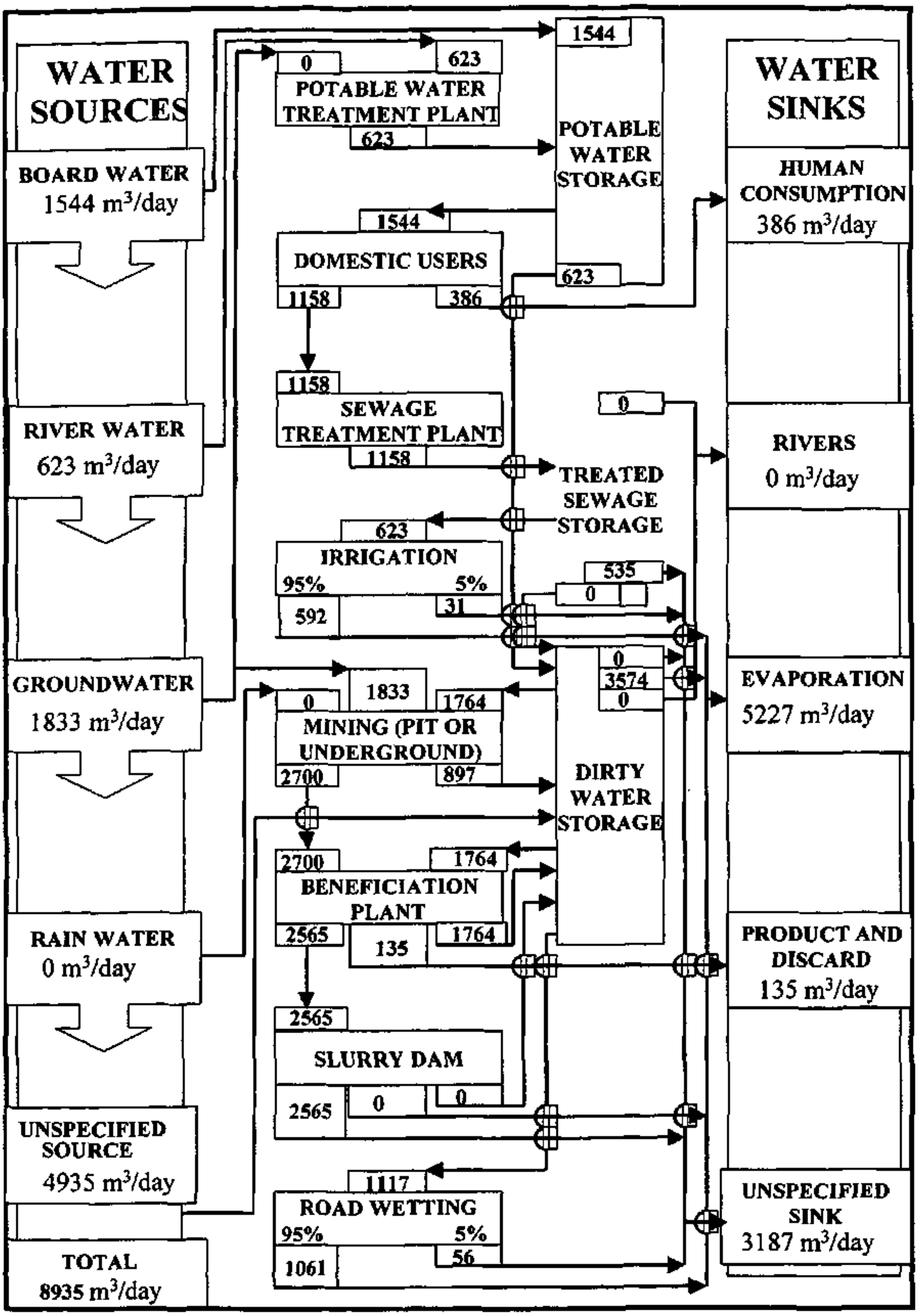


WATER SOURCES
BOARD WATER
260 m³/day
RIVER WATER
3820 m³/day
GROUNDWATER
3520 m³/day
RAIN WATER
877 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
8477 m³/day
POTABLE WATER TREATMENT PLANT
0
3820
3820
POTABLE WATER STORAGE
260
3820
DOMESTIC USERS
260
195
65
SEWAGE TREATMENT PLANT
195
195
TREATED SEWAGE STORAGE
IRRIGATION
195
95%
5%
185
10
0
0
MINING (PIT OR UNDERGROUND)
877
3520
0
800
3597
DIRTY WATER STORAGE
3917
3500
0
BENEFICIATION PLANT
800
0
760
40
0
SLURRY DAM
760
760
0
0
ROAD WETTING
0
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION
65 m³/day
RIVERS
0 m³/day
EVAPORATION
3685 m³/day
PRODUCT AND DISCARD
40 m³/day
UNSPECIFIED SINK
4687 m³/day

A4

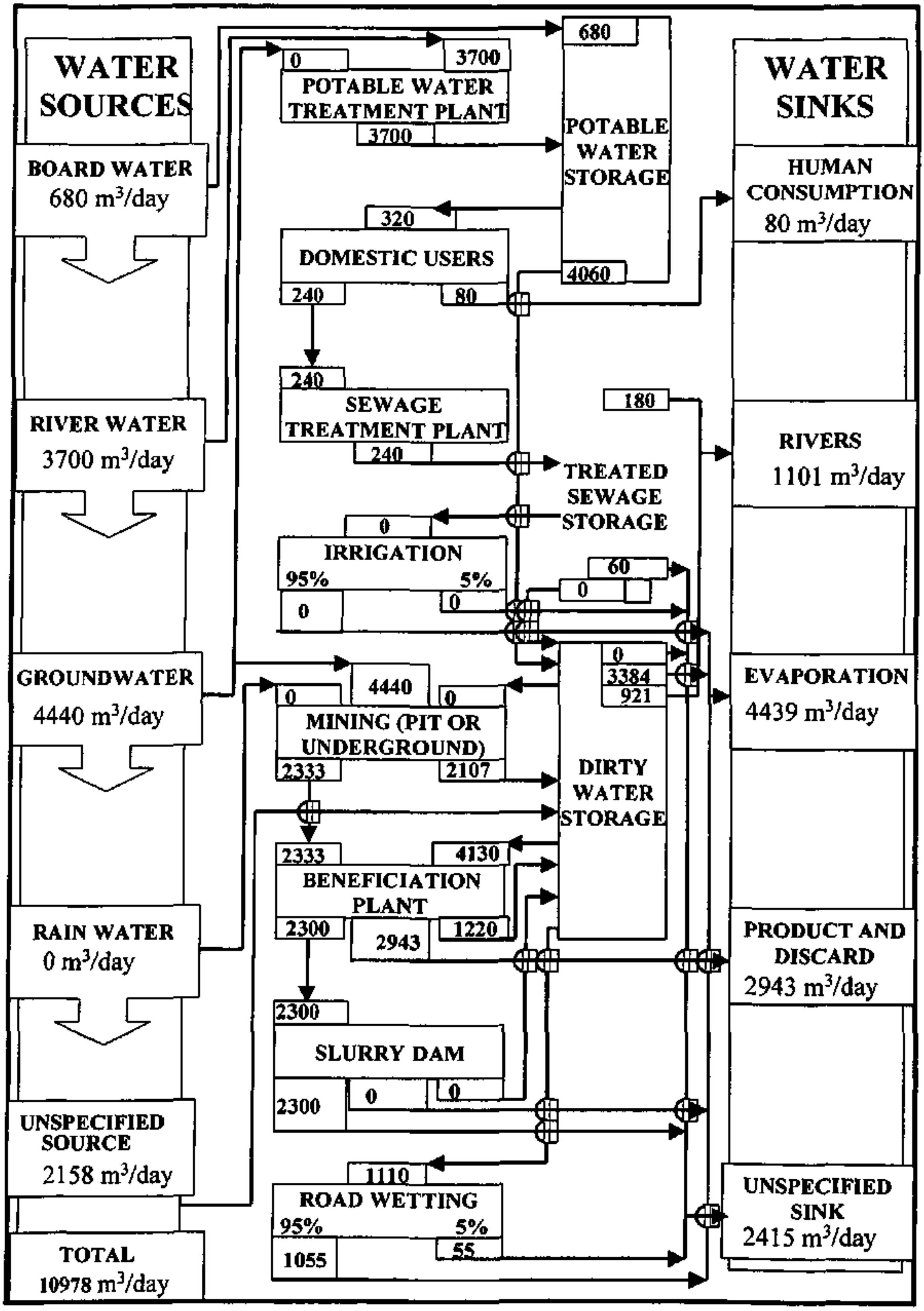

WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
5103 m³/day
GROUNDWATER
127 m³/day
RAIN WATER
664 m³/day
UNSPECIFIED SOURCE
2342 m³/day
TOTAL
8236 m³/day
0
5103
POTABLE WATER TREATMENT PLANT
5103
0
POTABLE WATER STORAGE
4603
500
DOMESTIC USERS
375
125
375
SEWAGE TREATMENT PLANT
375
TREATED SEWAGE STORAGE
0
0
IRRIGATION
95%
5%
0
0
375
0
0
2326
0
127
664
1930
MINING (PIT OR UNDERGROUND)
1474
1247
DIRTY WATER STORAGE
1474
5031
BENEFICIATION PLANT
2262
2672
1571
2262
SLURRY DAM
836
1426
0
0
ROAD WETTING
95%
5%
452
24
WATER SINKS
HUMAN CONSUMPTION
125 m³/day
RIVERS
0 m³/day
EVAPORATION
4204 m³/day
PRODUCT AND DISCARD
2672 m³/day
UNSPECIFIED SINK
1235 m³/day

A5



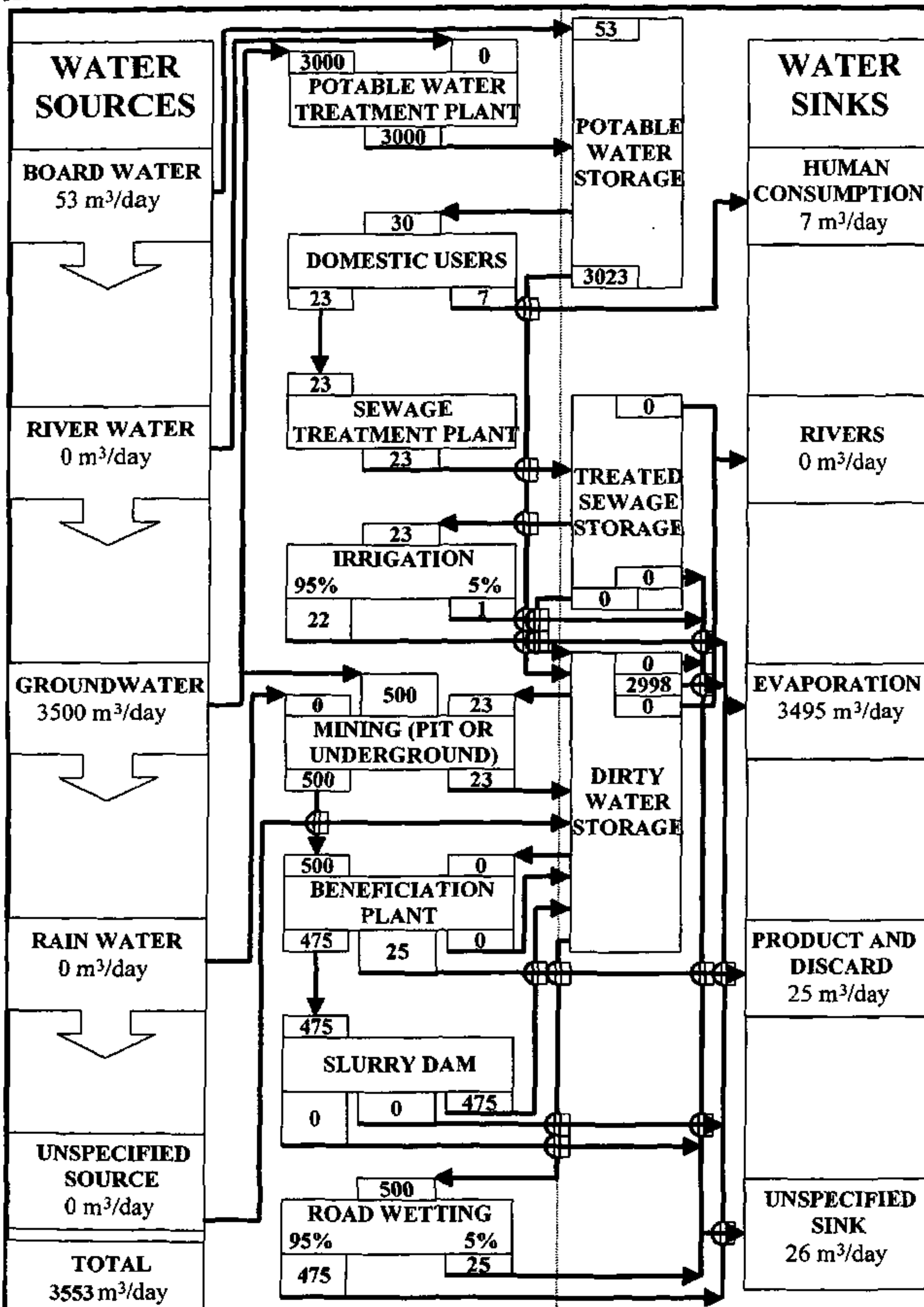
WATER SOURCES
BOARD WATER
1544 m³/day
RIVER WATER
623 m³/day
GROUNDWATER
1833 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
4935 m³/day
TOTAL
8935 m³/day
POTABLE WATER TREATMENT PLANT
0
623
623
POTABLE WATER STORAGE
1544
623
DOMESTIC USERS
1544
1158
386
SEWAGE TREATMENT PLANT
1158
1158
TREATED SEWAGE STORAGE
0
IRRIGATION
623
95%
5%
592
31
535
0
MINING (PIT OR UNDERGROUND)
0
1833
1764
2700
897
DIRTY WATER STORAGE
0
3574
0
BENEFICIATION PLANT
2700
1764
2565
135
1764
SLURRY DAM
2565
2565
0
0
ROAD WETTING
1117
95%
5%
1061
56
WATER SINKS
HUMAN CONSUMPTION
386 m³/day
RIVERS
0 m³/day
EVAPORATION
5227 m³/day
PRODUCT AND DISCARD
135 m³/day
UNSPECIFIED SINK
3187 m³/day

A6

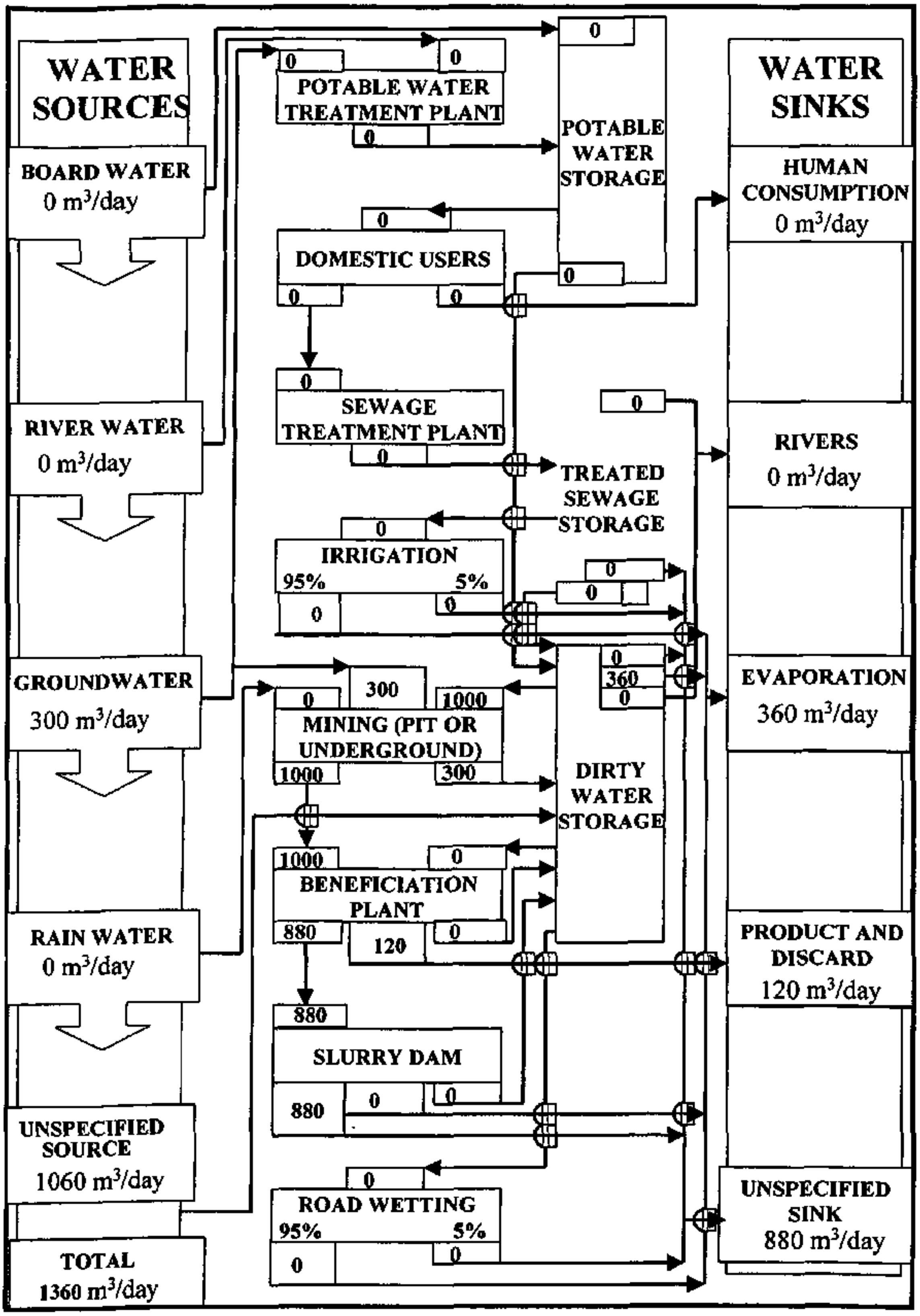


WATER SOURCES
BOARD WATER
680 m3/day
RIVER WATER
3700 m3/day
GROUNDWATER
4440 m3/day
RAIN WATER
0 m3/day
UNSPECIFIED SOURCE
2158 m3/day
TOTAL
10978 m3/day
POTABLE WATER TREATMENT PLANT
0
3700
3700
POTABLE WATER STORAGE
680
4060
DOMESTIC USERS
320
240
80
SEWAGE TREATMENT PLANT
240
240
TREATED SEWAGE STORAGE
180
IRRIGATION
0
95%
5%
0
0
60
0
MINING (PIT OR UNDERGROUND)
4440
0
0
2333
2107
DIRTY WATER STORAGE
0
3384
921
BENEFICIATION PLANT
2333
4130
2300
1220
2943
SLURRY DAM
2300
2300
0
0
ROAD WETTING
1110
95%
5%
1055
55
WATER SINKS
HUMAN CONSUMPTION
80 m3/day
RIVERS
1101 m3/day
EVAPORATION
4439 m3/day
PRODUCT AND DISCARD
2943 m3/day
UNSPECIFIED SINK
2415 m3/day

A7

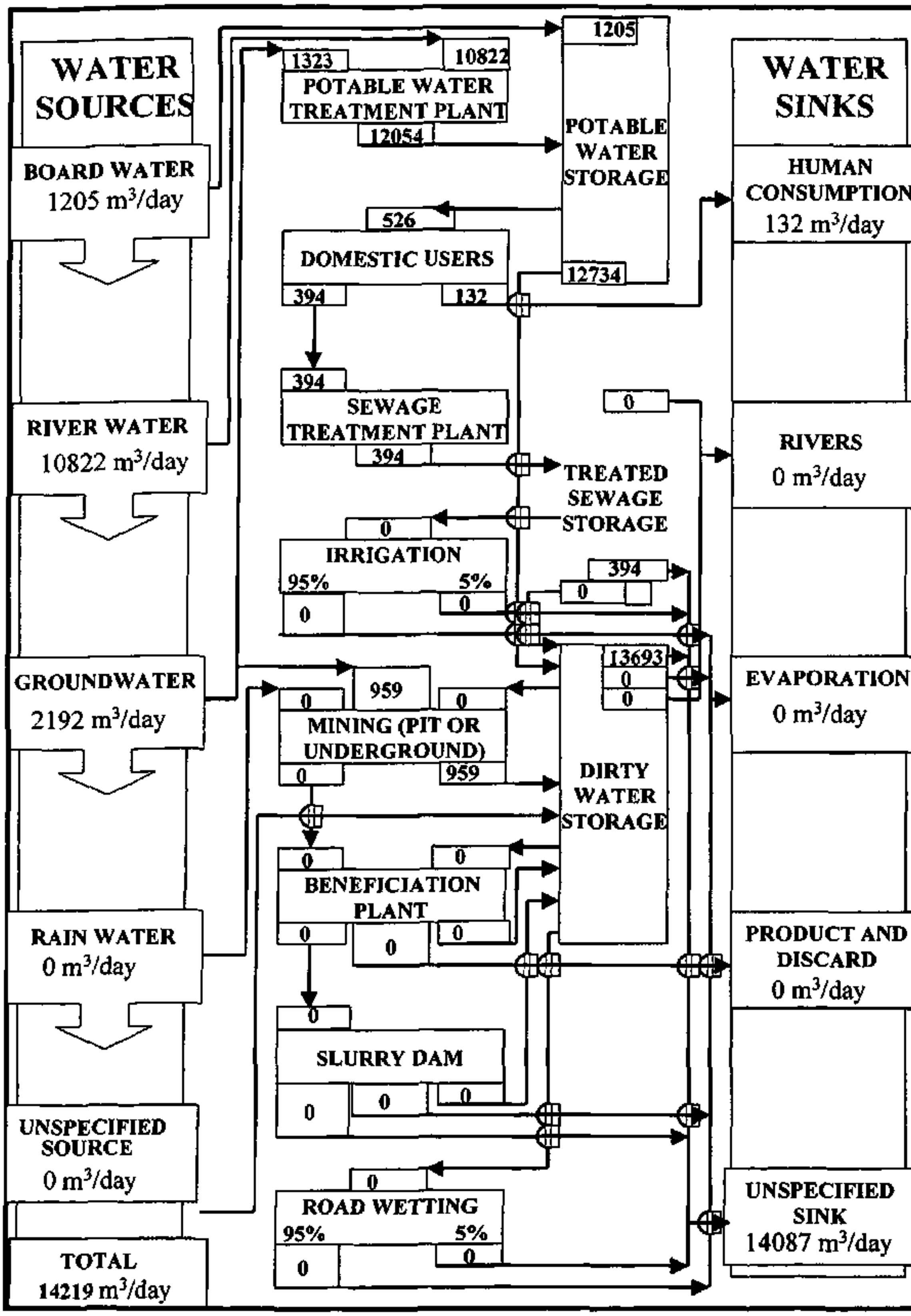

WATER SOURCES
BOARD WATER
53 m³/day
RIVER WATER
0 m³/day
GROUNDWATER
3500 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
3553 m³/day
3000
0
POTABLE WATER TREATMENT PLANT
3000
53
POTABLE WATER STORAGE
3023
30
DOMESTIC USERS
23
7
23
SEWAGE TREATMENT PLANT
23
0
TREATED SEWAGE STORAGE
0
0
23
IRRIGATION
95%
5%
22
1
500
0
23
MINING (PIT OR UNDERGROUND)
500
23
0
2998
0
DIRTY WATER STORAGE
500
0
BENEFICIATION PLANT
475
25
0
475
SLURRY DAM
0
0
475
500
ROAD WETTING
95%
5%
475
25
WATER SINKS
HUMAN CONSUMPTION
7 m³/day
RIVERS
0 m³/day
EVAPORATION
3495 m³/day
PRODUCT AND DISCARD
25 m³/day
UNSPECIFIED SINK
26 m³/day

A8

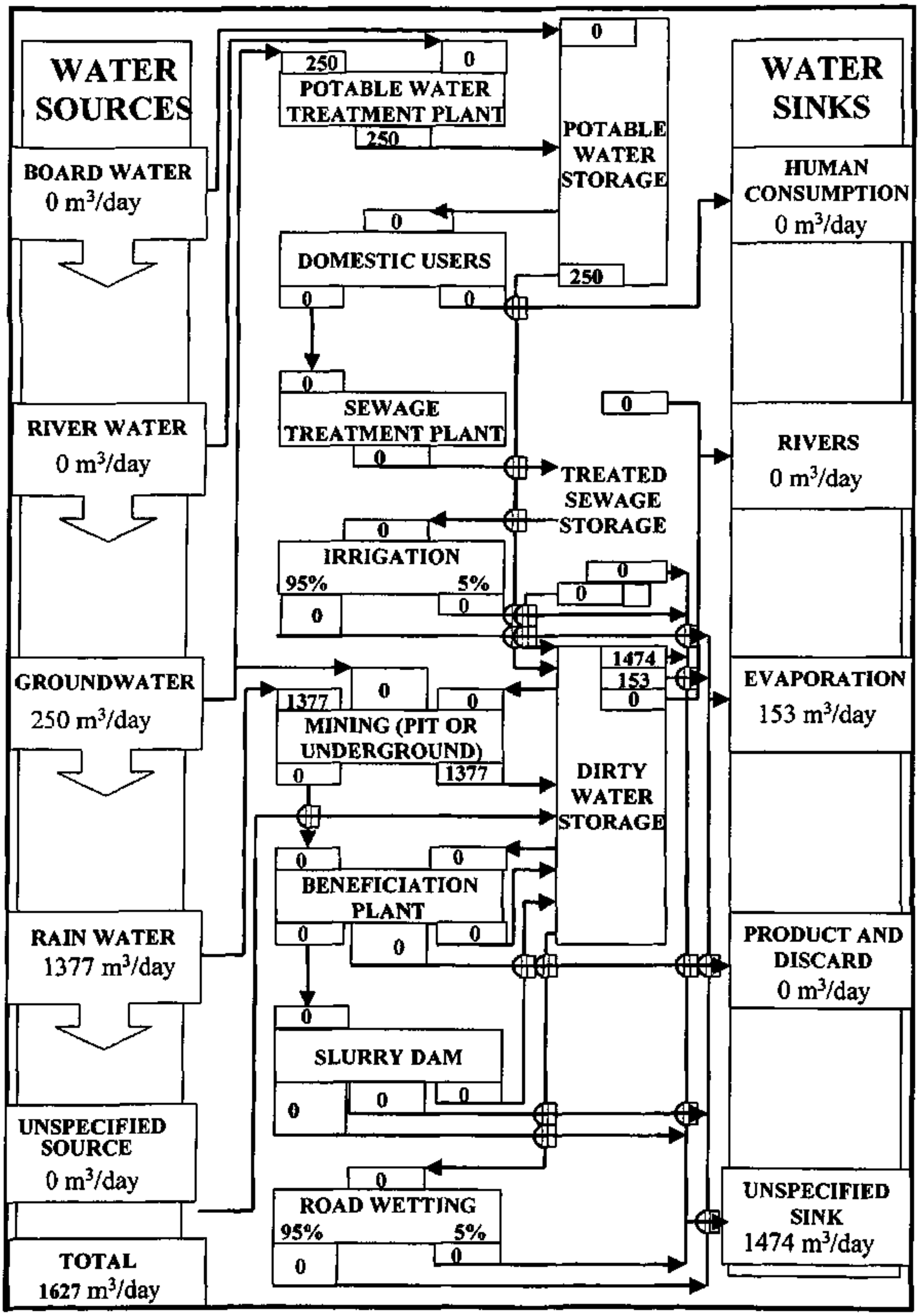


WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
0 m³/day
GROUNDWATER
300 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
1060 m³/day
TOTAL
1360 m³/day
POTABLE WATER TREATMENT PLANT
POTABLE WATER STORAGE
DOMESTIC USERS
SEWAGE TREATMENT PLANT
TREATED SEWAGE STORAGE
IRRIGATION
95%
5%
MINING (PIT OR UNDERGROUND)
DIRTY WATER STORAGE
BENEFICIATION PLANT
SLURRY DAM
ROAD WETTING
95%
5%
WATER SINKS
HUMAN CONSUMPTION
0 m³/day
RIVERS
0 m³/day
EVAPORATION
360 m³/day
PRODUCT AND DISCARD
120 m³/day
UNSPECIFIED SINK
880 m³/day
300
1000
360
120
880

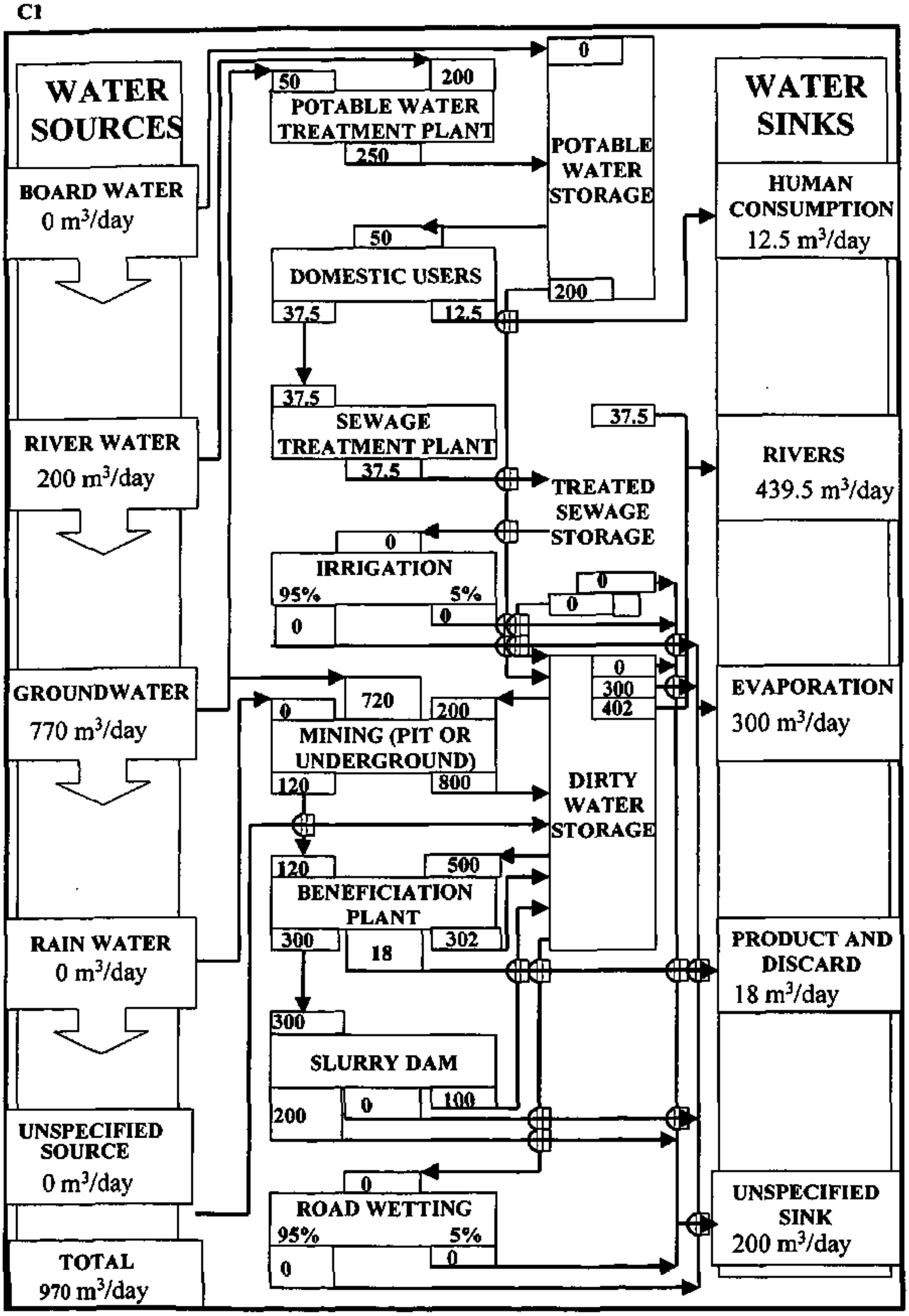
B1


WATER SOURCES
BOARD WATER
1205 m3/day
RIVER WATER
10822 m3/day
GROUNDWATER
2192 m3/day
RAIN WATER
0 m3/day
UNSPECIFIED SOURCE
0 m3/day
TOTAL
14219 m3/day
1323
10822
POTABLE WATER TREATMENT PLANT
12054
1205
POTABLE WATER STORAGE
12734
526
DOMESTIC USERS
394
132
394
SEWAGE TREATMENT PLANT
394
TREATED SEWAGE STORAGE
0
0
IRRIGATION
95%
5%
0
0
394
0
959
0
0
MINING (PIT OR UNDERGROUND)
0
959
13693
0
0
DIRTY WATER STORAGE
0
0
BENEFICIATION PLANT
0
0
0
0
SLURRY DAM
0
0
0
0
ROAD WETTING
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION
132 m3/day
RIVERS
0 m3/day
EVAPORATION
0 m3/day
PRODUCT AND DISCARD
0 m3/day
UNSPECIFIED SINK
14087 m3/day

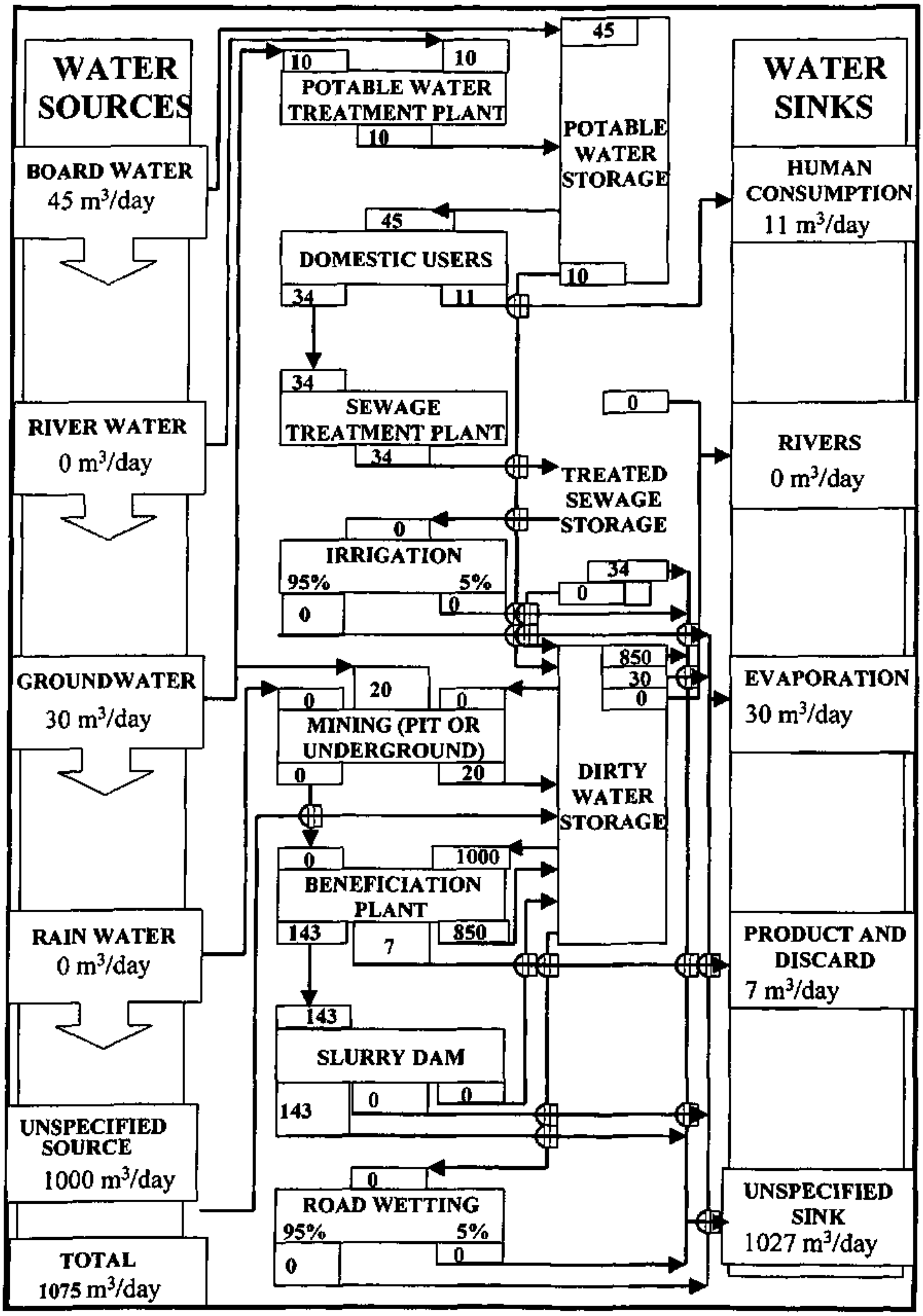
B2


WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
0 m³/day
GROUNDWATER
250 m³/day
RAIN WATER
1377 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
1627 m³/day
POTABLE WATER TREATMENT PLANT
250
0
250
POTABLE WATER STORAGE
0
250
DOMESTIC USERS
0
0
0
SEWAGE TREATMENT PLANT
0
0
TREATED SEWAGE STORAGE
0
IRRIGATION
0
95%
5%
0
0
0
0
MINING (PIT OR UNDERGROUND)
1377
0
0
0
1377
DIRTY WATER STORAGE
1474
153
0
BENEFICIATION PLANT
0
0
0
0
0
SLURRY DAM
0
0
0
0
ROAD WETTING
0
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION
0 m³/day
RIVERS
0 m³/day
EVAPORATION
153 m³/day
PRODUCT AND DISCARD
0 m³/day
UNSPECIFIED SINK
1474 m³/day

C1

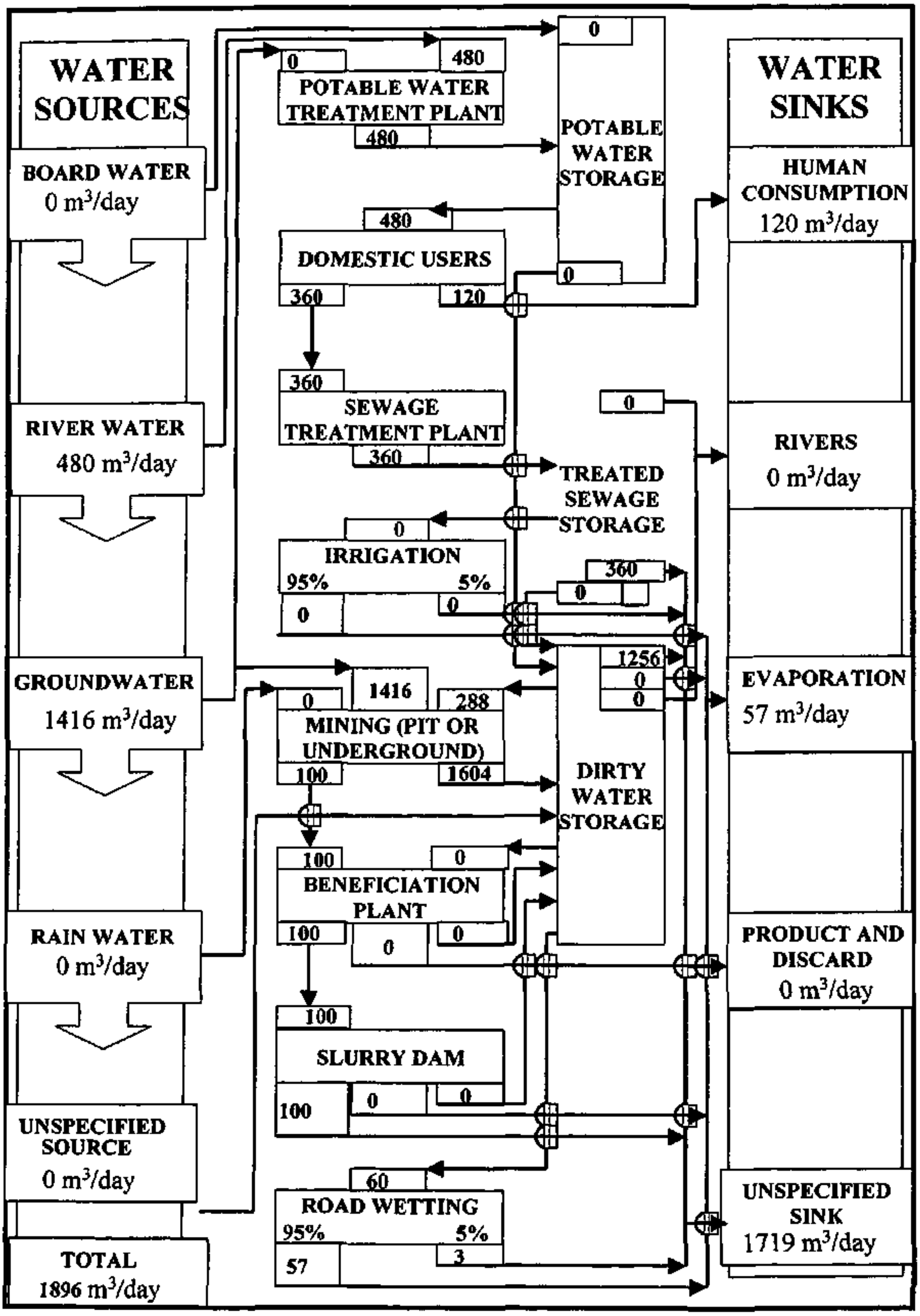

WATER SOURCES
BOARD WATER 0 m³/day
RIVER WATER 200 m³/day
GROUNDWATER 770 m³/day
RAIN WATER 0 m³/day
UNSPECIFIED SOURCE 0 m³/day
TOTAL 970 m³/day
POTABLE WATER TREATMENT PLANT
50
200
250
0
POTABLE WATER STORAGE
200
50
DOMESTIC USERS
37.5
12.5
37.5
SEWAGE TREATMENT PLANT
37.5
37.5
TREATED SEWAGE STORAGE
0
IRRIGATION
95%
5%
0
0
0
0
MINING (PIT OR UNDERGROUND)
0
720
200
120
800
0
300
402
DIRTY WATER STORAGE
120
500
BENEFICIATION PLANT
300
18
302
300
SLURRY DAM
200
0
100
0
ROAD WETTING
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION 12.5 m³/day
RIVERS 439.5 m³/day
EVAPORATION 300 m³/day
PRODUCT AND DISCARD 18 m³/day
UNSPECIFIED SINK 200 m³/day

C2

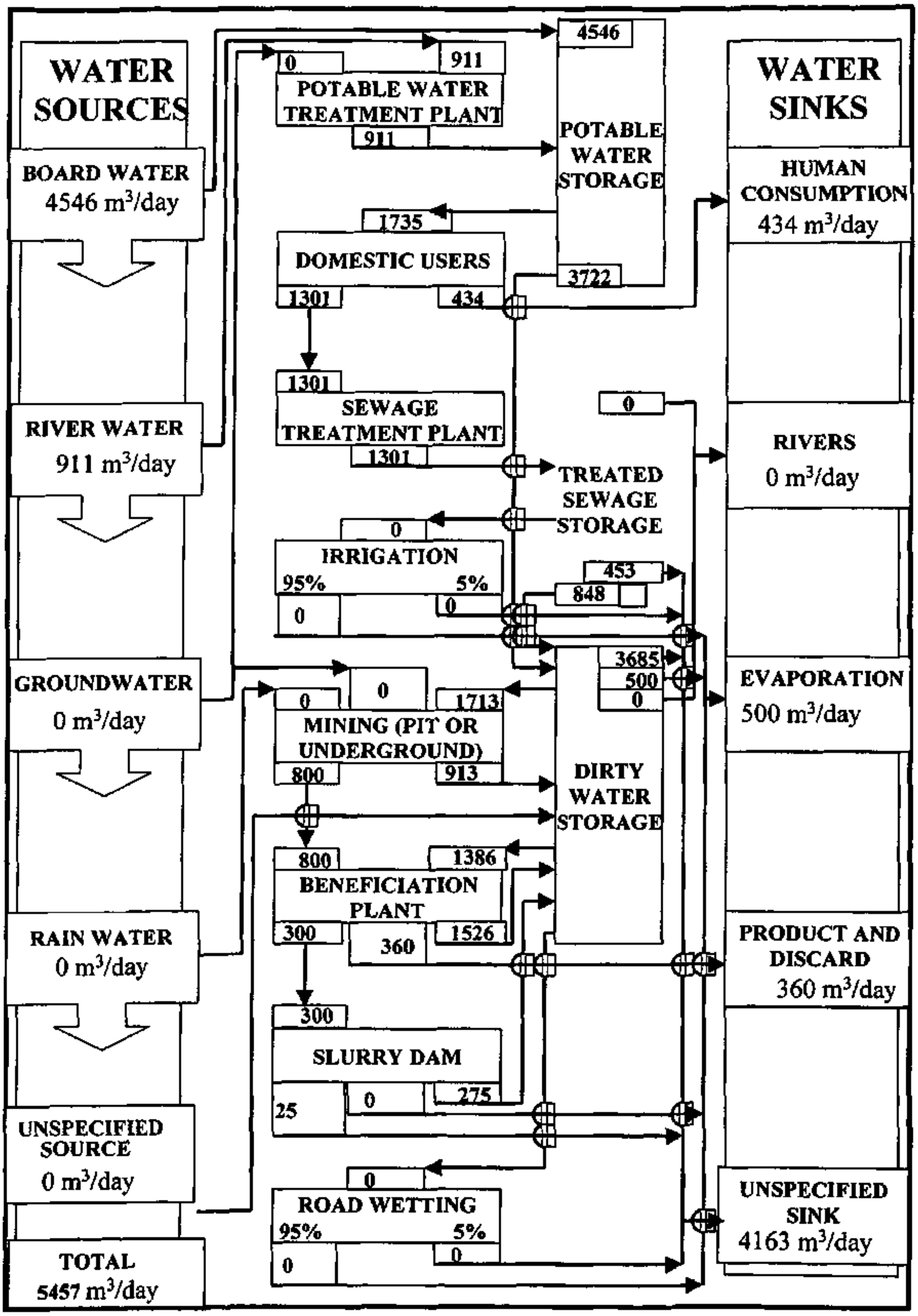


WATER SOURCES
BOARD WATER
45 m³/day
RIVER WATER
0 m³/day
GROUNDWATER
30 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
1000 m³/day
TOTAL
1075 m³/day
POTABLE WATER TREATMENT PLANT
10
10
10
POTABLE WATER STORAGE
45
10
DOMESTIC USERS
45
34
11
SEWAGE TREATMENT PLANT
34
34
TREATED SEWAGE STORAGE
0
IRRIGATION
0
95%
5%
0
0
34
0
MINING (PIT OR UNDERGROUND)
0
20
0
0
20
DIRTY WATER STORAGE
850
30
0
BENEFICIATION PLANT
0
1000
143
7
850
SLURRY DAM
143
143
0
0
ROAD WETTING
0
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION
11 m³/day
RIVERS
0 m³/day
EVAPORATION
30 m³/day
PRODUCT AND DISCARD
7 m³/day
UNSPECIFIED SINK
1027 m³/day

C3

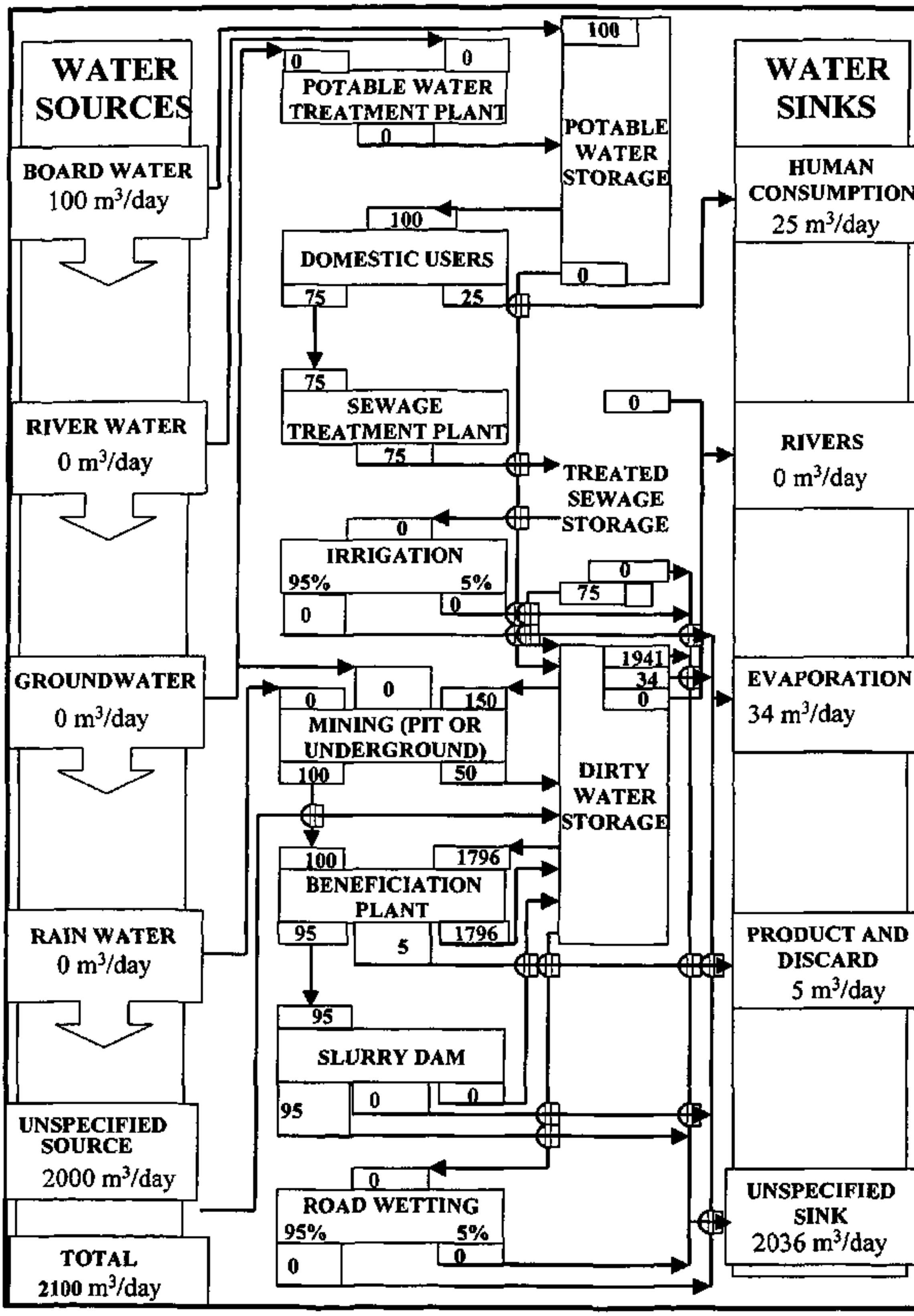

WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
480 m³/day
GROUNDWATER
1416 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
1896 m³/day
POTABLE WATER TREATMENT PLANT
0
480
480
POTABLE WATER STORAGE
0
0
DOMESTIC USERS
480
360
120
SEWAGE TREATMENT PLANT
360
360
TREATED SEWAGE STORAGE
0
IRRIGATION
0
95%
5%
0
0
360
0
MINING (PIT OR UNDERGROUND)
0
1416
288
100
1604
1256
0
0
DIRTY WATER STORAGE
BENEFICIATION PLANT
100
0
100
0
0
SLURRY DAM
100
100
0
0
ROAD WETTING
60
95%
5%
57
3
WATER SINKS
HUMAN CONSUMPTION
120 m³/day
RIVERS
0 m³/day
EVAPORATION
57 m³/day
PRODUCT AND DISCARD
0 m³/day
UNSPECIFIED SINK
1719 m³/day

C4



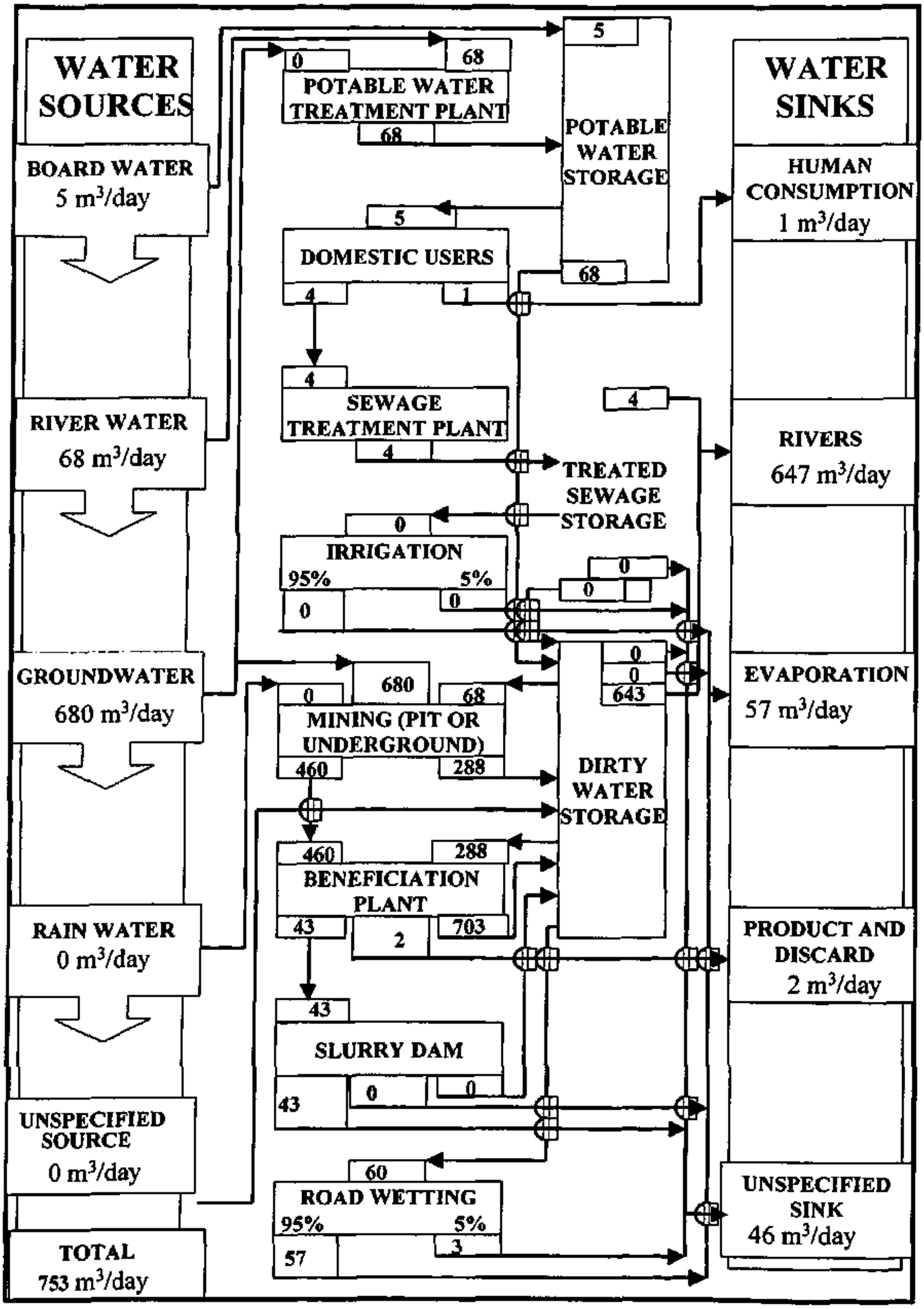
WATER SOURCES
BOARD WATER
4546 m³/day
RIVER WATER
911 m³/day
GROUNDWATER
0 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
5457 m³/day
POTABLE WATER TREATMENT PLANT
0
911
911
4546
POTABLE WATER STORAGE
3722
1735
DOMESTIC USERS
1301
434
1301
SEWAGE TREATMENT PLANT
1301
TREATED SEWAGE STORAGE
0
0
IRRIGATION
95%
5%
0
0
453
848
3685
500
0
MINING (PIT OR UNDERGROUND)
0
0
1713
800
913
DIRTY WATER STORAGE
800
1386
BENEFICIATION PLANT
300
360
1526
300
SLURRY DAM
25
0
275
0
ROAD WETTING
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION
434 m³/day
RIVERS
0 m³/day
EVAPORATION
500 m³/day
PRODUCT AND DISCARD
360 m³/day
UNSPECIFIED SINK
4163 m³/day

C5



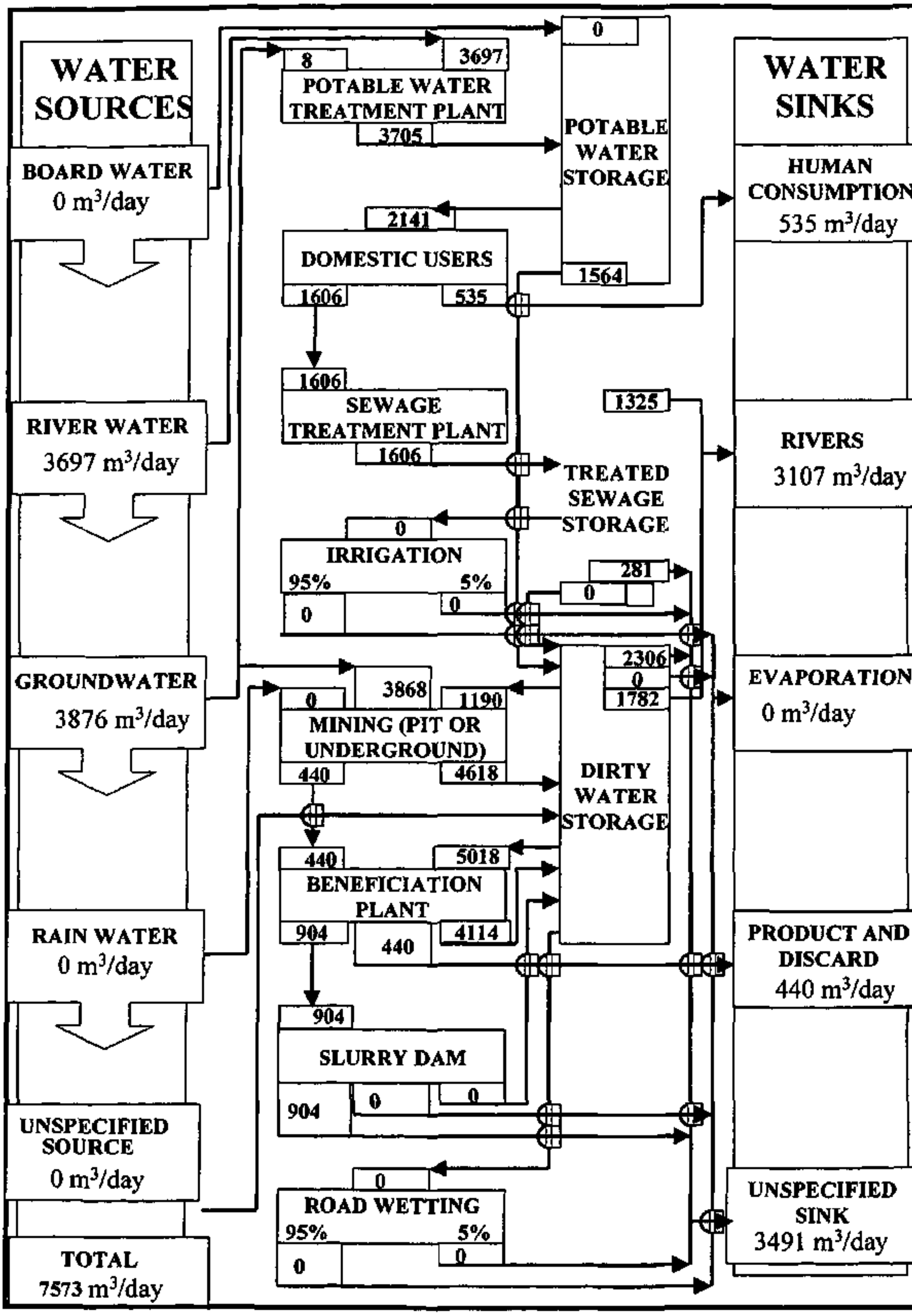
WATER SOURCES
BOARD WATER
100 m³/day
RIVER WATER
0 m³/day
GROUNDWATER
0 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
2000 m³/day
TOTAL
2100 m³/day
POTABLE WATER TREATMENT PLANT
POTABLE WATER STORAGE
DOMESTIC USERS
SEWAGE TREATMENT PLANT
TREATED SEWAGE STORAGE
IRRIGATION
95%
5%
MINING (PIT OR UNDERGROUND)
DIRTY WATER STORAGE
BENEFICIATION PLANT
SLURRY DAM
ROAD WETTING
95%
5%
WATER SINKS
HUMAN CONSUMPTION
25 m³/day
RIVERS
0 m³/day
EVAPORATION
34 m³/day
PRODUCT AND DISCARD
5 m³/day
UNSPECIFIED SINK
2036 m³/day

C6

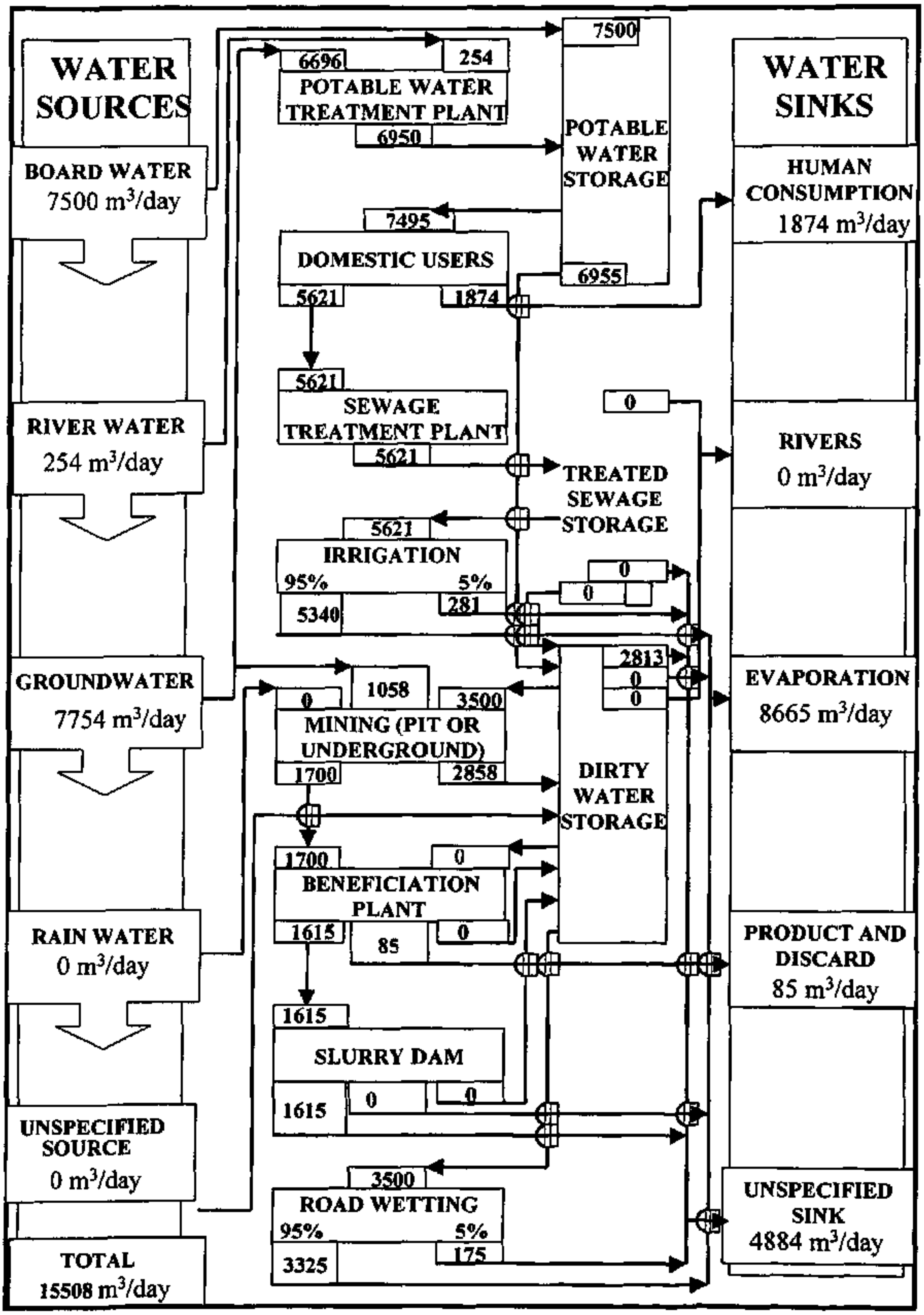


WATER SOURCES
BOARD WATER
5 m³/day
RIVER WATER
68 m³/day
GROUNDWATER
680 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
753 m³/day
POTABLE WATER TREATMENT PLANT
0
68
68
POTABLE WATER STORAGE
5
68
DOMESTIC USERS
5
4
1
SEWAGE TREATMENT PLANT
4
4
TREATED SEWAGE STORAGE
4
IRRIGATION
0
95%
5%
0
0
0
0
MINING (PIT OR UNDERGROUND)
0
680
68
460
288
DIRTY WATER STORAGE
0
0
643
BENEFICIATION PLANT
460
288
43
2
703
SLURRY DAM
43
43
0
0
ROAD WETTING
60
95%
5%
57
3
WATER SINKS
HUMAN CONSUMPTION
1 m³/day
RIVERS
647 m³/day
EVAPORATION
57 m³/day
PRODUCT AND DISCARD
2 m³/day
UNSPECIFIED SINK
46 m³/day

C7

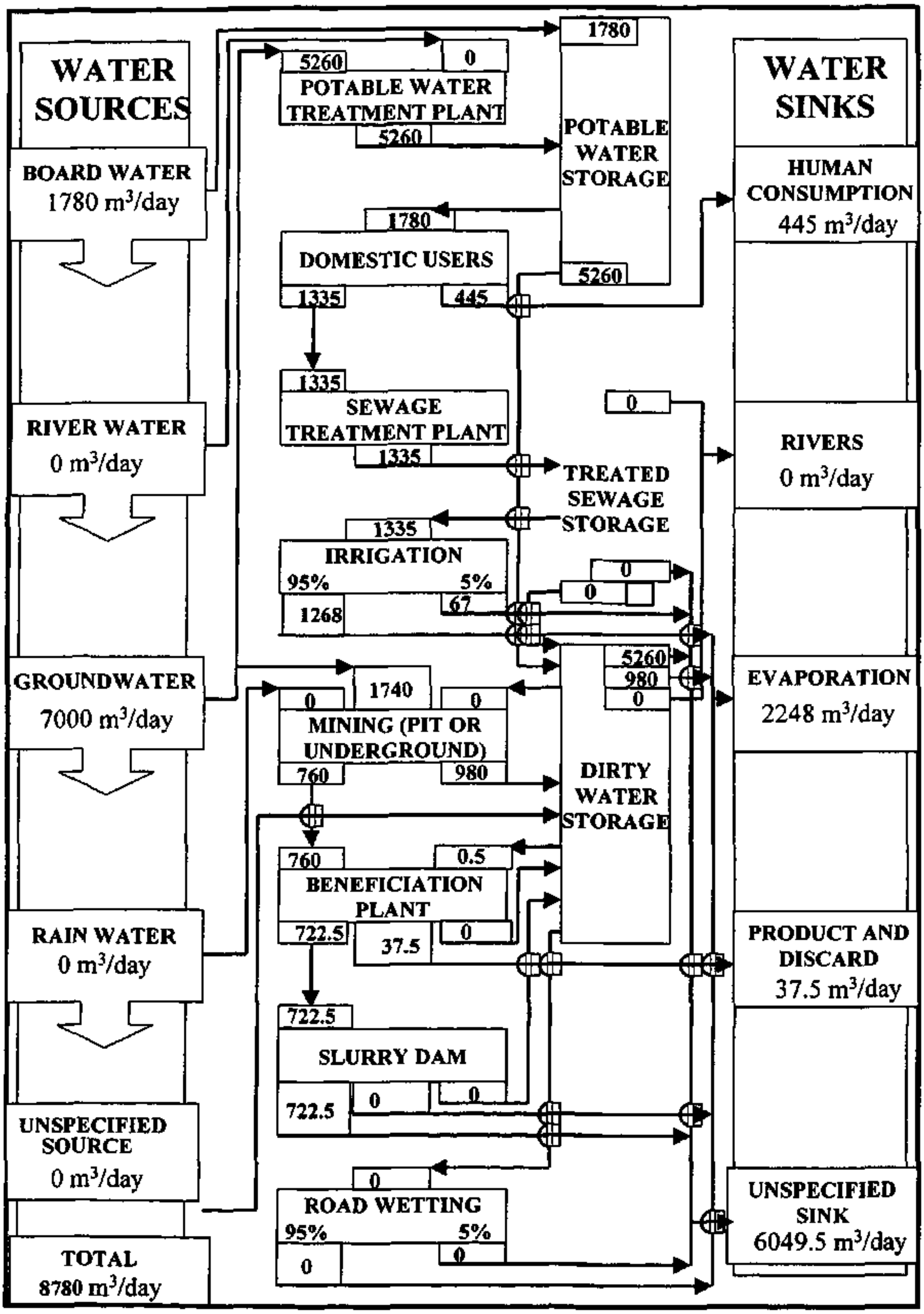

WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
3697 m³/day
GROUNDWATER
3876 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
7573 m³/day
8
3697
POTABLE WATER TREATMENT PLANT
3705
0
POTABLE WATER STORAGE
1564
2141
DOMESTIC USERS
1606
535
1606
SEWAGE TREATMENT PLANT
1606
1325
TREATED SEWAGE STORAGE
0
IRRIGATION
95%
5%
0
0
281
0
2306
0
1782
3868
0
1190
MINING (PIT OR UNDERGROUND)
440
4618
DIRTY WATER STORAGE
440
5018
BENEFICIATION PLANT
904
440
4114
904
SLURRY DAM
904
0
0
0
ROAD WETTING
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION
535 m³/day
RIVERS
3107 m³/day
EVAPORATION
0 m³/day
PRODUCT AND DISCARD
440 m³/day
UNSPECIFIED SINK
3491 m³/day

C8

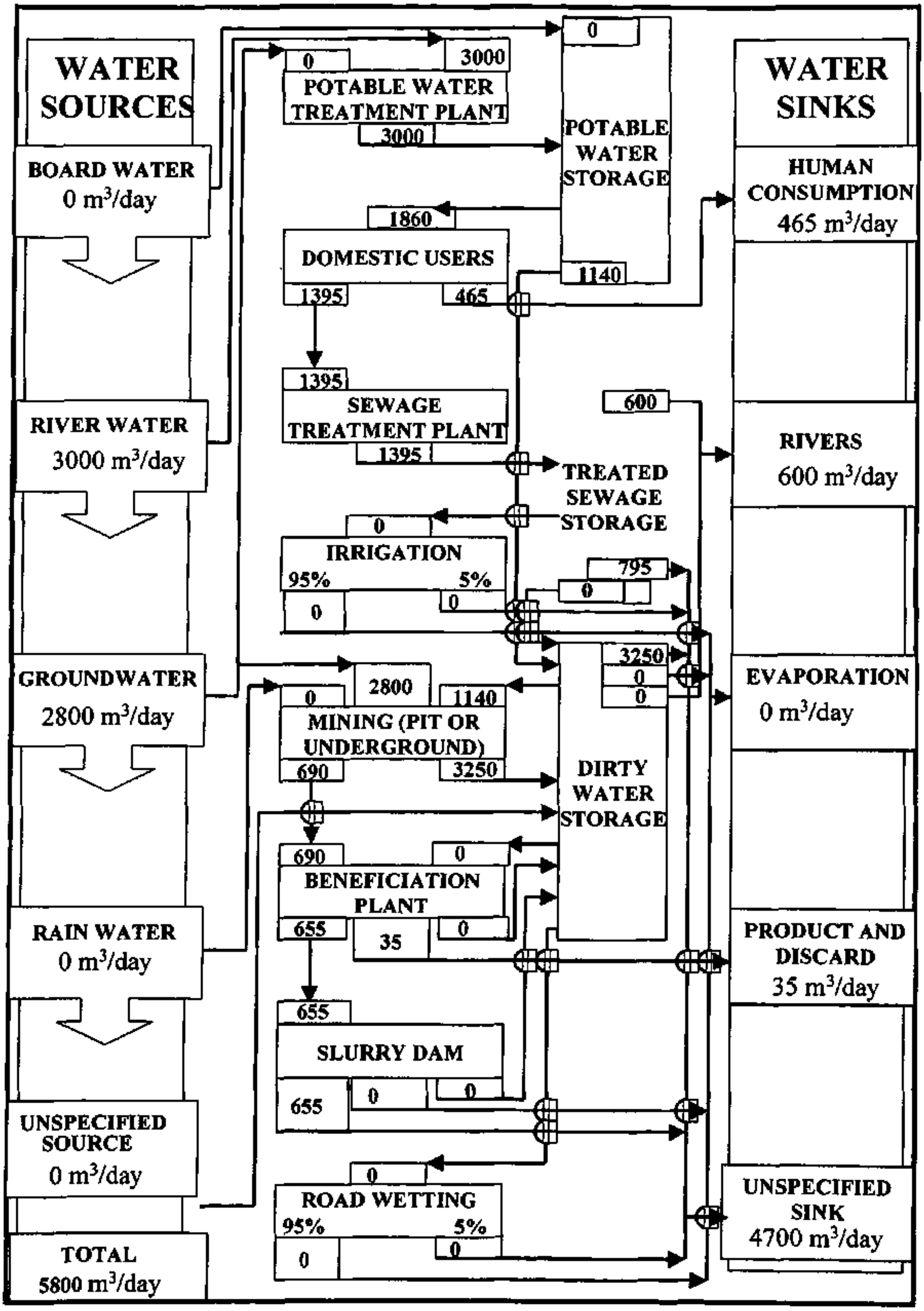


WATER SOURCES
BOARD WATER
7500 m³/day
RIVER WATER
254 m³/day
GROUNDWATER
7754 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
15508 m³/day
6696
254
POTABLE WATER TREATMENT PLANT
6950
7500
POTABLE WATER STORAGE
6955
7495
DOMESTIC USERS
5621
1874
5621
SEWAGE TREATMENT PLANT
5621
TREATED SEWAGE STORAGE
0
5621
IRRIGATION
95%
5%
5340
281
0
0
2813
0
0
1058
0
3500
MINING (PIT OR UNDERGROUND)
1700
2858
DIRTY WATER STORAGE
1700
0
BENEFICIATION PLANT
1615
85
0
1615
SLURRY DAM
1615
0
0
3500
ROAD WETTING
95%
5%
3325
175
WATER SINKS
HUMAN CONSUMPTION
1874 m³/day
RIVERS
0 m³/day
EVAPORATION
8665 m³/day
PRODUCT AND DISCARD
85 m³/day
UNSPECIFIED SINK
4884 m³/day

C9

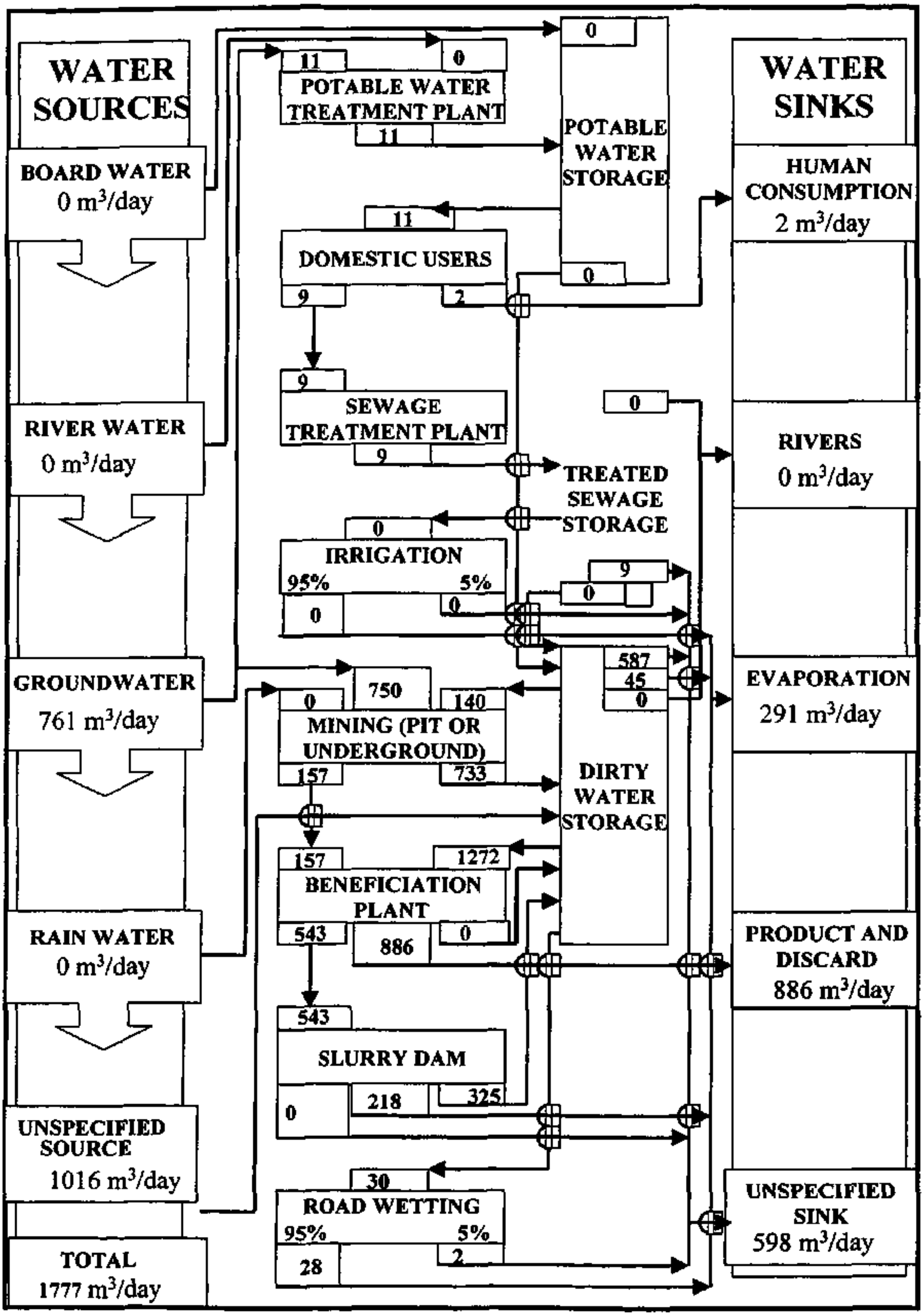

WATER SOURCES
BOARD WATER 1780 m³/day
RIVER WATER 0 m³/day
GROUNDWATER 7000 m³/day
RAIN WATER 0 m³/day
UNSPECIFIED SOURCE 0 m³/day
TOTAL 8780 m³/day
5260
0
POTABLE WATER TREATMENT PLANT
5260
1780
POTABLE WATER STORAGE
5260
1780
DOMESTIC USERS
1335
445
1335
SEWAGE TREATMENT PLANT
1335
TREATED SEWAGE STORAGE
1335
IRRIGATION
95%
5%
1268
67
0
0
1740
0
0
MINING (PIT OR UNDERGROUND)
760
980
5260
980
0
DIRTY WATER STORAGE
760
0.5
BENEFICIATION PLANT
722.5
37.5
0
722.5
SLURRY DAM
722.5
0
0
0
ROAD WETTING
95%
5%
0
0
0
WATER SINKS
HUMAN CONSUMPTION 445 m³/day
RIVERS 0 m³/day
EVAPORATION 2248 m³/day
PRODUCT AND DISCARD 37.5 m³/day
UNSPECIFIED SINK 6049.5 m³/day

C10

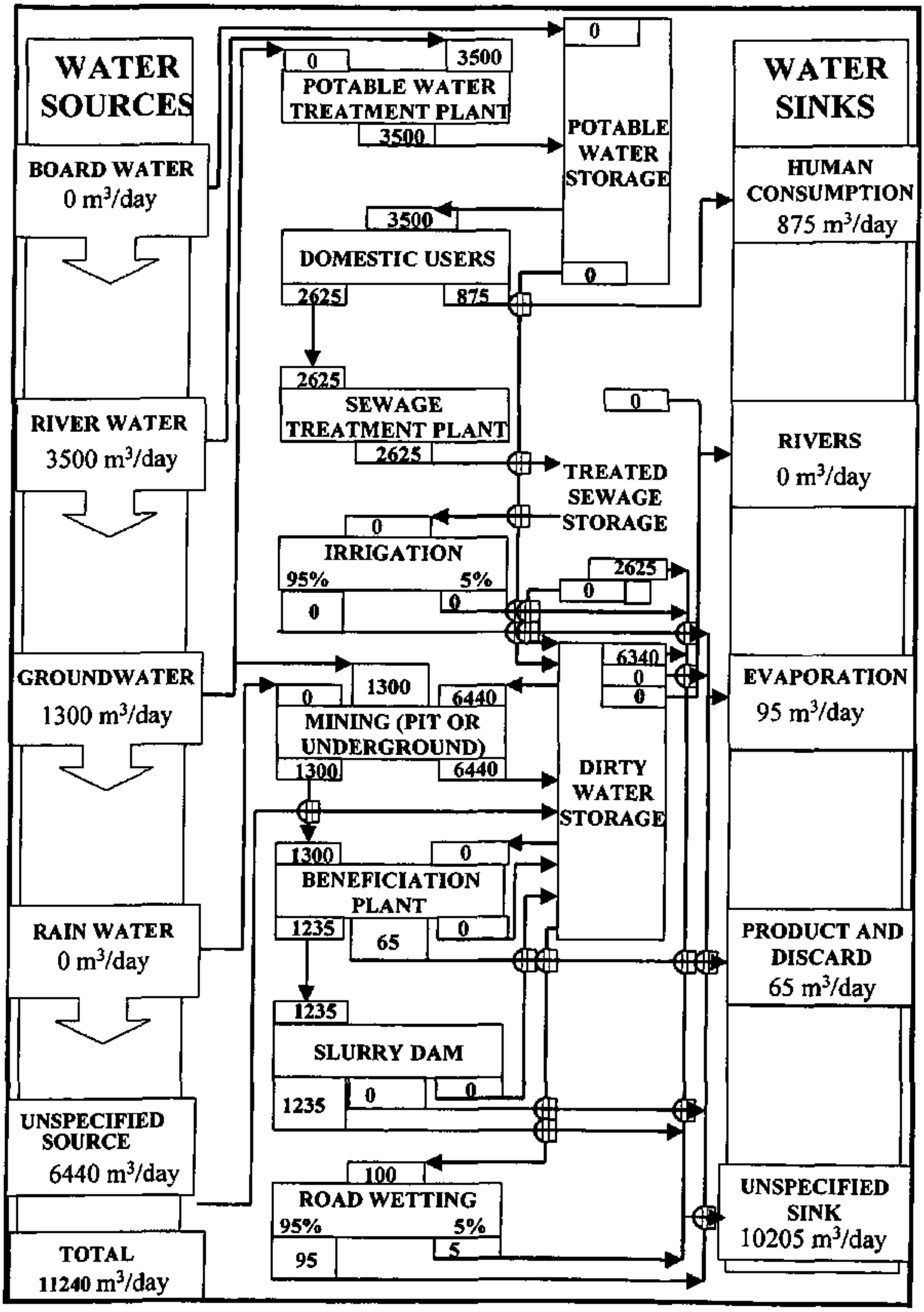


WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
3000 m³/day
GROUNDWATER
2800 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
5800 m³/day
POTABLE WATER TREATMENT PLANT
0
3000
3000
POTABLE WATER STORAGE
0
1140
DOMESTIC USERS
1860
1395
465
SEWAGE TREATMENT PLANT
1395
1395
TREATED SEWAGE STORAGE
600
IRRIGATION
0
95%
5%
0
0
795
0
MINING (PIT OR UNDERGROUND)
0
2800
1140
690
3250
3250
0
0
DIRTY WATER STORAGE
BENEFICIATION PLANT
690
0
655
35
0
SLURRY DAM
655
655
0
0
ROAD WETTING
0
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION
465 m³/day
RIVERS
600 m³/day
EVAPORATION
0 m³/day
PRODUCT AND DISCARD
35 m³/day
UNSPECIFIED SINK
4700 m³/day

C11

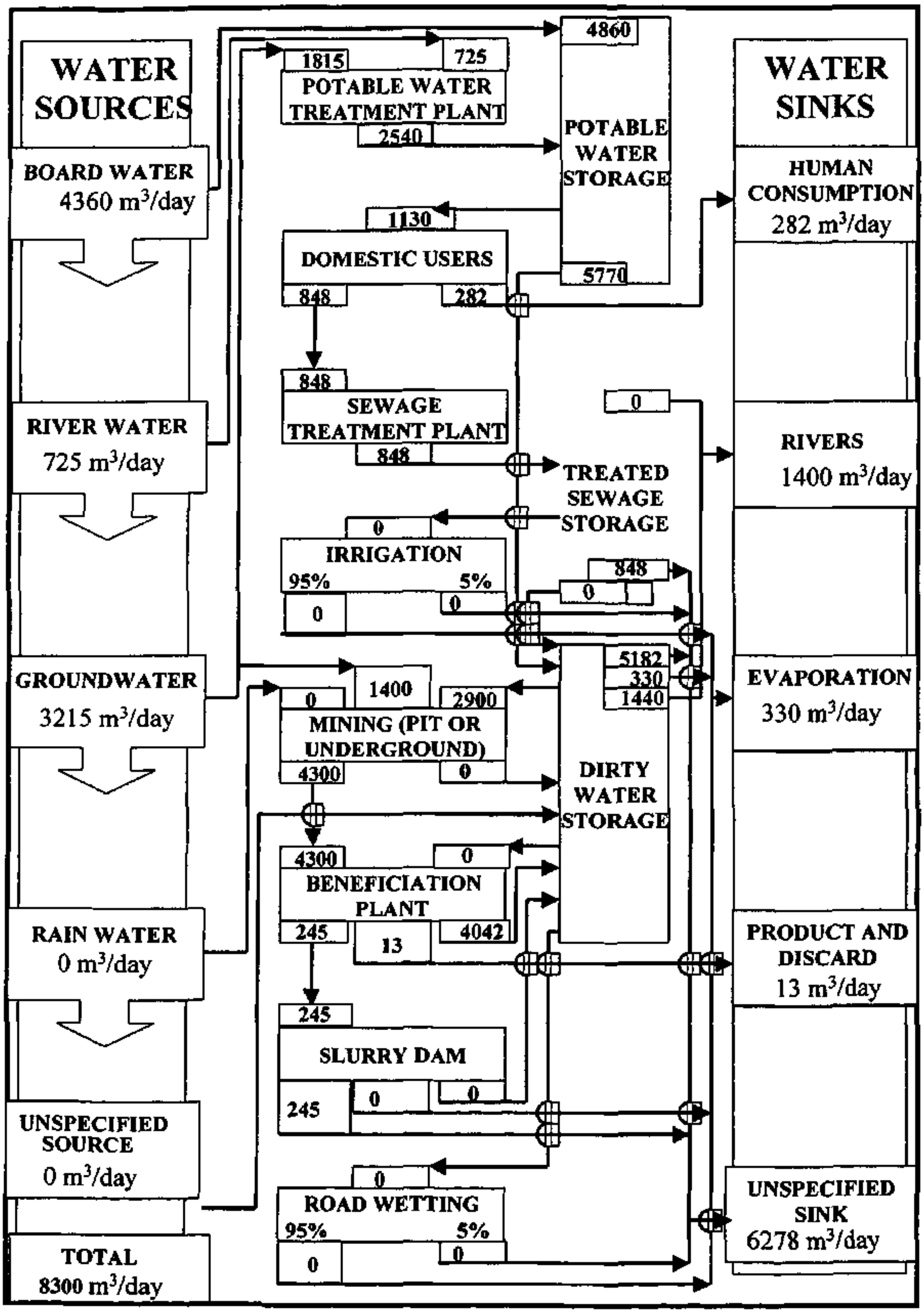

WATER SOURCES
BOARD WATER 0 m3/day
RIVER WATER 0 m3/day
GROUNDWATER 761 m3/day
RAIN WATER 0 m3/day
UNSPECIFIED SOURCE 1016 m3/day
TOTAL 1777 m3/day
POTABLE WATER TREATMENT PLANT
11
0
11
POTABLE WATER STORAGE
0
0
DOMESTIC USERS
11
9
2
SEWAGE TREATMENT PLANT
9
9
TREATED SEWAGE STORAGE
0
IRRIGATION
0
95%
5%
0
0
9
0
MINING (PIT OR UNDERGROUND)
750
0
140
157
733
DIRTY WATER STORAGE
587
45
0
BENEFICIATION PLANT
157
1272
543
886
0
SLURRY DAM
543
0
218
325
ROAD WETTING
30
95%
5%
28
2
WATER SINKS
HUMAN CONSUMPTION 2 m3/day
RIVERS 0 m3/day
EVAPORATION 291 m3/day
PRODUCT AND DISCARD 886 m3/day
UNSPECIFIED SINK 598 m3/day

C12

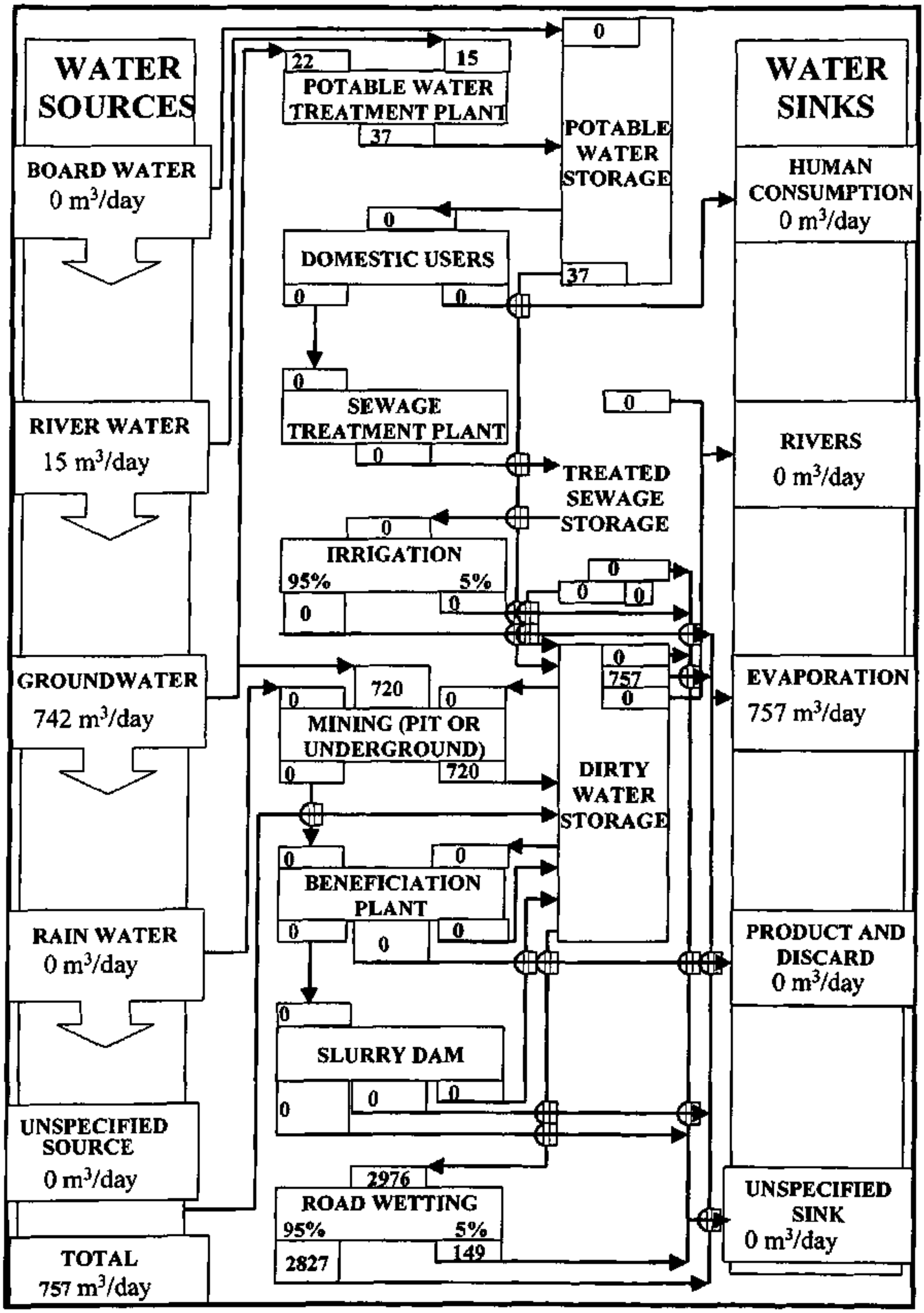


WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
3500 m³/day
GROUNDWATER
1300 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
6440 m³/day
TOTAL
11240 m³/day
POTABLE WATER TREATMENT PLANT
0
3500
3500
POTABLE WATER STORAGE
0
0
DOMESTIC USERS
3500
2625
875
SEWAGE TREATMENT PLANT
2625
2625
TREATED SEWAGE STORAGE
0
IRRIGATION
0
95%
5%
0
0
2625
0
MINING (PIT OR UNDERGROUND)
0
1300
6440
1300
6440
DIRTY WATER STORAGE
6340
0
0
BENEFICIATION PLANT
1300
0
1235
65
0
SLURRY DAM
1235
1235
0
0
ROAD WETTING
100
95%
5%
95
5
WATER SINKS
HUMAN CONSUMPTION
875 m³/day
RIVERS
0 m³/day
EVAPORATION
95 m³/day
PRODUCT AND DISCARD
65 m³/day
UNSPECIFIED SINK
10205 m³/day

C13

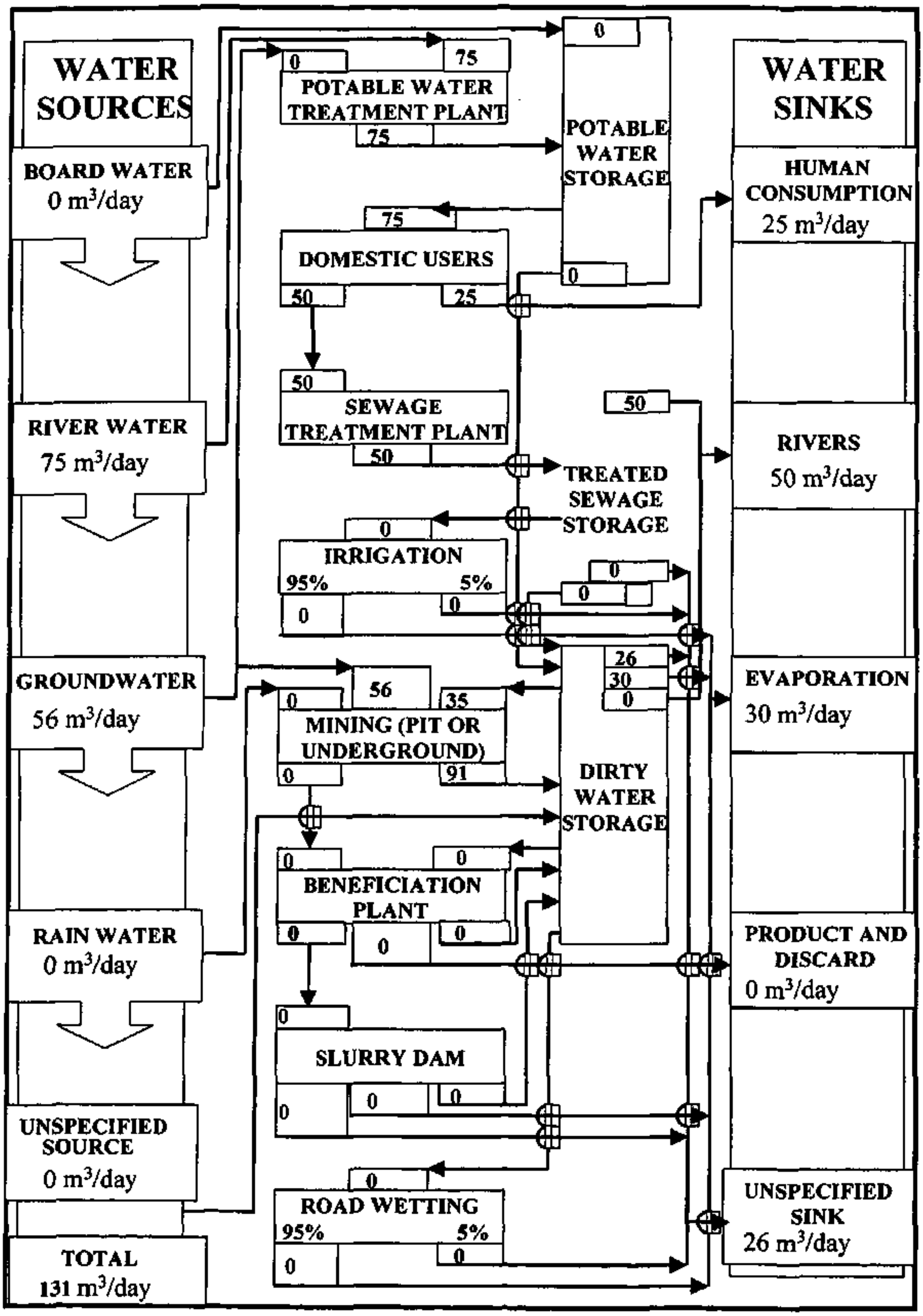

WATER SOURCES
BOARD WATER
4360 m^3/day
RIVER WATER
725 m^3/day
GROUNDWATER
3215 m^3/day
RAIN WATER
0 m^3/day
UNSPECIFIED SOURCE
0 m^3/day
TOTAL
8300 m^3/day
1815
725
POTABLE WATER TREATMENT PLANT
2540
4860
POTABLE WATER STORAGE
5770
1130
DOMESTIC USERS
848
282
848
SEWAGE TREATMENT PLANT
848
TREATED SEWAGE STORAGE
0
IRRIGATION
95%
5%
0
0
848
0
0
1400
0
2900
MINING (PIT OR UNDERGROUND)
4300
0
5182
330
1440
DIRTY WATER STORAGE
4300
0
BENEFICIATION PLANT
245
13
4042
245
SLURRY DAM
245
0
0
0
ROAD WETTING
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION
282 m^3/day
RIVERS
1400 m^3/day
EVAPORATION
330 m^3/day
PRODUCT AND DISCARD
13 m^3/day
UNSPECIFIED SINK
6278 m^3/day

D1

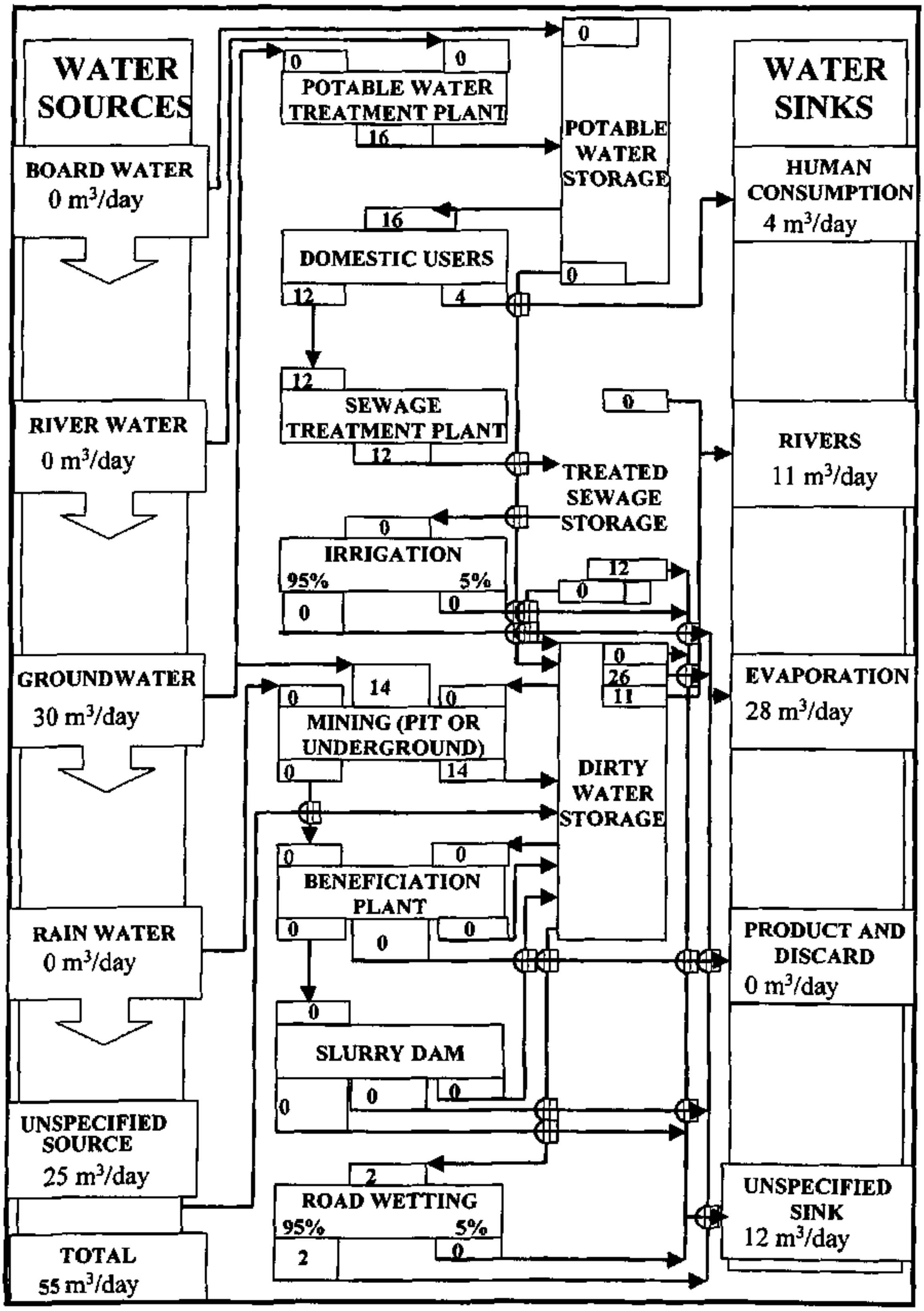


WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
15 m³/day
GROUNDWATER
742 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
757 m³/day
POTABLE WATER TREATMENT PLANT
22
15
37
POTABLE WATER STORAGE
0
37
DOMESTIC USERS
0
0
0
SEWAGE TREATMENT PLANT
0
0
TREATED SEWAGE STORAGE
0
IRRIGATION
0
95%
5%
0
0
0
0
0
MINING (PIT OR UNDERGROUND)
720
0
0
0
720
DIRTY WATER STORAGE
0
757
0
BENEFICIATION PLANT
0
0
0
0
0
SLURRY DAM
0
0
0
0
ROAD WETTING
2976
95%
5%
2827
149
WATER SINKS
HUMAN CONSUMPTION
0 m³/day
RIVERS
0 m³/day
EVAPORATION
757 m³/day
PRODUCT AND DISCARD
0 m³/day
UNSPECIFIED SINK
0 m³/day

D2

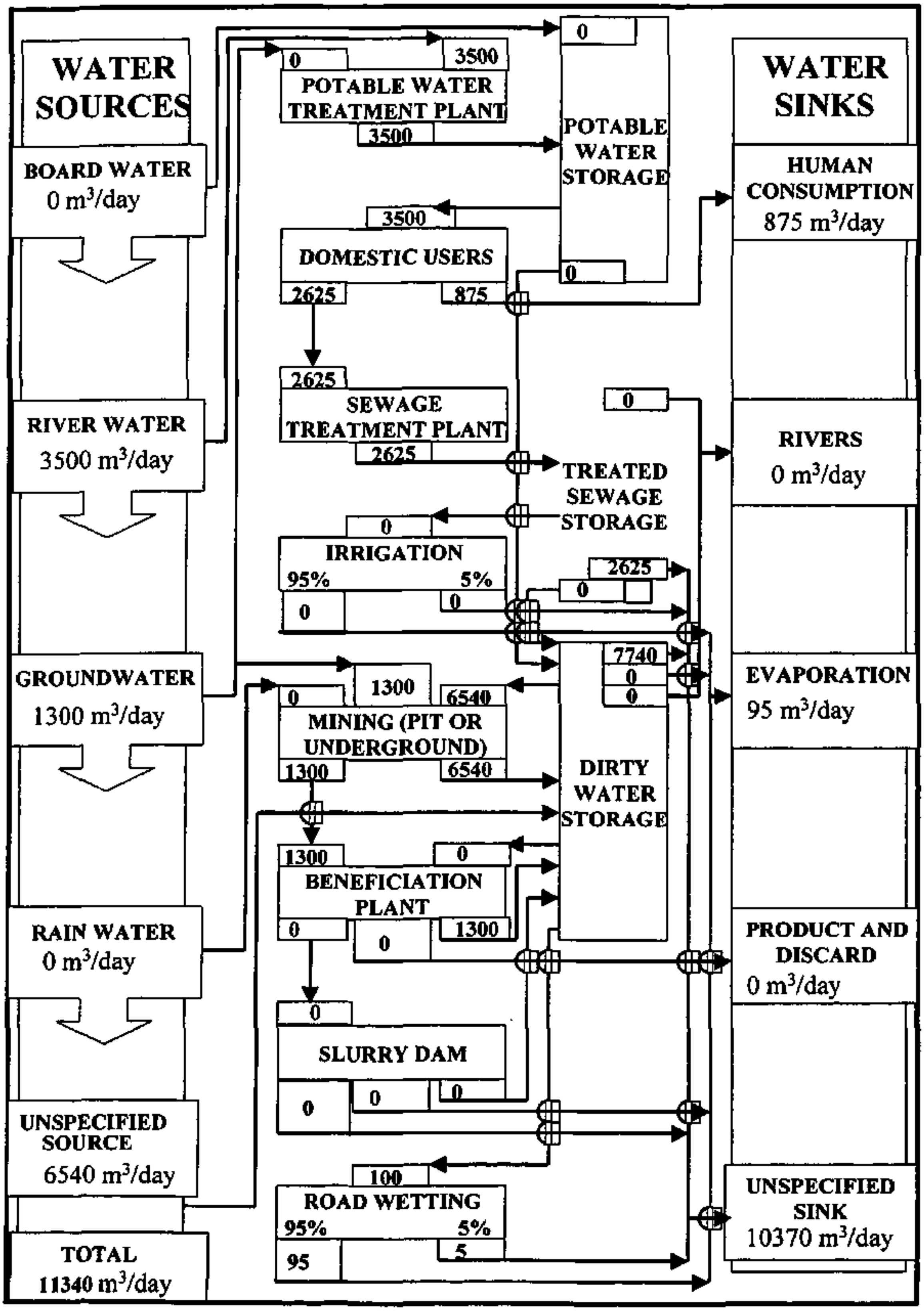

WATER SOURCES
BOARD WATER
0 m3/day
RIVER WATER
75 m3/day
GROUNDWATER
56 m3/day
RAIN WATER
0 m3/day
UNSPECIFIED SOURCE
0 m3/day
TOTAL
131 m3/day
POTABLE WATER TREATMENT PLANT
0
75
75
POTABLE WATER STORAGE
0
0
DOMESTIC USERS
75
50
25
SEWAGE TREATMENT PLANT
50
50
TREATED SEWAGE STORAGE
50
IRRIGATION
0
95%
5%
0
0
0
0
MINING (PIT OR UNDERGROUND)
56
0
35
0
91
DIRTY WATER STORAGE
26
30
0
BENEFICIATION PLANT
0
0
0
0
0
SLURRY DAM
0
0
0
0
ROAD WETTING
0
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION
25 m3/day
RIVERS
50 m3/day
EVAPORATION
30 m3/day
PRODUCT AND DISCARD
0 m3/day
UNSPECIFIED SINK
26 m3/day

D3

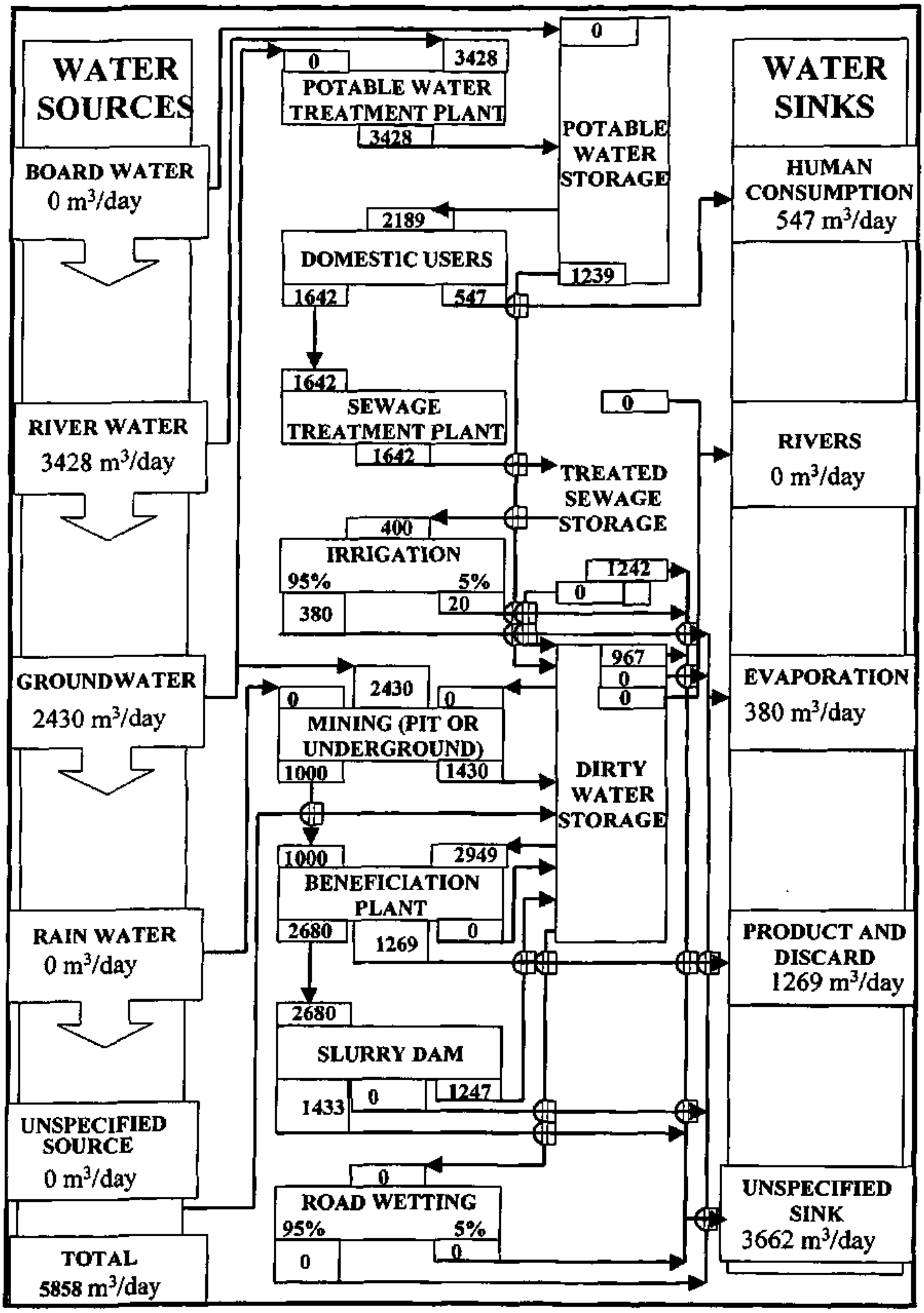


WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
0 m³/day
GROUNDWATER
30 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
25 m³/day
TOTAL
55 m³/day
POTABLE WATER TREATMENT PLANT
POTABLE WATER STORAGE
DOMESTIC USERS
SEWAGE TREATMENT PLANT
TREATED SEWAGE STORAGE
IRRIGATION
95%
5%
MINING (PIT OR UNDERGROUND)
DIRTY WATER STORAGE
BENEFICIATION PLANT
SLURRY DAM
ROAD WETTING
WATER SINKS
HUMAN CONSUMPTION
4 m³/day
RIVERS
11 m³/day
EVAPORATION
28 m³/day
PRODUCT AND DISCARD
0 m³/day
UNSPECIFIED SINK
12 m³/day

E1

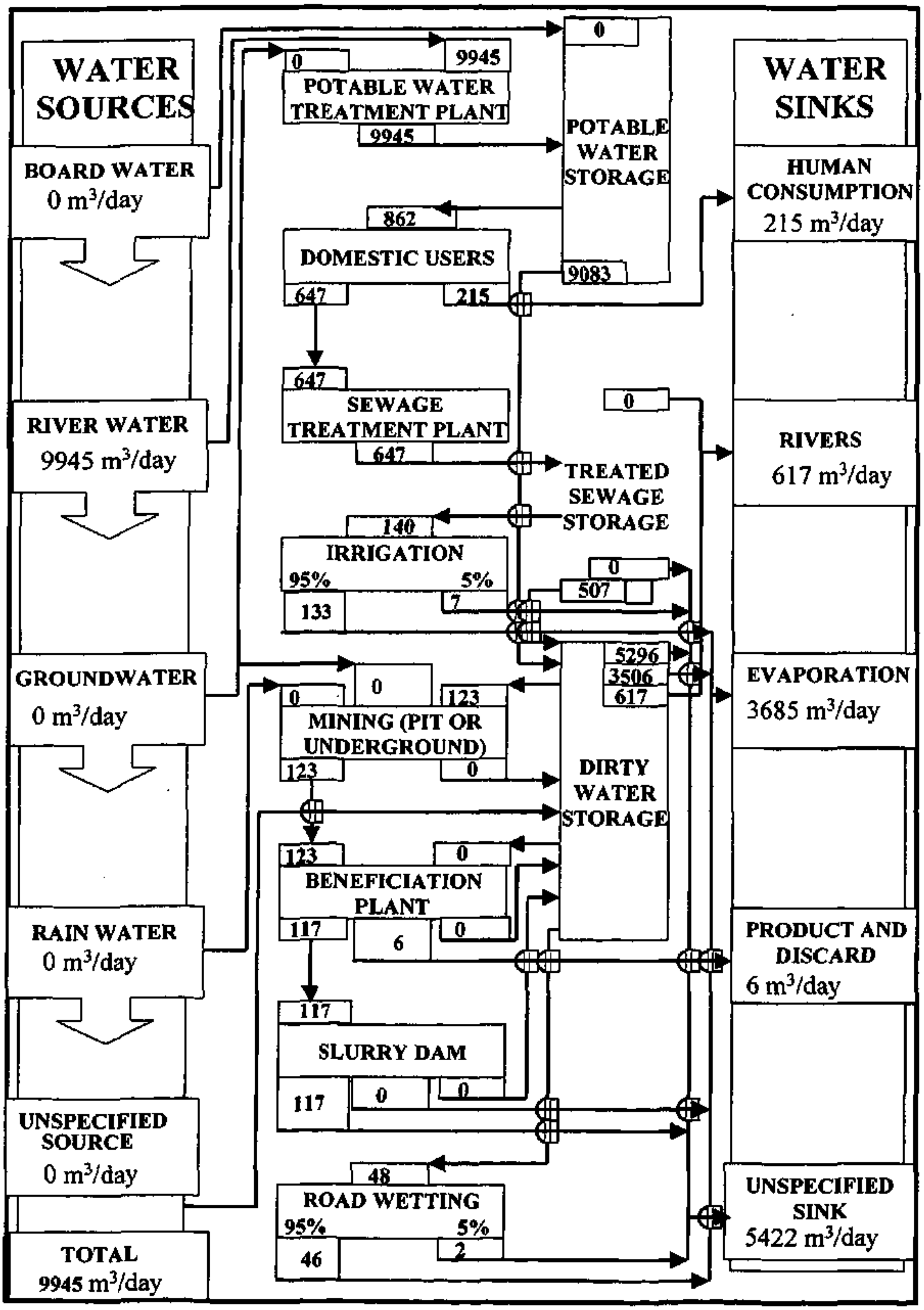

WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
3500 m³/day
GROUNDWATER
1300 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
6540 m³/day
TOTAL
11340 m³/day
POTABLE WATER TREATMENT PLANT
0
3500
3500
POTABLE WATER STORAGE
0
0
DOMESTIC USERS
3500
2625
875
SEWAGE TREATMENT PLANT
2625
2625
TREATED SEWAGE STORAGE
0
IRRIGATION
0
95%
5%
0
0
2625
0
MINING (PIT OR UNDERGROUND)
0
1300
6540
1300
6540
DIRTY WATER STORAGE
7740
0
0
BENEFICIATION PLANT
1300
0
0
0
1300
SLURRY DAM
0
0
0
0
ROAD WETTING
100
95%
5%
95
5
WATER SINKS
HUMAN CONSUMPTION
875 m³/day
RIVERS
0 m³/day
EVAPORATION
95 m³/day
PRODUCT AND DISCARD
0 m³/day
UNSPECIFIED SINK
10370 m³/day

F1

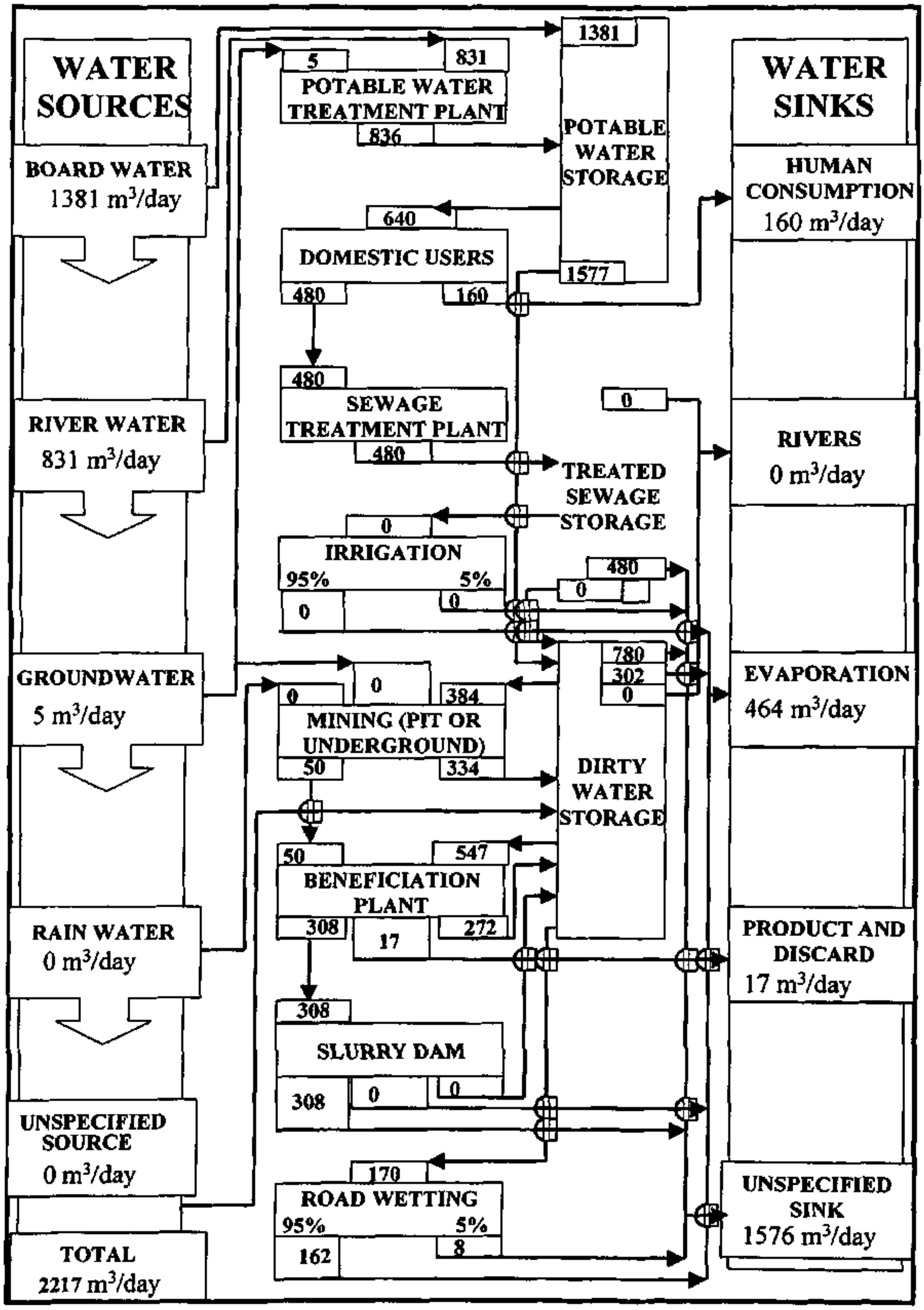


WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
3428 m³/day
GROUNDWATER
2430 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
5858 m³/day
POTABLE WATER TREATMENT PLANT
0
3428
3428
POTABLE WATER STORAGE
0
1239
DOMESTIC USERS
2189
1642
547
SEWAGE TREATMENT PLANT
1642
1642
TREATED SEWAGE STORAGE
0
IRRIGATION
400
95%
5%
380
20
1242
0
MINING (PIT OR UNDERGROUND)
2430
0
0
1000
1430
967
0
0
DIRTY WATER STORAGE
BENEFICIATION PLANT
1000
2949
2680
1269
0
SLURRY DAM
2680
1433
0
1247
ROAD WETTING
0
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION
547 m³/day
RIVERS
0 m³/day
EVAPORATION
380 m³/day
PRODUCT AND DISCARD
1269 m³/day
UNSPECIFIED SINK
3662 m³/day

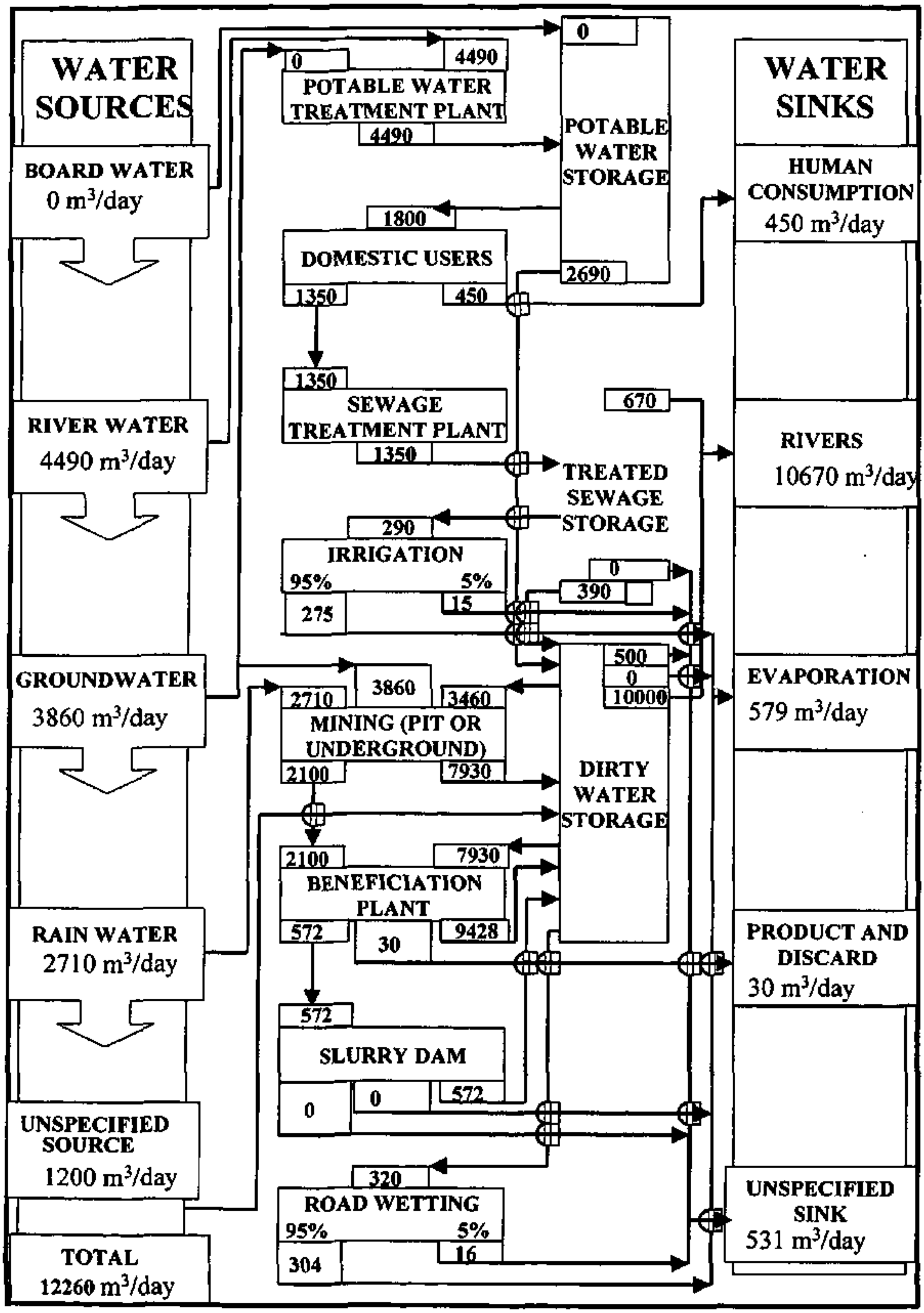
F2


WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
9945 m³/day
GROUNDWATER
0 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
9945 m³/day
0
9945
POTABLE WATER TREATMENT PLANT
9945
0
POTABLE WATER STORAGE
9083
862
DOMESTIC USERS
647
215
647
SEWAGE TREATMENT PLANT
647
TREATED SEWAGE STORAGE
0
140
IRRIGATION
95%
5%
133
7
0
507
5296
3506
617
0
0
123
MINING (PIT OR UNDERGROUND)
123
0
DIRTY WATER STORAGE
123
0
BENEFICIATION PLANT
117
6
0
117
SLURRY DAM
117
0
0
48
ROAD WETTING
95%
5%
46
2
WATER SINKS
HUMAN CONSUMPTION
215 m³/day
RIVERS
617 m³/day
EVAPORATION
3685 m³/day
PRODUCT AND DISCARD
6 m³/day
UNSPECIFIED SINK
5422 m³/day

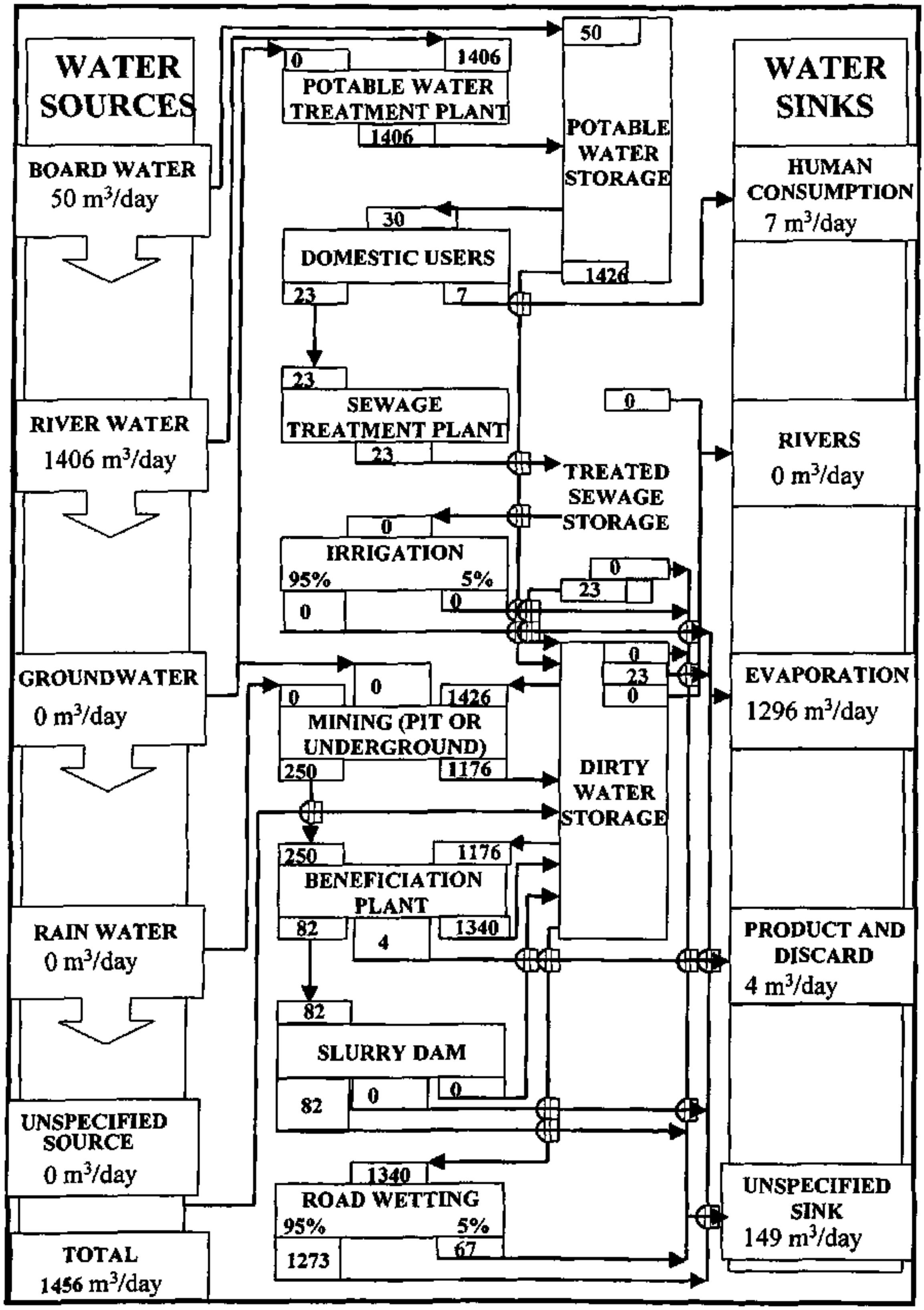
F3


WATER SOURCES
BOARD WATER
1381 m³/day
RIVER WATER
831 m³/day
GROUNDWATER
5 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
0 m³/day
TOTAL
2217 m³/day
POTABLE WATER TREATMENT PLANT
5
831
836
POTABLE WATER STORAGE
1381
1577
DOMESTIC USERS
640
480
160
SEWAGE TREATMENT PLANT
480
480
TREATED SEWAGE STORAGE
0
IRRIGATION
0
95%
5%
0
0
480
0
MINING (PIT OR UNDERGROUND)
0
0
384
50
334
DIRTY WATER STORAGE
780
302
0
BENEFICIATION PLANT
50
547
308
17
272
SLURRY DAM
308
308
0
0
ROAD WETTING
170
95%
5%
162
8
WATER SINKS
HUMAN CONSUMPTION
160 m³/day
RIVERS
0 m³/day
EVAPORATION
464 m³/day
PRODUCT AND DISCARD
17 m³/day
UNSPECIFIED SINK
1576 m³/day

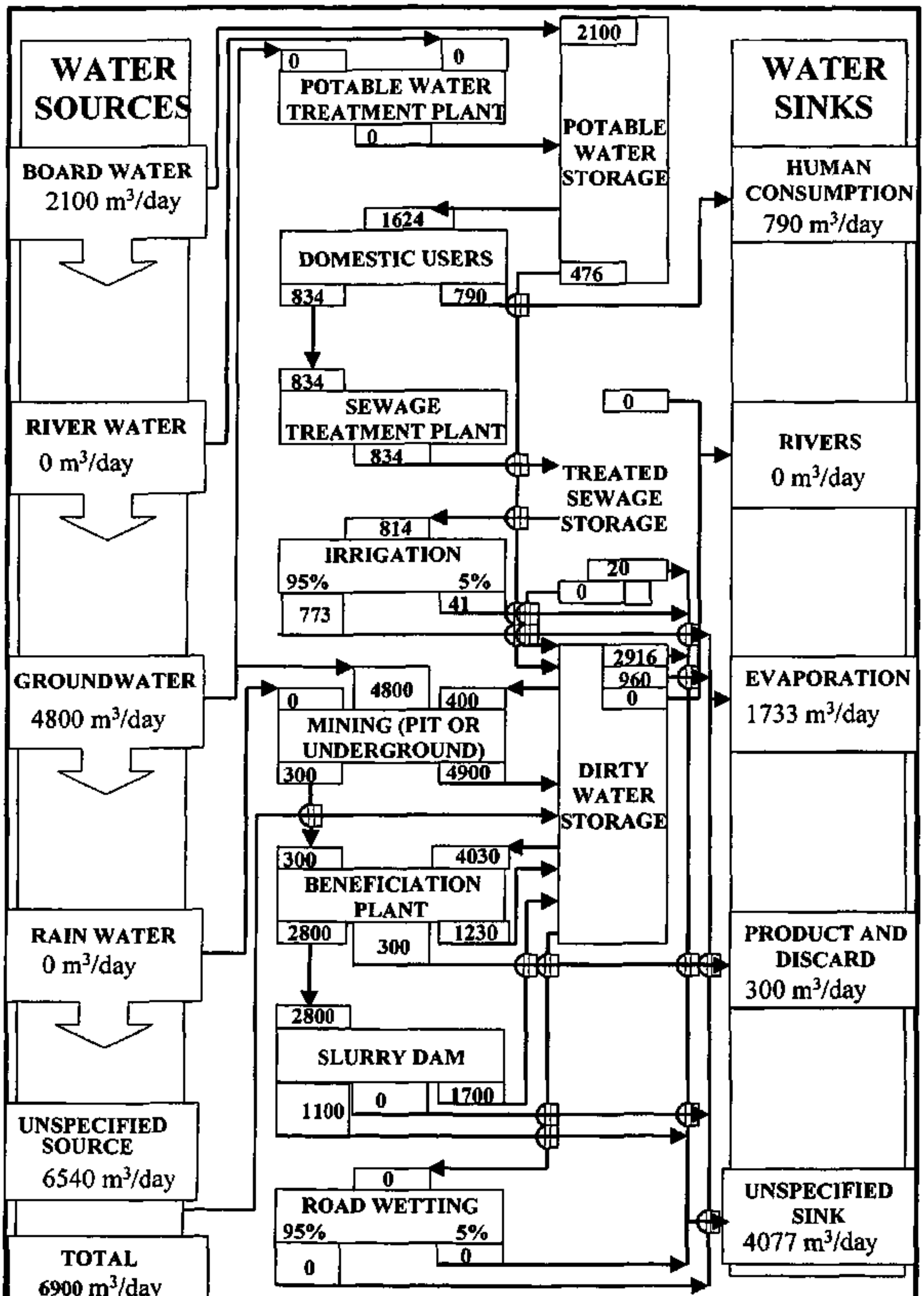
F4


WATER SOURCES
BOARD WATER 0 m^3/day
RIVER WATER 4490 m^3/day
GROUNDWATER 3860 m^3/day
RAIN WATER 2710 m^3/day
UNSPECIFIED SOURCE 1200 m^3/day
TOTAL 12260 m^3/day
POTABLE WATER TREATMENT PLANT
0
4490
4490
POTABLE WATER STORAGE
0
2690
DOMESTIC USERS
1800
1350
450
SEWAGE TREATMENT PLANT
1350
1350
TREATED SEWAGE STORAGE
670
IRRIGATION
290
95%
5%
275
15
0
390
MINING (PIT OR UNDERGROUND)
2710
3860
3460
2100
7930
DIRTY WATER STORAGE
500
0
10000
BENEFICIATION PLANT
2100
7930
572
30
9428
SLURRY DAM
572
0
572
0
ROAD WETTING
320
95%
5%
304
16
WATER SINKS
HUMAN CONSUMPTION 450 m^3/day
RIVERS 10670 m^3/day
EVAPORATION 579 m^3/day
PRODUCT AND DISCARD 30 m^3/day
UNSPECIFIED SINK 531 m^3/day

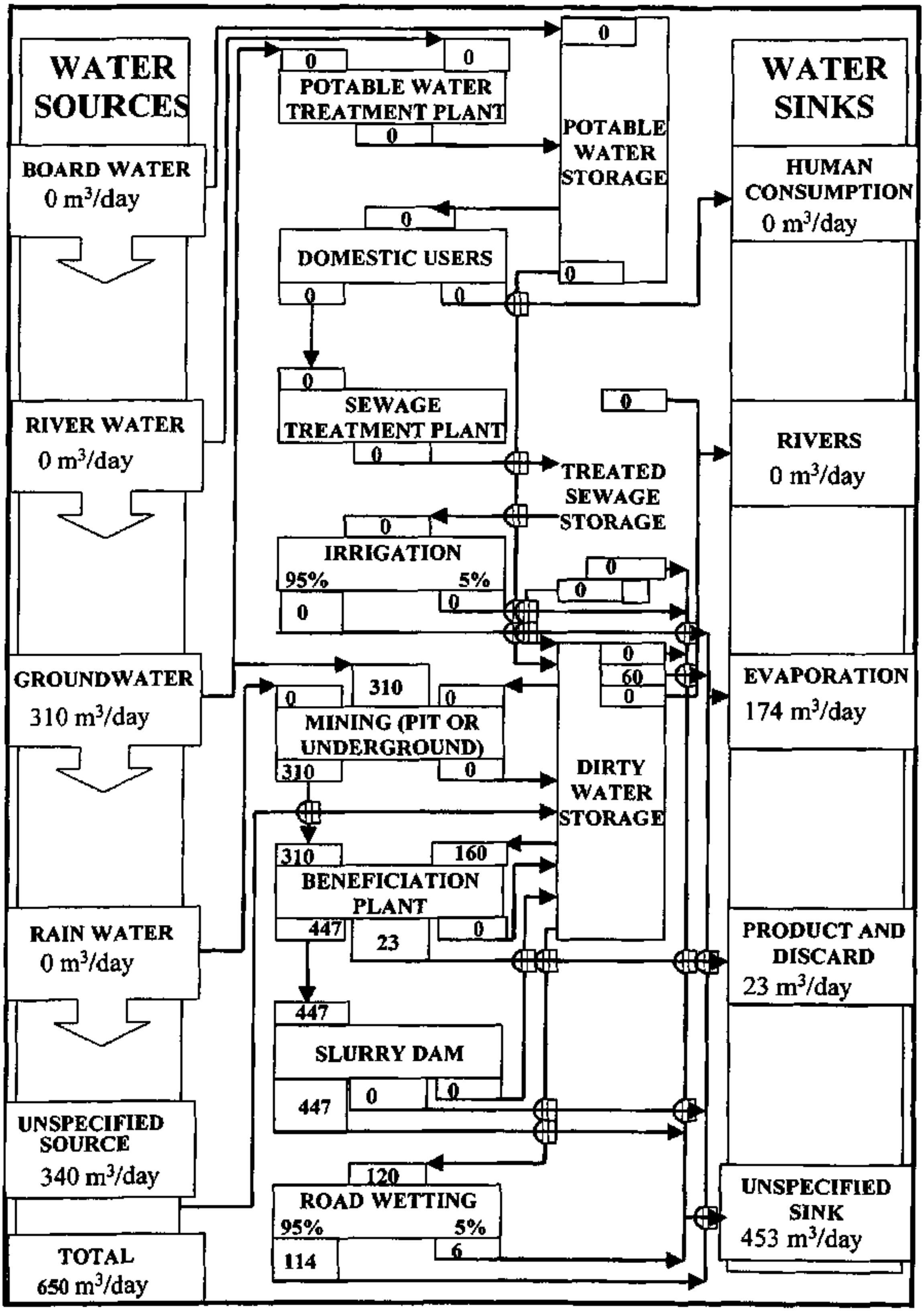
F5


WATER SOURCES
BOARD WATER 50 m³/day
RIVER WATER 1406 m³/day
GROUNDWATER 0 m³/day
RAIN WATER 0 m³/day
UNSPECIFIED SOURCE 0 m³/day
TOTAL 1456 m³/day
POTABLE WATER TREATMENT PLANT
POTABLE WATER STORAGE
DOMESTIC USERS
SEWAGE TREATMENT PLANT
TREATED SEWAGE STORAGE
IRRIGATION
95%
5%
MINING (PIT OR UNDERGROUND)
DIRTY WATER STORAGE
BENEFICIATION PLANT
SLURRY DAM
ROAD WETTING
WATER SINKS
HUMAN CONSUMPTION 7 m³/day
RIVERS 0 m³/day
EVAPORATION 1296 m³/day
PRODUCT AND DISCARD 4 m³/day
UNSPECIFIED SINK 149 m³/day

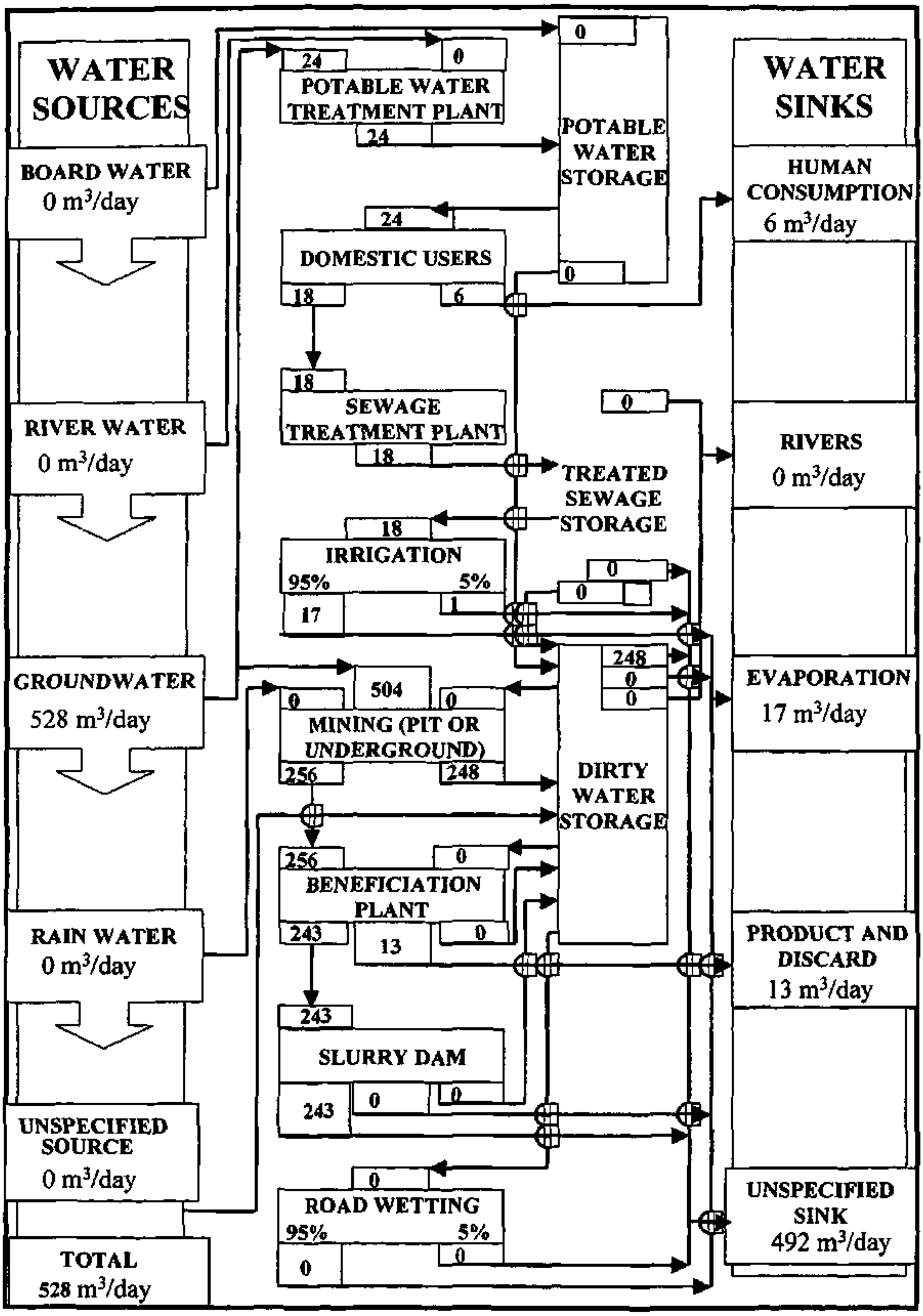
F6


WATER SOURCES
BOARD WATER 2100 m³/day
RIVER WATER 0 m³/day
GROUNDWATER 4800 m³/day
RAIN WATER 0 m³/day
UNSPECIFIED SOURCE 6540 m³/day
TOTAL 6900 m³/day
POTABLE WATER TREATMENT PLANT
POTABLE WATER STORAGE
DOMESTIC USERS
SEWAGE TREATMENT PLANT
TREATED SEWAGE STORAGE
IRRIGATION
95%
5%
MINING (PIT OR UNDERGROUND)
DIRTY WATER STORAGE
BENEFICIATION PLANT
SLURRY DAM
ROAD WETTING
95%
5%
WATER SINKS
HUMAN CONSUMPTION 790 m³/day
RIVERS 0 m³/day
EVAPORATION 1733 m³/day
PRODUCT AND DISCARD 300 m³/day
UNSPECIFIED SINK 4077 m³/day
2100
0
0
0
1624
476
834
790
834
834
0
814
20
0
41
773
2916
960
0
0
4800
400
300
4900
300
4030
2800
300
1230
2800
1100
0
1700
0
0
0

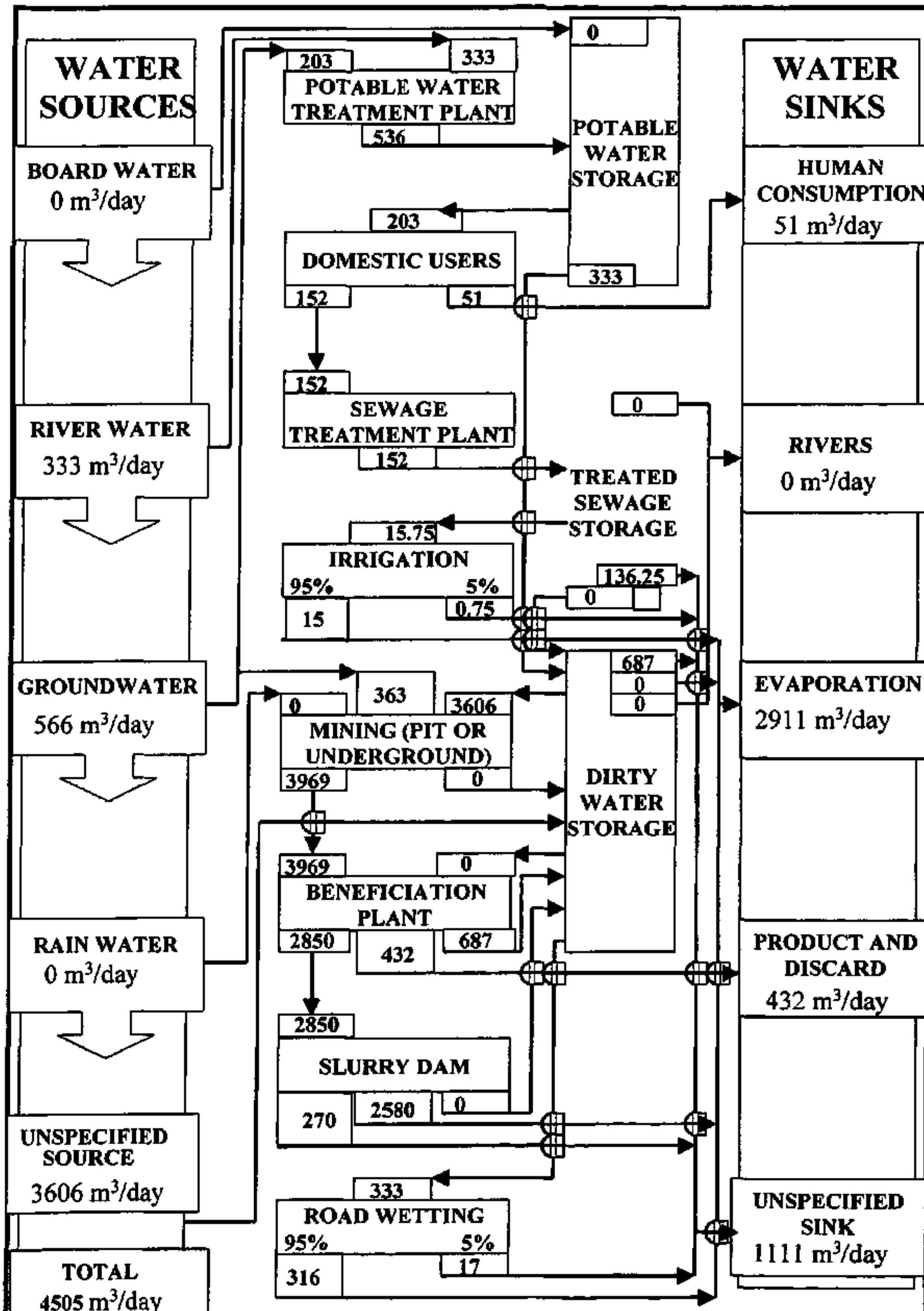
F7


WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
0 m³/day
GROUNDWATER
310 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
340 m³/day
TOTAL
650 m³/day
POTABLE WATER TREATMENT PLANT
POTABLE WATER STORAGE
DOMESTIC USERS
SEWAGE TREATMENT PLANT
TREATED SEWAGE STORAGE
IRRIGATION
95%
5%
MINING (PIT OR UNDERGROUND)
310
DIRTY WATER STORAGE
60
BENEFICIATION PLANT
310
160
447
23
SLURRY DAM
447
ROAD WETTING
120
95%
5%
114
6
WATER SINKS
HUMAN CONSUMPTION
0 m³/day
RIVERS
0 m³/day
EVAPORATION
174 m³/day
PRODUCT AND DISCARD
23 m³/day
UNSPECIFIED SINK
453 m³/day

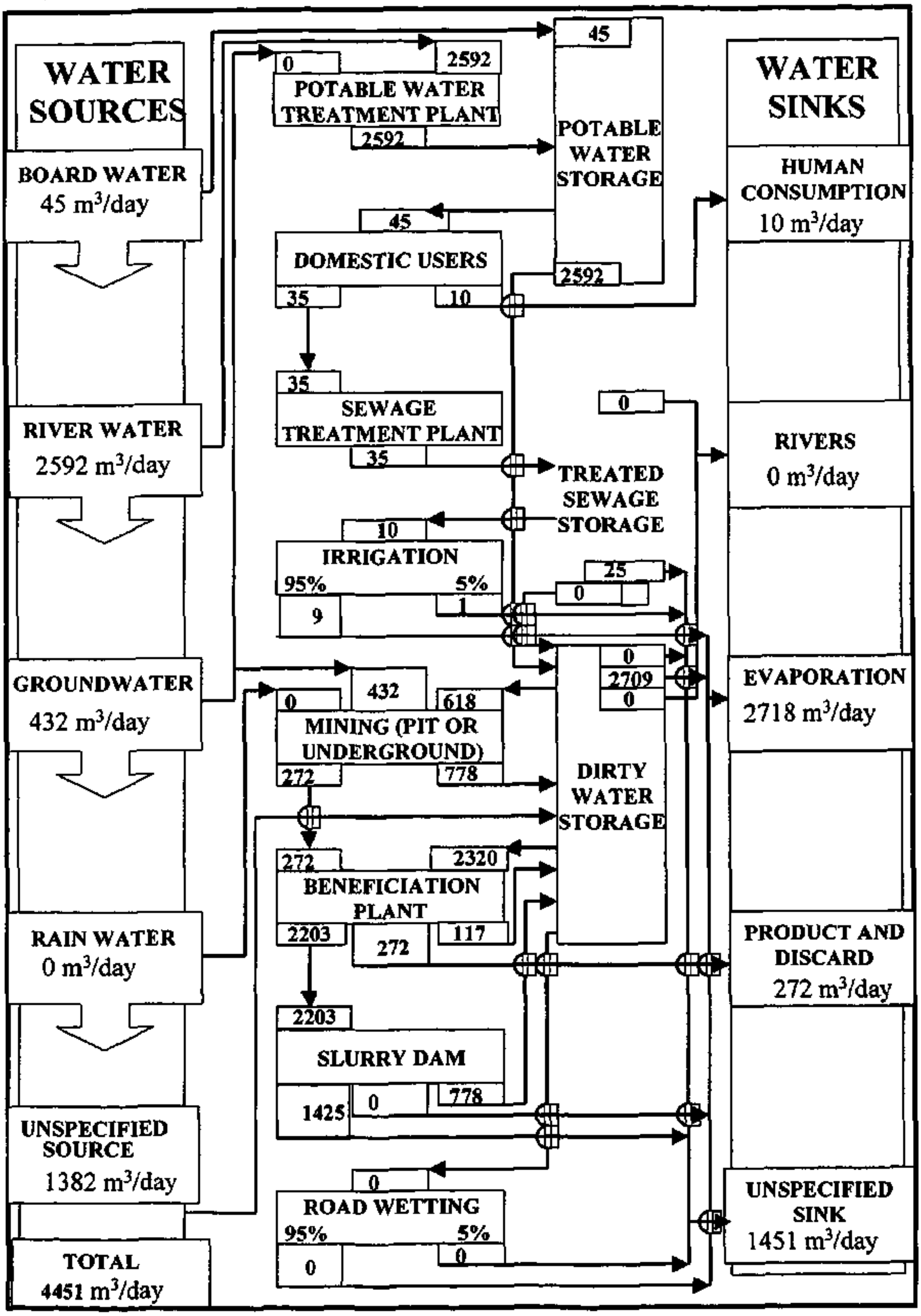
F8


WATER SOURCES
BOARD WATER
0 m3/day
RIVER WATER
0 m3/day
GROUNDWATER
528 m3/day
RAIN WATER
0 m3/day
UNSPECIFIED SOURCE
0 m3/day
TOTAL
528 m3/day
24
0
POTABLE WATER TREATMENT PLANT
24
0
POTABLE WATER STORAGE
0
24
DOMESTIC USERS
18
6
18
SEWAGE TREATMENT PLANT
18
TREATED SEWAGE STORAGE
0
18
IRRIGATION
95%
5%
17
1
0
0
504
0
0
MINING (PIT OR UNDERGROUND)
256
248
248
0
0
DIRTY WATER STORAGE
256
0
BENEFICIATION PLANT
243
13
0
243
SLURRY DAM
243
0
0
0
ROAD WETTING
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION
6 m3/day
RIVERS
0 m3/day
EVAPORATION
17 m3/day
PRODUCT AND DISCARD
13 m3/day
UNSPECIFIED SINK
492 m3/day

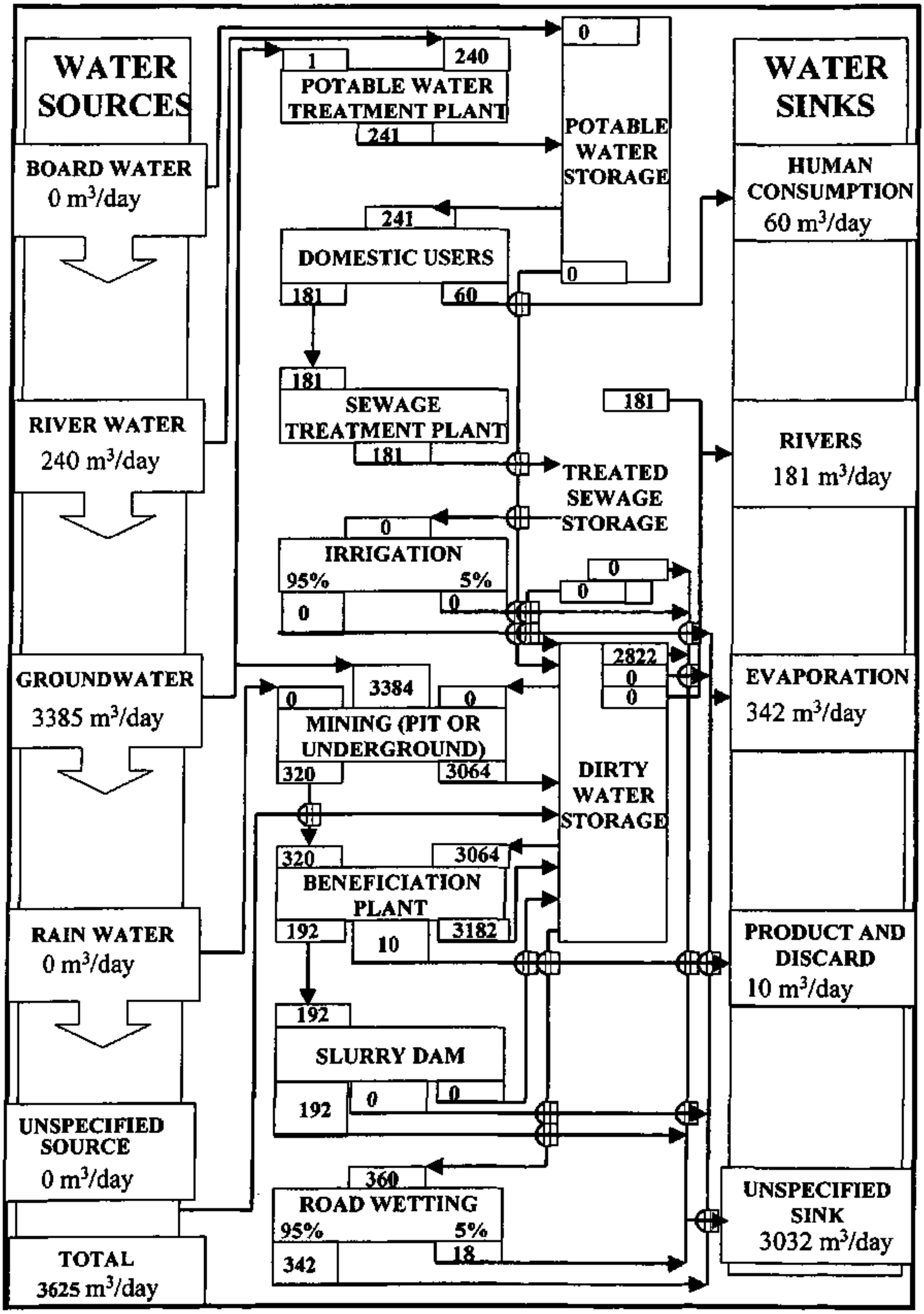
F9


WATER SOURCES
BOARD WATER
0 m³/day
RIVER WATER
333 m³/day
GROUNDWATER
566 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
3606 m³/day
TOTAL
4505 m³/day
POTABLE WATER TREATMENT PLANT
203
333
536
0
POTABLE WATER STORAGE
333
DOMESTIC USERS
203
152
51
SEWAGE TREATMENT PLANT
152
152
TREATED SEWAGE STORAGE
0
IRRIGATION
15.75
95%
5%
15
0.75
136.25
0
MINING (PIT OR UNDERGROUND)
0
363
3606
3969
0
687
0
0
DIRTY WATER STORAGE
BENEFICIATION PLANT
3969
0
2850
432
687
SLURRY DAM
2850
270
2580
0
ROAD WETTING
333
95%
5%
316
17
WATER SINKS
HUMAN CONSUMPTION
51 m³/day
RIVERS
0 m³/day
EVAPORATION
2911 m³/day
PRODUCT AND DISCARD
432 m³/day
UNSPECIFIED SINK
1111 m³/day

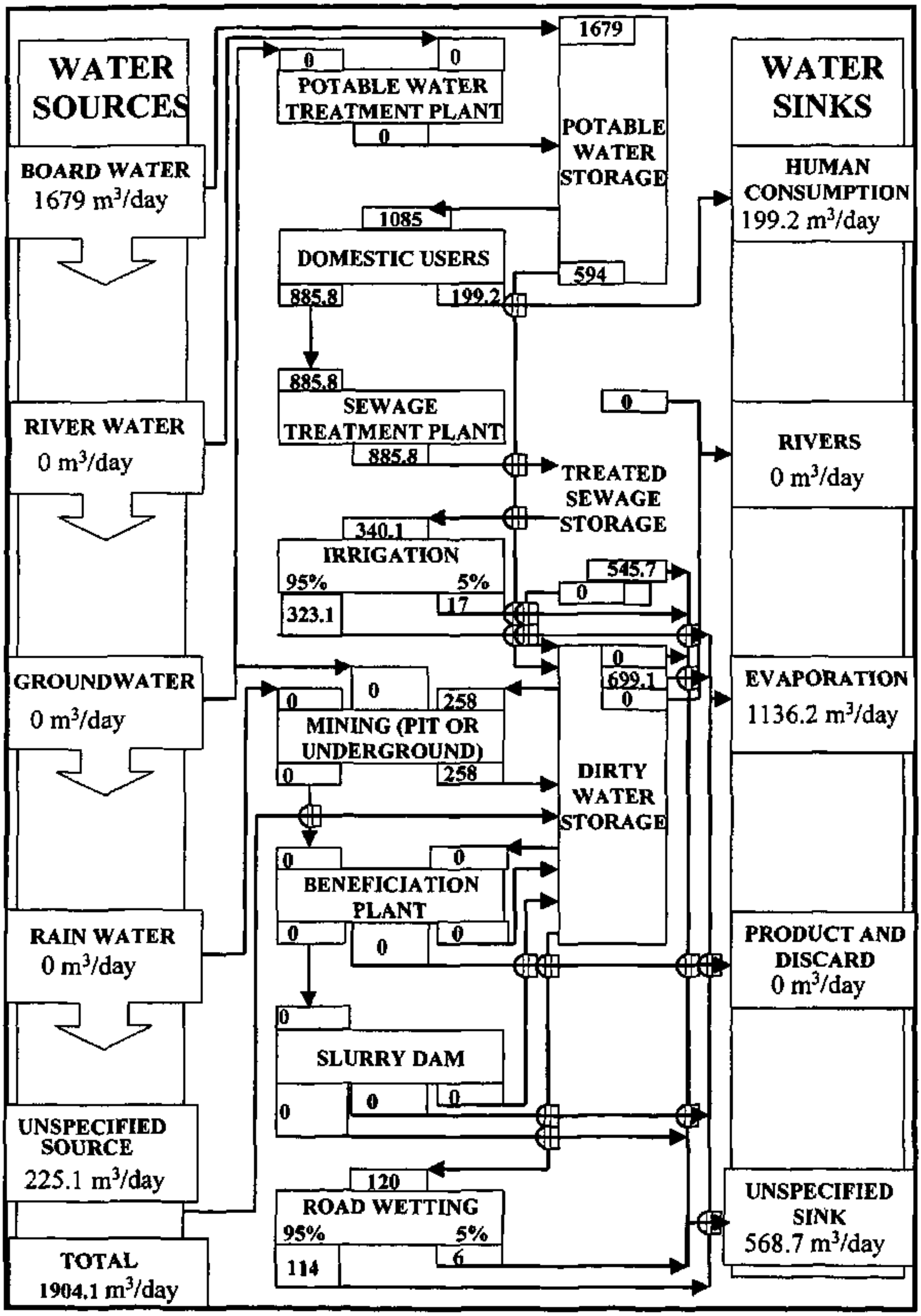
F10


WATER SOURCES
BOARD WATER
45 m³/day
RIVER WATER
2592 m³/day
GROUNDWATER
432 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
1382 m³/day
TOTAL
4451 m³/day
POTABLE WATER TREATMENT PLANT
0
2592
2592
POTABLE WATER STORAGE
45
2592
DOMESTIC USERS
45
35
10
SEWAGE TREATMENT PLANT
35
35
TREATED SEWAGE STORAGE
0
IRRIGATION
10
95%
5%
9
1
25
0
MINING (PIT OR UNDERGROUND)
432
0
618
272
778
DIRTY WATER STORAGE
0
2709
0
BENEFICIATION PLANT
272
2320
2203
272
117
SLURRY DAM
2203
1425
0
778
ROAD WETTING
0
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION
10 m³/day
RIVERS
0 m³/day
EVAPORATION
2718 m³/day
PRODUCT AND DISCARD
272 m³/day
UNSPECIFIED SINK
1451 m³/day

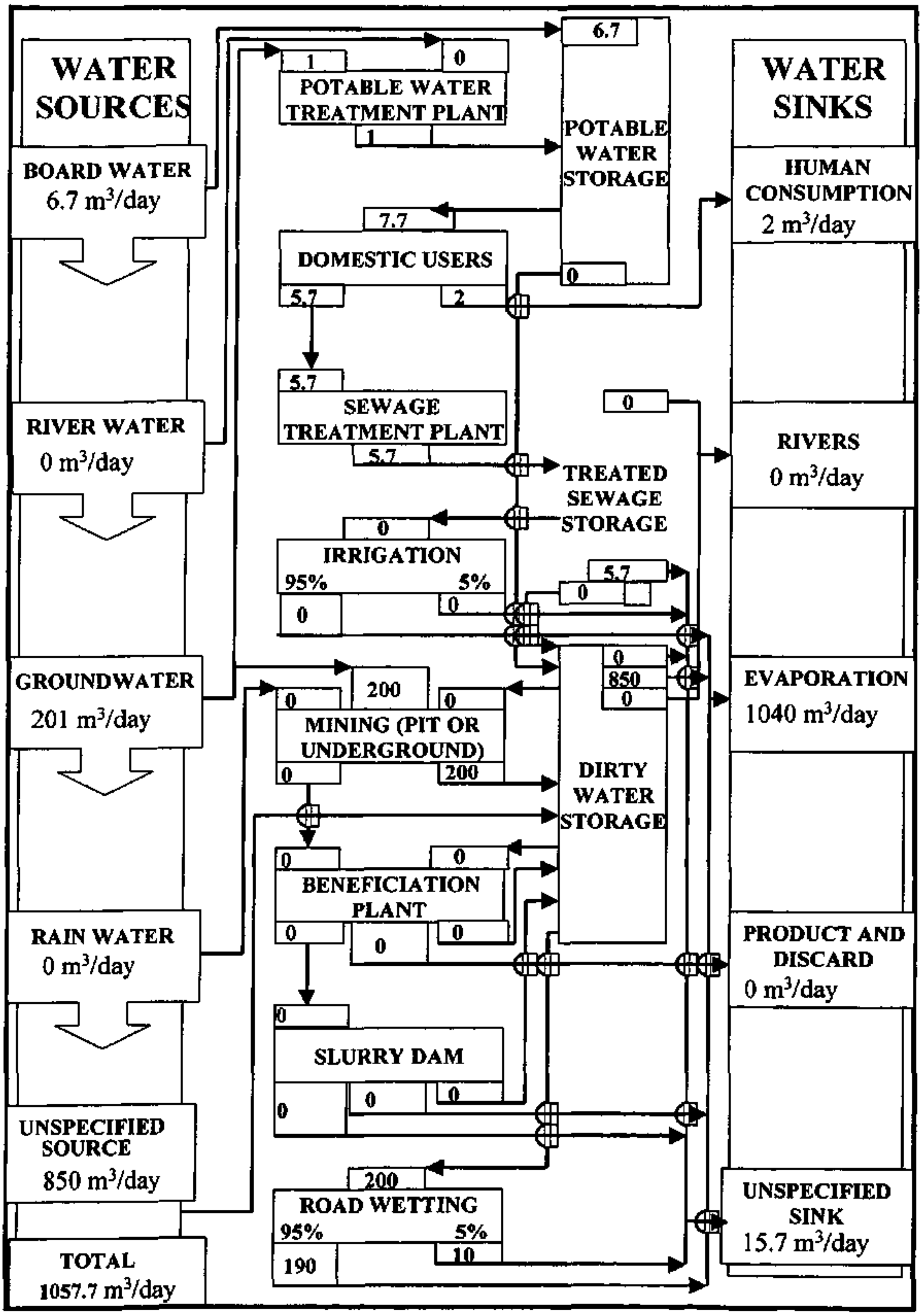
F11


WATER SOURCES
BOARD WATER 0 m³/day
RIVER WATER 240 m³/day
GROUNDWATER 3385 m³/day
RAIN WATER 0 m³/day
UNSPECIFIED SOURCE 0 m³/day
TOTAL 3625 m³/day
POTABLE WATER TREATMENT PLANT
1
240
241
POTABLE WATER STORAGE
0
0
DOMESTIC USERS
241
181
60
SEWAGE TREATMENT PLANT
181
181
TREATED SEWAGE STORAGE
181
IRRIGATION
95%
5%
0
0
0
0
0
MINING (PIT OR UNDERGROUND)
3384
0
0
320
3064
DIRTY WATER STORAGE
2822
0
0
BENEFICIATION PLANT
320
3064
192
10
3182
SLURRY DAM
192
192
0
0
ROAD WETTING
360
95%
5%
342
18
WATER SINKS
HUMAN CONSUMPTION 60 m³/day
RIVERS 181 m³/day
EVAPORATION 342 m³/day
PRODUCT AND DISCARD 10 m³/day
UNSPECIFIED SINK 3032 m³/day

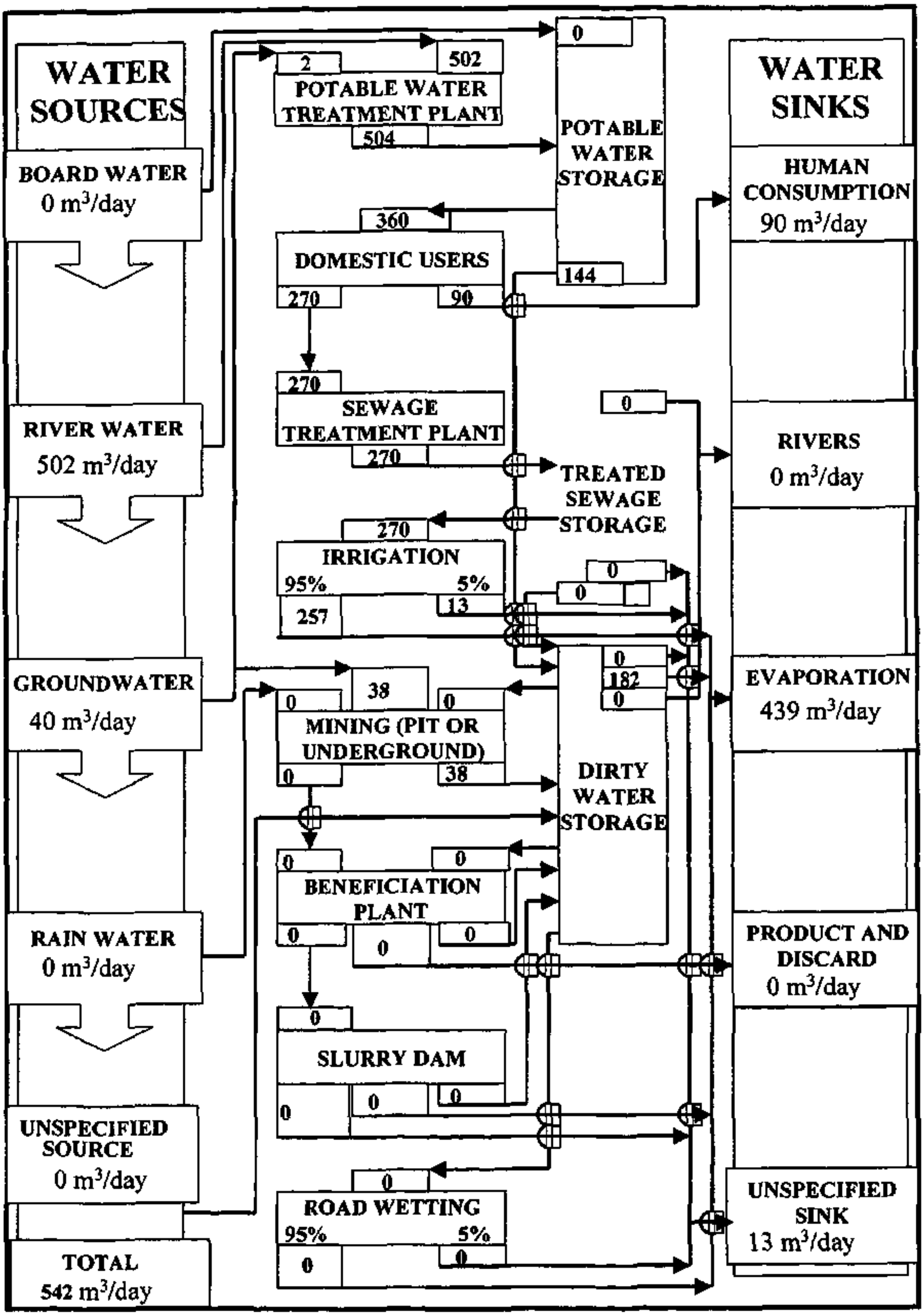
G1


WATER SOURCES
BOARD WATER
1679 m3/day
RIVER WATER
0 m3/day
GROUNDWATER
0 m3/day
RAIN WATER
0 m3/day
UNSPECIFIED SOURCE
225.1 m3/day
TOTAL
1904.1 m3/day
POTABLE WATER TREATMENT PLANT
0
0
0
1679
POTABLE WATER STORAGE
594
1085
DOMESTIC USERS
885.8
199.2
885.8
SEWAGE TREATMENT PLANT
885.8
TREATED SEWAGE STORAGE
340.1
IRRIGATION
95%
5%
323.1
17
545.7
0
0
699.1
0
0
258
MINING (PIT OR UNDERGROUND)
0
258
DIRTY WATER STORAGE
0
0
BENEFICIATION PLANT
0
0
0
0
SLURRY DAM
0
0
0
120
ROAD WETTING
95%
5%
114
6
WATER SINKS
HUMAN CONSUMPTION
199.2 m3/day
0
RIVERS
0 m3/day
EVAPORATION
1136.2 m3/day
PRODUCT AND DISCARD
0 m3/day
UNSPECIFIED SINK
568.7 m3/day

G2


WATER SOURCES
BOARD WATER
6.7 m³/day
RIVER WATER
0 m³/day
GROUNDWATER
201 m³/day
RAIN WATER
0 m³/day
UNSPECIFIED SOURCE
850 m³/day
TOTAL
1057.7 m³/day
6.7
1
0
POTABLE WATER TREATMENT PLANT
1
POTABLE WATER STORAGE
0
7.7
DOMESTIC USERS
5.7
2
5.7
SEWAGE TREATMENT PLANT
5.7
0
TREATED SEWAGE STORAGE
0
IRRIGATION
95%
5%
0
0
5.7
0
0
850
0
200
0
0
MINING (PIT OR UNDERGROUND)
0
200
DIRTY WATER STORAGE
0
0
BENEFICIATION PLANT
0
0
0
0
SLURRY DAM
0
0
0
200
ROAD WETTING
95%
5%
190
10
WATER SINKS
HUMAN CONSUMPTION
2 m³/day
RIVERS
0 m³/day
EVAPORATION
1040 m³/day
PRODUCT AND DISCARD
0 m³/day
UNSPECIFIED SINK
15.7 m³/day

G3


WATER SOURCES
BOARD WATER 0 m³/day
RIVER WATER 502 m³/day
GROUNDWATER 40 m³/day
RAIN WATER 0 m³/day
UNSPECIFIED SOURCE 0 m³/day
TOTAL 542 m³/day
POTABLE WATER TREATMENT PLANT
2
502
504
POTABLE WATER STORAGE
0
144
DOMESTIC USERS
360
270
90
SEWAGE TREATMENT PLANT
270
270
TREATED SEWAGE STORAGE
0
IRRIGATION
270
95%
5%
257
13
MINING (PIT OR UNDERGROUND)
0
38
0
0
38
DIRTY WATER STORAGE
0
182
0
0
0
BENEFICIATION PLANT
0
0
0
0
0
SLURRY DAM
0
0
0
0
ROAD WETTING
0
95%
5%
0
0
WATER SINKS
HUMAN CONSUMPTION 90 m³/day
RIVERS 0 m³/day
EVAPORATION 439 m³/day
PRODUCT AND DISCARD 0 m³/day
UNSPECIFIED SINK 13 m³/day

APPENDIX 3:
RAW DATA TABLES

Catchment	Production (tons/month)	Production (tons/day)	Age of Mine	Remaining Life	Type of Mining	Stream '001	Stream '002	Stream '003	Stream '004	Stream '005	Stream '006	Stream '007	Stream '008	Stream '009	Stream '010	Stream '011	Stream '012	Stream '013	Stream '014	Stream '015
Olifants River	111111	3704	-	17	f	1381	831	5			5	831	836	640	480	160	480			
Olifants River	350000	11667	46	20	c	4546	911					911	911	1735	1301	434	1301			
Klein Olifants	50000	1667	4	8	c	100				2000				100	75	25	75			
Wilge River	230000	7667	32	14	c	5	68	680				68	68	5	4	1	4			
Olifants River	1000000	33333	45	25	f		9945					9945	9945	862	647	215	647	140	133	7
Kalbas River	220000	7333	66	8	e		3697	3876			8	3697	3705	2141	1606	535	1606			
Grootspruit	50000	1667	-	13	b			250	1377		250		250							
Olifants River	127000	4233	3	19	c			761		1016	11		11	11	9	2	9			
Steelpoort	50000	1667	108	15	g	7		201		850	1		1	8	6	2	6			
Olifants River	100000	3333	52	14	d		75	56				75	75	75	50	25	50			
Olifants River	420000	14000	46	100	f	2100		4800						1624	834	790	834	814	773	41
Waterberg	35000000	1166667	-	17	b	1205	10822	2192			1233	10822	12055	526	394	132	394			
Marzana River	25000	833	6	8	d		15	742			22	15	37							
Nkongolwana	45000	1500	100	1	c		3500	1300		6440		3500	3500	3500	2625	875	2625			
Witbank Dam	386666	12889	-	10	f			310		340										
Olifants River	646667	20556	70	30	a		5170	7870	565			5170	5170	1320	990	330	990	450	428	22
Olifants River	700000	23333	30	17	c	4360	725	3215			1815	725	2540	1130	848	282	848			
Olifants River	605000	20167	19	25	g	1679				225				1065	886	199	886	340	323	17
Wilge and Olifants	400000	13333	5	23	a		408	5136			4848	408	5256	48	36	12	36			
Wilge and Olifants	400000	13333	40	24	a	260	3820	3520	877			3820	3820	260	195	65	195	195	185	10
Bronkhorstspruit	128000	4267	-	19	f			528			24		24	24	18	6	18	18	17	1
Great Usutu River	60000	2000	-	15	a			30		25	16		16	16	12	4	12			
Olifants River	787500	26250	-	67	a		3000	2800				3000	3000	1860	1395	465	1395			
Olifants River	640000	21333	14	21	a		5103	127	664	2342		5103	5103	500	375	125	375			
Olifants River	126552	4218	98	5	g		502	40			2	502	504	360	270	90	270	270	257	13
Vaal River	850000	28333	16	24	c	7500	254	7754			6696	254	6950	7495	5621	1874	5621	5621	5340	281
Vaal River	1350000	45000	10	30	a	1544	623	1833		4935		623	623	1544	1158	386	1158	623	592	31
Klein Olifants	1200000	40000	26	16	a	680	3700	4440		2158		3700	3700	320	240	80	240			
Vaal River Barrage	380000	12667	41	19	c	1780		7000			5260		5260	1780	1335	445	1335	1335	1268	67
Vaal River	100000	3333	2	20	a	53		3503			3000		3000	30	23	7	23	23	22	1
Vaal River	170000	5667	30	20	i		333	566		3606	203	333	536	203	152	51	152	16	15	1
Steenkoolspruit	80000	2667	12	12	f	45		30		1000	10		10	45	34	11	34			
Grootpan	80000	2667	-	12	c	45	2592	432		1382		2592	2592	45	35	10	35	10	9	1
Blesbokspruit / Klein Komati	65000	2167	-	3	a			300		1060										
Hlelo River	50000	1667	-	6	c		200	770			50	200	250	50	38	13	38			
Olifants River	1050000	35000	6	67	f		4490	3860	2710	1200		4490	4490	1800	1350	450	1350	290	275	15
Boesmanspruit	125000	4167	6	5	f	50	1406					1406	1406	30	23	7	23			
Mohlo River	50000	1667	14	17	c		480	1416				480	480	480	360	120	360			
Olifants River	500000	16667	-	30	f		3428	2430				3428	3428	2189	1642	547	1642	400	380	20
Nkongolwana	25000	833	74	4	e		3500	1300		6540		3500	3500	3500	2625	875	2625			
Olifants River	160000	5333	16	7	f		240	3385			1	240	241	241	181	60	181			
					N	18	28	36	5	16	19	28	36	37	37	37	37	15	15	15
					MS/DAY	27340	69838	77455	6193	35119	23455	69838	93293	37582	27872	9710	27872	10545	10017	528
					L/S	316	808	896	72	406	271	808	1079	435	322	112	322	122	116	6
					L/TON	17	43	48	4	22	14	43	57	23	17	6	17	6	6	0

Stream '016	Stream '017	Stream '018	Stream '019	Stream '020	Stream '021	Stream '022	Stream '023	Stream '024	Stream '025	Stream '026	Stream '027	Stream '028	Stream '029	Stream '030	Stream '031	Stream '032	Stream '033	Stream '034	Stream '035	Stream '036	Stream '037	Stream '038	Stream '039	Stream '040
		384	50	334	547	308	17	272	308			170	162	8	1577		480		780	302			464	1576
		1713	800	913	1386	300	360	1526	25		275				3722		453	848	3685	500			500	4163
		150	100	50	1796	95	5	1796	95									75	1941	34			34	2036
	680	68	460	288	288	43	2	703	43			60	57	3	48	4					643	647	57	46
		123	123			117	6		117			48	46	2	9083			507	5296	3506	617	617	3685	5422
	3868	1190	440	4618	5018	904	440	4114	904						1564	1325	281		2306		1782	3107		3491
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	750	140	157	733	1272	543	884			218	325	30	28	2			9		587	45			291	598
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	56	35		91												50			26	30		80	30	26
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	720			720											37					757			757	
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	310		310		160	447	23		447			120	114	6						60			174	453
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	1400	2900	4300			245	13	4042	245						5770		848		5182	330	1400	1400	330	6275
		258		258								120	114	6	594		546			699			1136	569
	288		168	120		160	8		160			2976	2827	149	5208			36		2388			6215	309
877	3520		800	3597		760	40		760						3820				3917	3500			3685	4687
	504		256	248		243	13		243										248				17	492
	14			14								2	2				12			26	11	11	28	12
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464	127	1930	1474	1247	5031	2262	2672	1571	836	1426		476	452	24	4603		375			2326			4204	1235
	38			38											144					182			439	13
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	1833	1764	2700	897	1764	2565	135	1764	2565			1117	1061	66	623		535			3574			5227	3187
	4440		2333	2107	4130	2300	2943	1220	2300			1110	1055	55	4060	180	60			3384	921	1101	4439	2415
	1740		760	980	1	723	38		723						5260				5260	980			2248	6050
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	432	678	272	778	2320	2203	272	117	1425		778				2592		25			2709			2718	1451
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	720	200	120	800	500	300	18	302	200		100				200	38				300	402	440	300	200
2710	3860	3460	2100	7930	7930	572	30	9428			572	320	304	16	2690	670		390	500		10000	10670	579	531
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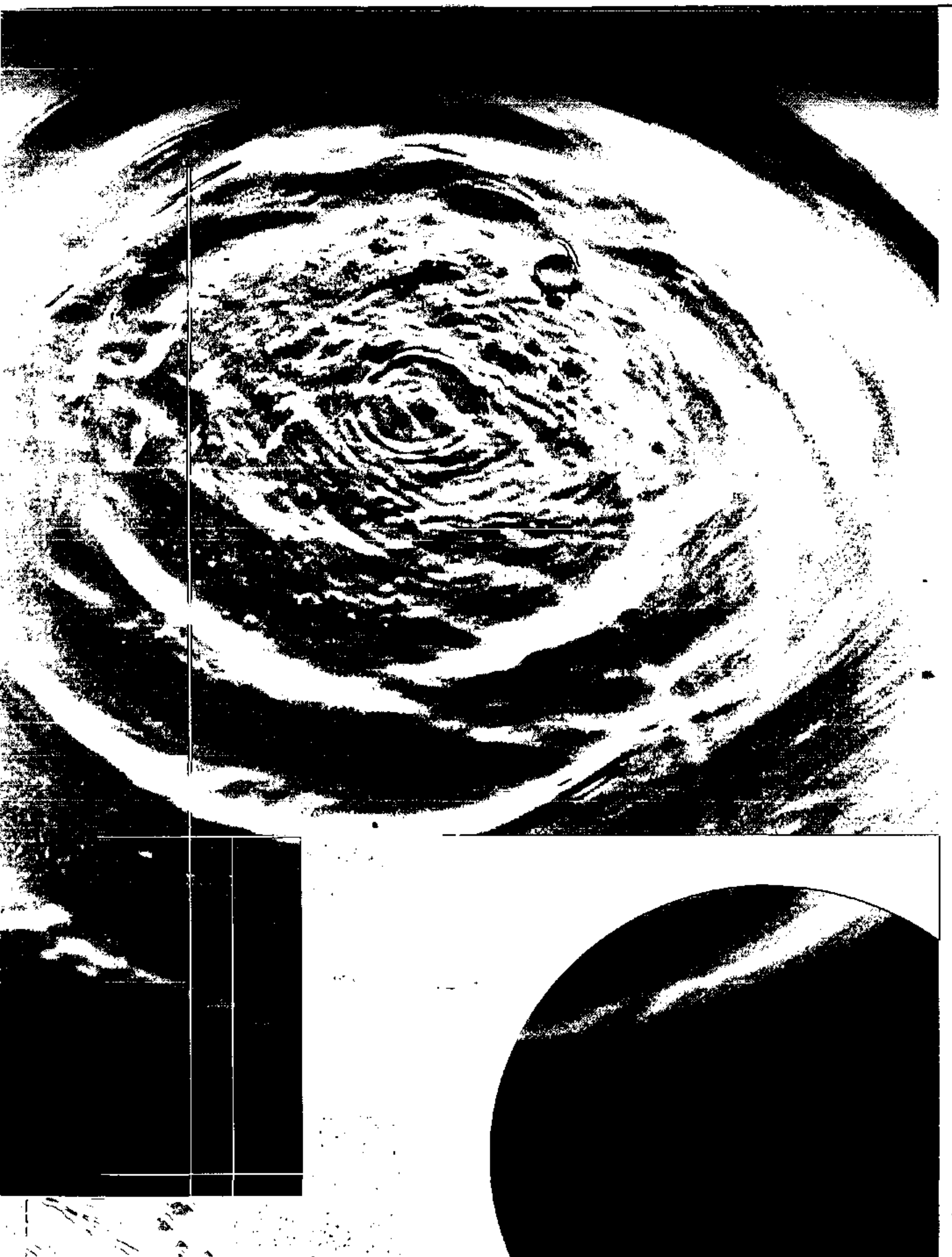

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