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Steve O'Connor
Commissioner Independent Planning Commission NSW (IPC)
Chair, IPC Narrabri Gas Project Hearing
NSW, Australia.

IPC Narrabri Gas Project Hearing: Waste Salt Disposal

Dear Commissioner O'Connor,

Thank you for the opportunity to make this written submission to the IPC Narrabri Gas Project Hearing. This submission follows my online statement to the Commissioners on Thursday 23 July. I was also most grateful for that opportunity. My key message in both instances is that the salt disposal aspect of this project cannot be approved.

About Me

I am a professor in the School of Civil & Environmental Engineering at the University of New South Wales. My areas of professional expertise are water and wastewater quality, and water and wastewater treatment. I have particularly worked with advanced treatment processes, such as reverse osmosis membrane filtration. I have been engaged with the issue of produced water and salt management for coal seam gas operations for most of the last decade.

In 2013, I was commissioned to prepare a background paper on the topic of "Coal Seam Gas: Produced Water and Salts" [1] for the NSW Chief Scientist and Engineer. This was to support the larger report being prepared by the Chief Scientist in response to a request from the NSW Government [2]. That background paper was extensively drawn upon for the Chief Scientist's CSG Report and it remains on the website of the NSW Chief Scientist and Engineer [3].

NSW Parliamentary Inquiry into CSG (2011)

In 2011, I appeared as a Witness at the NSW Parliamentary Inquiry for Coal Seam Gas. An excerpt from the final report from that Inquiry [4]:

> *A significant issue arising from the treatment of produced water to very high standards through processes such as reverse osmosis, is that as contaminants are removed from the water, a large volume of solid waste is generated. Dr Khan described the water treatment process as follows:*
>
> *"The problem is that when you treat water by reverse osmosis you are not destroying the chemicals and salts, you are separating the water into two components: one is a highly purified component and an equally highly concentrated component. It is managing that concentrated brine that presents a number of challenges.… Then you have a solid waste disposal problem. You have large volumes of contaminated salts that need to be disposed somewhere, usually to landfill".*
>
> *The Committee was not advised of any feasible commercial options for the re-use of the solid waste generated from treated water. As noted by Dr Khan, solid waste is usually sent to landfill. When questioned on whether there are industrial uses for the brine from produced water, Dr Khan responded by comparing solid waste to the salt generated by desalination plants, and noted that industry re-use is not 'economically feasible':*
>
> *The Committee is aware that work is being done to find a beneficial use for the solid waste generated by the coal seam gas industry. For example, the Committee received a submission from the company Fodder King, which advised that they are in the process of '… demonstrating that we can devise cost-effective solutions for sustainably using CSG water that can mutually benefit both the agricultural and resources industries and their host communities'.*
>
> *Coal seam gas companies are also investigating how to deal with solid waste products generated by coal seam gas activities, with Santos advising that they are undertaking a study of the 'commercial and technical feasibility of brine disposal'.*
>
> *In relation to the disposal of solid waste, the Committee considers that the NSW Government should not approve any coal seam gas activity without a solid waste management plan included in the relevant approval.*

And indeed, Recommendation 5 from that Parliamentary Inquiry was as follows [4]:

Recommendation 5:

> *"That the NSW Government not approve any coal seam gas activity without a solid waste management plan included in the relevant approval".*

Salt production from the Narrabri Gas Project

The 2013/14 background paper I prepared for the NSW Chief Scientist and Engineer includes detail on the risks associated with salt production from CSG activities, approaches that can be adopted to manage the produced water and salt, and opportunities for beneficial reuse or ultimate disposal of the salts [1].

Among the various options identified is treatment of the saline produced water by advanced water treatment processes including reverse osmosis membrane filtration. Various options for managing the concentrated brine solution from the reverse osmosis process were identified. These included further volume reduction by thermal brine concentration, followed by crystallisation of the salts to produce a solid waste product.

This concept has now been adopted by the Narrabri Gas Project. It is the "Rolls Royce" of produced water management options, being highly energy-intensive and expensive. But as previously indicated, a major obstacle is the production of a solid waste salt product, requiring further management and/or disposal. According to the Environmental Impact Statement, submitted with the Development Application, 430,000 tonnes of salt are projected to be produced over the life of the project [5]. That's more than 10,000 B-double truck-loads of salt. To put this in a more visual context:

- The Eiffel Tower weighs 10,000 tonnes, the mass of salt produced from this project is equivalent to **43 Eiffel Towers**;
- The mass of steel in the Sydney Harbour Bridge is 50,000 tonnes. The mass of salt produced by this project is **more than 8x the mass of steel in the Sydney Harbour Bridge**.

But that's only half the story. In their Assessment Report, the NSW Department of Planning, Industry and Environment stated that "*due to significant community concerns about the land and water impact, the Department established an independent Water Expert Panel (WEP) for the project*" [6].

The DPIE Assessment Report notes that the proponent's Environmental Impact Statement predicted that some 430,000 tonnes of salt would be produced over the life of the project. But it then states: "*However, based on updated water baseline information in the Response to Submissions, the Water Expert Panel considers that salt production could be up to approximately 850,000 tonnes over the project life*" [6]. If so, we're now talking about **85** Eiffel Towers or **17**x the mass of steel in the Sydney Harbour Bridge. This is a considerable mass of salt to manage, by any standard.

Waste Classification for Water-Soluble Salt

For such a significant mass of salt waste, the Environmental Impact Statement, submitted with the Development Application for this project is very brief on the issue of salt disposal. But it does state that the salt would be classified as **general solid waste** under the NSW EPA Waste Classification Guidelines [7].

In their Response to Submissions, Santos further emphasised that the salt would be classified as **general solid waste**. To support this, they provided chemical analysis of potential chemical contaminants in the salt to demonstrate that they are expected to be below the contaminant thresholds included in the Waste Classification Guidelines for waste to be classified as "general solid waste".

I believe this seriously misses the point of the NSW EPA Waste Classification Guidelines. These guidelines, last updated in 2014, were not prepared with large masses of salt in mind as "general solid waste". In fact, they provide a long list of some types of solid wastes that are pre-classified as "general solid waste". To give you the picture, examples include glass, plastic, rubber, plasterboard, ceramics, bricks, concrete and metal.

The list is long, but a common characteristic is that these are substances that will not rapidly dissolve in water, be that groundwater or rainfall that falls on the landfill surface. Highly water soluble salt is fundamentally different. It dissolves in water. Some other types of waste are explicitly prohibited from classification as general solid waste and these include "liquid waste". The reason for this is that liquids are mobile and cannot be effectively contained in a landfill designed and licenced only for "general solid wastes".

As CSG salts do not appear on the list of pre-classified general solid waste, the Guidelines require that they be subject to chemical contaminant assessment to ensure that no harmful contaminants are present above the identified acceptable concentrations. But these contaminants include things like benzene, cadmium, lead, mercury, various harmful pesticides and carcinogenic polyaromatic hydrocarbons. Anyone with experience in the field of chemical contaminants will immediately recognise that the intention is to prevent harm from exposure to toxic chemicals. The idea of highly saline water, containing hundreds of thousands of tonnes of salt, leaching from these landfills is an entirely unrelated and unconsidered concept in these Guidelines.

In my opinion, these Guidelines, and the waste management regulatory regime that they underpin, are <u>not fit for the purpose of classifying the containment requirements of a large mass of highly water soluble salt</u>. The NSW Waste Classification Guidelines cannot be reasonably applied to hundreds of thousands of tonnes of CSG salt, and attempts to use them for that purpose will inevitably lead to the production of highly saline leachate and an associated high risk of seriously contaminated groundwater and surface water.

Limitations of Landfill Design and Operation for General Solid Waste

I was concerned to read that the NSW Department of Planning, Industry and Environment accepted and supported the assumption that this material could be classified as “general solid waste”. Page xiv of the DPIE Assessment Report states “*the salt is likely to be classified as general solid waste which can routinely be disposed of at one of the 11 licenced waste facilities within 150 kilometres of the site”* [6].

The NSW EPA also has Environmental Guidelines for the design of solid waste landfills [8]. For general solid waste landfills, there are requirements for barrier systems to control contaminated leachate. These include a compacted sub-base and a compacted clay liner. As rainwater enters the landfill, this barrier system is designed to prevent it mixing with groundwater. However, the saline solution produced will need to go somewhere.

General solid waste landfills must be constructed with a leachate collection system [8]. This is composed of a layer of gravel along the bottom and pipework to drain the leachate from the landfill. The next issue then is disposing of the leachate, which will eventually wash out all of the salts. The challenges for a solid waste landfill operator in disposing of a concentrated brine solution are effectively the same as the challenges that a coal seam gas company faces in disposing of concentrated brine solutions. One option to consider might be reverse osmosis treatment, followed by a thermal brine concentrator, followed by crystallisation of the salt. But while these “Rolls Royce” highly energy-intensive and expensive technologies might be viable for a coal seam gas company, they’re unlikely to be affordable to a solid waste landfill operator. In that case, the saline landfill leachate would present significant contamination risks to local surface water groundwater.

And in this scenario, a lot of energy, money and greenhouse footprint has been invested in shifting a problem from one location to another. That is, the problem is simply shifted from the CSG well site to one or more solid waste landfill sites. But the problem is far from solved.

A more ideal scenario might be that the salt waste is appropriately classified as a hazardous waste that requires significantly enhanced containment and leak detection measures. But even this is a temporary solution since risk of loss of containment exists for perpetuity. The salt does not break down and will require ongoing management to contain long after any solid waste landfill ceases to operate. The future will necessarily involve at least one of the following three options:

1. Ongoing active management of the landfill storage, forever;
2. Acceptance that the containment will eventually fail and salts will be released to groundwater and surface water; or
3. Recovery of the salts, by digging them all out again.

In any of these three circumstances, we will be passing the burden of addressing this problem on to future generations. In my opinion, such an arrangement is not acceptable and should not be approved under any circumstances.

Beneficial Reuse of Soda Ash and Sodium Bicarbonate

The good news is that disposal of the salt by landfill is not necessary. At effectively the 11th hour of the project approval, Santos has indicated that it has signed a Memorandum of Understanding with American company Natural Soda. Together, they plan to beneficially reuse the salt removed from the Narrabri Gas Project. To quote a recent statement from Santos [9]:

> "*Natural Soda produces pure, natural sodium bicarbonate at its facility in…Colorado, using energy efficient and environmentally friendly processes. Natural Soda is the second-largest producer in North America and its sodium bicarbonate is imported into Australia and around the world for use in a range of commercial products including food, pharmaceuticals, swimming pool chemicals, industrial chemicals and animal feed. The two companies have been working together for over a year on a commercially-viable model that could create a new sodium bicarbonate industry for Narrabri and Australia, bringing more local jobs to the region. Sodium bicarbonate is commonly known as 'baking soda'. Santos and*

Natural Soda plan to complete a concept study to inform an investment decision to produce sodium bicarbonate in Narrabri".

Opportunities to recover and beneficially reuse salts including sodium bicarbonate and sodium carbonate (soda ash) were highlighted in the report that I provided for the NSW Chief Scientist in 2013/14 [1]. In fact, I was quoted in an article by journalist Peter Hannam, published in the Sydney Morning Herald in 2013 (7 years ago). The article states [10]:

While Santos is "actively exploring" commercial uses for the salt, the company's challenges are shared across the industry, Dr Khan said. …"You've got huge amounts of water and salt looking for a home."

A Santos spokesman said "the industry has a range of options to safely and sustainably deal with the produced water and associated salt, and we continue to look at new and innovative options".

Santos is "considering the conversion of some of the salt into saleable products such as sodium bicarbonate", the spokesman said. "A less preferable but regulatory acceptable option would be to send the salt to waste treatment and containment facilities."

Dr Khan said buyers of the salt will probably be hard to find after Penrice Soda, Australia's only commercial manufacturer of sodium bicarbonate ended a joint venture with GE Power & Water to extract salt from CSG water earlier this year. *He recommended CSG companies form a co-operative to make such products, even at a loss.*

Penrice Soda was an Australian Public Company [11]. It was the only supplier of soda ash and bicarb in the domestic market and it exported sodium bicarbonate to more than 25 countries. It was based in Adelaide and employed 174 people. It was listed on the Australian Stock Exchange since 2005, but the company's origins date back to 1935, when it was formed by ICI to manufacture soda ash.

Unfortunately, business turned bad for Penrice in the couple of years leading up to 2013. In the face of an increasingly unfavourable exchange rate and increasing costs in its soda ash business, Penrice found that it was unable to compete with cheap imported soda ash and bicarb. Penrice closed its soda ash production in 2013 and switched to an import and distribution model. In its 2013 Annual Report, Penrice declared a Statutory net loss after tax of $50 million and a net debt of >$100 million [11].

But while it operated, Penrice had one of the five largest sodium bicarbonate plants in the world. It played a vital role as a producer of raw material for products ranging from glass bottles, flat glass for building and construction, to powder detergents. During its final 10 years, Penrice expanded the capacity of its bicarb plant from 20,000 to 100,000 tonnes per year. The Narrabri Gas Project would produce around 17,000 tonnes per year, and this is an amount which could certainly be absorbed by domestic supply alone.

A Consortium between Penrice and GE Power & Water previously had plans to provide the Australian CSG industry with a brine removal solution [1]. Using water from several CSG projects, Penrice conducted laboratory and small scale field trials, extracting sodium carbonate, sodium bicarbonate and sodium chloride from produced waters. While Penrice ultimately ceased to operate, my understanding is that there are not likely to be major technical barriers to soda ash and sodium bicarbonate production from CSG produced water.

Furthermore, I am informed that new technology is available and new production facilities, using this new technology have opened in China and are successfully operating. **Given this development, I strongly propose that the establishment of an operational soda ash and sodium bicarbonate production facility be a mandatory requirement to any CSG development approval in NSW**. It is not possible to sustainably manage the salt waste without this mandatory requirement.

I strongly suggest that development approval be conditional upon much more than just a Memorandum of Understanding or even a detailed business case. A full-scale commercial soda ash production facility needs to be seen to be well under construction and realistic financial commitments to its completion must be in place. Peak water and salt production will occur during the first 4 years of a CSG operation and a sodium bicarbonate plant needs to be operational by that time in order to process the salts as they are produced. Zero salt should be approved to be produced until there is an operational plant. Anything less is, in my opinion, unsatisfactory condition for approval of this or any other CSG project in NSW.

Responses to some questions raised at the IPC Hearing

***Question*: The Water Expert Panel (WEP) notes that the classification of waste salt would appear to meet the requirement of general solid waste, however some details not provided in EIS. Is there real doubt as to whether salt could be considered general solid waste?**

This question appears to be a reference to the “Key Observation” 15 in the Water Expert Panel Report [12]. The WEP observed that “*Information provided in the NGP EIS suggests the salt product will meet the requirements to be treated as a general solid waste and to be categorised as “non-trackable*”.

I agree with this statement that the crystallised salt produced from the NGP would, at face value, appear to meet the requirements for classification as General Solid Waste under the NSW Waste Classification Guidelines (2014), pending chemical contaminant limits. However, this is a consequence of this type of waste material (in these quantities) not having been thoroughly or seriously considered in the development of these guidelines.

As highly water soluble salts, which will be highly mobile in landfill leachate, this waste is fundamentally different to the types of waste normally classified as general solid waste. The challenges relating to physical containment of these salts, as well as the risks they present to the environment, are fundamentally different from all other wastes that would normally be classified as general solid wastes. In my opinion, the NSW Waste Classification Guidelines (2014) should not be applied for the classification of this particular type of waste material.

Question: What is your view on the brine’s suitability for use for bicarb given the level of contaminants. What is the state of technology to allow this?

I have no expertise in the area of either soda ash or sodium bicarbonate production. This would be an appropriate question to direct to the proposed future partner, Natural Soda. In general terms, all salts can be purified to any level of purity if the right investments in technology and processing are made. Thus I believe that it is most certainly technically possible to produce high quality soda ash and sodium bicarbonate from even highly contaminated crystallised coal seam salts. But I cannot comment on the costs or whether it would be commercially viable.

Question: The WEP recommended Santos provide EPA with a formal statement re necessary landfill facility but they haven’t done so. If the Project goes ahead and can't get someone to take waste, what happens?

A broad range of potential management solutions were canvassed in the report that I provided to the NSW Chief Scientist in 2013/14 [1]. I can’t provide a specific answer in this case. I suggest that this would be a highly pertinent question to pose to Santos.

Question: Is incineration an option?

No. As inorganic substances, incineration of sodium carbonate and sodium bicarbonate is not a viable waste management process.

I would be very happy to provide further explanation of any of the issues that I have raised in this submission. Furthermore, I would have happy to provide copies of any of the references cited.

Yours sincerely,

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