# A Research Well for the Pawsey Geothermal Supercomputer Cooling Project

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Abstract:

The Australian Government has funded the Pawsey supercomputer in Perth, providing computational infrastructure intended to support the future operations of the Australian Square Kilometre Array (SKA) and to boost next-generation computational geosciences in Australia. Supplementary Federal EIF funds have been directed to the development of a geothermal exploration well to research the potential for direct heat use applications at the Pawsey Centre site. Cooling the Pawsey supercomputer may be achieved by geothermal heat exchange rather than by conventional electrical power cooling, thus reducing the carbon footprint of the Pawsey Centre and demonstrating an innovative green technology that is widely applicable in industry and urban centres across the world. The exploration well is scheduled to be completed in 2013, with drilling due to commence in the third quarter of 2011. One year is allocated to finalizing the design of the exploration, monitoring and research well, and first concepts will be presented at AGEC for discussion and participation. Success in the geothermal exploration and research program will result in an industrial-scale geothermal cooling facility at the Pawsey Centre, and will provide a world-class student training environment in geothermal energy systems.

Keywords: Direct Heat, Absorption Chiller, Hot Sedimentary Aquifer, SKA, High Performance Computing

## Introduction

June 9th, 2010 marks the first step to one of the largest direct heat demonstrators in Australia. A direct heat geothermal demonstration project, using hot sedimentary aquifers to provide cooling and ventilation to the Pawsey High-Performance Computing Centre and the co-located CSIRO facility the Australian Resources Research Centre secured funding through the Sustainability Round of the Education Investment Fund (EIF). The Pawsey Centre demonstrator is part of the infrastructure of Australia and New Zealand's bid to host the SKA (square kilometre array) radio telescope. The Pawsey Centre (see Figure 1) supports the enormous data requirements for deep space research and is also planned to be a prime enabling platform for Australia's computational geoscience and nanoscience communities. The supercomputer-cooling project will be the first of its kind and will demonstrate the feasibility for widespread use of the clean and sustainable geothermal energy source to power, for example, hospitals, shopping centres and other industrial scale applications.

The Pawsey Centre is to be situated on the deep sediments of the Perth Basin, where a vertical sequence of hot sedimentary aquifers suitable for direct heat geothermal applications is now being studied.

Construction on the exploration well project is scheduled to commence in November 2010, drilling of the exploration hole is scheduled for November 2011 and the project is to be completed in August 2013 (see table 1), the provisional timetable is coordinated with the international SKA decision-making process. Australia and New Zealand, together, are in competition with an African SKA bid, involving South Africa, Namibia, Botswana, Mozambique, Madagascar, Mauritius, Kenya and Ghana. A decision is expected to be made in 2012. The Pawsey Centre geothermal demonstrator is part of a portfolio of solar and geothermal technologies, notably an additional ground source heat pump design for radio antenna cooling. The overall goal is to supply a reliable and clean, sustainable energy solution for the Australian/NZ SKA bid.

This contribution gives a brief overview of the entire concept, its location, timing, and the above and below ground technology concepts planned to support the design of a production geothermally powered cooling system. Collaborations between Australian and NZ researchers on potential designs for the exploration well are discussed.

## The Pawsey Supercomputer Cooling project, a brief overview

One of the strategic goals of the successful EIF Sustainability Round proposal is to form through demonstration projects a joint research focus for scientists and students from all over Australia and NZ in renewable energy, as well as in astronomy, computer science, engineering, geology and environmental management.

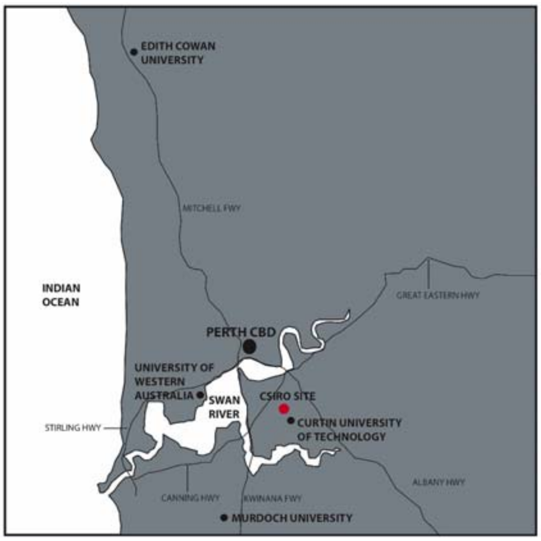


Figure 1. The Pawsey High-Performance Computing Centre cooling project will be located on the CSIRO Technology Park site near the Perth CBD close to Western Australian universities.

The Pawsey Supercomputer Cooling (PSC) project is located centrally in Perth (Figure 1) and its collaborations with Australian and NZ partners sets a sound basis for achieving this goal. The additional placement of a research well offers the necessary infrastructure investment for research collaboration in the wider Australian and NZ geoscience community for testing, monitoring and exploitation of hot sedimentary aquifers.

The PSC direct heat geothermal demonstrator utilises a hot sedimentary aquifer under Perth with an estimated temperature of 100 °C at 3 km depth.

Based on the available information and extrapolation from a 3 km deep petroleum exploration well (Cockburn 1, see Figure 3) located 21 km away from the Pawsey site one possible scenario could be a 3 km deep extraction and injection well into the Cadda formation with a measured permeability of 632-732 mDarcy and a measured layer thickness of 350 m. Another optional target layer is the Yarragadee aquifer directly above the Cadda formation featuring permeabilities of up 1200 mDarcy according to the Cockburn 1 records. The advantage of this target is its expected lower salinity than the Cadda Formation. Shallower portions of the Yarragadee aquifer have been successfully used in ten different fully commercial low-temperature projects in Perth, mainly for swimming pool heating. The injection wells in such systems are much shallower than the extraction bores which implies minimal risk of thermal breakthrough. The selection of injection depth is governed by local permeability, net formation water balance and water quality. Choice of the lower Yarragadee over the Cadda will depend on the trade off between flow rates and temperatures encountered in the exploration well.

The first design of the above ground infrastructure comprises two absorption chillers (Figure 4) at a

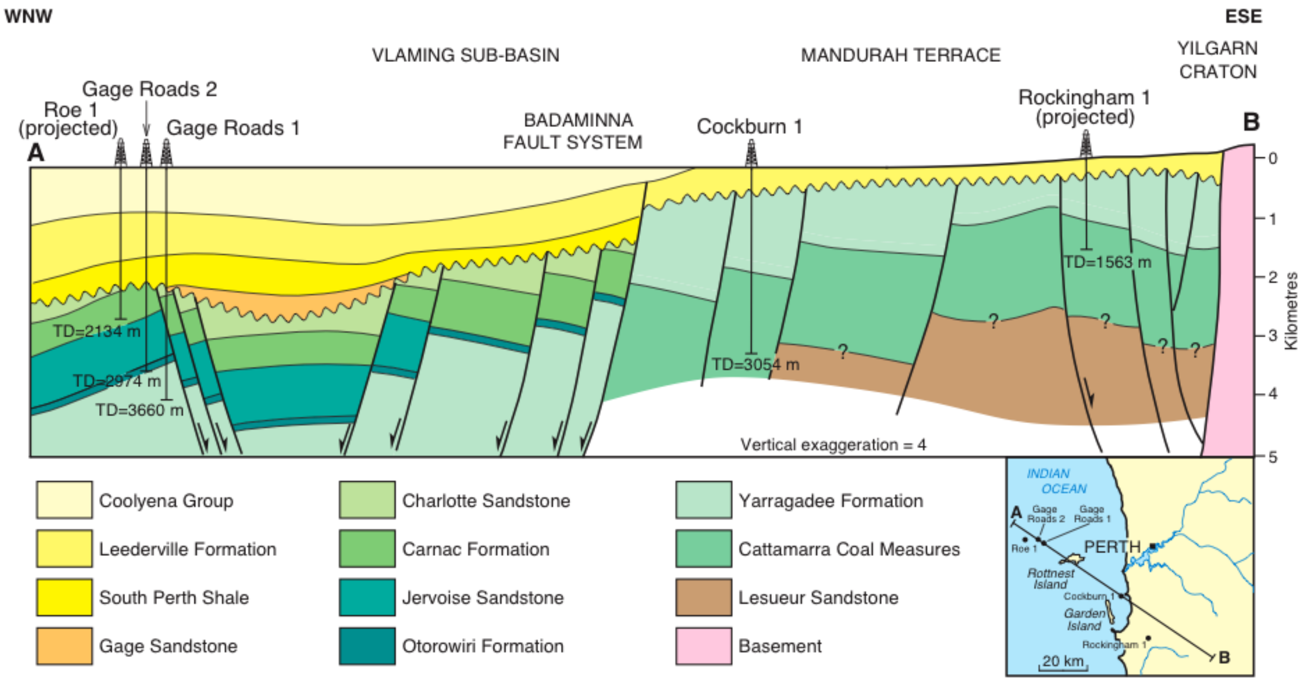


Figure 2. Stratigraphy along a section through Cockburn 1 deep petroleum exploration well, passing ~20 km to the south-west of the Pawsey Centre. Section from Crostella and Backhouse (2000).

maximum capacity 5 $MW_{th}$ each, one unit is implemented as a backup unit. The dimension for each chiller is around 9.38m(L) x 2.2m (W) x 3.6m (H). The absorption chillers require heat rejection with an approximate maximum capacity of 25 $MW_{th}$. The preliminary design will be adjusted once the actual cooling requirement of the PSC is known.

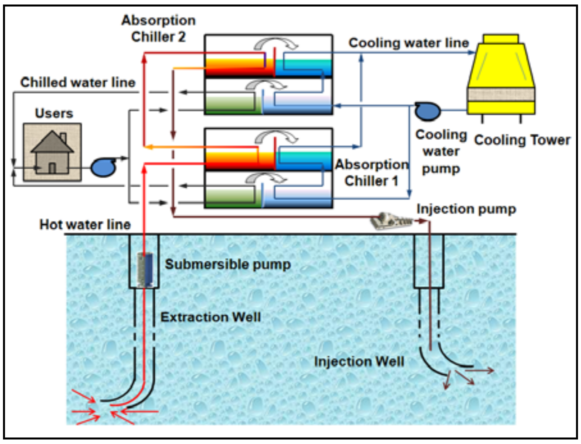


Figure 3. The Pawsey High Performance Computer cooling demonstrator design scheme consists of absorption chiller technology driven by heat from the hot sedimentary aquifer.

Table1 Preliminary Timetable*

| Planned Project Milestone | Planned Completion Date |
|---|---|
| Project start | October 2010 |
| Perth geothermal drilling program commences | August 2011 |
| Perth geothermal drilling completed | November 2011 |
| Project completion | December 2013 |

* timings are tentative only and subject to revision

## The Dual Purpose of the Exploration/Research Well

The exploration/research well is designed for a dual purpose: (1) it breaks the ground and obtains the first direct samples of the chosen site prior to installation of the geothermal production wells; and (2) it offers the unique opportunity for implementing purpose-designed downhole-sensors, long term monitoring and active testing.

An additional attraction for research may be a small flux of geothermal waters from the aquifer, which could be abstracted for testing small scale above ground demonstrators. Key aspects of the sampling include water quality analyses that provide important indicators for heat exchange plant and reinjection sustainability. Given, the long lead-up time for commencement of drilling (Table 1) the design of the exploration well and the above and below ground research components are fully open for discussion. In the spirit of the EIF funding we call here for active research collaborations that can complement the funded infrastructure with the best available expertise and interpretation.

## Preliminary design scenarios of the Exploration well

There is no hard data indicating water temperature (and chemistry) at depths of ~3 km in the Perth Basin – the proposed depth of the geothermal production wells. Data acquired from the drilling program associated with the UWA geothermal demonstration site will provide a better indication of water temperature at depth in the Perth Basin, but will not obviate the need for the ARRC geothermal exploration/research well.

This depth of drilling is based on data sourced from a ~800m Water Corporation bore adjacent to the ARRC site. Data recently acquired from re-logging this bore by the WA Geothermal Centre of Excellence suggests water temperatures of ~100 °C at a depth of 3 km. Temperature, (fluid and sediment) chemistry and permeability data will be acquired through the proposed geothermal exploration/research well. Data on the advective regimes operating at depth in the stratigraphic sequence will also be sought in order to facilitate the construction of a geothermal reservoir model for the Pawsey Centre.

The reservoir model will include hydrothermal flow processes necessary to describe circulation phenomena in moderate-permeability HSA geothermal plays. The reservoir model will inform the design specifications of the subsequent production and injection well infrastructure.

In preparation to the EIF bid IPS Australasia has been tasked to prepare potential design scenarios for the exploration well which are here laid open for discussion. A number of scenarios have been considered for the drilling, evaluation, testing and completion of the exploration well with proposed schematics shown in Figure 4.

### Scenario 1 (Base Case)

Scenario 1 (Base Case) is designed with a three-string casing program with final hole section cased with 178mm (7") casing to 3000 m True Vertical Depth from Rotary Table (TVD RT) (Figure 5). This design places the 244 mm (9-

5/8") surface casing at 1000 m TVD RT in the Yarragadee Formation and contains the above Leederville and South Perth Shale behind casing (Figure 2). This design offers a 216 mm (8-1/2") open hole to conduct straddle testing of the proposed target intervals to 3000 m TVD RT.

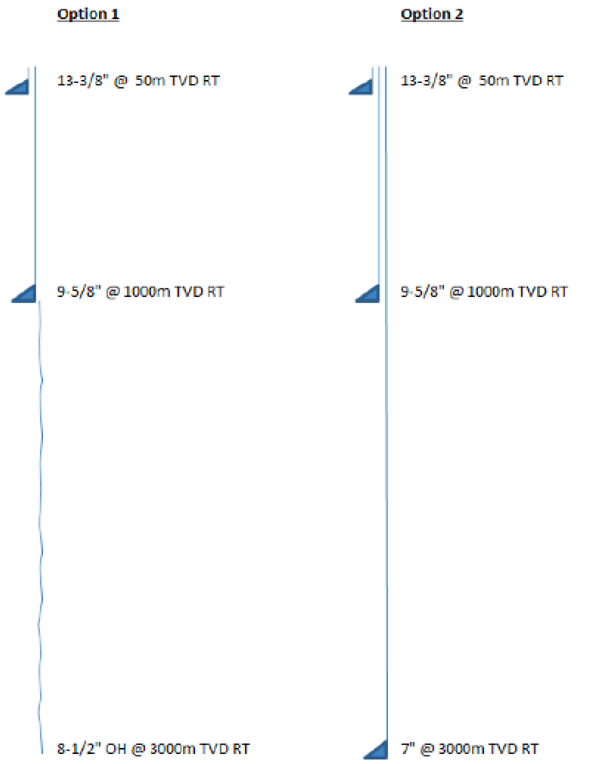


Figure 4. Wellbore schematics of the exploration well according to a Desk Study of IPS Australasia

The casing configuration is summarized as follows:

- The 340 mm (13-3/8") conductor shoe is set at a depth between 50 and 100 m TVD RT.
- The 244 mm (9-5/8") casing shoe is set at a depth of approximately 1000 m TVD RT.
- At well TD of 3000 m TVD RT following open hole testing of target intervals, a 178 mm (7") casing string will be set.

### Scenario 2

Scenario 2 is of a similar design to Scenario 1 with a three-string casing program to 3000 m TVD RT with the addition of a 152 mm (6") hole section drilled to 3500 m TVD RT. This design places the 244 mm (9-5/8") surface casing at 1000 m TVD RT in the Yarragadee Formation and contains the above Leederville Formation and South Perth Shale behind casing. This design offers a 216 mm (8-1/2") open hole to conduct straddle testing of the proposed target intervals to 3000 m TVD RT. The 152 mm (6") hole section drilled to 3500 m TVD RT will allow formation evaluation of deeper target intervals with the option of testing and casing with a 5" liner.

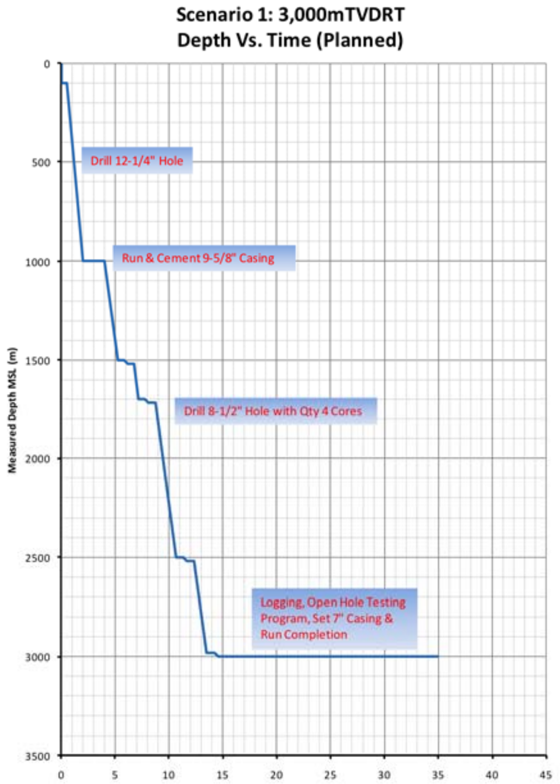


Figure 5. Wellbore schematics of Scenario 1 exploration well suggested by IPS Australasia (2009).

The casing configuration is summarized as follows:

- The 340 mm (13-3/8") conductor shoe is set at a depth between 50 and 100 m TVD RT.
- The 244 mm (9-5/8") casing shoe is set at a depth of approximately 1000 m TVD RT.
- Following open hole testing of target intervals to 3000 m TVD RT, a 178 mm (7") casing string will be set.

## Preliminary Design of the Research Equipment

The preliminary list of research equipment for deployment in the exploration well includes:

**Along-Casing Sensors**: Optical fibre temperature monitoring system (Raman scattering based), Optical fibre pressure, temperature, acoustic, EM (Bragg grating/cladding based), Surface optical system, electromagnetic/magneto-telluric-receiver-station.

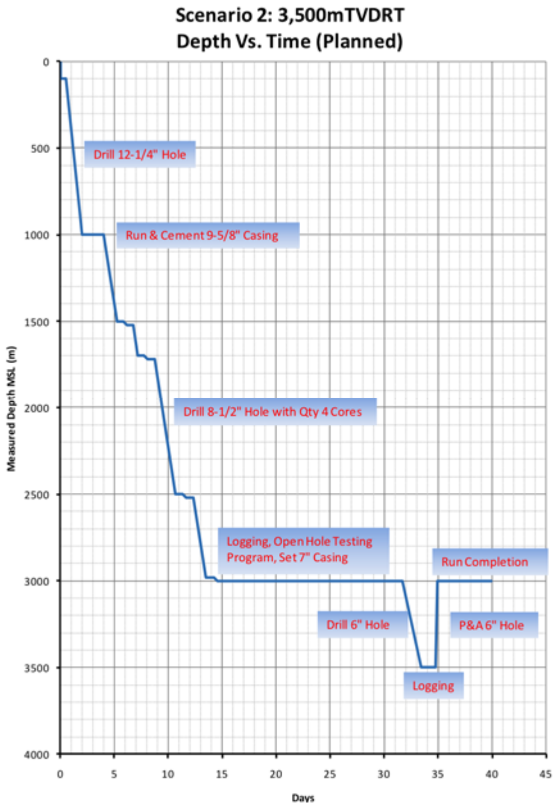


Figure 6. Wellbore schematics of Scenario 2 exploration well suggested by IPS Australasia (2009)

**Inside Hole:** Water pressure tube, mechanical packers, banding standoffs (cable protectors between pipes), pressure transducer, geochemical / environmental monitoring sampling system

**Downhole Sonde:** Deep sonde (seismometer) thermistor, fluxmeters (desorption method which need to be deployed in packed zones to isolate from in-well gradients.

**Redeployable Wireline Exploration System:** Wire / data cable and winch system flow meter downhole formation imager, spectral gamma tool, electrical conductivity, caliper log.

This equipment will allow us to monitor the pressure, temperature and acoustics of the aquifer along time and depth, collect fluid samples at a range of depths for geochemistry analyses, seismic, flow rate and temperature data to monitor the impact of the production plant.

## Above Ground Engineering Research

While this project is demonstrating the direct use of the geothermal heat in space cooling, another objective for the Australian geothermal energy sector is the generation of electricity using geothermal heat. Additional targets are proof of technology for geothermal desalination of seawater, saline aquifer water and industrial process water. Both Australian based inventions are currently being built with support from different Centres of Excellence in Australia.

The Queensland Geothermal Energy Centre of Excellence (QGECE) is developing new supercritical cycle technologies to increase electricity production from a given geothermal resource by up to 25% for low temperature geothermal resources and by up to 50% for high temperature geothermal resources. One of the current research projects at the QGECE is aiming to develop a 100-kWe portable power plant to demonstrate a supercritical power generation capability for a sub-150°C geothermal resource. Using this plant as a test bed, optimum design and operating conditions can be ascertained for electricity generation using the geothermal fluid produced by a Perth Basin hot sedimentary aquifer in local ambient conditions.

The Western Australian Geothermal Centre of Excellence (WAGCoE) in collaboration with the National Centre of Excellence for Desalination intends to use the extracted geothermal water both as a heat source and feedstock to develop a WAGCoE's protected distillation based desalination technology by constructing a containerized 4 $m^3$/day desalination plant, as schematically suggested in Figure 7. This technology is expected to boost the freshwater yield of conventional technology by 30%.

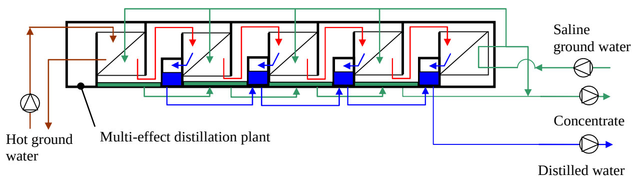


Figure 7. A geothermal distillation desalination plant

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