6 December 2010

Shoal Point Bay Developments Pty Ltd
Level 3 'The Forum'
26 Orchid Avenue
Surfers Paradise, Qld, 4217

Attention: sch4p4(6) Personal information **Project Manager**

Dear sch4p4(6) Personal information

Re:ADDENDUM TO STAGE 1 & STAGE 2 INVESTIGATION-LOT 4 ON RP817122, HODGES ROAD, SHOAL POINT, MACKAY - REMEDIATION OPTIONS FOR ARSENIC IN GROUNDWATER

Gilbert & Sutherland Pty Ltd (G&S) has prepared this addendum report in response to recent discussions between G&S and the Third Party Reviewer (TPR) sch4p4(6) Personal information relating to the remediation of groundwater on Lot 4 on RP817122, Hodges Road, Shoal Point, Mackay, Qld (hereafter referred to as 'the site'). This addendum report presents a summary of available treatment options considered suitable for the remediation of arsenic contaminated groundwater, which has been identified at the site.

Gilbert & Sutherland have prepared a Draft Site Management Plan (DSMP) and Remediation Action Plan (RAP) for the site. The RAP suggests remediation options including precipitation/co-precipitation, adsorption, ion exchange or membrane filtration for the treatment of the arsenic contaminated groundwater located within the foreshore (northern) portion of the site. This addendum report aims to expand on those suggested treatment options proposed within the RAP by detailing/analysing their suitability to meet the remediation objective.

Background

The entire allotment is currently listed on the Department of Environment and Resource Management's Environmental Management Register (EMR) because of the

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Our Reference: 10527_ADR_NMS1F
Your Reference: Addendum Report-Shoal Point
By: ☐ Courier ☑ Email ☐ Facsimile ☐ Post
Enclosures: Nil

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Notifiable Activity of "Livestock Dip or Spray Race Operations." The existing land use identified during the Stage 1 & Stage 2 investigation is rural activities. The site is to be redeveloped for residential purposes and the remediation area, defined by the metes and bounds, is to be redeveloped as a foreshore park and used for recreational and coastal buffer purposes.

Gilbert & Sutherland completed a Stage 1 & Stage 2 Investigation Lot 4 on RP817122, Hodges Road, Shoal Point, November 2010 (the 'report'). The report identified arsenic contamination within two groundwater-monitoring wells (GW3 and GW4), which were installed immediately adjacent to, and to the south east of the former livestock dip location. Arsenic concentrations exceeding the Groundwater Investigation Levels (GILs) for the protection of aquatic ecosystems (Marine Ecosystems) were identified in groundwater samples extracted from GW3 and GW4. The arsenic concentrations in GW4 also exceeded the GIL for long term irrigation. The groundwater contamination has been delineated by G&S during the Stage 1 & Stage 2 investigation and is limited to the foreshore park area, defined by the metes and bounds detailed within the DSMP and RAP.

Arsenic contamination identified within GW3 and GW4 is displayed on the amended Drawing No. 10527.1.8 attached.

Remediation Strategy

The current strategy proposed for the remediation of arsenic contamination in groundwater is a two stage process. The initial stage involves the following steps:

- Excavate the soil material within the vicinity of the former livestock dip which includes that area surrounding the groundwater monitoring well (GW4) which had confirmed arsenic contamination. An excavation pit of approximately 15 x 15 x 3 metres to intercept the groundwater is proposed for the site.
- We estimate 800 tonnes of sand material (bulk density of 1.2) would be excavated from this area and stockpiled within a bunded/contained area.
- Stockpiled material would be sampled in accordance with the Australian Standards (AS4482.1) and classified accordingly. All run-off will be collected and stored on-site within tanks or pre-engineered sumps and sampled for arsenic.
- Groundwater infiltrating the excavation pit would be pumped and stored within a tank (s) on-site and sampled for arsenic to establish a baseline concentration.

Once a baseline concentration of arsenic has been established an assessment of its suitability against the ANZECC (2000), *Guidelines for Fresh and Marine Water Quality, Volume 3, Primary Industries* Short-Term Trigger Value (STV) for arsenic of 2.0mg/L can be made. If the stored groundwater contains concentrations of arsenic below the STV then G&S propose to irrigate approximately 1.5ha of the foreshore area. Once the pumping rate and volume of groundwater extracted from the excavation has been

calculated an appropriate irrigation rate would then be determined considering the irrigation plot size, potential dilution (if any) required of the irrigated groundwater and the potential accumulation volumes of arsenic within irrigated soils.

Alternatively, if the STV for arsenic cannot be met then the following treatment options are commercially available for the treatment of arsenic in groundwater:

Precipitation/Co-precipitation

Precipitation uses chemicals to transform dissolved contaminants into an insoluble solid. (USEPA, 2002). Precipitation and co-precipitation involves the mixing of treatment chemicals into the extracted groundwater. The addition of treatment chemicals, primarily for pH adjustment and flocculation of suspended solids, occurs within a primary tank or vessel where precipitation, coprecipitation and the formation of solid particles occurs. Solids are then settled within a second tank or vessel.

After the solids are removed from suspension further treatment of the arsenic contaminated groundwater may occur. Additional chemical injection of a chemical oxidant such as, potassium permanganate, sodium hypochlorite and hydrogen peroxide can occur after the settling of solids. A final polishing process may be added to the treatment train, post oxidation. This polishing process generally involves further settlement or, more commonly, filtration of the treated groundwater to further remove any suspended sediments.

Precipitation of arsenic in groundwater via the process of chemical addition and sludge removal is a relatively simple and effective ex-situ treatment process. Constraints to this process involve the production of potentially concentrated arsenic sludge that requires dewatering and disposal to an approved waste facility. Disposal of contaminated sludge material will require a disposal permit from the Department of Environment and Resource Management (DERM) if analytical data reveals arsenic concentrations above the relevant Draft QLD guideline for arsenic in soils.

G&S have made enquiries and Enivropacific Pty Ltd (Envirpacific) an Australian remediation company, have indicated that they currently have the technology and expertise to undertake a precipitation/coprecipitation treatment program for the contaminated groundwater. Enviropacific have indicated this system has been successful in previous installations and can be retro-fitted to a variety of groundwater well networks and/or via stored groundwater supplies. Enviropacific's strategy and quote is included as Attachment C.

Adsorption treatment for arsenic

Adsorption treatment follows a similar principle to that of precipitation and coprecipitation, however this treatment process occurs within a single vessel via a fixed bed of media. Adsorption of arsenic from groundwater is achieved by passing the contaminated influent, under pressure, through a fixed bed of specialised media. The fixed bed acts to precipitate/coprecipitate, ion exchange and filter the influent within a single pass (USEPA, 2002). Alternatives utilised in Bangladesh, India where naturally occurring arsenic levels

in groundwater used by rural communities and villages for drinking water exceeds health based levels are based on similar technologies, however are applied in a much simpler method. Typical treatment systems attached to small community tube-wells in the Bangladesh region include:

- **Stevens Institute Technology.** This technique employs a two-bucket system with manual mixing and passive filtration. The first bucket is for the addition of oxidisers and flocculants which are mixed by hand. The second bucket contains an inner smaller bucket that fills creating a weir effect. Once overflowing (weir effect) the liquid passes through filter sand for use as treated drinking water (Ahmed, 2001).
- **Fill and Draw units.** This 600 L tank with a tapered bottom for sludge collection is filled manually and mixed manually via a geared impeller system. Oxidants and coagulants are added to the covered tank and mixed by hand to disperse and settle solids. The settled water is then drawn through a pipe fitted at a level above the base of the tank and fills a sand bed filter (gravity fed) which in turn provides treated water for the community. Settled sludge is removed via a sludge pipe in the base of the tapered tank (Ahmed, 2001).

Adsorption of arsenic in groundwater by using a fixed media bed or by using one of the simpler systems which involve the use of a flocculant or coagulation such as Activated Alumina (AA) does produce a waste stream of sludge which can contain a concentrated volume of arsenic. The waste product from the used media and the contaminated sludge would require dewatering and subsequent laboratory testing. Based on the analytical results of the waste material, off-site disposal may be required.

Membrane filtration

Membrane filtration can remove a wide range of contaminants from both drinking water and groundwater influent streams. Typically there are four main variants of membrane filtration: reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF) and microfiltration (MF). All four are pressure driven and are categorised by the particle sizes that can pass through the membranes. RO and NF require high pressures to allow the influent to pass across the permeable membranes, whilst UF and MF require lower influent pressures and primarily filter out suspended solids.

Because arsenic occurs in dissolved form and tends to have a low molecular weight, only NF and RO membrane processes are likely to effectively treat the dissolved form of arsenic. Whilst RO and NF systems can be used effectively ex-situ for groundwater treatment, the process can be costly. In addition, as both treatment systems require the pressurised transfer of particles across a permeable membrane, a high maintenance schedule is required to keep these systems running efficiently. Maintenance steps include backwashing and chemical treatment of the membranes. Both filtration options produce a concentrated waste stream which requires storage and potentially further treatment prior to disposal.

Conclusion

The treatment options, briefly summarised within this addendum report, provide a knowledge base for the remediation of arsenic contaminated groundwater occurring at the site. Arsenic removal from drinking water and groundwater has been successfully undertaken in numerous Australian settings and has been used effectively within the United States (US) for many years. Based on current research from the US the treatment of arsenic occurring in low concentrations (< 0.5mg/L) is readily achievable via one or all of the discussed treatment processes. Further research and analysis of each technique would be required prior to its implementation. G&S would undertake detailed analysis and analyse each process based on the following:

- Its specific site suitability.
- Total cost
- Potential waste generated
- Maintenance steps and;
- Degree of specialisation required to maintain and run each process.

G&S considers the identified arsenic contamination in groundwater to be at a concentration and be of a quality that would respond well to the application of one or all of the discussed treatment processes. In addition, G&S considers the site's setting, the known depth to groundwater and geology at the site to be suitable for the application of a form of ex-situ treatment which would render the groundwater suitable for irrigation and in turn meet the remedial goal proposed within the RAP.

We trust this is acceptable. Please do not hesitate to contact this office if you require any further details or elaboration.

Yours sincerely,

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References:

1. USEPA, 2002, *Proven Alternatives for Aboveground Treatment of Arsenic in Groundwater'*, Engineering forum issue paper. United Staes Environmental Protection Agency (EPA). EPA-542-02-002 (revised 2002 edition). www.epa.gov/tio/tsp.

2. Ahmed, M. F. 2001, *An Overview of Arsenic Removal Technologies in Bangladesh and India.* Department of Civil Engineering, Bangladesh University of Engineering & Technology, Dhaka-1000, Bangladesh.

Attachments:

Attachment A: USEPA Engineering forum paper on groundwater treatment of arsenic.

Attachment B: Ahmed, M. F. 2001, *An Overview of Arsenic Removal Technologies in Bangladesh and India.* BU paper.

Attachment C: Enviropacific quote

SCALE
1:200

ORIENTATION
NORTH

LEGEND
- Site Boundary
- GW Groundwater Piezometer Location (19/10/10)
- GW6 Delineation Piezometer Locations (11/11/10)
- Inferred extent of arsenic contamination in groundwater

SOURCES
Image Source: Nearmap 2010

NOTE
GW2 re-drilled 11/11/10 to 4.5m below NSL
Conours in mAHD wtih a 0.2m interval.
Arsenic concentrations in GW4:

GILBERT SUTHERLAND

PROJECT
SHOAL POINT MACKAY

CLIENT
SHOAL POINT BAY DEVELOPMENTS

DRAWING
APPROXIMATE EXTENT OF ARSENIC CONTAMINATION IN GROUNDWATER

DATE	DRAWN
3/12/2010	NG
SCALE	**CHECKED**
1:200	-

PROJECT NO	DRAWING NO	REVISION
10527	10527.1.8	1

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