GHT CONSULTING SCIENTISTS

Komati Power Station

DRAFT HYDROCENSUS REPORT

FEBRUARY 2009

For

Eskom

KOMATI POWER STATION

By

GHT CONSULTING SCIENTISTS

PROJECT TEAM
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GHT CONSULTING SCIENTISTS

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25 February 2009 Our ref.: RVN 537.3/907

The Manager
Chemical Services
Komati Power Station
Private Bag
Blinkpan
2250

FOR ATTENTION: ***Me. Venessa Naidoo***

Dear Madam

It is our pleasure in enclosing two copies of the report RVN 537.3/907 "KOMATI POWER STATION – HYDROCENSUS REPORT - FEBRUARY 2009".

We trust that the report will fulfil the expectations of the Power Station and we will supply any additional information if required.

Yours sincerely,

Louis J van Niekerk (Pr.Sci.Nat.)

Copies: Electronic copy to Komati Power Station

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1 INTRODUCTION

1.1 General

Geo-Hydro Technologies (GHT) was commissioned to conduct a Hydrocensus on the area around Komati Power Station in order to establish the use of groundwater in the region.

1.2 Date and number of the monitoring events

This investigation reports on a Hydrocensus conducted between 2 December and 3 December over the area around Komati Power Station.

1.3 Approach to study

This report investigates the groundwater use as well as the general state of equipment installed at the sites. Sites were visited and the following data were recorded at each site: Refer to Table 1 for a summary of the data stipulated below.

- Site coordinates;
- A photograph of the site;
- Casing heights;
- Type of equipment;
- Pipe diameter;
- State of installed equipment (wording condition or not);
- Water usage (Agricultural or Domestic);
- Measuring of a static water level;
- Collecting a sample for chemical analyses;
- Farm detail;
- Farm owner and detail and;
- Farmer detail.

The collected data was entered into a Hydrobase Database with an assigned “Site ID” as well as a designated “Number on Map” for future reference.

2 SUMMARY OF THE HYDROCENSUS INFORMATION

2.1 Hydrocensus Sites

There are at least thirty seven boreholes that exist around Komati Power Station and nine boreholes in the Power Station (refer to Appendix A – Map 1). There are twenty one surface water sites that have been identified as part of the surface water monitoring system at Komati Power Station (refer to Appendix A – Map 2).

2.2 Equipment

The general condition of installed equipment that was encountered during the investigation was found to be good.

A variety of equipment is installed in various boreholes that were inspected (refer to Appendix A – Map 3). A total of five boreholes are equipped with windmill but none are in a working condition. Three sites were recorded having hand pumps installed. A few sites (four) have mono pumps installed with all four of these pumps in use and in working condition. Submersible pumps were found at sixteen sites with fourteen of the pumps in a working condition.

A total of six boreholes (were recorded without any equipment installed (refer to Appendix A – Map 4).

2.3 Monitoring boreholes

There are seven boreholes installed at the Ashing Area, one in the Coal Stockyard Area and one at the Power Station Area (Refer to Appendix A – Map 5). The groundwater monitoring network at Komati Power Station comprises of a total of nine boreholes installed around the Power Station Area, the Ashing area and the Coal Stockyard Area. The monitoring boreholes have no pizometers installed, but the boreholes are sampled at specific depths.

2.4 Groundwater use

Twenty four boreholes are in use with equipment in working condition. Nineteen of these boreholes are being used for domestic purposes only. A total of seven boreholes are being used for both agricultural and domestic purposes (refer to Appendix A – Map 6).

2.5 Static Water Levels

Limited access to boreholes because of installed equipment resulted in water levels that were measured at only nineteen boreholes during the hydrocensus (refer to Appendix A – Map 7). Two boreholes were dry. There is only one set of data available for the water levels of the monitoring boreholes at the Power Station. Groundwater contours with groundwater elevations in meters above mean sea level (mamsl) can be seen in (refer to Appendix A – Map 11).

2.6 Sampling sites

2.6.1 Groundwater

Groundwater samples were collected from thirty-six boreholes for analyses (refer to Appendix A – Map 8). Historical data exist for nine boreholes of Komati Power Station. Historical chemical analyses are available for the nine monitoring boreholes of Komati Power Station. Refer to Photo 1 to 46 for all the groundwater sites sampled.

Table 1. Groundwater sites – Hydrocensus information.

Site ID	Site Tipe	X	Y	WL	Elevation (mamsl)	Sample Depth	Borehole Depth	Casing Diameter (mm)	Casing Hight (m)	Pipe Diameter (mm)	Use (Agricultural, Domestic, Monitoring)	Status (G In Use, U Unused)	Equipment	Condition	Photo Nr.
AB01	Borehole	29.46623	26.10865	1.71	1648	15	35.5	170	0.34	~	M	G	None	No Equipment	1
AB02	Borehole	29.46762	26.09937	2.56	1625	6	32.5	170	0.81	~	M	G	None	No Equipment	2
AB03	Borehole	29.46824	26.09800	1.93	1620	19	7.5	170	0.34	~	M	G	None	No Equipment	3
AB04	Borehole	29.46748	26.09403	1.54	1616	8.5	38.0	170	0.28	~	M	G	None	No Equipment	4
AB05	Borehole	29.46447	26.09088	1.05	1600	20	8.5	170	0.37	~	M	G	None	No Equipment	5
AB06	Borehole	26.47720	26.09450	1.30	1620	~	~	~	~	~	~	~	None	No Equipment	6
AB07	Borehole	29.47692	26.09034	2.96	1612	15	37.0	170	0.28	~	M	G	None	No Equipment	7
CB08	Borehole	29.47383	26.08835	3.62	1606	13	35.5	170	0.20	~	M	G	None	No Equipment	8
PB09	Borehole	29.47118	26.08552	1.59	1600	31	36.5	170	0.95	~	M	G	None	No Equipment	9
BB10	Borehole	29.42091	26.04868	~	1624	~	~	~	~	30	D	G	Submersible	Good working condition	10
BB11	Borehole	29.45898	26.06239	~	1627	Pumped	~	170	0.04	~	D	G	Hand pump	Good working condition	11
BB12	Borehole	29.46227	26.06161	~	1626	Tap	~	170	0.03	40	D	G	Submersible	Broken	12
BB13	Borehole	29.48487	26.05461	16.20	1646	Tap	27.2	120	0.03	40	D	G	Submersible	Good working condition	13
BB14	Borehole	29.48488	26.05460	11.80	1644	Tap	~	~	~	60	D	G	Submersible	Good working condition	14
BB15	Borehole	29.49044	26.05852	~	1631	Dam	~	170	0.04	50	D	G	Submersible	Good working condition	15
BB16	Borehole	29.50683	26.07076	~	1645	Pumped	~	170	0.04	~	D	G	Hand pump	Good working condition	16
BB17	Borehole	29.49821	26.07593	24.00	1647	Tap	66.0	~	Ground level	60	D	G	Prospect hole	Good working condition	17
BB18	Borehole	29.49866	26.07736	Dry	1650	~	85.0	~	~	~	~	U	None	Dry hole	18
BB19	Borehole	29.49865	26.07737	~	1649	Pumped	~	170	0.01	~	D	G	Hand pump	Good working condition	19
BB20	Borehole	29.48213	26.08393	14.10	1633	Tap	26.1	170	0.01	50	D	G	Submersible	Good working condition	20
BB21	Borehole	29.45835	26.37589	2.20	1674	15	26.8	150	0.02	~	~	U	None	No Equipment	21
BB22	Borehole	29.47907	26.10586	~	1646	Tap	~	~	~	50	D	G	Submersible	Good working condition	22
BB23	Borehole	29.47905	26.10632	4.50	1647	~	11.0	170	0.02	40	D	U	Submersible	Broken	23
BB24	Borehole	29.47125	26.11574	15.00	1702	Tap	~	150	0.03	50	D	G	Submersible	Good working condition	24
BB25	Borehole	29.47127	26.11574	20.50	1662	Krip/Dam	26.5	180	0.03	50	AD	G	Submersible	Good working condition	25
BB26	Borehole	29.46985	26.46188	Dry	1679	~	6.1	100	~	~	~	U	None	Dry hole	26
BB27	Borehole	29.47912	26.11710	32.00	1661	Tap	42.0	150	0.04	50	AD	G	Submersible	Good working condition	27
BB28	Borehole	29.50721	26.11221	~	1661	Tap	~	200	0.04	50	D	G	Mono pump	Good working condition	28
BB29	Borehole	29.49529	26.12859	13.00	1631	Tap	~	170	0.05	50	AD	G	Submersible	Good working condition	29
BB30	Borehole	29.50947	26.13509	8.50	1617	16	40.0	170	0.04	~	~	U	None	No Equipment	30
BB31	Borehole	29.50961	26.13511	~	1624	Tap	~	~	~	~	D	G	Mono pump	Good working condition	31
BB32	Borehole	29.53378	26.14317	5.00	1660	12	~	150	0.04	~	~	U	None	No Equipment	32
BB33	Borehole	29.53378	26.14317	2.00	1656	6	8.0	160	0.05	~	~	U	None	No Equipment	33
BB34	Borehole	29.53470	26.14244	~	1656	Dam	~	~	~	~	AD	G	Mono pump	Good working condition	34
BB35	Borehole	29.49518	26.15330	3.00	1603	Tap	15.0	150	0.02	50	AD	G	Submersible	Works only in dry season	35
BB36	Borehole	29.49503	26.16079	18.00	1628	Dam	32.0	150	0.02	50	AD	G	Submersible	Good working condition	36
BB37	Borehole	29.51189	26.17976	3.50	1614	Tap	12.0	150	0.02	50	D	G	Submersible	Good working condition	37
BB38	Borehole	29.48366	26.17902	~	1631	~	~	150	0.03	50	~	U	Windmill	Not in use for a long time	38
BB39	Borehole	29.48336	26.17877	~	1626	Dam	~	~	~	~	D	G	Mono pump	Good working condition	39
BB40	Borehole	29.48339	26.17864	3.00	1634	Tap	9.0	150	0.03	40	D	G	Submersible	Good working condition	40
BB41	Borehole	29.47363	26.16277	~	1583	~	~	150	0.03	40	~	U	Windmill	Not in use for a long time	41
BB42	Borehole	29.47537	26.16495	~	1591	~	~	150	Ground level	40	~	U	Windmill	Not in use for a long time	42
BB43	Borehole	29.42195	26.12209	8.00	1621	Dam	15.0	150	0.05	40	D	G	Submersible	Good working condition	43
BB44	Borehole	29.42193	26.12198	5.00	1642	5.10	5.5	160	0.01	30	AD	G	Submersible	Good working condition	44
BB45	Borehole	29.41625	26.11591	~	1612	~	~	~	~	~	~	U	Windmill	Not in use for a long time	45
BB46	Borehole	29.42719	26.11853	~	1627	~	~	~	~	~	~	U	Windmill	Not in use for a long time	46


Photo 1. *AB01*


Photo 2. *AB02*


Photo 3. *AB03*


Photo 4. *AB04*


Photo 5. *AB05*


Photo 6. *AB06*


Photo 7. *AB07*


Photo 8. *CB08*

Photo 9. PB09

Photo 10. BB10

Photo 11. BB11

Photo 12. BB12

Photo 13. BB13

Photo 14. BB14

Photo 15. BB15


Photo 16. BB16


Photo 17. BB17


Photo 18. BB18


Photo 19. BB19


Photo 20. BB20


Photo 21. BB21


Photo 22. BB22


Photo 23. BB23


Photo 24. BB24


Photo 25. BB25


Photo 26. BB26


Photo 27. BB27


Photo 28. BB28


Photo 29. BB29


Photo 30. BB30


Photo 31. BB31


Photo 32. BB32


Photo 33. BB33


Photo 34. BB34


Photo 35. BB35


Photo 36. BB36


Photo 37. BB37


Photo 38. BB38


Photo 39. BB39

Photo 40. *BB40*

Photo 41. *BB41*

Photo 42. *BB42*

Photo 43. *BB43*

Photo 44. *BB44*

Photo 45. *BB45*

Photo 46. *BB46*

2.6.2 Surface water

There are twenty surface water sites that form part of the surface water monitoring network of Komati Power Station (refer to Appendix A – Map 9). Fourteen of these sites are canals or pans being actively monitored as part of surface monitoring sites, whereas six sites are being actively monitored as part of the river water monitoring network. Three sites were dry during the time of monitoring. Historical analyses are available for most of these sites. Refer to Photo 47 to 68 for the surface water sites.

Table 2. Surface water sites – Hydrocensus information.

Site ID	Site Tipe	X	Y	Sampled	WL	Photo Nr.
AC01	Canal	29.46700	-26.10879	No	Dry	47
AC02	Canal	29.47275	-26.09593	Yes	Low	48
AC03	Canal	29.47941	-26.09947	Yes	Low	49
AC04	Canal	29.48020	-26.09685	No	Low	50
AC05	Canal	29.47773	-26.09571	Yes	Low	51
PC06	Canal	29.47688	-26.09036	No	Dry	52
PC07	Canal	29.47073	-26.08812	No	Dry	53
PC08	Canal	29.46644	-26.09138	Yes	Low	54
AP02	Pan	29.46850	-26.09545	Yes	Mod Full	55
AP03	Pan	29.47757	-26.09300	Yes	Very High	56
PP04	Pan	29.48138	-26.09848	No	Mod Full	57
PP05	Pan	29.47373	-26.08900	No	Low	58
PP06	Pan	29.46883	-26.08691	Yes	High	59
PE01	Pan	29.46624	-26.08742	Yes	Mod Full	60
KR01	River	29.46539	-26.09248	Yes	Low	61
KR02	River	29.46345	-26.08958	Yes	Low	62
GR03	River	29.48235	-26.09474	Yes	Low	63
GR04	River	29.47134	-26.08493	Yes	Low	64
BR05	River	29.44499	26.08252	Yes	Low	65-66
BR06	River	29.48671	26.07354	Yes	Low	67-68

Photo 47. AC01.

Photo 48. AC02.

Photo 49. AC03.

Photo 50. AC04.

Photo 51. AC05.

Photo 52. PC06.

Photo 53. PC07.

Photo 54. PC08.

Photo 55. AP02.

Photo 56. AP03.

Photo 57. PP04.

Photo 58. PP05.

Photo 59. PP06.

Photo 60. PE01.

Photo 61. KR01.

Photo 62. KR02.

Photo 63. GR03.

Photo 64. GR04.

Photo 65. BR05.

Photo 66. BR05.

Photo 67. BR06.

Photo 68. BR06.

2.7 Groundwater and Surface water quality

Data Tables

Inorganic chemical analyses have been performed on water samples obtained during the Hydrocensus at Komati Power Station. The results of the chemical analyses of the current monitoring phase are given in table format in this section.

Water Quality Tables

In these tables the water samples from each monitoring site are colour-coded according to the "South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, First Edition 1993" and the "South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, Second Edition 1996", as well as according to the publication "Quality of Domestic Water Supplies, DWA&F, Second Edition 1998". A description of the various classes is given in Table 3 while the health and aesthetic effects associated with the use of water from the different classes are described in Table 4.

Table 3. Classification system used to evaluate water quality classes.

Quality of Domestic Water Supplies, DWA&F, Second Edition 1998

Class 0	- **Ideal water quality** - Suitable for lifetime use.
Class 1	- **Good water quality** - Suitable for use, rare instances of negative effects.
Class 2	- **Marginal water quality** - Conditionally acceptable. Negative effects may occur in some sensitive groups
Class 3	- **Poor water quality** - Unsuitable for use without treatment. Chronic effects may occur.
Class 4	- **Dangerous water quality** - Totally unsuitable for use. Acute effects may occur.

South Africa Water Quality Guidelines, Volume 1: Domestic Use, DWA&F, First Edition 1993 & Second Edition 1996

NR	- **Target water quality range** - No risk.
IR	- **Good water quality** - Insignificant risk. Suitable for use, rare instances of negative effects.
LR	- **Marginal water quality** - Allowable low risk. Negative effects may occur in some sensitive groups
HR	- **Poor water quality** - Unsuitable for use without treatment. Chronic effects may occur.

Table 4. Health and aesthetic effects associated with the water quality classes.

CLASS	DESCRIPTION	EFFECTS
CLASS 0	**Ideal water quality**	**Drinking Health:** No effects, suitable for many generations. **Drinking Aesthetic:** Water is pleasing. **Food preparation:** No effects. **Bathing:** No effects. **Laundry:** No effects.
CLASS 1	**Good water quality**	**Drinking Health:** Suitable for lifetime use. Rare instances of sub-clinical effects. **Drinking Aesthetic:** Some aesthetic effects may be apparent. **Food Preparation:** Suitable for lifetime use **Bathing:** Minor effects on bathing or on bath fixtures. **Laundry:** Minor effects on laundry or on fixtures.
CLASS 2	**Marginal water quality**	**Drinking Health:** May be used without health effects by the majority of individuals of all ages, but may cause effects in some individuals in sensitive groups. Some effects possible after lifetime use. **Drinking Aesthetic:** Poor taste and appearance are noticeable. **Food preparation:** May be used without health or aesthetic effects by the majority of individuals. **Bathing:** Slight effects on bathing or on bath fixtures. **Laundry:** Slight effects on laundry or on fixtures.
CLASS 3	**Poor water quality**	**Drinking Health:** Poses a risk of chronic health effects, especially in babies, children and the elderly. **Drinking Aesthetic:** Bad taste and appearance may lead to rejection of the water. **Food preparation:** Poses a risk of chronic health effects, especially in children and the elderly. **Bathing:** Significant effects on bathing or on bath fixtures. **Laundry:** Significant effects on laundry or on fixtures.
CLASS 4	**Unacceptable water quality**	**Drinking Health:** Severe acute health effects, even with short-term use. **Drinking Aesthetic:** Taste and appearance will lead to rejection of the water. **Food preparation:** Severe acute health effects, even with short-term use. **Bathing:** Serious effects on bathing or on bath fixtures. **Laundry:** Serious effects on laundry or on fixtures.

2.7.1 Groundwater Quality

Contour maps of the EC values, SO_4 concentrations and the pH can be seen in Appendix A – Map 12, 13 and 14. It should be note that these contours were interpolated from chemical analyses of fairly sparse distribution of boreholes over the area under investigation.

Table 5. Water quality – Groundwater sites.

No.	Date	pH	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO_4 mg/L	T.Alk mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	PO_4 mg/L	B mg/L
AB01	20081203	7.1	348	362	242	236	30.5	299	1188	684	0.00	0.00	0.00	0	0.00
AB02	20081203	7.1	251	90	281	211	44.9	45	1545	294	0.00	0.00	0.00	0	0.00
AB03	20081203	6.6	74	43	42	25	7.3	41	203	121	0.19	0.00	0.00	0	0.01
AB05	20081202	7.2	257	374	121	76	7.2	234	879	327	0.00	0.00	2.35	0	0.00
AB07	20081203	6.9	227	145	178	178	10.3	59	1308	158	0.00	0.00	0.00	0	0.00
CB08	20081203	6.7	107	122	43	27	3.6	68	261	226	0.87	0.00	0.00	0	0.00
PB09	20081203	7.5	69	28	64	20	3.5	15	132	212	0.90	0.00	0.47	0	0.00
BB10	20090219	7.8	52	19	33	12	4.7	21	8	210	0.40	0.00	3.84	0	0.07
BB11	20090219	7.4	75	63	29	18	7.6	91	86	177	0.42	0.00	0.00	0	0.06
BB12	20090219	7.9	70	34	61	19	3.8	32	61	282	0.56	0.00	0.00	0	0.05
BB13	20090219	7.7	51	22	37	12	3.3	20	10	249	0.58	0.00	0.00	0	0.07
BB14	20090219	7.8	109	31	84	56	3.7	114	103	310	0.00	0.00	41.67	0	0.05
BB15	20090219	7.7	98	35	77	48	2.7	62	92	366	0.00	0.00	37.48	0	0.05
BB16	20090219	7.3	67	23	53	17	2.8	82	14	149	0.00	0.94	70.68	0	0.05
BB17	20090219	7.8	51	15	42	16	3.7	16	7	257	0.37	0.00	0.69	0	0.07
BB19	20090219	7.4	31	13	14	8	2.5	12	1	116	0.20	0.00	34.67	0	0.05
BB20	20090219	7.9	53	17	35	14	5.0	15	9	194	0.00	0.00	1.39	0	0.06
BB21	20090219	7.4	35	10	19	10	3.4	10	5	144	0.22	0.00	31.14	0	0.05
BB22	20090219	7.8	48	17	31	14	4.2	13	32	177	0.24	0.00	8.29	0	0.06
BB24	20090219	7.6	59	16	40	16	15.4	26	7	271	0.53	0.00	14.94	0	0.08
BB25	20090219	7.4	54	35	21	10	12.2	44	8	240	0.35	0.00	0.83	0	0.09
BB27	20090219	7.2	43	13	22	9	9.7	14	2	163	0.35	0.18	0.59	2	0.07
BB28	20090219	7.6	43	10	23	12	4.2	14	1	133	0.22	0.00	68.23	0	0.05
BB29	20090219	7.6	42	14	24	13	3.2	16	11	144	0.25	0.00	0.16	0	0.06
BB30	20090219	7.4	80	55	42	23	3.5	112	11	249	0.55	0.00	0.51	0	0.09
BB31	20090219	7.9	55	26	36	17	3.2	28	19	238	0.27	0.00	0.00	0	0.07
BB32	20090219	6.5	57	19	23	20	8.2	44	70	135	0.00	0.00	87.89	0	0.05
BB33	20090219	6.7	56	19	23	19	10.0	38	94	103	0.00	0.00	49.70	0	0.05
BB34	20090219	7.3	34	17	16	6	4.0	9	8	142	0.30	0.00	10.23	0	0.06
BB35	20090219	7.5	87	28	63	23	7.2	134	19	131	0.00	0.00	161.82	0	0.06
BB36	20090219	7.5	80	28	52	21	7.2	129	20	116	0.00	3.06	119.18	0	0.06
BB37	20090219	7.9	50	14	41	10	2.2	10	20	177	0.70	0.00	1.32	0	0.06
BB39	20090219	8.4	32	9	17	11	2.3	11	6	175	0.21	0.00	0.00	0	0.06
BB40	20090219	7.4	35	8	18	10	3.3	13	4	116	0.25	0.00	61.48	0	0.06
BB43	20090219	6.8	12	6	3	2	3.5	5	4	51	0.18	0.00	0.00	2	0.07
BB44	20090219	6.4	18	9	6	2	4.1	20	1	86	0.14	0.00	0.00	0	0.07

The Ashing Area

- AB01 (monitoring borehole at domestic waste site), AB02 (monitoring borehole east of new ash dams) and AB07 (monitoring borehole below seepage recovery dam) is classified as dangerous due to the concentrations of Mg and SO_4 and is classed as Class 4 water quality totally unsuitable for human use. Acute effects may occur.
- AB05 (monitoring borehole at dam) can be classified as poor due to the concentrations of SO_4.
- AB03 (monitoring borehole east of old ash dams), AC03 (dirty water canal on eastern side of ash dam), AC05 (north of ash dam where road crosses over pipelines) and AP03 (seepage recovery dam previously labelled D26) can be classified as good water quality.

Power Station and Coal Stockyard Area

The groundwater from the Power Station and Coal Stockyard area are classified as ideal to good. It can be summarised as follows:

- CB08 (monitoring borehole below station north of Coal Stockyard.), PB09 (monitoring borehole at Lake Fin) and PC08 (first bridge south of Power Station where road crosses Komati Spruit) can be classified as good water quality.

<u>Hydrocensus groundwater sites (Background boreholes)</u>

The groundwater around the Power Station Area is classified as ideal to dangerous. It can be summarised as follows:

- Boreholes BB24 and BB34 are classified as marginal due to the concentrations of NO_3 and are classed as Class 2 water quality unsuitable for use without treatment. Acute effects may occur in babies.
- Boreholes BB15, BB19 and BB21 are classified as poor due to the concentrations of NO_3 and are classed as Class 3 water quality unsuitable for use without treatment. Acute effects may occur in babies.
- Boreholes BB14, BB16, BB28, BB32, BB33, BB35, BB36 and BB40 are classified as dangerous due to the concentrations of NO_3 and are classed as Class 4 water quality totally unsuitable for human use. Acute effects may occur in babies.

The high concentrations of NO_3 in the groundwater might be attributed to agricultural activity in the area.

2.7.2 Surface water Quality

Table 6. Water quality - Surface water sites

No.	Date	pH	EC mS/m	Na mg/L	Ca mg/L	Mg mg/L	K mg/L	Cl mg/L	SO_4 mg/L	T.Alk mg/L	F mg/L	NO_2-N mg/L	NO_3-N mg/L	PO_4 mg/L	B mg/L
AC02	20081203	3.1	233	143	306	35	25.1	66	1318	0	0.79	0.00	0.00	0	0.59
AC03	20081203	6.8	83	73	38	14	11.9	51	148	203	0.48	0.00	0.00	0	0.14
AC04	20081203	7.4	137	87	133	48	10.8	42	478	285	0.79	0.00	0.00	0	0.09
AC05	20081203	7.3	107	99	78	12	16.4	49	387	121	0.40	0.00	2.68	0	0.26
PC08	20081202	7.0	92	25	89	39	3.4	29	263	205	0.44	0.00	0.00	0	0.03
AP02	20081203	7.3	131	112	104	27	15.5	50	523	215	0.87	0.00	1.34	0	0.24
AP03	20081203	7.1	114	100	86	17	16.6	52	392	142	0.62	0.00	0.00	0	0.00
PP06	20081203	7.5	66	56	32	13	5.9	21	171	142	0.50	0.00	3.80	0	0.14
PE01	20081202	6.6	61	37	21	9	7.4	47	63	147	0.19	30.35	0.77	2	0.15
KR03	20081203	7.2	151	133	122	40	23.2	55	646	224	0.86	0.00	0.00	0	0.42
KR04	20081203	7.5	79	51	50	18	9.3	30	244	135	0.48	0.00	0.00	0	0.21
GR03	20081203	7.5	40	15	22	12	2.8	13	40	147	0.31	0.00	0.00	0	0.11
GR04	20081203	7.1	118	50	118	46	5.0	18	240	481	0.00	0.00	0.00	0	0.16
BR06	20090219	7.4	54	25	23	19	3.8	37	41	166	0.47	0.00	20.80	0	0.08
BR07	20090219	7.4	86	58	53	25	6.1	31	274	173	0.60	0.00	3.54	2	0.14

<u>The Ashing Area</u>

The surface waters from the sites of the Ashing Area can be classified as good to poor water quality due to high concentrations of mainly Mg and Ca. It can be summarised as follows:

- AC02 (north-western side of ash dam) is classified as dangerous due to the concentrations of Ca and SO_4 and is classed as Class 4 water quality totally unsuitable for human use. Acute effects may occur.
- AP02 (clean water dam where Komati Spruit originates west of ash dam) and AC04 (north-eastern corner of ash dam where road crosses over pipelines) can be classifies as marginal due to the concentrations SO_4.

Power Station and Coal Stockyard Area

The waters from the Power Station and Coal Stockyard area are classified as ideal to good. It can be summarised as follows:

- PP06 (station drain holding dam at north-western corner of Power Station) can be classified as water with an ideal quality.

Sewage Plant Area

- PE01 (sewage PSE outlet) at the sewage plant can be classified as poor due to the concentrations of NO_2.

Komati Spruit Area

- KR01 (second bridge south of Power Station where road crosses Komati Spruit) can be classified as poor due to the concentrations of SO_4.

Geluk Spruit Area

- The waters from the Geluk Spruit can be classified as ideal to good.

Hydrocensus surface water sites (Background rivers)

- Site BR06 can be classified as poor due to the concentration of NO_3 and are classed as Class 3 water quality unsuitable for use without treatment. Acute effects may occur in babies.

The high concentrations of NO3 in the surface water might be attributed to agricultural activity in the area.

3 GEOPHYSICAL INVESTIGATIONS

The geophysical survey was conducted at the western, southern and eastern boundary of the Ash Dam. The purpose of the geophysical investigations was to detect and delineate geological features that may be associated with preferential pathways for groundwater migration and contaminant transport. Intrusive magmatic bodies are often associated with baked zones that are usually highly fractured and weathered. Such zones could form preferential pathways along which rapid groundwater flow and contaminant transport can take place. The magnetic method was used during the geophysical survey since this method is often very successful in detecting intrusive magmatic bodies such as dolerite/diabase sills or dykes.

Magnetic data were recorded on 9 traverses. The location of the traverses is as follow:

- Three traverses were recorded west of the site.
- One traverse was recorded south of the site and
- Five traverses east of the site, (Refer to the locality maps in Appendix A – Map 15**).**

The lengths of the traverses ranged from a few metres to 720 m and the total length of all the traverses was approximately 3.5 km. Data on the traverses were recorded using station spacing of 10 metres, depending on the variability of the data and the detail required. The magnetic profiles are presented in Appendix C and Appendix C2**.**

3.1 Geophysical Survey West of the Ash Dam

Data were recorded on three traverses on the western boundary of the Ash Dam. All three of the traverses have an approximate south/north strike (Traverses 1, 2 and 3).

The anomalies recorded on Traverse 1 and 2 generally had low amplitudes (40 nT) and were observed at only single stations. Most of these anomalies might be due to the presence of metal objects such as poles, pipes and fences. No magnetic anomalies of any significance were recorded on these two traverses.

An anomaly was recorded on Traverse 3 indicating the possible presence of a dolerite sill with a dip in a northwest southeast direction.

3.2 Geophysical Survey South of the Ash Dam

Data was recorded on one traverses south of the Ash Dam with an approximate west/east strike (Traverses 4). No magnetic anomalies of any significance were recorded on traverse 4.

3.3 Geophysical Survey East of the Ash Dam

Data were recorded on five traverses east of the Ash Dam. Four traverses with an approximate southwest/northeast strike (Traverse 5, 6, 7 and 8) and one with a southeast/northwest strike (Traverse 9).

Anomalies were recorded on two of the traverses namely, Traverses 5 and 9. These anomalies are due to the presence of power lines. No magnetic anomalies of any significance were recorded on the other traverses on the eastern side of the Ash Dam.

4 HYDRAULIC TESTING OF BOREHOLES

4.1 Factors Controlling Water in Rocks

Permeability of the Aquifer

Permeability is the intrinsic capacity of a rock to transmit fluids. Materials that do not allow water to pass through them are classified as impermeable. Sands and gravel, which have large pore spaces, are highly permeable; clays, on the other hand, are practically impermeable because pore spaces are extremely small and the water contained in them is virtually stationary.

During the execution of permeability tests, also known as “slug tests”, a certain volume of water is either added, or removed from, the column water inside the borehole. The rate at which the recovery towards the original rest water level takes place after the addition/removal, is measured. A displacement in the order of 10 cm – 50 cm is considered to be sufficient to enable the investigator to obtain useful results from the exercise. The transmissivity (T) and/or hydraulic conductivity (K) are determined from these measurements. It must, however, be kept in mind that the values obtained from the slug test represent only the aquifer properties in the immediate vicinity around the borehole, since disturbances in the equilibrium conditions are only experienced over small distances from the borehole.

Hydraulic Conductivity (K)

Hydraulic conductivity is defined as the volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured at a right angle to the direction of flow. Hydraulic conductivity has units of Length/Time.

Transmissivity (KD or T)

Transmissivity is the product of the average hydraulic conductivity (K) and the saturated thickness of the aquifer (D). Consequently, transmissivity is the rate of flow under a unit hydraulic gradient through a cross-section of unit width over the whole saturated thickness of the aquifer. Transmissivity has the units of $Length^2$/Time.

Storativity (S)

The storativity of a saturated confined aquifer of thickness (D) is the volume of water released from storage per unit surface area of the aquifer per unit decline in the component of hydraulic head normal to that surface. In a vertical column of unit area extending through the confined aquifer, the storativity S equals the volume of water released from the aquifer when the piezometric surface drops over a unit distance. As storativity involves a volume of water per volume of aquifer, it is a dimensionless quantity.

4.2 Results of the permeability Tests

The Bouwer-Rice method was used to analyses the permeability tests performed on eight of the Power Station boreholes (refer to Appendix A – Map 1). The results of the tests are presented in Figure 1 to Figure 8 and Table 7.

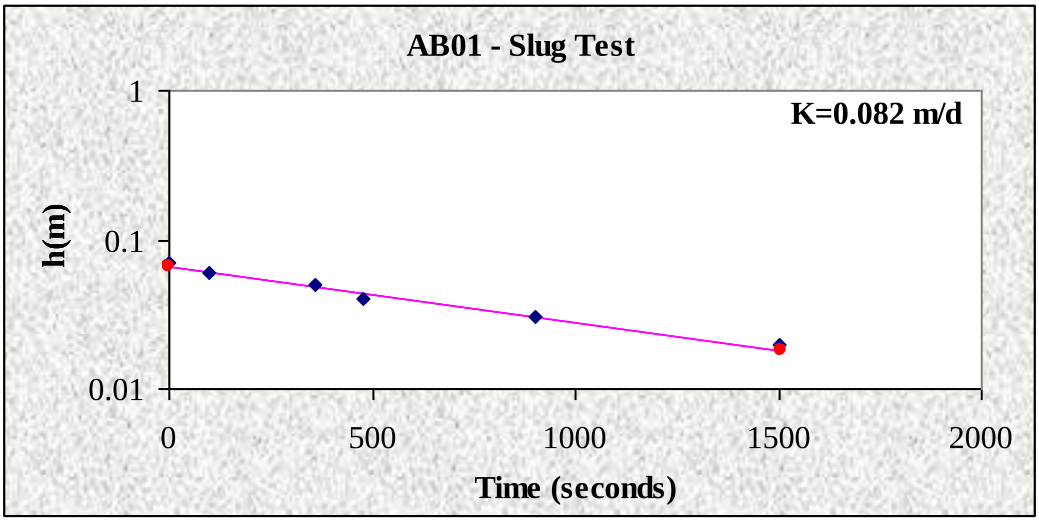

Figure 1. Results of the permeability test performed on AB01.

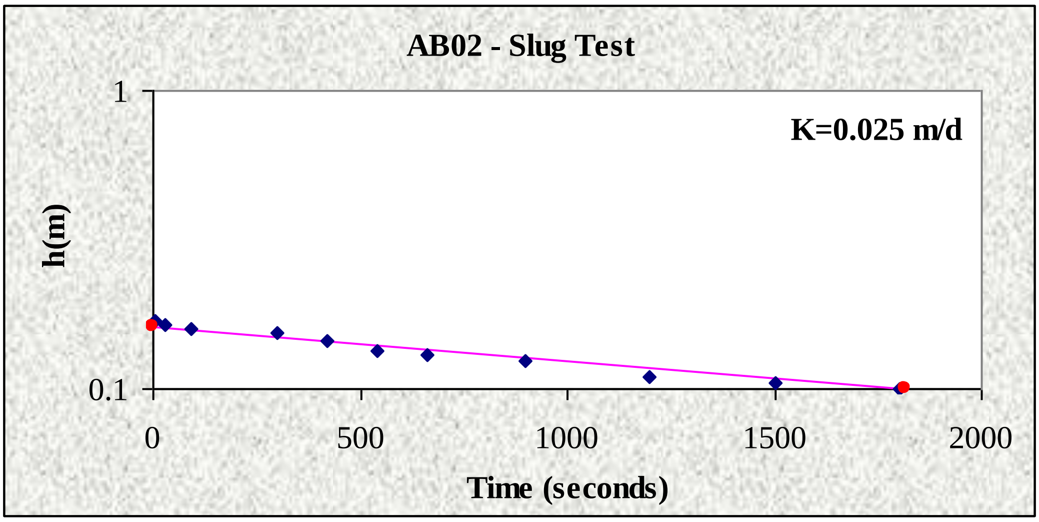

Figure 2. Results of the permeability test performed on AB02.

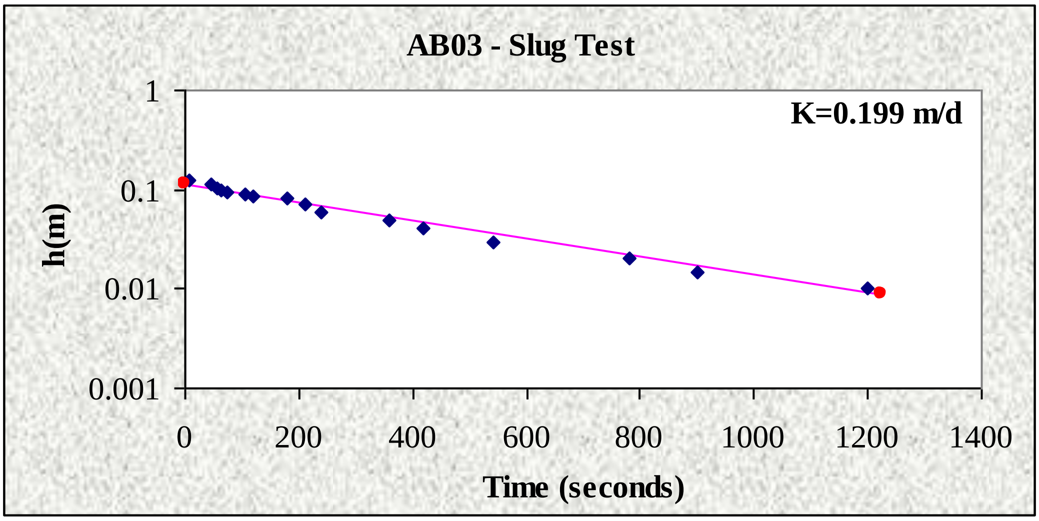

Figure 3. Results of the permeability test performed on AB03

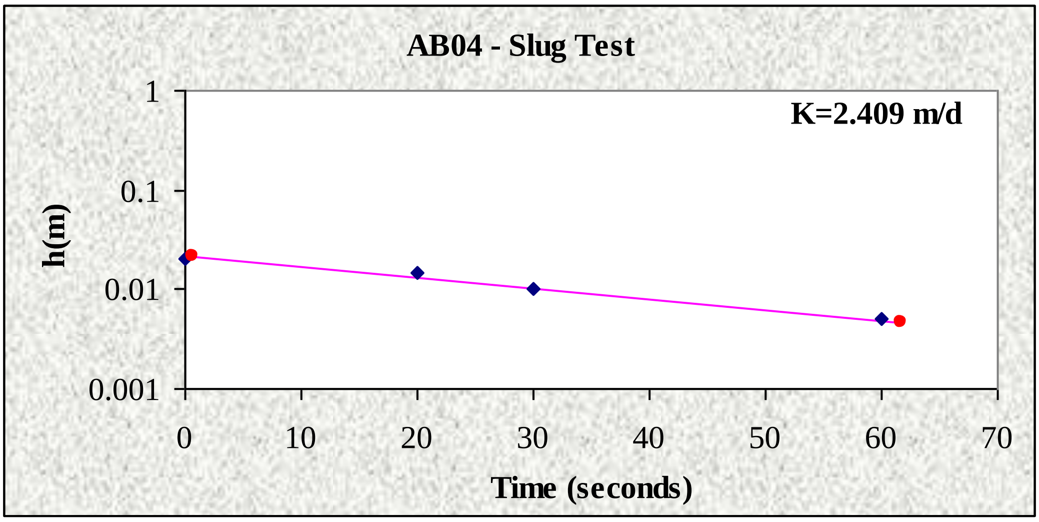

Figure 4. Results of the permeability test performed on AB04.

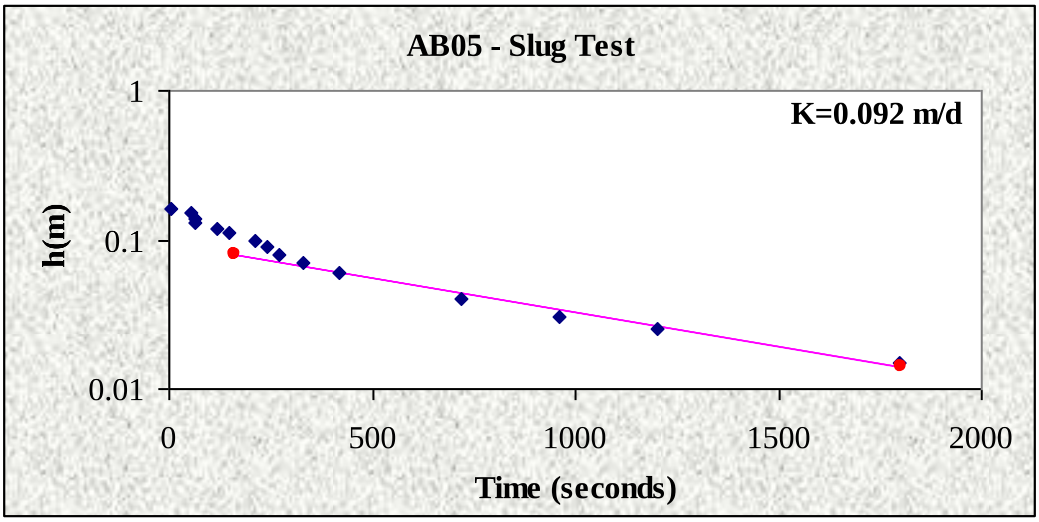

Figure 5. Results of the permeability test performed on AB05.

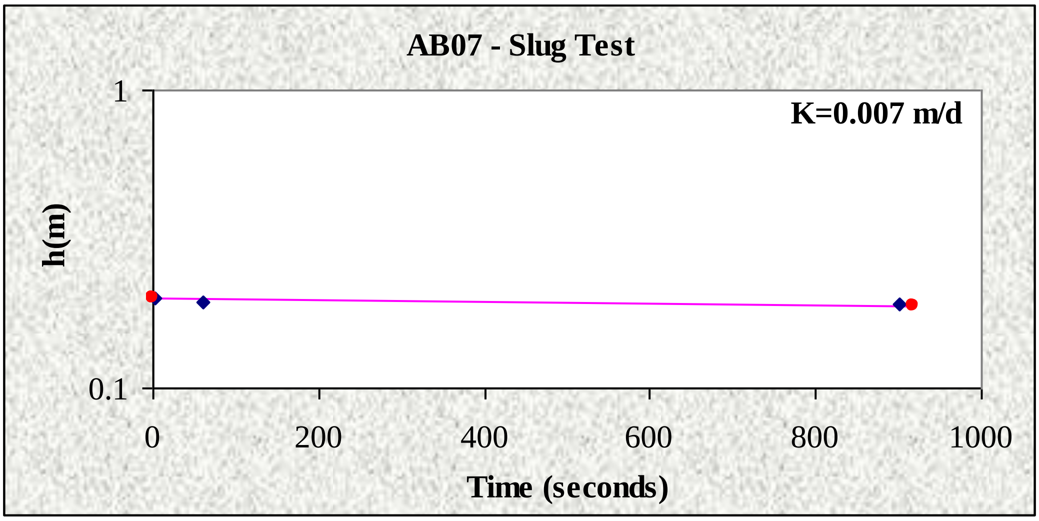

Figure 6. Results of the permeability test performed on AB07.

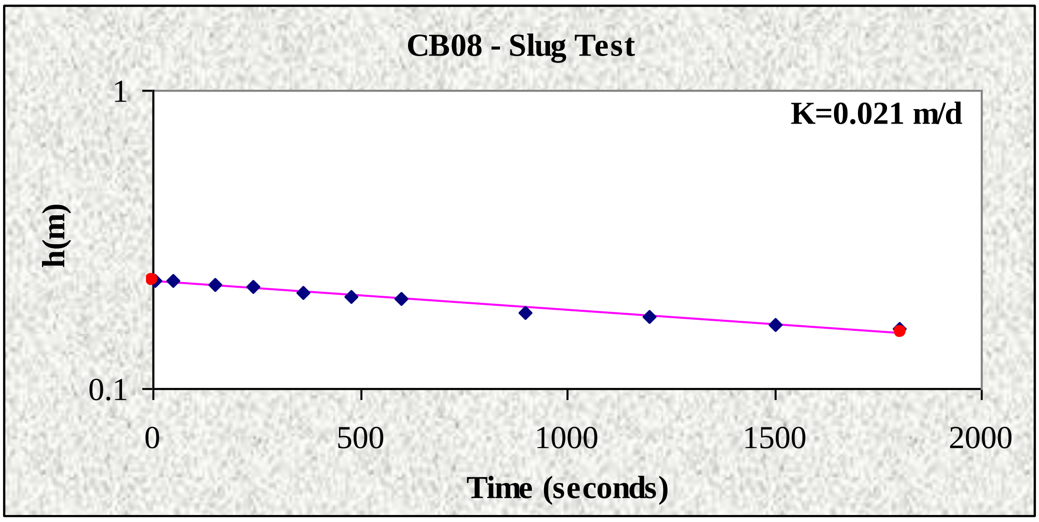

Figure 7. Results of the permeability test performed on CB08.

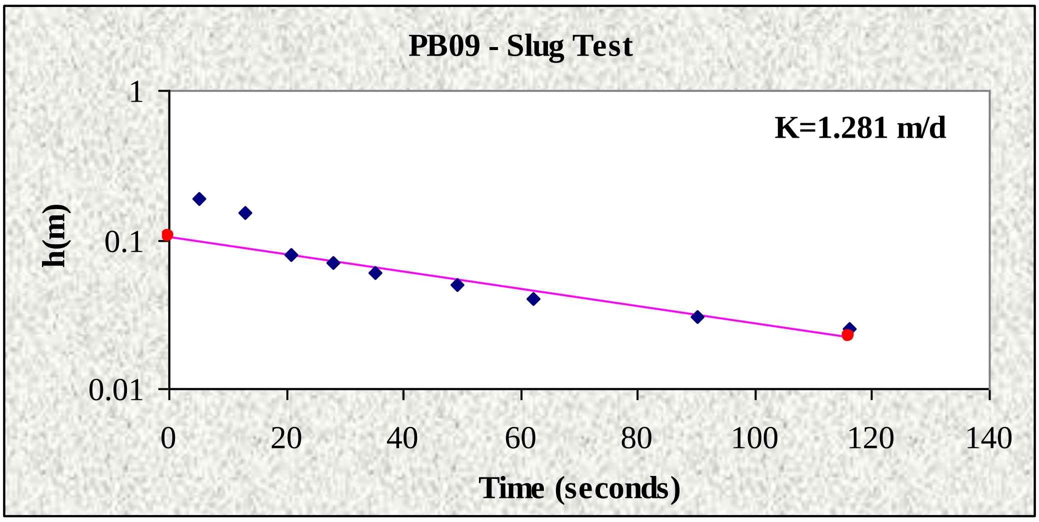

Figure 8. Results of the permeability test performed on PB09.

These observations suggest that the rocks on and in the vicinity of Komati Power Station generally have low permeabilities and hydraulic conductivities. The presence of preferential pathways, such as fractured zones, might be present in the region and may cause marked increases in the hydraulic conductivities. Migration of groundwater and/or contaminants can be expected to be high along such pathways. Permeability tests were not performed during this investigation on boreholes located on the neighbouring farms due to the presence of equipment in the boreholes.

The results of the permeability tests are implemented in the calculation of the flow velocities of the groundwater (which acts as the carrier of pollution [if any] in the geohydrological environment). The calculations are performed as follows:

$$v_s = \frac{K}{n}\frac{\Delta h}{\Delta l}$$

where v_s is Darcy's flow velocity, K is the hydraulic conductivity, $\Delta h/\Delta l$ is the hydraulic gradient, and n is the porosity, assumed to be 30% (0.3). The hydraulic gradient is assumed to equal the local topographic gradient of 0.03 (1:40). The results of the calculations are presented in Table 7.

Table 7. Darcy's flow velocities for the two newly drilled boreholes

No.	Hydraulic Conductivity *K* (m/d)	n Porosity	Hydraulic Gradient	Flow Velocity (m/y)
AB01	0.082	0.3	0.03	2.4942
AB02	0.025	0.3	0.03	0.7604
AB03	0.199	0.3	0.03	6.0529
AB04	2.409	0.3	0.03	73.2738
AB05	0.092	0.3	0.03	2.7983
AB07	0.007	0.3	0.03	0.2129
CB08	0.021	0.3	0.03	0.6388
PB09	1.281	0.3	0.03	38.9638
Average				**1.6273**

The flow velocities listed in Table 7 suggest that fluid/contaminant migration in the rock formations at Komati Power Station will be slow, except for AB04 which has a mush higher flow velocity. However, it must be remembered that the results obtained from permeability tests only represent the characteristics of the aquifer in the immediate vicinity of the boreholes tested. In the presence of preferential pathways these flow velocities may be much higher. The velocity will also be much lower as hydraulic gradient become less in the flat areas.

5 IMPACT OF CONTAMINATION

5.1 Introduction

The Water Act (1998) is based on a number of principles one of which is that the quantity, quality and reliability of water required maintaining the ecological functions on which humans depend shall be reserved so that the human use of water does not individually or cumulatively compromise the long-term sustainability of aquatic and associated ecosystems. In this instance, drinking water guidelines (South African Domestic Water Supplies, 2001) and aquatic ecosystem guidelines (DWAF, 1996) were used as a basis to determine the potential impacts of a given contaminant on water quality.

Domestic water supplies are categorised according to classes (refer to Table 4), and it is with these classes that groundwater quality in the vicinity of the Komati Power Station has been compared (refer Table 8 and Table 9). Although most of the boreholes exceed the target water quality range documented in the aquatic ecosystem guidelines, it is difficult to quantify the associated impacts.

5.2 Risk Assessment

A risk can be defined broadly as the probability that an adverse event will occur in specified circumstances. Effective decision-making involves the management of risks, that is, the identification, evaluation, selection and implementation of actions to reduce risk. Risk assessment is a technique that provides such information to the manager, thereby facilitating the complex and integrated decisions required.

A health risk assessment is the process or method of determining if an activity (man-made or natural) will negatively impact human health. Once a contaminant is released into the groundwater, its resultant concentrations found in the human body is dependent upon the physical and chemical properties of both the contaminant and the groundwater. In addition, the concentrations found in a human are subject to the person’s exposure to groundwater. Exposure is defined by the frequency, magnitude and duration of contact with the contaminant i.e.

- Frequency - whether a person is exposed daily or just occasionally;
- Magnitude - the amount of exposure. For example, occupational exposure will be greater than community exposure;
- Duration - Whether a given exposure episode lasts for minutes, hours, days or years.

Once the contaminant is inside the body it may be further transformed via metabolism or detoxification, the ability to transform chemicals varying with the individual. For example, children, the elderly and those with chronic conditions, react differently to the same dose compared to average, healthy middle-aged adults. The impact of contaminants for the various scenarios must therefore be characterized in a health risk assessment. Unfortunately, however, there is insufficient data to allow a detailed health risk assessment to be performed, and thus a rapid, low to medium confidence was conducted in this instance.

Table 8. Summary of analyses for parameters included in water quality guidelines.

Parameters included in water quality guidelines

Parameter	Class 4 sites	Information
pH		Alkali Burns. Tastes extremely soapy and burns eyes.
EC		Increasing risk of dehydration. Tastes extremely salty and bitter. Corrosive
Sodium		Definite health risk especially to babies placing strain on kidneys and the heart. Tastes extremely salty.
Calcium		Chronic health effects in sensitive groups only, with forming of kidney stones.
Magnesium		Tastes very bitter. Leads to Diarrhoea in all individuals.
Chloride		Dehydration in infants and leads to nausea and vomiting.
Sulphates	AB01, AB02, AB07	High chance of diarrhoea. Very bitter and salty taste. Extremely corrosive.
Fluoride		Increasing health risk and staining of teeth. Hardening of bones may occur which then becomes brittle and breaks under mild stress. Diarrhoea, nausea and vomiting.
Nitrate	BB14, BB16, BB28, BB32, BB33, BB35, BB36, BB40	Increasing acute health risk to babies.
Iron		Risk of iron poisoning, particularly in sensitive groups. Repulsive taste and appearance. Severe staining of clothes
Manganese		Increasing health risk to all individuals. Repulsive taste and appearance. Staining

Table 9. Summary of analyses for parameters not included in water quality guidelines.

Parameters not included in water quality guidelines

Parameter	Class 4 sites	Information
Phosphates		
Boron		
Aluminium		Low-level exposure to aluminium from food, air, water, or contact with skin is not thought to harm your health. Aluminium, however, is not a necessary substance for our bodies and too much may be harmful. People who are exposed to high levels of aluminium in air may have respiratory problems including coughing and asthma from breathing dust. Aluminium has been linked to Alzheimer's disease because those patients have high levels of aluminium in their brains. We do not know whether aluminium causes the disease or whether the build-up of aluminium happens to people who already have the disease. Infants and adults who received large doses of aluminium as a treatment for another problem developed bone diseases, which suggest that aluminium may cause skeletal problems.
Lead		Lead can affect almost every organ and system in your body. The most sensitive is the central nervous system, particularly in children. Lead also damages kidneys and the immune system. The effects are the same whether it is breathed or swallowed. Exposure to lead is more dangerous for young and unborn children. Unborn children can be exposed to lead through their mothers. Harmful effects include premature births, smaller babies, and decreased mental ability in the infant, learning difficulties, and reduced growth in young children. These effects are more common after exposure to high levels of lead. In adults, lead may decrease reaction time, cause weakness in fingers, wrists, or ankles, and possibly affect the memory. Lead may cause anaemia, a disorder of the blood. It can cause abortion and damage the male reproductive system. Anticipated to be carcinogenic.

5.3 Discussion

As the large majority of the borehole sites were only sampled once, it should be stressed that the alarming concentrations of some elements from these sites may not be indicative of the overall risk.

It should also be remembered, however, that this assessment is based on low confidence calculations based on a few data sets.

5.3.1 Groundwater sites

The sulphate concentration of AB01, AB02 and AB07 poses a very high risk in sensitive groups and a high risk for the average healthy population. The sulphate concentration of AB05 poses a high risk to sensitive groups and a medium risk for the average healthy population.

The very high risk of nitrate concentrations in BB14, BB15, BB16, BB19, BB21, BB28, BB32, BB33, BB35, BB36 and BB40 that raises reasons for concern might be linked to agricultural activities in the region.

Refer to Appendix A, for the EC, PH and SO4 concentrations in the area under investigation.

5.3.2 Surface water sites

The high sulphate and calcium concentrations and very low pH measured at site AC02 poses a very high risk in sensitive groups and a high risk for the average healthy population.

Site KR03 is dominated by high sulphate concentrations with high risks. This is a clear indication of a river being polluted by runoff water.

Site BR03 is dominated by high nitrate concentrations with high risks. This is a clear indication of a river being polluted by runoff water.

25 February 2009

L.J. van Niekerk (Pr. Sci. Nat.) ***Date***