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matters

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Fact Sheet: **Heavy metals and the environment.**

AGL Gloucester Gas Project
September 2014

What are heavy metals?

The term heavy metals refers to certain elements which are naturally present in the environment. In small doses some heavy metals are necessary to support life, but they can be harmful in larger doses.

Where do heavy metals come from?

Heavy metals are naturally part of the environment and can be found in soil and rocks and also dissolved in rivers, streams and groundwater. Certain rocks like granite, basalt and some shales can be naturally high in heavy metals. As groundwater or surface water (such as river water) moves through or across these rocks, some of these elements can dissolve into the water. Likewise, soil water can also contain heavy metals if these elements are found in the soil profile (or if certain fertilisers have been applied) or if the soils are saturated for a long period of time.

Does coal seam gas increase the amount of heavy metals in the environment?

Part of the process of producing natural gas from coal seams involves removing some very old, deep groundwater. This water – known as "produced water" – can have different concentrations of elements than the water closer to the surface. Because of this, AGL tests and monitors not only produced water but also a variety of other water sources wherever our activities occur.

Parsons Brinckerhoff's hydrogeologist Carolina conducting water testing at Gloucester.

What has AGL learned about water in the Gloucester region?

AGL's hydrogeologists have been studying water in the Gloucester Basin for more than four years. Because of this, we know that the water in the Avon, Gloucester and Manning Rivers are generally very low in salt and dissolved solids, including heavy metals (although the Avon River is typically more salty than the other rivers).

As the Manning River approaches the Pacific Ocean it becomes saltier due to the influence of the sea.

We have also tested the water from deep in the coal seams within the Gloucester Basin. Although this water has higher concentrations of heavy metals than water closer to the surface, the amount of elements like arsenic, cadmium, lead and mercury in this water is very small and typically well below the levels recommended by Australian drinking water and freshwater ecosystem guidelines.

What is the Gloucester area's water normally like?

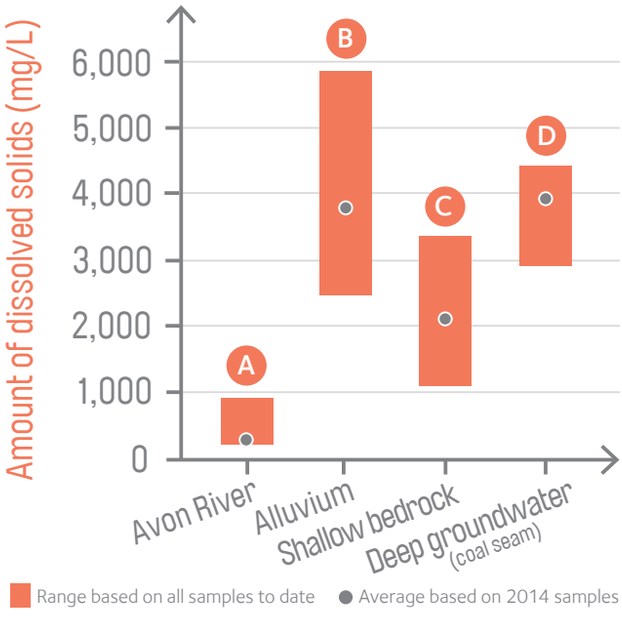
Because water picks up salts and heavy metals as it travels, water we test in one place might have different characteristics to water we test elsewhere. Water in deep coal seams will typically have more dissolved solids in it than water closer to the surface. Similarly, water in shallow bedrock or in alluvial sediments typically contains more dissolved solids than fresh water flowing in streams and rivers.

Surface water and groundwater salinity in Gloucester.

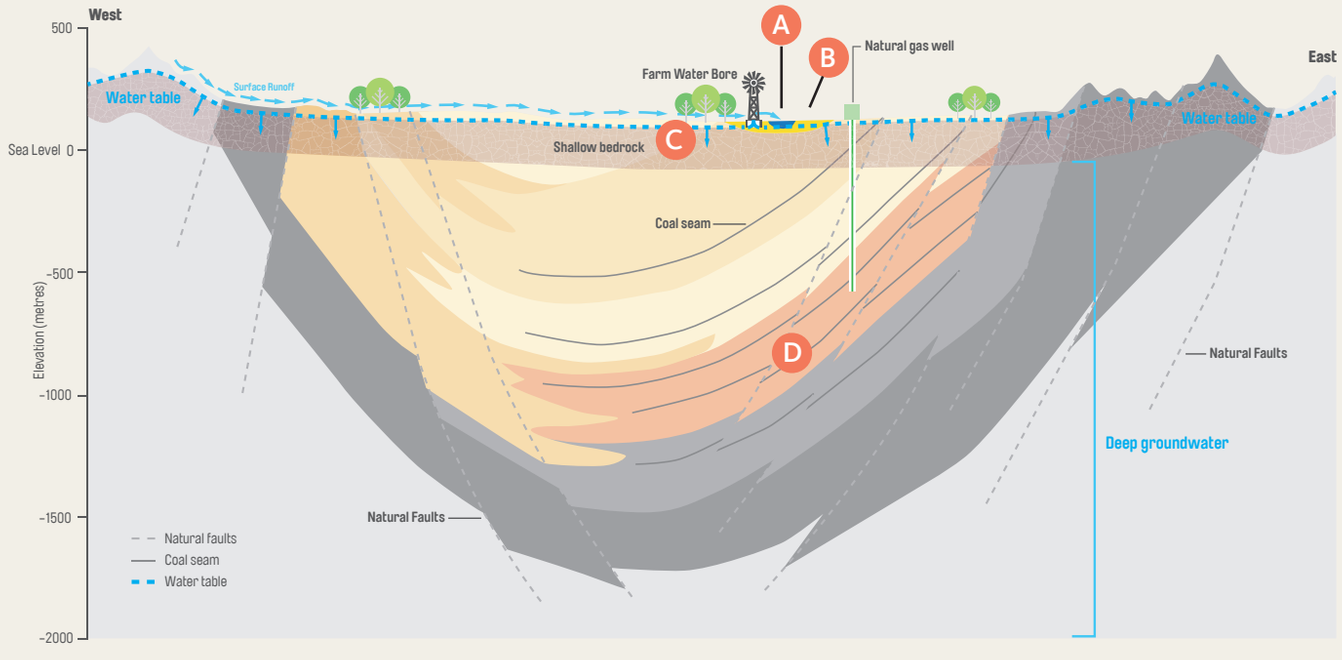
Surface water and groundwater can contain different amounts of dissolved salt, depending on how old the water is and what rocks it has moved past or through.

The longer the water has been flowing through soil and rock, the saltier the water is likely to be. That's why, in Gloucester, we see water from deeper underground (D) being typically saltier than shallow groundwater (C) or river water (A) (see the chart at right).

How salty is the water?



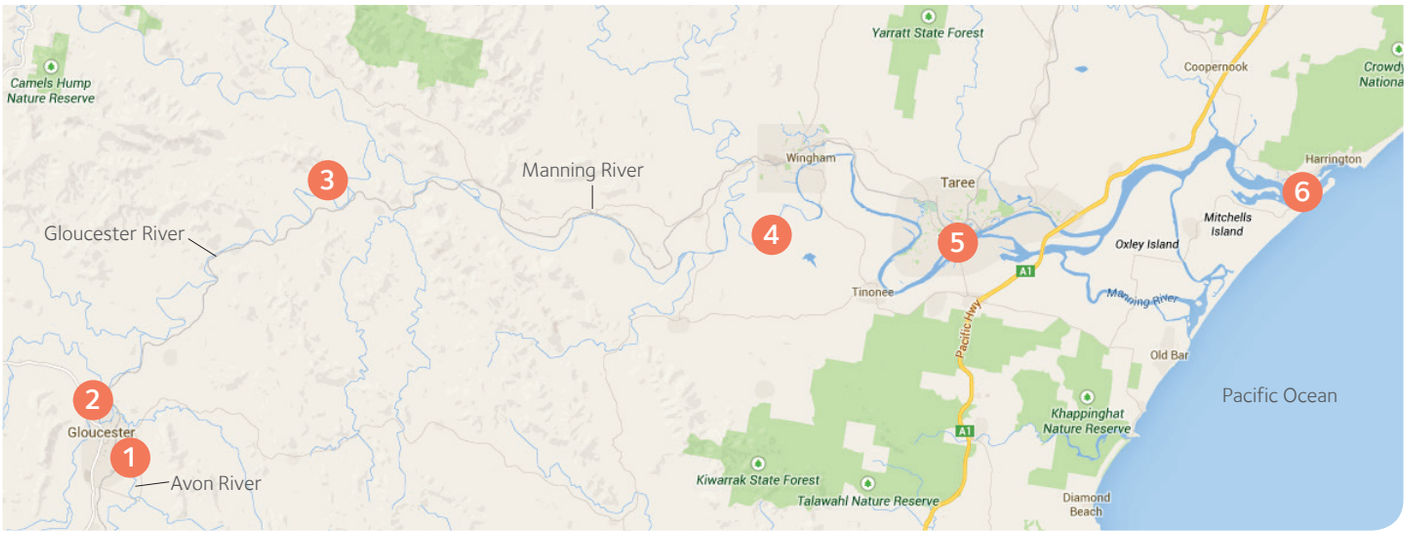
Water sample locations from Gloucester Basin.



How does the amount and type of heavy metals compare for different waters?

The amount and types of heavy metals in groundwater and surface water differs depending on the types of soil and rock the water has flowed past or through. Older (typically deeper) groundwater has had more time to pick up more heavy metals (if they are present in the source rocks).

For example (see table on page four), deep groundwater (D) has more dissolved heavy metals in it than shallow groundwater (C). Different soil and rock types will also dissolve different amounts of each heavy metal within the water. For example, the heavy metals in the groundwater in the alluvium (mostly river sands) are mostly strontium with some iron and manganese, while the heavy metals in the deep groundwater within the coal seams are mostly iron with a smaller amount of barium and strontium. Most of the other heavy metals are in very low concentrations.



The Avon-Gloucester-Manning River system and sample locations.

Understanding water quality in the Avon-Gloucester-Manning River system.

In May 2014, AGL took water samples from points along the Avon, Gloucester and Manning River systems to understand how the quality of the river water differs. The sample points are shown in the map above. Samples were taken from the Avon River in AGL's Gloucester Gas Project Stage 1 area (1), the Gloucester River (before the Avon River joins it) (2), the Gloucester River (before it joins the Manning River) (3), the Manning River (at the MidCoast Water offtake point) (4), the Manning River (at Taree) (5), and the Pacific Ocean, at the mouth of the Manning River (6).

Salinity in the Avon-Gloucester-Manning River system.

From upstream to downstream, the amount of dissolved salt in the river water changes depending on where the water has come from. The Avon River (1) is typically saltier than the Gloucester River (2) as it has a higher contribution from saltier groundwater. The Manning River (4) is typically quite fresh until it gets closer to the sea and has influence from tides and sea water. The Manning River at Taree (5) is quite salty because of tidal influence.

How does the amount and type of heavy metals compare for the river waters?

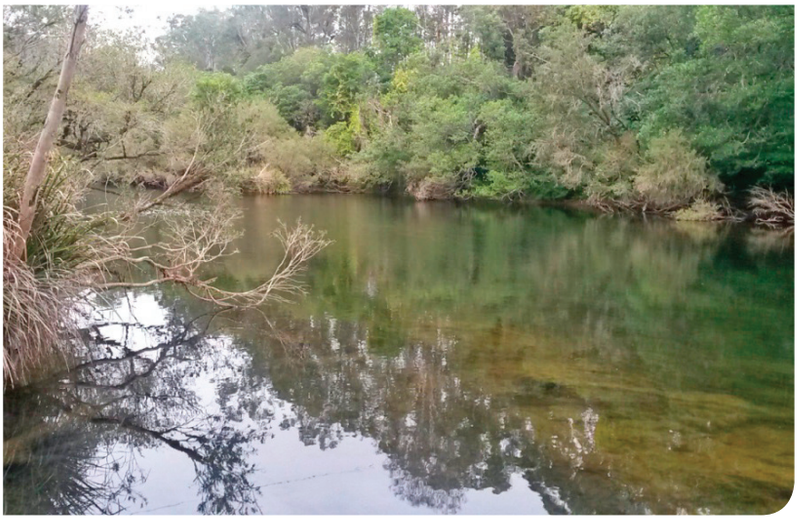
The Avon River naturally has more dissolved heavy metals in it than the Gloucester River. The heavy metals in the Avon River (1) are mostly iron with some manganese and strontium, while the heavy metals in the Gloucester River upstream of the Manning River (3) are mostly aluminium and some strontium. The tidal-influenced river water at Taree (5) contains mostly strontium and boron, which is similar to ocean water (6). Most of the other heavy metals are in very low concentrations.

How is AGL ensuring that the environment and groundwater remains protected?

AGL's natural gas wells are insulated from beneficial aquifers and shallow groundwater by four layers of high integrity steel pipe and cement. AGL also draws on years of experience producing natural gas from coal seams in Camden, south-west of Sydney. AGL conducts frequent, regular testing in the areas in which we operate and publishes those results so that the public can see what is going on.

We are also implementing plans to use proven reverse osmosis technology to desalinate produced water from coal seams, removing salts, solids and heavy metals and providing a resource which could be used for a variety of purposes.

The Gloucester River, Bundook (location 3).



What are the heavy metal levels in our local waters?

The following table displays average values for heavy metals, electrical conductivity (which is a measure of salinity), pH and total dissolved solids (TDS) for different local water sources. These values are compared against the Australian Drinking Water Guidelines and ANZECC Ecosystem Guidelines for freshwater aquatic ecosystems. pH is a measure of how acidic or alkaline the water is (pH of 7 is neutral, pH less than 7 indicates increasing acidity, and pH greater than 7 indicates increasing alkalinity). TDS is another way of comparing salinity.

Comparison of heavy metals found in different water types.*

Water quality parameters	Units	Avon River (A) / (1)	Alluvium groundwater (B)	Shallow bedrock groundwater (C)	Deep groundwater (coal seam) (D)	Gloucester River upstream of Avon River (2)	Gloucester River upstream of Manning River (3)	Manning River MidCoast Water offtake (4)	Manning River Taree (5)	Pacific Ocean Manning River mouth (6)	Australian Drinking Water Guidelines (2011)		ANZECC Ecosystem Guidelines[a]
											Aesthetic	Health	
pH	pH units	7.01	6.38	7.19	7.92	7.43	8.14	7.84	7.42	8			
Electrical conductivity	µS/cm	569	6365	4005	7300	72	96	151	32,000	53,100			125-2200[b]
TDS	mg/L	309	3735	2119	3973	41	54	76	23,000	42,400	600		
Dissolved metals													
Aluminium	mg/L	0.06	0.06	0.06	0.02	0.02	0.24	<0.01	0.12	<0.01	0.2		0.055
Arsenic	mg/L	0.003	0.003	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	0.002		0.01	0.013
Barium	mg/L	0.073	0.445	0.389	5.28	0.006	0.005	0.01	0.018	0.005		2	
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		0.06	ID
Boron	mg/L	<0.05	<0.05	0.09	0.17	<0.05	<0.05	<0.05	2.06	3.44		4	0.37
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		0.002	0.0002
Chromium	mg/L	<0.001	<0.001	0.001	0.019	<0.001	<0.001	<0.001	<0.001	<0.001			0.001
Cobalt	mg/L	0.002	0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			ID
Copper	mg/L	0.003	0.015	0.003	0.006	<0.001	0.002	<0.001	<0.001	<0.001	1	2	0.0014
Iron	mg/L	1.71	3.95	1.05	21.7	0.17	<0.05	<0.05	<0.05	<0.05	0.3		ID
Lead	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		0.01	0.0034
Manganese	mg/L	0.607	1.422	0.217	0.264	0.008	0.002	0.005	0.015	0.002	0.1	0.5	1.7
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		0.001	0.0006
Molybdenum	mg/L	<0.001	<0.001	0.032	0.005	<0.001	<0.001	<0.001	0.007	0.013		0.05	ID
Nickel	mg/L	0.002	<0.001	0.071	0.002	<0.001	<0.001	<0.001	<0.001	<0.001		0.02	0.011
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01		0.01	0.011
Strontium	mg/L	0.415	6.44	5.45	3.66	0.046	0.056	0.07	4.6	8.15			
Uranium	mg/L	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.002	0.004		0.017	ID
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			ID
Zinc	mg/L	0.012	0.014	0.039	0.064	<0.005	<0.005	<0.005	<0.005	<0.005	3		0.008

* Average values based on data collected in 2014.
[a] ANZECC (2000) guidelines for the protection of freshwater aquatic ecosystems: 95% protection levels (trigger values).
[b] ANZECC (2000) guidelines for the protection of freshwater aquatic ecosystems: trigger values for lowland rivers in south-east Australia.
ID - insufficient data to derive a reliable trigger value.