

Update on Broke Groundwater Monitoring Program – AGL Hunter Gas Project

Presentation to BCCC – 30 September 2009

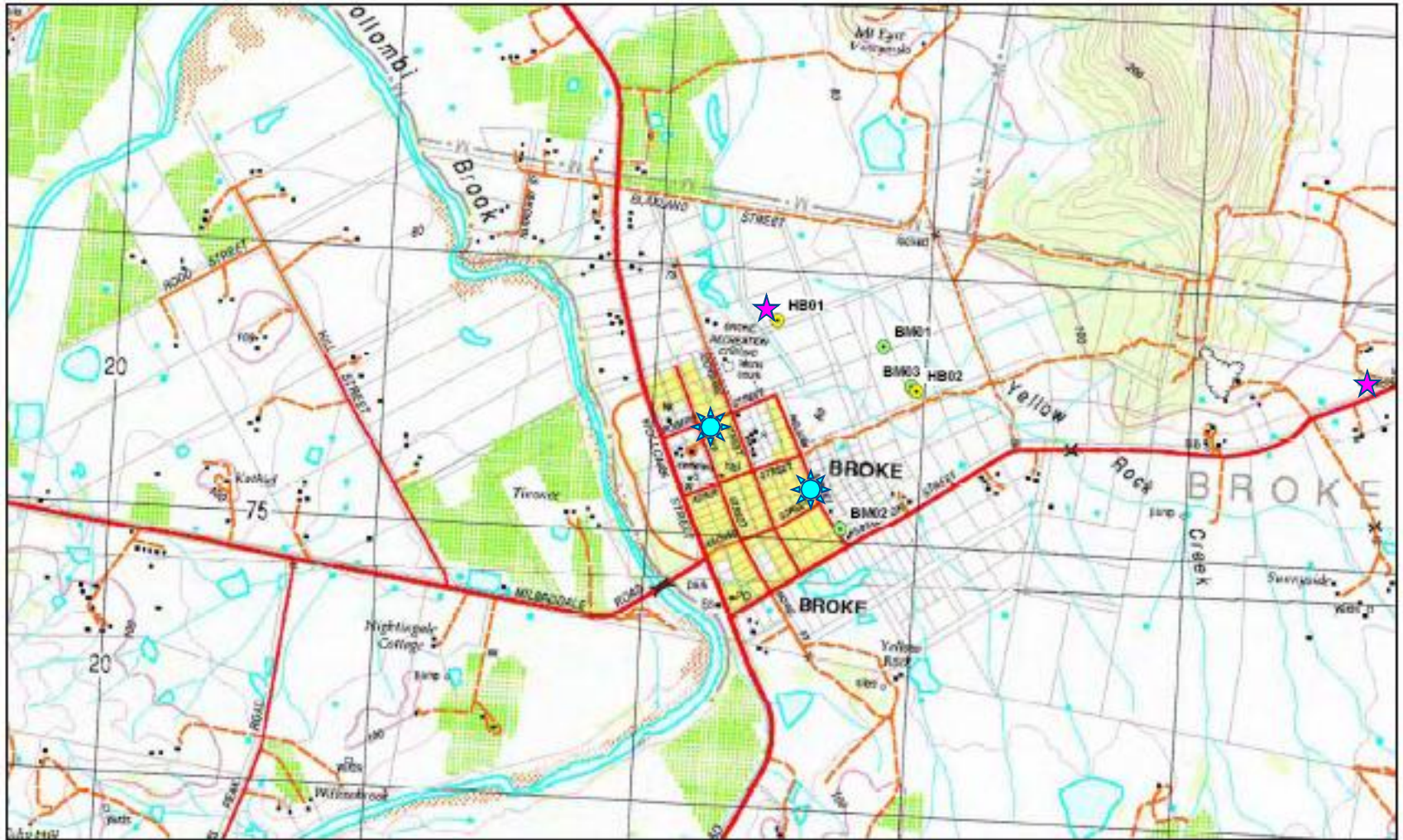
Groundwater Program Objectives

- Provide more information on groundwater in the Broke area by determining whether the underlying aquifers are connected (or not) at various depths
- Help the community understand what impacts, if any, there might be on the local water supplies and groundwater as a result of gas exploration

Scope and Work Program

1. Installation of monitoring bores (alluvium and deeper rock aquifers) and report
2. Baseline groundwater sampling ('wet', intermediate, 'dry' **then pumping test and recovery events**)
 - Field parameters
 - Major anions/cations
 - Nutrients, heavy metals
 - Hydrocarbon gases
 - Environmental and radio-isotopes, tritium
3. Datalogger installation and operation
4. **Pumping test of HB02**
5. **Final reporting**

Site Locality Plan



- Borehole
- Sydney Gas&GLL exploration borehole
- Groundwater monitoring location
- ★ Xstrata piezometer
- ★ Private bore/well



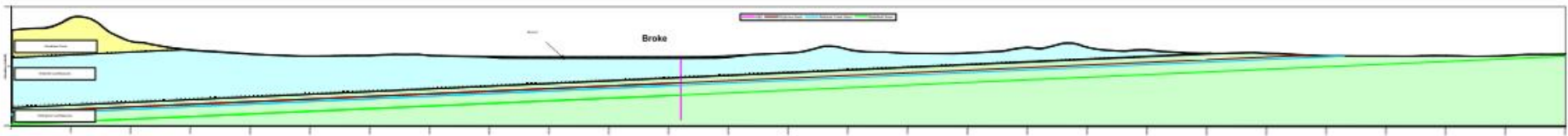
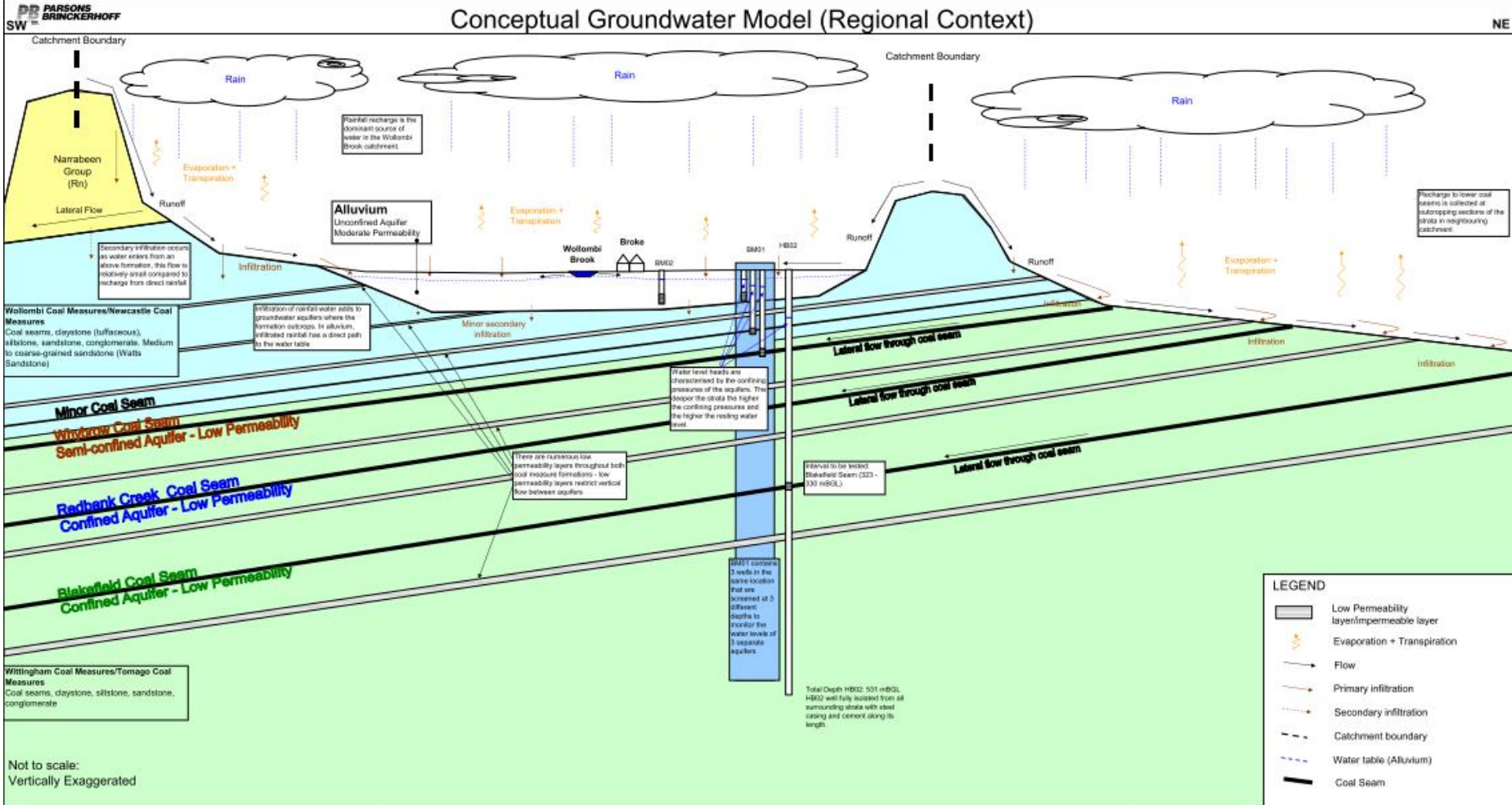
Monitoring Bore Construction Details

- Selected construction details for AGL monitoring bores

Local Bore Number	Bore Depth (m)	Screened Interval (m)	Aquifer Monitored	Initial Water Level (mTOC)	Conductivity $\mu\text{s/cm}$
BM01s	6.6	1.5-6	Shallow alluvium	2.47	3470
BM01a	10	6-10	Deep alluvium	2.5	3940
BM01b	68	56-68	Shale and sandstone	3.55	7560
BM01c	220	160-220	Whybrow Coal Seam	4.95	7160
BM02s	7.5	1.5-6	Shallow alluvium	3.26	2110
BM02a	13	7-13	Deep alluvium	3.58	5770
BM03s	5	1.5-5	Shallow alluvium	2.82	1810
BM03a	10	4.5-10	Intermediate and deep alluvium	3.15	1600
BM03b	96 (backfilled to 74)	68-74	Shale and minor sandstone	4.94	3550

Conceptual Model

Conceptual Groundwater Model (Regional Context)

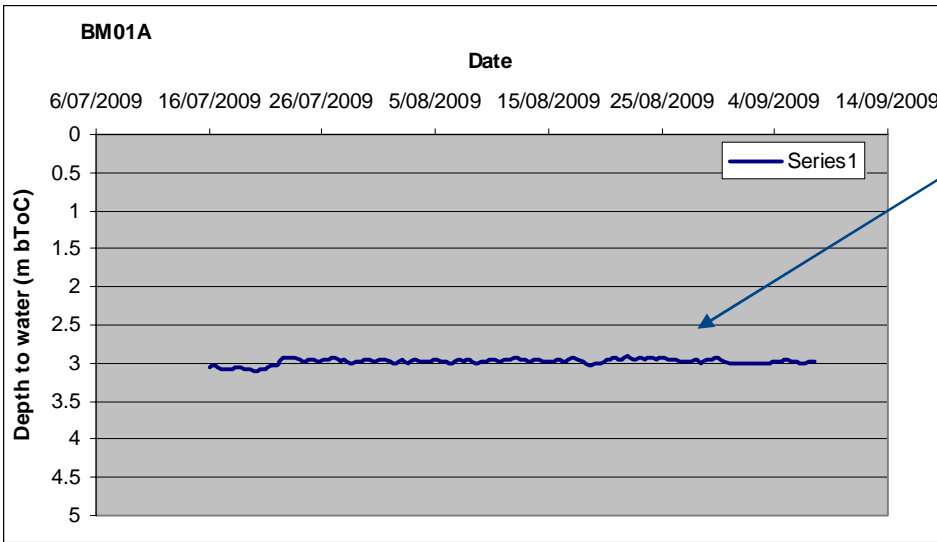


No Vertical Exaggeration

Water Level Monitoring Program

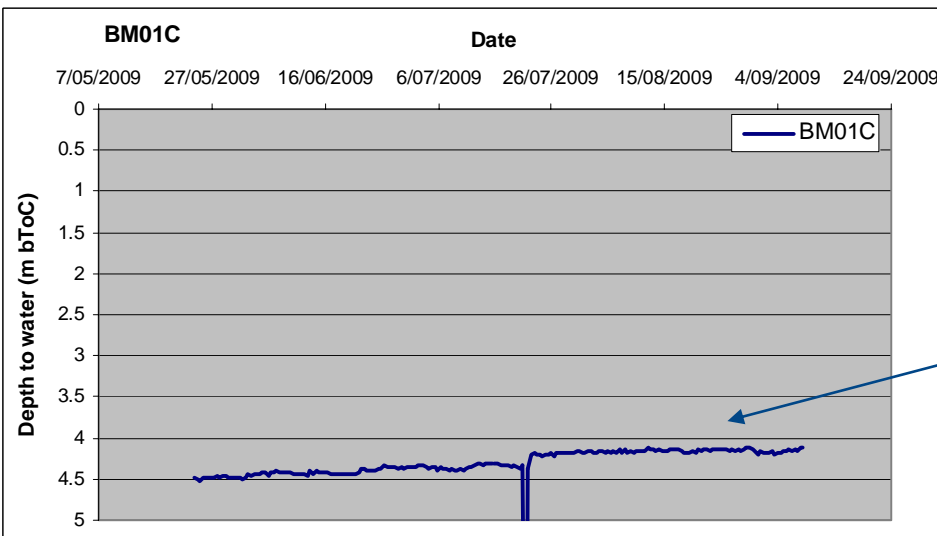
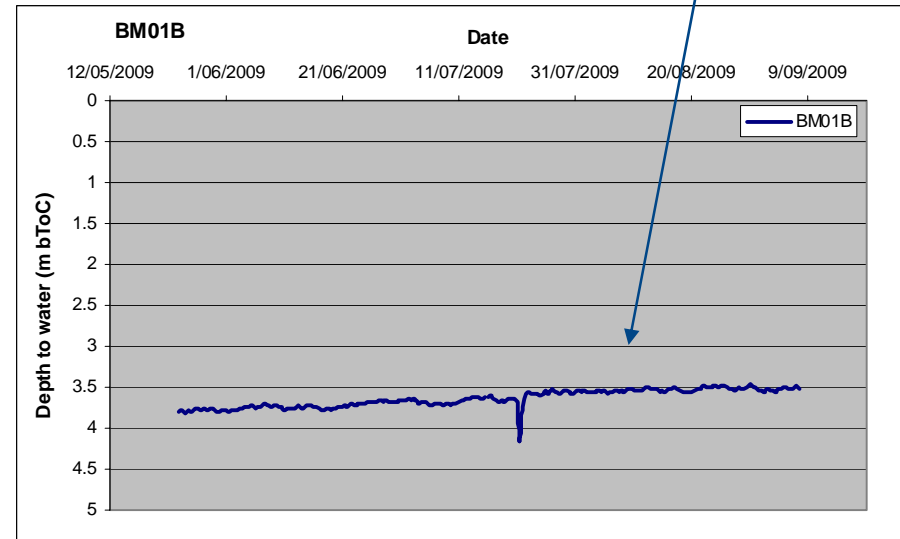
- Objectives
 - Determine the natural variability in aquifer water levels given different seasonal conditions and local stock, domestic and agricultural uses (baseline)
 - Determine the variability in aquifer water levels and possible connectivity of aquifers (if any) under gas well extraction conditions (the pumping test and recovery period)
 - Primary (impact assessment) method

Water Levels – typical traces



Alluvial WL trace from mid July
Slotted interval 6-10m

Shale/sandstone WL trace from
mid May
Slotted interval 56-68m



Coal seam WL trace
from mid May
Slotted interval
160-220m

Water Quality Monitoring Program

- Objectives

- Determine the natural variability in aquifer water chemistry given different seasonal conditions and local stock, domestic and agricultural uses (baseline)
- Determine the variability in aquifer water chemistry and possible connectivity of aquifers (if any) under gas well extraction conditions (the pumping test and recovery period)
- Secondary (impact assessment) method

Water Quality - chemical suite

Chemical suites	Individual Analytes	Reason for sampling
Field parameters	EC, pH, Eh and temperature	General water quality
Major ions	Calcium, magnesium, sodium, potassium, chloride, sulphate, dissolved silica	General water quality
Sulphide	Sulphide	General water quality
Nutrients	Nitrate, nitrite, Reactive phosphorus Ammonia, Total phosphorus Total Organic Carbon	General water quality
Metals	<i>Dissolved metals</i> – Al, As, Ba, Br, Co, Cu, Fe, Li, Mn, Ni, Pb, Sr, Zn	General water quality
Hydrocarbons	TPH/BTEX	General water quality
Hydrocarbon Gases	Methane	Methane present in aquifer
Stable Isotopes	Oxygen-18 and Deuterium	Water source and amount of mixing occurring between aquifers
Radiocarbon	Carbon 13 and Carbon 14	Age of aquifer water (50yrs – 50000yrs)
Tritium	Tritium	Time since water was last at the surface (up to 50yrs)

Key EC – Electrical Conductivity (a measure of salinity);
 Eh – Oxidation – reduction potential (a measure of chemical species to be oxidised or reduced)
 Al – aluminium, As – arsenic, Ba – barium, Br – bromine, Co – cobalt, Cu – copper, Fe – iron, Li – lithium, Ni – nickel, Pb – lead, Sr – strontium, Zn - zinc

Completed Field Work Programs (as at 28 September 2009)

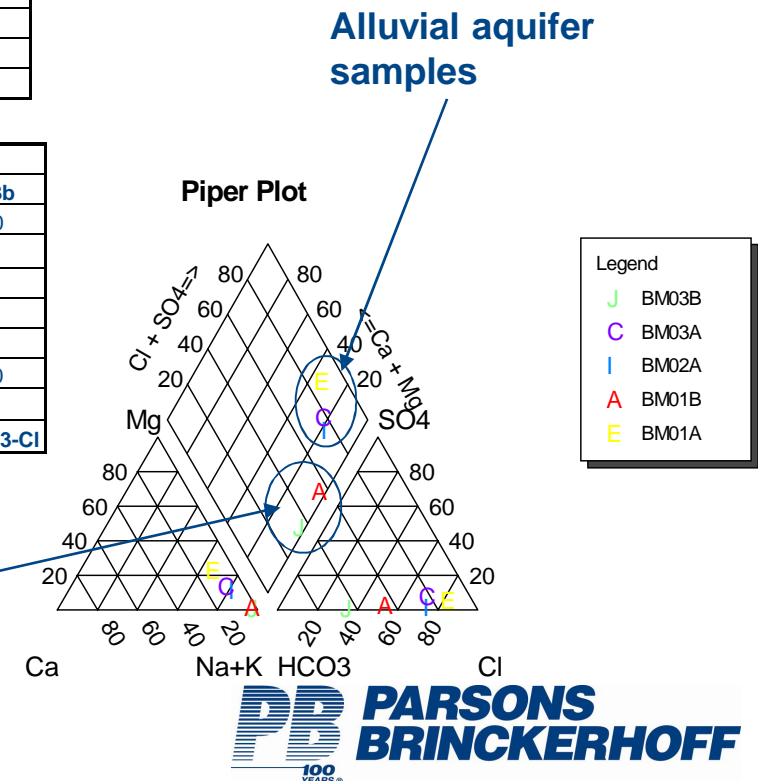
Local Bore Number	Water Quality Sampling Events			Datalogger Installation Date	Falling Head Test Date
	"Wet" event 20-24 May 09	Intermediate event 21-23 July 09	"Dry" event 7-10 Sep 09		
BM01s	-	Yes	Yes	21 July	21 July
BM01a	Yes	Yes	Yes	15 July	15 July
BM01b	Yes	Yes	Yes	23 May	tbc
BM01c	No	Yes	Yes	23 May	tbc
BM02s	-	Yes	Yes	22 July	22 July
BM02a	Yes	Yes	Yes	15 July	15 July
BM03s	-	Yes	Yes	21 July	21 July
BM03a	Yes	Yes	Yes	15 July	15 July
BM03b	Yes	Yes	Yes	23 May	tbc
HB02	No	No	Yes	15 Sep	Pumping Test
Xstrata 7B		NS	-	22 July	-
Xstrata P8		NS	-	22 July	-
Private – M Newman		Yes	Yes	NR	
AGL – Oakley Lane		Yes	Yes	NR	
Private – K Taggart		Yes	Yes	NR	

Important Water Quality Results – Field parameters and major anions/cations

- May “wet” sampling event

Field WQ Parameters	Units	BM01a	BM01b	BM02a	BM03a	BM03b
Water Level	m	2.65	3.55	3.49	2.48	2.02
Temperature	oC	19.69	19.47	19.4	19.39	16.22
Conductivity	μS/cm	3950	7570	5450	1670	5040
Dissolved Oxygen	mg/L	1.66	0.52	3.63	1.75	1.7
pH		6.17	7.76	7.09	6.78	7.97

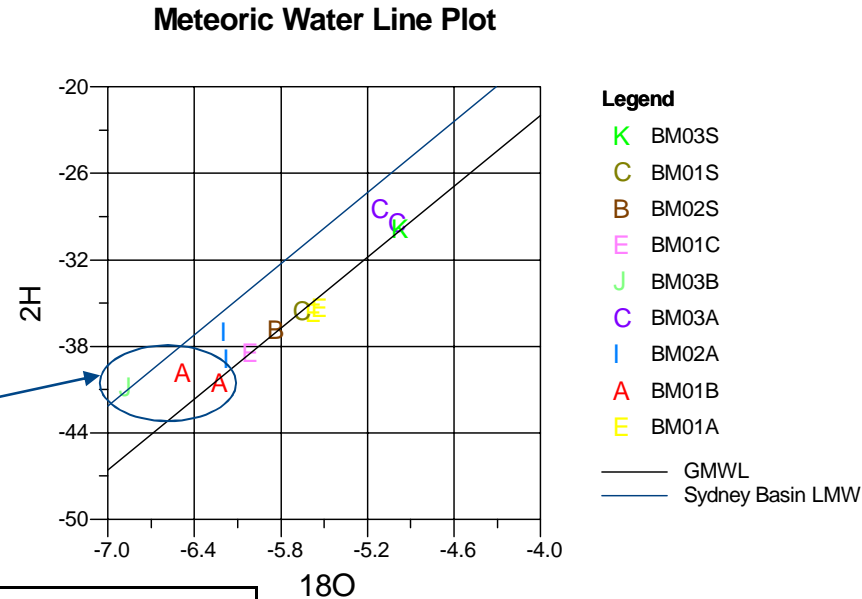
Analyte	Units	May 2009				
		BM01a	BM01b	BM02a	BM03a	BM03b
Total Alkalinity as CaCO ₃	mg/L	201	1250	534	151	1930
Sulfate as SO ₄ 2-	mg/L	93	62	38	50	25
Chloride	mg/L	1070	1080	1330	360	755
Calcium	mg/L	70	11	38	24	8
Magnesium	mg/L	98	9	63	23	6
Sodium	mg/L	548	1150	904	248	1320
Potassium	mg/L	4	5	15	5	6
Water Type		Na-Mg-Cl	Na-Cl-HCO ₃	Na-Cl-HCO ₃	Na-Cl-HCO ₃	Na-HCO ₃ -Cl



Important Water Quality Results – Dissolved gases and isotopes

- May “wet” sampling event – Gases and Isotopes

More depleted signature for rock aquifer water samples



Analyte	Units	May 2009				
		BM01A	BM01B	BM02A	BM03A	BM03B
Aquifer Type		Deep alluvium	Shale & SS	Deep alluvium	Deep alluvium	Shale & SS
Dissolved Gases						
Methane	µg/L	<10	6740	635	25	8930
Isotopes						
Oxygen-18	‰	-5.56	-6.47	-6.15	-5.11	-6.86
Deuterium	‰	-35.7	-39.9	-37.1	-28.5	-40.9
Carbon-13	‰	-12.1	-4.4	-15	-11.7	-0.4
Radiocarbon	pMC	81.88±0.2	10.41±0.09	31.06±0.14	93.81±0.22	5.23±0.07
Radiocarbon Age (uncorrected)	yrs BP	1549±20	18116±70	9336±35	456±20	23640±110
Tritium	TU	1.0	0	0.3	1.5	0.1

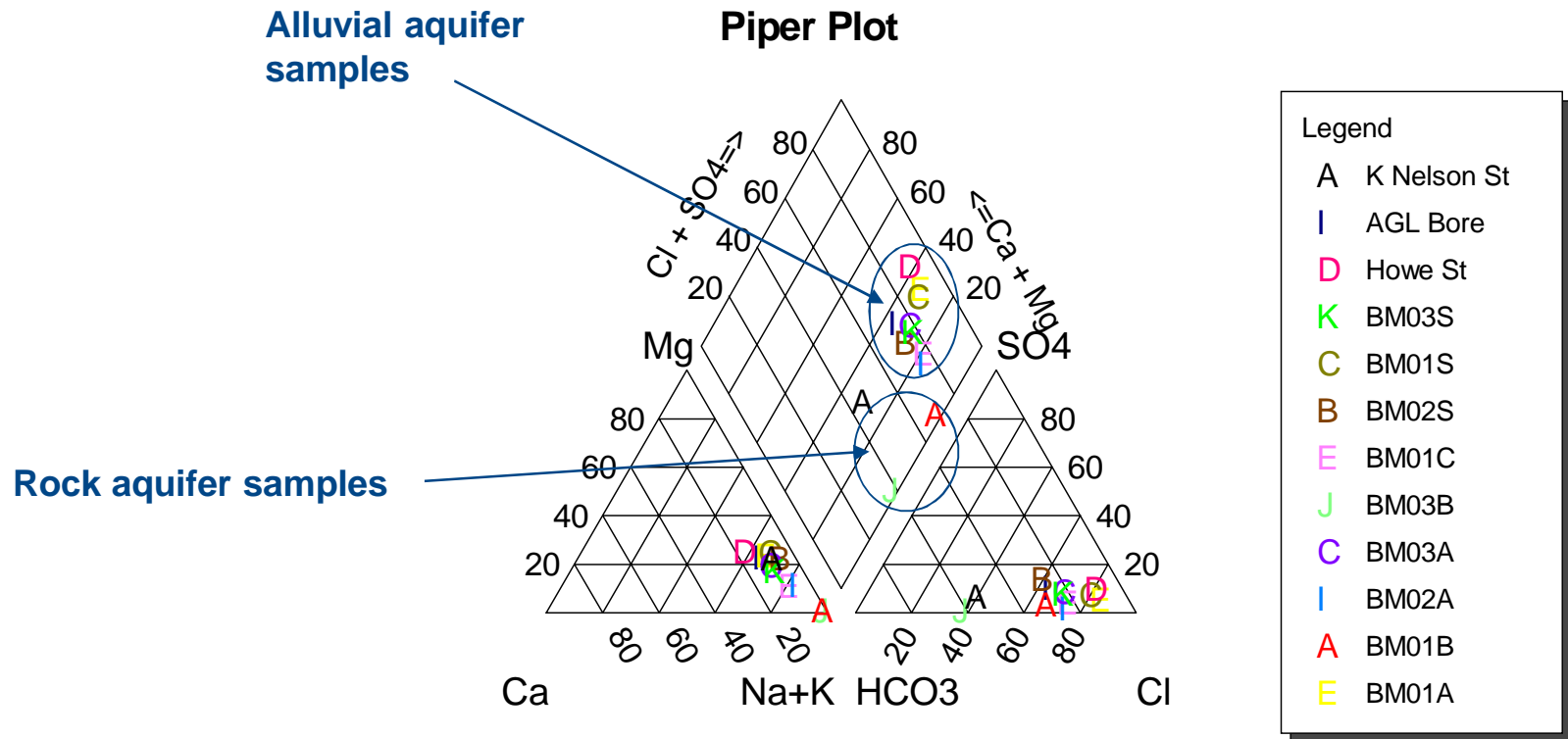
Important Water Quality Results – Field parameters and major anions/cations

- July “intermediate” sampling event

Field WQ Parameters	Units	BM01s	BM01a	BM01b	BM01c	BM02s	BM02a	BM03s	BM03a	BM03b	Taggarts	Spring Mt	Neuman
Water Level	m	2.49	2.51	3.37	3.47	3.24	3.26	2.81	2.67	3.29	5.77	1.61	3.63
Temperature	oC	18.77	20.03	19.39	22.55	19.01	19.23	18.07	19.46	19.48	19.45	17.56	16.76
Conductivity	µS/cm	3470	3940	7630	7160	2110	5770	1810	1600	5700	2002	1056	2006
Dissolved Oxygen	mg/L	4.25	1.87	0.9	3.05	6.0	2.3	4	1.48	1.9	4.44	3.74	4.9
pH		7.86	6.1	8.68	8.04	7.84	7.02	8.62	6.81	9.16	8.14	7.89	8.42

Analyte	Units	July 2009											
		BM01s	BM01a	BM01b	BM01c	BM02s	BM02a	BM03s	BM03a	BM03b	Taggarts	Spring Mt	Neuman
Total Alkalinity as CaCO ₃	mg/L	212	207	1200	822	255	575	178	170	2000	72	127	180
Sulfate as SO ₄ 2-	mg/L	110	101	105	128	127	35	58.6	64	16.2	68.1	50.2	88.2
Chloride	mg/L	974	1330	1910	2010	422	1390	417	401	900	436	246	449
Calcium	mg/L	52	74	8	102	22	34	25	36	6	64	22	32
Magnesium	mg/L	98	115	5	90	56	62	27	41	4	56	27	52
Sodium	mg/L	515	625	1680	1310	349	906	291	283	1360	233	153	317
Potassium	mg/L	3	3	6	15	14	12	6	6	6	33	2	2
Methane	µg/L	<10	<10	18800	3780	<10	250	<10	<10	18300	-	-	-
Water Type		Na-Mg-Cl	Na-Mg-Cl	Na-Cl-HCO ₃	Na-Cl-HCO ₃	Na-Mg-Cl-HCO ₃	Na-Cl-HCO ₃	Na-Cl-HCO ₃	Na-Cl-HCO ₃	Na-HCO ₃ -Cl	Na-Mg-Cl	Na-Mg-Cl-HCO ₃	Na-HCO ₃ -Cl

Important Water Quality Results – Piper Diagram



Anomalies outside of expected groupings - A and E

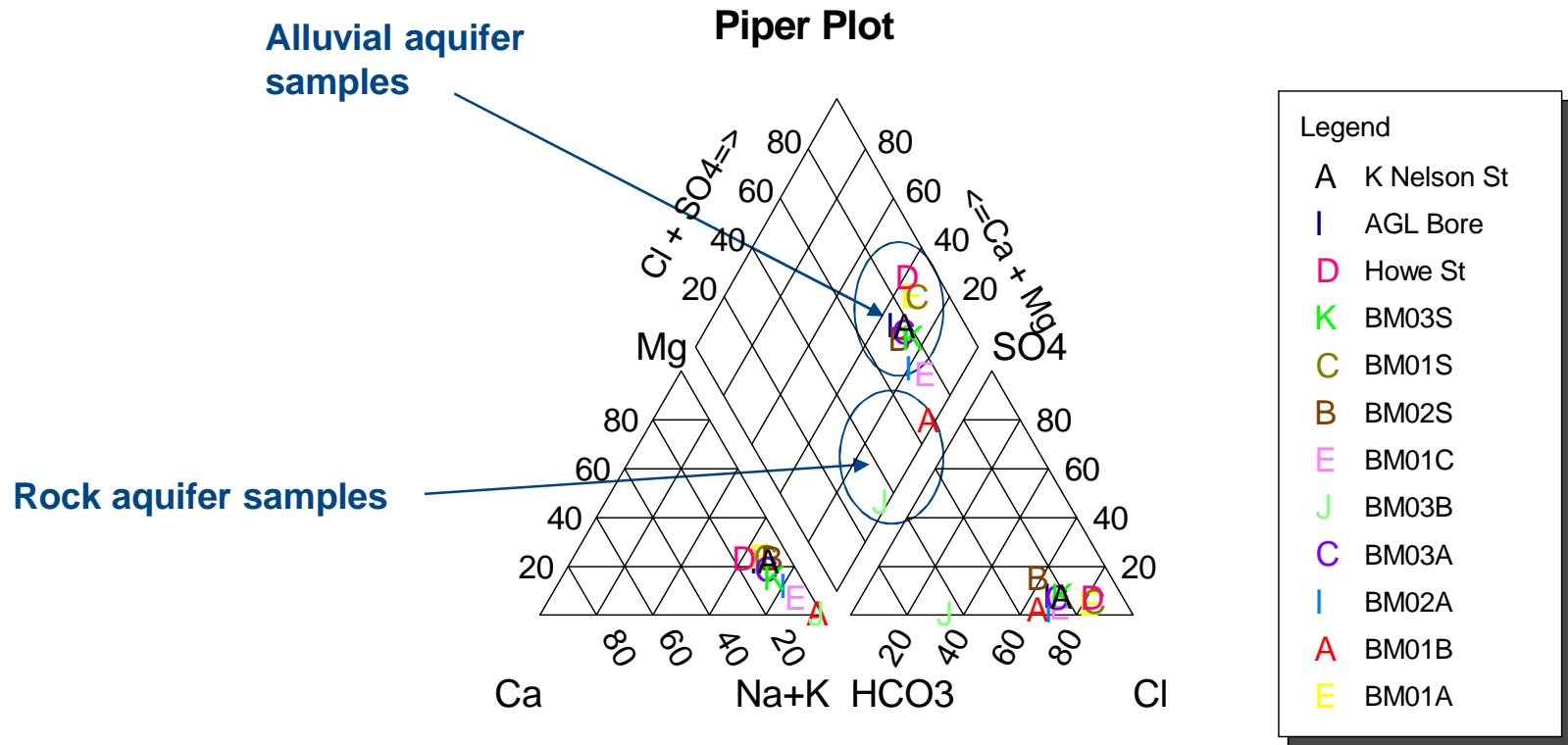
Important Water Quality Results – Field parameters and major anions/cations

- September “dry” sampling event

Field WQ Parameters	Units	BM01s	BM01a	BM01b	BM01c	BM02s	BM02a	BM03s	BM03a	BM03b	HB02	Taggarts	Spring Mt	Neuman
Water Level	m	2.47		3.33	3.43	3.36	3.38	2.84	2.735	3.43	51.5			
Temperature	oC	17.64	18.83	19.11	22.13	17.88	19.01	17.39	18.45	18.73	23.58	17.21	17.66	16.44
Conductivity	μS/cm	3360	4100	7420	7260	2310	4250	1750	1540	5560	5600	2010	1008	2009
Dissolved Oxygen	mg/L	4.02	0.58	1.79	0.3	3.54	1.72		0.77	2.09	0.68	11.71	2.04	1.59
pH		6.61	5.96	7.8	7.29	6.86	7.03	6.48	6.45	8.45	8.47	5.75	5.78	6.76

Analyte	Units	September 2009												
		BM01s	BM01a	BM01b	BM01c	BM02s	BM02a	BM03s	BM03a	BM03b	Taggarts	Spring Mt	Neuman	
Total Alkalinity as CaCO ₃	mg/L	178	227	1150	808	231	511	176	161	1950	80	110	200	
Sulfate as SO ₄ 2-	mg/L	79.5	81.3	78.7	88.6	132	32.5	61.3	47.1	11.7	51	34	66.9	
Chloride	mg/L	960	1100	1690	1790	386	1020	442	346	740	438	232	490	
Calcium	mg/L	52	72	8	71	24	41	32	31	5	60	21	30	
Magnesium	mg/L	92	114	6	60	63	60	32	33	3	52	27	54	
Sodium	mg/L	514	608	1680	1450	357	808	314	241	1370	245	160	334	
Potassium	mg/L	2	3	5	11	28	11	6	6	6	31	2	2	
Methane	μg/L	<10	<10	21500	5310	<10	246	<10	29	1880	<10	12	<10	
Water Type		Na-Mg-Cl	Na-Mg-Cl	Na-Cl-HCO ₃	Na-Cl-HCO ₃	Na-Mg-Cl-HCO ₃	Na-Cl-HCO ₃	Na-Cl	Na-Cl-HCO ₃	Na-HCO ₃ -Cl	Na-Mg-Cl	Na-Mg-Cl-HCO ₃	Na-Mg-Cl-HCO ₃	

Important Water Quality Results – Piper Diagram



Anomalies outside of expected groupings - E

Pumping Test and Recovery Program

- Proposal
 - 7-day extraction test on HB02 at 18 L/minute (0.3 L/s)
 - (equivalent to ~ 26,000 L/day and ~182,000 L/week)
 - Dataloggers set in HB02 to measure drawdown
 - Dataloggers set in all AGL bores and Xstrata piezometers 7B and P8 to assess whether any connectivity/drainage
 - Continuous salinity monitoring of pumped water from HB02
 - Water quality sampling of HB02 (minimum Day 2, Day 5 and Day 7 – only likely to submit Day 7)
 - On site monitoring:
 - Subtle changes in WL or WQ - will continue
 - Totally unexpected change in WL or WQ – will stop
 - Liaise with peer reviewer
 - Recovery for 7-14 days after test (or until full recovery of WLs)
 - WQ sampling round (all sites) after full recovery – comprehensive analysis

Scientific Rigor and Peer Review

- PB's laboratories are all NATA registered
- PB's reports are all internally peer reviewed and approved prior to release
- Peer Review - Professor Garry Willgoose
 - 17 September Report
 - Drilling completion report
 - Monitoring program methodology
 - Water quality summary sheets for each event
 - Pumping test protocol
 - Site inspection/s and pumping test liaison
 - October BCCC presentation
 - Review of Final PB report

Reporting

- Drilling completion report (completed August)
- Tabulated data for each water quality event
- Groundwater monitoring report (end of year)
 - Methodology
 - Conceptual model
 - Baseline data sets(Peer Review)
 - Falling head test data
 - Pumping (extraction) test data sets
 - Recovery data set
 - Discussion of trends and water supply implications
 - Conclusions and recommendations(Peer Review)

