Development of Geothermal Waters for Recreational Purposes – Mornington Peninsula Australia

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Peninsula Hot Springs is Victoria's first hot spring and spa facility that uses naturally elevated temperature groundwater. This paper presents an overview of the spa development, from its original conception through to the technical summary of the facility's production bores.

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Introduction

Peninsula Hot Springs is a relaxation and recreation facility with a source of 47ºC thermal water drawn from an aquifer located 600 metres below the surface. Purchased in 1997 the 42 acre (17 hectare) property is located in Fingal on the Mornington Peninsula, approximately one and a half hour's drive south from Melbourne.

After eight years of planning, drilling and raising finance, the first trial phase of the facility opened in June 2005. The initial stage provided facilities including public and private hot spring pools, a massage spa centre, relaxation rooms, a café and gift shop. A second phase of development commenced operation in December 2009 with the opening of a large Bath House bathing facility.

Future stages will see a further expansion in bathing, 126 rooms of accommodation, a Wellness centre and a planned geothermal demonstration of greenhouse and aquaculture operations.

Conception and Inspiration

The inspiration for Peninsula Hot Springs came from a 1992 bathing experience in the Japanese town of Kusatsu. Laying in the hot thermal waters, with snow all around, Peninsula Hot Spring founder Charles Davidson wondered why hot springs were not available in Australia and became inspired. A chance conversation with the head of the Victoria State office in Tokyo in 1997 revealed the existence of thermal waters deep underground on the Mornington Peninsula. By December that year, a 17 hectare site was purchased at the northern end of Davenport Drive, Rye, and the master planning was under way.

As there was no hot spring bathing culture in Australia at the time, and as Australia was home to people from all cultures of the world, the idea became to blend the best of world bathing cultures within the unique natural Australian environment. Travels to 18 countries to research the bathing and spa cultures lead to the development of a global hot springs spa.

Facility Development

Peninsula Hot Springs has two bores which are constructed into the Lower Tertiary age Werribee Formation, the basal unconsolidated sedimentary sequence of the Port Phillip Basin. The original steel cased production bore is used to supply geothermal waters of in excess of 47^{o}C to the recreational complex for bathing and hydronic heating.

To enable further increase in bathing offerings and to create a sustainable business, a re-injection bore began construction soon after the opening of the stage two facility. The bore was completed in October 2010 and the re-injection system was commissioned in May 2011. The system installed is designed to provide sufficient capacity for the projected geothermal requirements for the completion of the facility.

Community Impact and Investment

Peninsula Hot Springs employs 143 staff and is attracting over 250,000 visitors annually. The on-going development of the site has been driven by the huge demand for bathing in thermal waters and the significant growth in the spa and well being industry over the past 10 years.

Annual turnover was $11.5 million in 2010/11 and will be more than $14 million in 2011/12. Many of the visitors to Peninsula Hot Springs stay in the region, dine at restaurants and cafes and visit wineries, golf courses and other tourism attractions during their stay. This provides flow on economic benefit to the local economy. In its six years of operation Peninsula Hot Springs has grown to be the most visited tourism attraction in the region.

Geothermal Resort Potential in Victoria

Victoria's Spa and Wellness Tourism Action Plan (2005 – 2010), a first for Australia, emphasised the under development of spa and recreational facilities in the Victoria. With over 100 recognised mineral springs, Victoria has by far the highest number of natural springs in the country. An update of this plan for the years 2011-2015 was

released in September, 2011 emphasizing the ongoing commitment of the Victorian Government to the growth of the spa and wellbeing market. Together with the launch of the spa and wellness action plan (Tourism Victoria 2011), a business case for geothermal spa development in coastal Victoria aiming to attract new investment in the industry.

The development of the geothermal resource and the spa facility has been a massive undertaking by Peninsula Hot Springs. Eight years in the start up phase and the subsequent 6 years of operation and ongoing development have seen over $14 million invested in the facility. Peninsula Hot Springs pioneered geothermal development in the Mornington Peninsula and established a premier Victorian tourist attraction.

Development of Peninsula Hot Springs predates the proclamation of the *Geothermal Energy Resources Act* (2005), a framework that provides resource security, allocation and environmental planning. Projects that involve bores at temperatures less than 70°C or where the heat source is less than 1 km below the earth's surface, will not require an exploration permit. This Act greatly encourages investment.

Other developments have subsequently occurred in Warrnambool in the States southwest, relying on similar age (Tertiary - Eocene) geological formations (Dilwyn, Pebble Point Formations) within the Otway Basin. Potential also exists elsewhere in the Port Phillip and Gippsland Basins, and to a lessor extent in the Murray Basin owing to its distance from major tourism centres.

Geological Targets

Stratigraphy

Peninsula Hot Springs is located at the southern end of the Mornington Peninsula, and lies within the geological structure referred to as the Port Phillip Basin. The basin has been infilled with several phases of volcanics and sediments during the Tertiary and Quaternary periods.

The general stratigraphic sequence for the Port Phillip Basin has been described by many (e.g. Birch, 2003) and a summary has been provided in Table 1.

Previous Drilling

The characteristics of the basin on the eastern side of Port Phillip Basin was determined through the drilling of two deep investigation (Nepean 37 and Nepean 38) drilled by the former Mines Department of Victoria. These bores, drilled at Sorrento and Rye respectively, extended to depths of 1,273 metres and 942 metres respectively. Nepean 38 was constructed for groundwater observation purposes and remains an integral bore in the State observation network. Nepean 37 was not constructed and was plugged and abandoned following the completion of drilling.

Period	Formation	Lithology
Quaternary (Pleistocene)	Bridgewater Fm	Variable mixtures or sands, clays, calcareous aeolinites
Tertiary (Pliocene)	Wannaeue Fm.	Shelly sandstones and calc-arenites
Tertiary (Miocene – Pliocene)	Brighton Group	Sands, clays
Tertiary (Miocene)	Fyansford Fm / Demons Bluff	Marls (marine deposition)
Tertiary (Eocene)	Werribee Fm	Sands, silts, clays and coals (fluviatile origin)
	Older Volcanics	Basalt
Palaeozoic	Basement	

Table 1 Port Phillip Basin Stratigraphy

Information gathered during the drilling and monitoring of these bores provided valuable information as to the potential for low grade geothermal development in this region. This information was listed in King *et al,* 1987 who noted that elevated groundwater temperatures and geothermal gradients were present along the Mornington Peninsula.

Geothermal Gradients

King *et al* (1987) reported a geothermal gradient of 5 ^{o}C/100 m depth. The source of the elevated geothermal gradient is believed to be the Selwyn Fault.

The Lower Tertiary age sedimentary sequence therefore presented itself, based on the historical drilling information, as being a potential low grade geothermal prospect for development for recreational purposes. In addition, being within the Mornington Peninsula tourism region, and the proximity to Melbourne provided added marketing opportunities for a spa development.

Licensing and Approvals

Victoria Groundwater Licensing Overview

The Victorian Department of Sustainability and Environment (DSE) have recognised areas of intensive groundwater use throughout Victoria. The principle management unit for groundwater resources in Victoria is the Groundwater Management Unit or GMU. A GMU may be a Groundwater Management Area (GMA), a Water Supply Protection Area (WSPA) or an Unincorporated Area. These are declared under the *Water Act* (1989) to ultimately provide sustained management of the groundwater resources.

The Peninsula Hot Springs facility is located within the Nepean GMA. The GMA was initially

defined to manage the surficial aquifers e.g. Bridgewater and Wannaeue Formation. No depth limit has been applied to the formation, and therefore management controls also apply to all aquifers in the vertical profile including the target aquifer for this project the deeper Werribee Formation.

Licensing

A groundwater extraction licence was issued by Southern Rural Water to 'take and use' groundwater under the *Water Act* (1989).

The groundwater licensing process involved referrals to South East Water and the Victorian Environment Protection Authority (EPA), and therefore a condition of the extraction licensing was the subsurface disposal of waste water.

Peninsula has installed a second production (injection) bore with the ultimate objective of returning their waste stream to the source aquifer.

Production Bores

Bore Design

The original bore installed on the property (bore 144197) was constructed with mild steel casing. The objective of this bore was to prove up the geothermal resource. It was completed in early 2002. The second production (injection) bore installed at the site (WRK056027) has been constructed with Fibre Reinforced Plastic (FRP) casing and stainless steel. It was completed in mid 2010.

The shallow groundwater resources within the Bridgewater and Wannaeue Formations are widely developed for irrigation use, hence the declaration of the Nepean GMA. Groundwater quality in the shallow aquifers is often less than 300 mg/L TDS (Birch ed, 2003). The groundwater in the deeper Werribee Formation is of poorer quality, approximately 3,000 mg/L TDS (Laing, 1980).

Casing Annular Seals

Owing to the differing water qualities, casing in both bores (144197 and WRK056027) was pressure cemented to provide a seal to hydraulically isolate the shallow and deeper aquifer system. Whilst this was a mandatory of the bore construction license issued by Southern Rural Water, it also provided confidence to local irrigators that their shallow resource would not be adversely impacted by the development.

Development Zones

Wireline geophysical logging (e.g. natural gamma, neutron, density and temperature) was used during the pilot hole drilling to identify permeable, coarse grained lenses within the Werribee Formation for development. The basal lenses within the Werribee Formation were selected to maximise the temperature of the production water.

Bore 144197 is screened over two intervals between whereas the second bore WRK056027 has a single 20 m screen (refer Table 2).

Screen Designs

Lithological samples collected during the drilling program underwent particle size distribution testing to determine appropriate sizes for screen apertures. Stainless steel screens were specifically designed to maximise production. The screen intervals are summarised in Table 2.

Bore	Screen From - To	Aperture
144197	533 m to 540 m (7 m)	0.635 mm
	612 m to 622 m (8 m)	0.76 mm
WRK056027	521 m to 541 m (20 m)	0.3 mm

Table 2 Bore screen intervals

Production Bore Testing

Performance (pumping) tests have been conducted on both bores. Bore WRK056027 was capable of flow rates in excess of 30 L/s and sustained flow rates rate over 1 ML/day over a 24 hour period.

Conclusions / Learnings

Peninsula Hot Springs has successfully developed the low grade geothermal groundwater resources of the Werribee Formation on the Mornington Peninsula.

Peninsula Hot Springs are the first to develop the deep geothermal groundwater resources in this region which came at some risk due to the paucity of deep drilling information in the region.

There were difficulties in securing competent drilling contractors during the period owing to prevailing drought conditions throughout Victoria. The timing of the second borehole was delayed by drilling contractor unavailability, and drilling difficulties were experienced during its drilling.

Geochemical modelling was undertaken to assess the compatibility of re-injection waters. Numerical groundwater modelling was also undertaken to determine the potential for recycling of waters and long term impacts on the heat resource. Peninsula Hot Springs are undertaking a comprehensive monitoring program for their re-injection bore to assess and monitor its performance.

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