Review of material relating to extraction of water from “water veins”

NSW Chief Scientist and Engineer

July 2015

NSW GOVERNMENT | Chief Scientist & Engineer

21 July 2015

The Hon Niall Blair MLC
Minister for Primary Industries
Minister for Lands and Water
GPO Box 5341
Sydney NSW 2001

Dear Minister

Review of extracting water from "water veins"

I refer to your request of 6 May 2015 to review and provide advice on the technique of extracting water from "water veins" currently being promoted as providing a long term and sustainable solution to water insecurity in regional NSW.

In your request for advice, you indicated that while you were aware that the claims about water veins were not consistent with peer-reviewed literature and that scientific details had not been provided, a pilot project might be considered should the science prove sound through this review. You also commented on the real concerns and vulnerability of regional communities regarding water security.

To inform the advice for you on this matter, we consulted respected experts in various relevant scientific disciplines. These experts could not find evidence to confirm the proponents' claims about the existence of "water veins". The experts found that the claimed properties were inconsistent with scientific knowledge. The details of the claims and of the experts' opinions of them are covered in the report below.

Given the experts' findings that the "water veins" technology does not appear to have a sound scientific basis, I recommend that a pilot test project funded by government not proceed.

However if the proponents are confident about the merits of their technology, they could be encouraged to commission a reputable third party organisation such as a leading university, CSIRO or Geoscience Australia to carry out a pilot test project to test their claims independently in a NSW setting.

In sending this report to you I would like to acknowledge the assistance of several people and organisations. ACE Drilling Pty Ltd and Quantum Water Corporation Ltd

provided answers to wide range to questions. The experts consulted prepared detailed reports.

I am happy to assist further on this matter if needed, and am available to discuss further steps that may be required, including communication more broadly across government and to local communities.

I will report further should information come to light that in any way affects this advice. In the interim, should you or your staff have any questions regarding this issue, please contact Dr Chris Armstrong, Director Office of the Chief Scientist and Engineer on 02 9338 6745 or chris.armstrong@chiefscientist.nsw.gov.au.

Yours sincerely

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Mary O'Kane
NSW Chief Scientist and Engineer

Acronyms

CMJ	C.M. Jewell & Associates Pty Ltd
GA	Geoscience Australia
OCSE	Office of the Chief Scientist & Engineer
PWBS	Premium Water Bore Service
QW	Quantum Water Corporation Ltd
UNSW	University of New South Wales
WRL	Water Research Laboratory

Executive Summary

The NSW firm, ACE Drilling Pty Ltd, is marketing a Premium Water Bore Service (PWBS), which is provided in addition to other water drilling services it provides. The PWBS is based on services and research undertaken by a European company called Quantum Water Corporation Ltd (Quantum Water), with laboratories in Germany and headquarters in the UK. Through this PWBS the proponents claim to be able to identify the location of "water veins", which it claims provide limitless non-conventional sources of potable underground water.

The proponents have produced a number of documents and websites that make claims about "water veins" and the methodologies to locate them, although no single document was identified that explained the phenomenon comprehensively, and further, as confirmed by the proponents, they have not published the results of their work in the peer-reviewed literature, nor through patents.

The prospect of a new limitless supply of pure water is of great interest to many residents of NSW given the current drought conditions in many parts of the state. Given this interest, and the lack of available information on this non-conventional water supply, the NSW Chief Scientist & Engineer was asked by the NSW Minister for Lands and Water to provide advice on the science and explore the possibility of undertaking a pilot trial of the technology.

A number of experts were consulted during this review, who commented on the claims made by the proponents, as set out below.

- The proponents' claims about the existence of "water veins" could not be confirmed with evidence, and the experts found that the claimed properties were inconsistent with scientific knowledge.
- The proponents' claims about high pressures and ultra-high frequency oscillations or ultra-high resonant oscillations changing the state of water such that it would move through unfractured hard rock has never been reported in the scientific literature and did not seem possible.
- Claims made by the proponents in relation to water quality were unsubstantiated and seemed not possible in some cases. One of the experts stressed that it is important that water quality is assessed when a new water source is accessed and ongoing monitoring is also important.
- Assertions by the proponents that minerals containing hydrogen atoms in solid crystalline rock 400 – 600km deep in the earth can act as a water reservoir for society appear to be incorrect.
- A number of the experts commented on the lack of detail provided on the identities or qualifications of the German laboratory team associated with Quantum Water, with one expert commenting that he found it concerning that the names and CVs cannot be released for security concerns.
- The proponents were unable to provide any information on what parameters of the "water veins" the proprietary technology was detecting.
- The proponents did appear to have a fast turnaround on identifying a drilling location.
- Other hydrogeological techniques commonly used to locate water were listed in the proponents' materials.
- The experts could see no scientific basis for the claims about "water veins" being made to date by the proponents. However, one expert has identified a set of

studies that could assist the proponents in demonstrating the merits (or otherwise) of their claims.

- There were a number of inconsistencies in the material developed by the proponents.

In the light of the experts' findings that the "water veins" technology does not appear to have a sound scientific basis, it is recommended that a pilot test project of the technology funded by government not proceed.

1. Introduction

On 6 May 2015, the Minister for Primary Industries and Minister for Lands and Water, the Hon Niall Blair MLC, requested the Chief Scientist & Engineer to review and provide advice on the technique of extracting water from "water veins" currently being promoted as providing a long term and sustainable solution to water insecurity in regional NSW (ACE Drilling, 2015d).

The company promoting the concept of extracting water from "water veins" in Australia is ACE Drilling Pty Ltd, which is a NSW-based drilling company. ACE Drilling is acting as the Australian agent for a European firm, Quantum Water Corporation Ltd ('Quantum Water'), and is the exclusive dealer of this technology throughout Australia (ACE Drilling, 2014). It is understood that Quantum Water is a private limited company headquartered in the UK but key personnel and activities are based in Germany (B. Joshi and M. O'Neill, personal communication, 27 May 2015).

The technology has been identified as proprietary by the firms, and is marketed in Australia as 'ACE Drilling Premium Water Bore Service' (ACE Drilling, 2015a). The technology/service (cited as a "water vein system") is claimed to be a new water bore drilling service, building on research by a team of German scientists over 30 years, accessing a network of water systems "totally unrelated to conventional groundwater systems (aquifers, fractures, faults, cavities etc)" (ACE Drilling, 2015d).

ACE Drilling has garnered significant interest from the community in regional NSW seeking a solution to water supply, which is of particularly high importance in drought-affected areas in the state. Given the water system being described by the companies is non-conventional, a review of the scientific basis behind the concept was sought, and consideration of whether a pilot test project would have merit.

There is little information in the public domain on either a "water veins" phenomenon, or the technology that Quantum Water has claimed to have developed to identify the water or "water veins". It is understood from information provided by Quantum Water that the company chose not to publish research findings or patent inventions to maintain confidentiality and protect its intellectual property (B. Joshi and M. O'Neill, personal communication, 27 May 2015; B. Joshi, personal communication 17 June 2015; Appendix 1).

It is noted that Quantum Water provided a reference to a magazine article from 1953 by Stephan Riess that discusses water in deep rock fault system, separate from alluvium sedimentary aquifers, with the deep water described as "life giving veins in the earth" (Quantum Water Corporation Ltd., n.d.) (Appendix 5).

This report reviews the technique claimed by ACE Drilling to access water from "water veins". To contextualise this review, it is relevant first to describe what the proponents (ACE Drilling and Quantum Water) are claiming to be the characteristics of "water veins" and also how the proponents describe the technologies used to locate "water veins". Section 2 explains the process used in preparing this report.

Section 3.1 aims to provide a description of "water veins" and Section 3.2 aims to describe the associated characterisation technologies, as described in material from the

proponents. Section 4 then sets out the comments of the experts on the various claims made by the proponents about “water veins” and their technology.

2. Methodology and process for this report

In preparing this advice, the Office of the Chief Scientist & Engineer (OCSE) contracted the University of New South Wales Water Research Laboratory (WRL) and the Geoscience Australia Environmental Geoscience Division (GA) to provide expert hydrogeological advice. Work was undertaken by:

- Mr Doug Anderson, Principal Engineer at WRL, a specialist in groundwater modelling
- the GA Groundwater Advice group with expertise in geology and hydrogeology; overseen by Dr Stuart Minchin, Chief of the Environmental Geoscience Division, Geoscience Australia.

Each of the experts was directed to the website of the NSW company promoting the technology (ACE Drilling); was provided with a presentation from the company outlining its claims and services (Premium Water Bore Service); and was initially asked to comment on a set of questions, posed as follows:

a. provide an assessment of and advice on the concept of the non-conventional water system known as “water veins” and claimed properties
b. provide an assessment of and advice on the accuracy of the claims and comparisons made between conventional and non-conventional water sources
c. insofar as possible comment on any unique features of technologies or approaches as described in available material or literature
d. provide overarching comments on the approach, including engineering/scientific value and merit.
e. provide any other comment you believe relevant.

In order to gain a more in-depth perspective of the claims made about “water veins” and associated technology, advice was also sought directly from the proponents. OCSE contacted ACE Drilling and spoke with Mr Mick O’Neill from ACE Drilling and Mr Brian Joshi, located with ACE Drilling as Principal Technology Advisor and the Asia Pacific agent of the parent company for the Premium Water Bore Service technology – Quantum Water.

OCSE explained the process that we would use in reviewing the technology, including that material would be sent to the WRL and GA experts (publicly available material, slides etc.). With regard to further questions that the experts from WRL and GA had for ACE Drilling, Mr Joshi requested that all questions be put in writing to him and that he would direct them to relevant personnel as required.

Following these discussions, a series of questions in writing were sent to Mr Joshi, some sent through OCSE, others sent directly by the review experts. These questions and responses are attached (Appendix 1), together with the expert reports from WRL and GA (Appendices 2-3).

Also attached is additional hydrogeological advice obtained from C.M. Jewell & Associates (CMJ), which was based on publicly available information (Appendix 4).

In response to questions posed by WRL, advice received from Mr Joshi on 29 June included a document Vein Water System The Additional Water Source from Quantum

Water (Appendix 5). OCSE sought further advice from GA and WRL on this document (Appendices 6-7), as well as expert advice on deep earth systems from Professor Suzanne O'Reilly, Director of the ARC Centre of Excellence for Core to Crust Fluid Systems, Macquarie University. Her advice is at Appendix 8.

The Vein Water System document references two recent articles published in the prestigious journal *Science*. While having a different focus, both articles are concerned with the source and presence of water during planetary development. The first (Cleeves et al., 2014) is concerned with the origins of earth's water (specifically, whether it predates the sun) and the implications this has for the presence of water in the formation of other planets and therefore potential life. The second (Schmandt et al., 2014) explores the high water storage capacity of minerals in the earth's mantle at 400-600 kilometres depth. The lead authors of both articles were sent a copy of the Vein Water System document and asked to comment on whether the concepts relating to their work were being used appropriately in support of the company claims. A response was obtained from Schmandt (see below).

OCSE was provided by the Minister's Office with a slide set on the "water veins" technology which was forwarded to WRL and GA, however this has not been included in appendices as it possibly contains confidential material. When we spoke with ACE and mentioned that we had a copy of the slides and were intending to send them to the reviewers, ACE commented that they were probably provided by a client.

3. Descriptions of "water vein" and proprietary technology claims made by the proponents

3.1 "Water vein" information as described by the proponents

Quantum Water's claims about water veins have not been published by them in the peer-reviewed literature nor in patents (B. Joshi and M. O'Neill, personal communication, 27 May 2015; B. Joshi, personal communication 17 June 2015; Appendix 1). However both Quantum Water and ACE Drilling have a number of documents or websites that include information on "water veins" including on the companies' websites (ACE Drilling, 2015a; Quantum Water Corporation Ltd., 2015), fact sheets (ACE Drilling, 2014) (ACE Drilling, 2015b, 2015c), proposals (ACE Drilling, n.d.), the Vein Water System document (Quantum Water Corporation Ltd., n.d.) as well as in correspondence with the Office of the Chief Scientist & Engineer during the development of this report (B Joshi, personal communication, 17-18 June 2015; 29 June 2015).

The following section of this report aims to bring these elements together to describe "water veins" by drawing on information available from the proponents.

3.1.1 "Water vein" existence and structure claims

Geology claims

The proponents have described "water vein systems" as being created by very large magnetic fields (Quantum Water Corporation Ltd., 2011, n.d.) (Appendix 5) and as "a natural phenomenon which traverse through hard rock formations at high pressure and ultra-high resonant oscillations, making it easy to pass through all types of rocks such as granite..." and further, that the type of rock associated with "water veins" "are hard rocks (igneous – sedimentary or metamorphic)" (ACE Drilling, 2015d).

The proponents claim "water veins" do not occur in some geologies, the "only material through which vein water can't flow - Columns Basalt – it is too hard and it's frequency is

to different from those of water veins" (Quantum Water Corporation Ltd., n.d.), while the website also extends this somewhat to say that they do not occur in sand, clay or soil of any kind (Quantum Water Corporation Ltd., 2015).

Structure and origin claims

In the Vein Water System document provided to OCSE by the proponents in response to questions, Quantum Water has included a diagram and description of a "water vein" (Quantum Water Corporation Ltd., n.d.) (Appendix 5). This description and diagram appear to describe some properties of "water veins" as having, *inter alia*, two magnetic poles (N and S) at the centre of a vein, with the space between the poles created by Alfvén Waves, and with some water in this space. Surrounding this core there are claimed to be further layers of water and magnetic field structures, and an 'electromagnetic ring' around the entire structure.

The document goes on to describe some claimed phenomena of Alfvén Waves in the "water veins", including that waves in the "water veins" have the same basic structure as Alfvén Waves, "although the longitudinal part consists of photon impulses that have a very high frequency. As a result, information can be transmitted with and within the structure and the high pulse sequence ensures a high degree of stability of these connections. One could therefore call them 'cosmic Alfvén Waves', as they require photons in order to expand throughout the cosmos." (Quantum Water Corporation Ltd., n.d.). The Quantum Water website claims that "the underground water veins that are created by cosmic Alfvén waves which constantly influence the Earth" (Quantum Water Corporation Ltd., 2015).

In the response by Quantum Water to posed questions as part of this review it stated: "Alf[v]en Waves are associated with the formation of the water veins. In addition - Jacque Dirac already mentioned in 1927 that there are magnetic bodies that are filled with water; other scientists have also been working in this field" (see Appendix 1).

Further information on the Quantum Water website includes that the "water system has very high energy levels which are created and sustained by their unique physical conditions. Due to these energy levels and the fact that each vein is part of a global network of water veins within a particular system, each one of them is a never ending source of water, irrespective of the rain or ground water situation" (Quantum Water Corporation Ltd., 2015).

3.1.2 Claims of the nature of water in or from "water veins"

In various material by ACE Drilling and Quantum Water some descriptions of the nature or properties of the water, such as flow, volume and quality have been claimed, and are described below.

Claims about the causes of water flow

In relation to the flow of water within hard rocks, ACE Drilling claims "Water veins are confined within hard rocks but flow seamlessly between hard rock formations under the influence of pressure, resonant frequency of its surroundings and electromagnetic forces" (ACE Drilling, n.d.).

The Quantum Water website claims that when subjected to electromagnetic energies, the special physical properties of water can result in a phenomenon whereby, under specific conditions, water can concentrate (Quantum Water Corporation Ltd., 2015). The

Vein Water System document also provides text and a diagram relating movement of water and magnetic fields (Quantum Water Corporation Ltd., n.d.) (Appendix 5).

In a number of locations (ACE Drilling, 2015d, n.d.; Quantum Water Corporation Ltd., 2015, n.d.), the proponents have made statements about the movement of water being influenced by the vibrational frequency of the rock and commenting "…fascinating situation where water simply appears and flows out of granite. Physically this can only be possible if the vibration frequency of the rock/material is very similar to, or the exact same, as that of the water" (Quantum Water Corporation Ltd., n.d.).

On the ACE Drilling slides, it is claimed that "Under high pressure, heat and subjected to geophysical forces including ultra-high resonant frequencies, water molecules change their state and are capable of moving through materials that match the resonant oscillation of its surroundings" (ACE Drilling, n.d.).

Alfvén Waves are also mentioned on the ACE Drilling website as having an influence on flow: "The flow and direction of the water inside the system is influenced by cosmic waves (Alfvén waves) which have a constant influence on the earth" (ACE Drilling, 2015d).

A number of documents by the proponents make claims about the movement of water through hard rock such as granite, being caused by high pressures underground (ACE Drilling, 2015d, n.d.; Quantum Water Corporation Ltd., 2011).

While the proponents claim that Darcy's Law (typically used to describe the movement of groundwater systems) is of limited use: "In this context it is also important to realise that 'Darcy's Law', being an empirical parameter, can provide only limited information with regards to the flow of the water within the veins; as the resistance of materials is only of little impact within veins due to the very high similarity of the vibration frequency of the vein and the material itself" (Quantum Water Corporation Ltd., n.d.).

Claims about the volume of water available

ACE Drilling slides claim that "water supply is perennial, regardless of pumping rate and draw down" (ACE Drilling, n.d.), with the website claiming the system has a sustainable source and yield (ACE Drilling, 2015d). The Frequently Asked Questions sheet on the Premium Water Bore Service from 2014 also states that: sustainable yield is guaranteed; water bores would be drought proof; there would be permanent water security; and that there would be sustainable supply through permanent recharge from underground (ACE Drilling, 2014).

Slides from ACE Drilling indicate that the water system estimated yields per bore from a "vein water hard rock" bore are approximately 1 – 40 L/s (ACE Drilling, n.d.).

Claims about water quality

A number of claims relating to water quality are made in Quantum Water or ACE Drilling materials, including that water from "water veins" is freshwater (ACE Drilling, 2015d), that the water is guaranteed to be potable (ACE Drilling, 2014) and that the water quality is "exceptionally high and potable, regardless of geographic location" (ACE Drilling, n.d.). The quality of the water is claimed to be "due to the unusual geophysical properties of the water system, bacterial or microbiological organisms cannot exist, preserving the quality of the water at all times" (ACE Drilling, n.d.).

The Quantum Water website extends concepts of purity indicating that there may be other benefits: “Water from water veins is especially recommended for use as drinking water because of some extraordinarily (*sic*) qualities that are a result of the high pressure that the water is subjected to within the vein. This high pressure forces a change in the inner structure of the water molecules which in turn results in an unusually high inflow of energy benefitting those who drink it regularly” (Quantum Water Corporation Ltd., 2015).

3.1.3 Claims about “water veins” location and connectivity

Network of structures

The proponents have proposed that there is a hierarchical network of “water veins” underground that interlink across the globe (Quantum Water Corporation Ltd., 2015). The hierarchical nature is described as “parent-child” in a number of places (ACE Drilling, 2015d, n.d.).

There is not a great deal in the proponent material to describe the distribution and size of “water veins”, although they have the following paragraph in their Vein Water System document: “With our technology we can locate spots that are located in irregular patterns, at which this vein water can be accessed near earth surface, many between 50 to 500 meters. Depending on the pressure and water quantity within the spot, horizontal veins can emanate from these spots” (Quantum Water Corporation Ltd., n.d.) (Appendix 5).

Depth

“Water veins” are described in documents to exist at a range of depths “So far most of these veins have been located in the range of 1 to 100 kilometer below earth surface; with the pattern that deeper veins are larger and contain more water than veins that are located less deep” (Quantum Water Corporation Ltd., n.d.) (Appendix 5).

In terms of “water veins” claimed to be in shallower depths, the Quantum Water document claims that they are the source of water for many waterfalls, including the ‘Santos Angel’ Falls in South America (Quantum Water Corporation Ltd., n.d.).

The Quantum Water website also claims that “a large percentage of Water Veins are located in a depth between 100 and 250 meters below the surface. However, their depth and direction of flow vary, sometimes rather dramatically” (Quantum Water Corporation Ltd., 2015).

On the ACE Drilling Frequently Asked Questions sheet the implications for how deep the bore would need to be drilled are discussed: “The water system may be found at shallow depths anywhere from **40 metres to 150 metres**. If however your property resides in alluvial flood plains, the water systems will be much deeper and the water bore will have to be mud drilled through the alluvial and down to bed rock. In these instances the depths maybe between **200 metres to 400 metres** depending on the depth of bed rock and water system“ (ACE Drilling, 2014) (bold formatting in original).

Replenishment and connectivity of deep (old) water and shallow water

The proponents claim that the water in “water veins” is replenished from oceans in some cases (Quantum Water Corporation Ltd., 2015) (Appendix 5), and also from underground deep within the earth (Quantum Water Corporation Ltd., 2015), (ACE Drilling, n.d.). It is claimed the recharge from underground is constant, and integrates into the system from the high pressure and oscillations within the hard rock formations

(ACE Drilling, 2015d), ACE Drilling claims that this means that “you can pump your water bore **24/7/365, year on year** without worrying about recharge, even during severe drought” (ACE Drilling, 2014) (bold formatting in original).

The Vein Water System document discusses the work of Schmandt and others (Schmandt et al., 2014) and water reservoirs deep within the American continent (Quantum Water Corporation Ltd., n.d.). The Vein Water System document provided to OCSE indicates that the water is not in liquid form but bound to mineral, and “It is estimated that these water reserves are far more than those available on the earth’s surface, incl. ocean water!” (Quantum Water Corporation Ltd., n.d.).

ACE Drilling material states that “water veins are recharged from underground through various ways, one of which is the subduction of tectonics (*sic*) plates that drive seawater into the crust and mantle before being forced back up from heat, pressure and geophysical forces” (ACE Drilling, n.d.). The proponents also claim that the replenishment of water is unrelated to, or independent of, rainfall (ACE Drilling, 2015b, 2015d, n.d.).

Another source of the water, discussed by Quantum Water (Quantum Water Corporation Ltd., n.d.) is the cosmos when the solar system was formed, referring to work of Cleeves and others (Cleeves et al., 2014). The Vein Water System document also claims that “this connection is highly likely to still be intact” (Quantum Water Corporation Ltd., n.d.).

The Quantum Water website appears also to suggest this connection: “One additional theory postulates that the water of some veins stems from cosmos and replaces the water which disappears from Earth through the atmosphere” (Quantum Water Corporation Ltd., 2015).

3.1.4 "Water veins" and other groundwater

Although the proponents claim that "water veins" exist relatively close to the earth's surface, they postulate that they are totally unrelated to conventional groundwater systems including aquifers, fractures, faults, cavities etc. (ACE Drilling, 2015d). The proponents also claim that extracting this water from "water veins" "has no impact to catchment hydrology, groundwater systems or groundwater table" (ACE Drilling, n.d.).

This separation of "water veins" from conventional groundwater is claimed to be due to the pressure: "The pressure within the veins isolates the water within them from surrounding water and prevents it from mixing with local ground water which may or may not be present. This means that the water in the veins is always potable even if surrounded by contaminated or saline water. It also means that tapping into this source does not lower the ground water level, but may well raise it, if it is used for local irrigation" (Quantum Water Corporation Ltd., 2015).

The proponents claim that "these water systems are totally unrelated to conventional groundwater systems and no other technology in the world can precisely locate these water systems other than our very own" (ACE Drilling, 2014) and that those who use the ACE Drilling Premium Water Bore Service are ensured water security on their property even during prolonged periods of drought where conventional water bores may have dried up (ACE Drilling, 2014).

As a point of differentiation, the Vein Water System document states that groundwater "can be located with commonly available technology as it has a very high microwave resonance" (Quantum Water Corporation Ltd., n.d.).

3.1.5 Proponents' research on "water veins"

Publicly available material from the proponents indicates that the research and studies on "water veins" and the associated technologies has been undertaken by a team of scientists from Germany over the last 30 years (ACE Drilling, 2015d).

Information about the skills and qualifications of scientists and the organisation were requested including the name and certifications of the German laboratory that the Premium Water Bore Water Service uses and the names, qualifications and curricula vitae of the scientists that developed the claimed technology. OSCE was advised that "Due to security and confidentiality of our staff and scientific team, we are unable to provide this information" (B. Joshi, personal communication, 17 June 2015) (Appendix 1).

3.2 Description of proponent's proprietary technologies for locating and analysing water

Quantum Water's claims about their proprietary technologies to identify "water veins" have not been published by them in the peer-reviewed literature nor in patents (B. Joshi, personal communication, 17-18 & 29 June 2015; Appendix 1) although the company has provided some material about the techniques they use on websites (ACE Drilling, 2015d; Quantum Water Corporation Ltd., 2011, 2015), in fact sheets (ACE Drilling, 2014, 2015b, 2015c), proposals (ACE Drilling, n.d.) and the Vein Water System document (Quantum Water Corporation Ltd., n.d.) as well as in correspondence with OCSE during the development of this report (B. Joshi, personal communication, 17-18 & 29 June 2015) (Appendix 1).

3.2.1 Proponent material relating to their research

The proponents have indicated that the Quantum Water team in Germany has been developing the technology drawing on Geophysics, Quantum Physics and Mathematics (ACE Drilling, n.d.), with collaborative efforts reportedly leading to both hardware and software technologies (ACE Drilling, n.d.) to locate the water systems. As indicated above, information is not available about the laboratory or number, names or qualifications of staff (B. Joshi, personal communication, 17-18 & 29 June 2015; Appendix 1).

The proponents claim that new technology was required, as "these water systems are not visible using conventional tools and instruments, proprietary technologies have been developed which can now accurately locate each system and can forecast the depth, yield and quality of the water inside the system, without the need of hydrogeological surveys, test holes or ground survey teams" (ACE Drilling, n.d.). However while developed to target "water vein systems" it is also claimed that the technology is capable of targeting other water systems as well (ACE Drilling, n.d.).

3.2.2 Proponent material related to the proprietary technology and its capabilities

As mentioned earlier, Quantum Water has not patented technologies that it claims to have developed, and there is no clear explanation of what the technology is or does; or what characteristics of a "water vein" 'fingerprint' the technology identifies. It is referred to in correspondence to OCSE as "Black Box" technology (B. Joshi, personal communication, 17 June 2015; Appendix 1).

Quantum Water claims that the technology has been "designed to identify specific characteristics/properties of vein water" (Quantum Water Corporation Ltd., n.d.) (Appendix 5). Although there is little detail about what these characteristics are, there are some suggestions in various materials from the proponents.

The ACE Drilling material suggests that "Geophysical anomalies and EMF signatures of interested resources (*sic*) allow precise targeting of water systems" (ACE Drilling, n.d.), noting that the abbreviation 'EMF' in physics often refers to 'Electromagnetic Field'. The Vein Water System document (Quantum Water Corporation Ltd., n.d.) includes some information about what the technology does not detect: "In the process of our surveys & analysis for water veins we do not analyse changes or anomalies of the seismic, magnetic or electromagnetic situation of the strata" (Quantum Water Corporation Ltd., n.d.). The ACE Drilling proposition appears contradicted by the Quantum Water Vein document (Quantum Water Corporation Ltd., n.d.).

Some of the descriptions in ACE Drilling and Quantum Water material of the processes involved in the Premium Water Bore Service include:

- hyperspectral satellite surveys conducted over sites (ACE Drilling, n.d.)
- conducting satellite surveys & study to identify water targets and mark well locations with GPS markers (ACE Drilling, n.d.)
- datasets mined and processed using proprietary methods and technologies (ACE Drilling, n.d.)
- calibrating GPS targets using aerial photographs of the GPS markers. Target can be 10 metres ± out (ACE Drilling, n.d.)
- commencing drilling on targets with real-time satellite relay from site to laboratory in Germany (ACE Drilling, n.d.)

The Vein Water System document notes that a fundamental element of their "proprietary technologies for locating and analysing water based on satellite and photographic images of any area is the fact that pictures/photos do contain all information of everything present in the photographed area; whether it is visible or invisible. Our technologies enable us to qualify the information and with particular procedures, including with specifically developed mathematical formulas, determine the quality and location (including the depth below surface) of the water vein and the water that it contains" (Quantum Water Corporation Ltd., n.d.).

ACE Drilling material mentions some of the proponent's equipment and approach: "Our satellites, hardware and software are equipped to identify each type of water system that exists in hard rocks, similar to the way a finger print identifies an individual. Each type of underground water system has its own unique finger print which our technology can identify and decode. We can even tell the quality of the water, how deep it is and the water yield, all from our laboratory in Europe, without having to send a person on site or conduct experimental drilling" (ACE Drilling, 2014).

3.2.3 Other information required for locating "water veins"

Materials used by the proponents make it clear that in undertaking surveys for clients, they seek access to existing materials from land owners such as GPS coordinates, title maps, existing bore well logs and existing water quality reports (ACE Drilling, n.d.). It is made clear that it is the responsibility of the property owner to apply for a water bore license and provide a copy to the ACE Drilling, as well as providing the company with advice on 'no drill' areas (ACE Drilling, 2015; ACE Drilling, n.d.). It appears that this information is then used in addition to satellite surveys conducted by the proponents together with the proprietary technology (unknown) and mining of "image data sets" (ACE Drilling, n.d.). However, ACE Drilling also says that they…"can forecast the depth, yield and quality of the water inside the system, without the need of hydrogeological surveys, test holes or ground survey teams" (ACE Drilling, 2015d).

4. Comments on proponents claims

4.1 Comments on existence of "water veins"

Geological, hydrogeological and geophysics expertise was sourced by OCSE in preparing this advice. The experts advise that the information that they had access to relating to "water veins", whether from the public domain (ACE Drilling, 2014, 2015d; Quantum Water Corporation Ltd., 2011, 2015), (ACE Drilling, 2014) the Moira proposal slide set (ACE Drilling, n.d.), or information provided by the proponents in answering questions put to them (Appendix 1), did not provide any evidence of the existence of "water veins" and that the claimed properties of this "non-conventional source" are inconsistent with accepted scientific knowledge of geology and known physics for movement of water through hard rock, including requisite pressures (C. M. Jewell & Associates Pty. Ltd., 2015; Geoscience Australia, 2015b; Water Research Laboratory, 2015b) (Appendices 2-4).

4.1.1 Comments on geological and structural claims of "water veins"

It is noted that in a number of locations the proponents have described "water veins" as a magnetic phenomenon, including on page 5 of Appendix 5 (Quantum Water Corporation Ltd., n.d.), however in reviewing this WRL noted the inconsistency in stating that detecting water veins is stated not to rely on the sensing of any electromagnetic, magnetic or seismic signals (Water Research Laboratory, 2015a) (Appendix 6).

Alfvén waves
As discussed in Section 3.1, the proponents mention a number of different claims about Alfvén waves, including: that the waves in "water veins" have the same basic structure as Alfvén waves; that the waves in "water veins" consist of "photon impulses"; that the "water veins" were created by cosmic Alfven waves that constantly influence the earth.

As explained in CMJ (Appendix 4), Alfvén waves were discovered by Hannes Alfvén in 1942. "Any movement within a conducting fluid that is in the presence of a magnetic field will generate electrical currents. These currents will then interact with the field to produce mechanical forces which act back on the fluid" (Nature, 2006).

Evidence of such waves in the earth's outer core in the iron-rich fluid has been collected, and the "transfer of the angular momentum between the mantle and torsional oscillations in outer core" has been used to explain some decadal changes in the rotation rate of the Earth (Finlay, 2007).

Alfvén waves have also been found in the earth's magnetosphere, the area of space, around a planet that is controlled by the planet's magnetic field (National Aeronautics and Space Administration, 2015). The earth's magnetosphere prevents most of the particles from the sun, carried in the solar wind, from hitting the Earth.

No scientific literature was identified that would support the claims by the proponents that Alfvén waves have an impact on the movement of such freshwater bodies within hard rock.

4.1.2 Comments on claims of water in or from "water veins"

Comments on claims about water flow in hard rock
The advice from GA noted that groundwater science does recognise groundwater systems in hard rock, such as aquifers in porous rock (e.g. sandstone), or in fractured rock systems (e.g. basalts). The flow of water in these systems is through connected pore spaces or fractures or faults, and GA comments that "there is no other way for water to flow through rock that is accepted by the scientific community" (Geoscience Australia, 2015b) (Appendix 3). In addition, GA remarks on the proponents' description (see Section 3.1.2) of Darcy's Law being an "empirical parameter", with GA stating, "Darcy's law is in fact an equation that defines the ability of a fluid to flow through a porous media such as rock" (Geoscience Australia, 2015a) (Appendix 7).

In commenting on the proponents' claims about the movement of water through hard rock, WRL noted: "Hard rocks have very low primary porosity and are effectively impermeable to the flow of liquid water. It is physically impossible to pump useable quantities of water out of hard rock unless it is fractured (a fractured rock system would be a conventional groundwater source)" (Water Research Laboratory, 2015b) (Appendix 2).

Comments on claims about water and rock oscillations and frequencies, and pressures causing flow
The proponents have made claims about high pressure and geophysical forces including ultra-high resonant frequencies changing the state of water " (ACE Drilling, n.d.) and moving through materials that match the resonant oscillations (Section 3.1.2).

GA comments that it is not aware of any geophysical forces that could result in water molecules changing state and moving through materials as described by the proponents (Geoscience Australia, 2015b) (Appendix 3). They state that the system and behaviour described by the proponents has never been reported in geological systems and does not seem possible based on their understanding of physics, geology and hydrogeology.

Similarly, none of the experts could make sense of the references made to 'ultra-high resonant oscillations'.

The WRL advice noted the claims by the proponents that the water is fresh and not ionised or salty, meaning it wouldn't contain charged ions (e.g. Na^+ or Cl^-), and thus the reviewer could not understand how the movement of water would give rise to an electromagnetic field that would enable its detection (Water Research Laboratory, 2015b) (Appendix 2).

"Quantum Water suggests that the vibrations of compounds in water and rock from incident energy causes water flow through solid rock. This is inconsistent with my understanding of thermodynamics and wave motion. In classical physics water flows because of pressure differences. The rate of water flow is proportional to the resistance (hydraulic conductivity) of the flow medium. The resistance of a material to water flow is proportional to the effective diameter of the pore-space or fracture within the flow medium. Solid, tight rock such as granite has a very high resistance (low hydraulic conductivity) because the pore-space of the material is very small and largely disconnected. Unless fractured, granite rock effectively precludes the passage of water. A fractured granite mass would be a conventional groundwater flow system, not a water vein system" (Water Research Laboratory, 2015a) (Appendix 6).

As indicated in Section 3.1.2 the proponents have claimed that the movement of water through "water veins" is caused by high pressures underground. They have not indicated how high the pressure is. The report provided to OCSE by CMJ includes some discussions of underground pressures that can be experienced including in deep mines, high-pressure water mains etc. (C. M. Jewell & Associates Pty. Ltd., 2015) (Appendix 4). CMJ has also provided information on the hydraulic conductivity of unfractured granite (claimed as a conduit for "water veins") of between 1×10^{-10} ms^{-1} to less than 1×10^{-13} ms^{-1}. The conclusion reached by CMJ is that "Even under the highest pressures identified above, flows through any significant thickness of unfractured granite would be so small as to be unmeasurable" (C. M. Jewell & Associates Pty. Ltd., 2015) (Appendix 4).

Comments on claims about water quality

As discussed in Section 3.2.3, there are several claims made about water quality, including ionic content, presence of microorganisms, that high pressures purify the water as well as statements about potability.

In responding to the proponents' claims that water quality is exceptionally high and potable regardless of geographic location, GA comments that it "is physically impossible for water to be of high quality regardless of geographic location" (Geoscience Australia, 2015b) (Appendix 3).

WRL noted: "If vein water were recharged from deep underground, it would have been subjected to high temperatures and pressures and would consequently be mineralised in nature, not fresh" (Water Research Laboratory, 2015b) (Appendix 2).

As set out in Section 3.1.2 in this report, the proponents claim that “bacterial or microbiological organisms cannot exist” in vein water. In responding to this “GA stresses the importance of assessing the water quality (both organic and inorganic components) of a new source prior to its use for water supply as well as the importance of ongoing monitoring to ensure that water quality does not degrade” (Geoscience Australia, 2015b) (Appendix 3).

4.1.4 Comments on claims about “water veins” location and connectivity

In relation to the claim by the proponents that the water from the Santos Angel Falls is fed by “water veins”, WRL comments: “In my opinion this is unscientific and unsupported by evidence. It would be logical to conclude that Santos Angel falls is fed by rainfall falling on the plateau of Auyan-Tepui. If Quantum Water’s claim is correct, the water pressure in the water vein would need to be some 2000m above sea level. I would be happy to review the unreferenced research by Quantum Water demonstrating that Santos Angel Falls are fed by vein water” (Water Research Laboratory, 2015a) (Appendix 6).

In commenting on the proponents’ claims about “water veins” being part of an interconnected network of water systems in a hierarchical nature (parent-child) and span the entire earth, GA notes that “…there is no evidence the earth is spanned by a giant network of interconnected groundwater systems” (Geoscience Australia, 2015b) (Appendix 3).

GA noted that “It is likely that ACE Drilling would be able to find water resources by drilling in hard rock systems to depths less than 400 metres, however the supply would not be limitless (as claimed in Section 3.1.2) and would drawdown connected systems and potentially impact other groundwater users” (Geoscience Australia, 2015b) (Appendix 3) .

Connectivity of deep (old) water and shallow water

The proponents have claimed that there is an underground network of “water veins” that interlink across the globe, with deeper veins being larger, and shallower veins smaller, and that vein water near the earth can be accessed (see Section 3.1.3).

To assist with their arguments, the QW Vein Water System document draws on the work of Schmandt et al. (2014) to argue that the existence of water deep in the earth supports the proponents’ theory of a network of “water veins” (Appendix 5).

Assistant Professor Brandon Schmandt from the Department of Earth and Planetary Science, University of New Mexico, replied to the request for advice on the use of his and his colleagues’ work, commenting that “The potential water reservoir that we wrote about cannot be accessed. It is composed of extra hydrogen atoms in solid crystalline rocks deep in the Earth. It is potentially interesting in terms of planetary evolution and understanding where Earth's water originally came from, but it is irrelevant with respect to providing water resources for society” (B. Schmandt, personal communication, 3 July 2015).

Professor Suzanne O'Reilly, Director of the ARC Centre of Excellence for Core to Crust Fluid Systems, Macquarie University, was given a copy of the Vein Water System document. She provided advice about deep water and its lack of connection to shallow crustal sources. She commented that a significant body of ancient or primitive water

may occur deep in the earth's mantle is well-recognised, our understanding aided by advances in sensing and modelling technologies in recent years. She noted that:

> *"With the present (extensive) knowledge of the distribution and residence sites of water in the deep Earth, it is not evident that there can be any relationship of this deep "water" (contained in mineral structures mainly as hydrogen), to the water veins referred to in the article "Vein Water System– the Additional Water Source". Large volumes of free water have not been shown to travel up to the subsurface in veins from 40 – 600 km deep; it forms hydrous minerals (including amphiboles, micas, serpentines, clay minerals etc.) that are stable at low-pressure conditions, or it may be dissolved in magmas that then crystallise hydrous minerals on cooling"* (O'Reilly, 2015) (Appendix 8).

4.1.5 Comments on "water veins" and other groundwater

In commenting on the proponents' claims about the lack of relationship between "water veins" and surrounding hydrogeology, rainfall and hydrology, and their claims about the underground recharge of "water veins" from seawater that has been subducted into the crust and mantle, GA comments that "These descriptions of a water resource are not scientifically or physically based."…"Whilst groundwater can be present as connate water (trapped in the geological unit during rock formation, usually saline) or fossil water (very old groundwater systems that receive little or no modern recharge), these are non-renewable sources of water" (Geoscience Australia, 2015b) (Appendix 3) .

The proponents have commented that groundwater can be detected from its high microwave resonance (see Section 3.1.4), however WRL has commented that to its knowledge microwave radiometry can only be used to sense water table depth to about 3 metres and when supported by other information sources (Water Research Laboratory, 2015a) (Appendix 6).

4.1.6 Comments on proponents' research on "water veins"

Several experts have commented on the absence of information or any references to the credentials or expertise underpinning the proponent's claims. Images and diagrams provided by the proponents are either lacking in any definition or detail that is scientifically meaningful or alternatively, could be images of any groundwater well or known water source (see for example WRL, Appendix 6).

4.2 Description of proponents' technologies for locating and analysing water

The material provided by the proponents, includes some descriptions of the techniques employed to decide on the locations to drill. Many of these systems are used in hydrogeology and drilling. They have claimed that specific technologies have been developed to enable the identification of "water veins", but have not described how the technology works.

OCSE also sought advice on other technologies of potential relevance, such as cosmic ray neutron soil moisture probes, to see whether these could fit the descriptions of the proprietary technologies. However, as indicated by both GA and WRL, this is not relevant to the depths under consideration (Appendices 2-3).

As set out in section 3.2.2, the proponents claimed "Each type of underground water system has its own unique finger print which our technology can identify and decode." (ACE Drilling, 2014). WRL framed a question to the proponents (Appendix 1) to understand better what characteristics or parameters of "water veins" finger print the

technology would detect. The response to this question (Question 19 in Appendix 1) provided no clarity, referring again to the “Black Box” nature of the techniques (B. Joshi, personal communication, 17-18 & 29 June 2015; Appendix 1).

There is an inconsistency within the proponents’ materials about whether their processes do or do not rely on electromagnetic fields (EMF), with ACE Drilling material saying EMF signatures are of interest (ACE Drilling, n.d.), while Quantum Water indicates that they do not analyse the “… magnetic or electromagnetic situation…” (Quantum Water Corporation Ltd., n.d.) (See section 3.2.2)

If it is the case that the proponents do not rely on EMF techniques, this would seem curious given the proponents claim that the “water veins” are a magnetic phenomenon (Quantum Water Corporation Ltd., n.d.) (Appendix 5), and also given the advice from GA (Appendix 3, page 3), indicating that of the geophysics methods used, the most prevalent conventional methods applied to identify local scale water resources are electrical and electromagnetic methods.

GA also comments on satellite survey claims, noting that the hyperspectral imagery referenced by the proponents is used in earth sciences, but is not able to provide information about the geology, temperature or volume of groundwater resource at any significant depth. Further, there is currently only one satellite mounted hyperspectral sensor in operation and, for the purposes claimed, the data is of limited breadth and quality (Geoscience Australia, 2015b) (Appendix 3).

As discussed in Section 3.2.3, the proponents claim that they “can forecast the depth, yield and quality of the water inside the system, without the need of hydrogeological surveys, test holes or ground survey teams” (ACE Drilling, 2015d), WRL has speculated that traditional photo-geological survey techniques may be deployed, although these have since been overtaken by geological and hydrogeological surveys and resource mapping (Water Research Laboratory, 2015b) (Appendix 2).

Also commenting on the same proponent material - “can forecast the depth…ground survey teams” (ACE Drilling, 2015d) - GA have pointed out that there is no evidence that geophysical methods can precisely target a water resource as described, “(t)here is no way to forecast the depth, yield and quality of groundwater without employing standard, accepted hydrogeological exploration techniques….” (Geoscience Australia, 2015b) (Appendix 3, page 4).

The comment from the Vein Water System document reproduced in Section 3.2.2, which includes the statement “that pictures/photos do contain all information of everything present in the photographed area; whether it is visible or invisible”, is puzzling as it seems to imply that photos contain information about invisible objects.

Conversely, if references to “water veins” as a new water source are put aside, many of the drilling program activities appear consistent with existing industry practice. For example, Step 1 Requirements in the ACE Drilling Premium Water Bore Service presentation includes utilisation of standard hydrogeological data and sources, such as existing bore well logs and water quality reports and Step 2 Survey and Study refers to mining data sets.

Proprietary Technology

In reviewing available material, WRL noted that while there do not appear to be any unique features of the claimed technology or approach, it is possible that the service may rely on GIS-enabled computer software to automate the workflow of skilled scientists and mine multiple data sources to determine drilling locations (Appendix 2). If this supposition is accurate, it might explain the ability of the service to undertake the survey and study components of the work as quickly as cited (7 days). This supposition was put to the proponents as a question (Question 14 in Appendix 1), with the response being to refer to the Vein Water System document (Appendix 5) “which explains in more detail”. A review of this document (Quantum Water Corporation Ltd., n.d.) (Appendix 5) did not provide any further clarity.

If it is the case that the proprietary technology that has been developed is simply a data analytics software tool, this would seem to put into question the statement made on the ACE Drilling website and reproduced in section 3.2.1, as “these water systems are not visible using conventional tools and instruments, proprietary technologies have been developed…” (ACE Drilling, n.d.).

5. Observations and Conclusions

Scientific basis

As noted above, the proponents (ACE Drilling/Quantum Water) make assertions that are not supported by established scientific knowledge and also draw on and appear to misapply a range of accepted scientific phenomena and observations in an attempt to support their claims. The experts consulted noted that the promotional and explanatory material at times uses scientific terms and references scientific phenomena inappropriately, without reference to available and current scientific knowledge, and “the methods purportedly employed by Quantum Water are not repeatable or testable, as they are not willing to release the details of those methods” (Appendix 7).

In summary, the experts can find no scientific basis for the existence of water veins as described. In the information that the experts had, either from publicly available sources or from other material prepared by the proponents, the experts found no evidence for the claims being made about the existence or properties of “water veins”, nor evidence to support claims being made about a unique technology to locate this or other water sources.

What could the water targets be?

The proponents claim that the water from their system is emerging from hard rock formations (Section 3.1.1). They explain this water-bearing hard-rock system using the concept of “water veins”. GA comments that groundwater systems do exist in a range of hard rock formations, and comments that “it is probably these groundwater systems that are being targeted” (Geoscience Australia, 2015b) (Appendix 3).

The proponents note, as described in Section 3.1.3, that depending on the geology under the property owner’s land, ACE Drilling may need to drill down to 400m to access water from “water veins”. GA comments (Appendix 3), that it is likely that “ACE Drilling would be able to strike potable water quality on most properties, by drilling in hard rock to a maximum depth of 400m, when informed by the freely available geological and hydrogeological data and maps” (Appendix 3). The water that the drillers would be accessing down to 400m would be that drawn from systems such as aquifers in porous rocks and fractured rock systems (Appendix 3).

GA notes that that these resources, if recharged, would be recharged by rainfall or from adjacent water resources, and that the resource would indeed be drawn down if the extraction rate exceeds the recharge rate, and thus the extraction could potentially impact other groundwater resources and potentially surface water resources (Appendix 3). GA does however indicate that they would reconsider this view if the proponents are able to provide additional technical detail regarding the proposed water resource and water-finding method that is supported by peer reviewed evidence (Appendix 3).

WRL made similar observations about the lack of scientific evidence to support the proponents' claims, and that independent field-based evidence would be needed to assess the accuracy of claims. WRL commented that in the material provided by the proponents in relation to their example projects, there was no evidence to provide that the water sourced was not from a conventional groundwater source (Water Research Laboratory, 2015b) (Appendix 2).

What could the technology be that they are using?

Besides the various inconsistencies in the explanations of some of the technologies that the proponents claim to utilise, they do appear to employ a range of tools that are commonly employed in hydrogeology. GA indicates that there is insufficient detail to comment on the efficacy of precision of the proposed methodology (Geoscience Australia, 2015b) (Appendix 3).

Aside from the claims about having developed proprietary technologies to access "water veins" using their unique properties, the proponents may have access to (or may have developed) a software tool to automate the mining of data sets. As discussed by WRL (Appendices 1 and 2), this could explain the proponents' relatively fast (1 week) survey and study work.

What are the implications?

The proponents are making concerted efforts to promote their services in Australia, and are proposing to charge very considerable sums for potential customers – the ACE Drilling website on the Premium Water Bore Service page disclaimer, says "For license holders with … budgets of $80,000 or less, this service will not be applicable" (ACE Drilling, 2015d), while their response to Question 15 (Appendix 1), mentions a proposal for the City of Broken Hill "at a price point of below $50 million dollars" to undertake services to deliver a supply rate of 50 mega litres per day which includes drilling services.

If, as it appears so far from this report, due to a lack of evidence otherwise, the proponents are accessing conventional groundwater sources (rather than non-conventional "water veins"), and the technologies being employed are combinations of conventional hydrogeological tools, and a potential additional data mining capability, then clients would need to make their own judgements about value for money. However, as noted by one of the reviewers, "GA considers that the promotion of 'water veins' as limitless water sources of good quality, available at any geographic location, as described by ACE Drilling, is inaccurate and potentially misleading for people making choices about investing money in water supply for towns or businesses" (Geoscience Australia, 2015b) (Appendix 3).

If it is the case that the proponents are indeed not providing access to a new perennial pure water source in "water veins", but rather providing access to conventional

groundwater resources, then the proponents should look to amending their marketing material. Should the proponents wish to continue making claims about "water veins" as described in this report, then they should develop scientifically credible material to back up their claims, with characteristics as described by GA such as adhering "to an acceptable use of the scientific method or the standards of evidence required by science. The scientific method relies on the ability of data or information to support a hypothesis by following closely linked, logical steps, and by being repeatable" (Geoscience Australia, 2015a) (Appendix 7). Indeed, WRL in sections b) and e) of Appendix 2 describes some steps to undertaking suitable analyses should the proponents be interested (Water Research Laboratory, 2015b).

6. Appendices

0. Letter from the Minister
1. Question and answer log
2. Water Research Laboratory, University of New South Wales, report to the Office of the Chief Scientist and Engineer, 15 June 2015
3. Geoscience Australia, report to the Office of the Chief Scientist and Engineer, 15 June 2015
4. C.M. Jewell & Associates Pty. Ltd., report to the Office of the Chief Scientist and Engineer, 2 July 2015
5. Quantum Water Corporation Ltd., *Vein Water System The Additional Water Source,* undated [received 29 June 2015]
6. Water Research Laboratory, University of New South Wales, additional advice to the Office of the Chief Scientist and Engineer, 9 July 2015
7. Geoscience Australia, additional advice to the Office of the Chief Scientist and Engineer, 9 July 2015
8. Professor Suzanne O'Reilly, Director, ARC Centre of Excellence for Core to Crust Fluid Systems, Macquarie University, advice to Office of the Chief Scientist and Engineer, 6 July 2015

7. References

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APPENDIX 0

The Hon Niall Blair MLC
Minister for Primary Industries
Minister for Lands and Water

IM15/10481

Professor Mary O'Kane
Office of the NSW Chief Scientist & Engineer
GPO Box 5477
Sydney NSW 2001

Dear Professor O'Kane

Several local councils, individuals and not-for-profit organisations have approached me about the potential of a new, non-conventional method of groundwater extraction. Many hold hopes that it could provide long-term, sustainable solutions to water insecurity issues in regional NSW communities.

ACE Drilling, a groundwater exploration company based in Orange NSW, claims to utilise a non-conventional water system known as "water veins". Given that the proposed technique is proprietary technology, ACE Drilling have not shared any specific scientific details, but an overview of the proposal is attached.

From the advice I have received I understand that the claims are not in line with mainstream, peer-reviewed hydrogeology. However, given the interest that has been generated by ACE Drilling's promises in regional NSW communities, I believe that your independent expert advice would be valuable. If you think the concept has merit, I would suggest that a pilot test project, conducted under your scrutiny, would be a productive way forward. There are several regional communities in NSW that are struggling with water security that would be happy to host the pilot.

Please don't hesitate to contact my Water Policy Advisor, Matt Coulton, to discuss this issue further. Mr Coulton can be reached on 0429 424 486 or at matt.coulton@minister.nsw.gov.au

Yours sincerely

The Hon Niall Blair MLC
Minister for Primary Industries
Minister for Lands and Water

06 MAY 2015

APPENDIX 1

Question and answer log

Questions of a similar nature are grouped

	Question put to Quantum Water Corporation Ltd [and provided to ACE Drilling]	Answer from Quantum Water Corporation Ltd [verbatim]
1	ACE Drilling's marketing material and the Quantum Water website describes water veins as an unconventional water source. My interpretation is that water veins do not exist in the solution cavities of karst or in the fractures and joints in rock. Is my interpretation correct?	Please see attached document which explains in more detail. (OCSE comment: this is the *Vein Water System The Additional Water Source* document, Appendix 5)
2	I understand your overseas partner is Quantum Water. Is this correct?	Quantum Water Corporation Limited
3	Does ACE or Your German business partner possess photos and microphotographs of water vein material/geology that you can supply to me?	Please see attached document which explains in more detail. (OCSE comment: this is the *Vein Water System The Additional Water Source* document, Appendix 5)
4	Is ACE or Your German business partner able to provide me with a graphical conceptual model illustrating a water vein at different spatial scales (microscopic and macroscopic)?	Please see attached document which explains in more detail. (OCSE comment: this is the *Vein Water System The Additional Water Source* document, Appendix 5)
5	I am having difficulty comprehending the media through which vein water flows and am concerned this might be a translation issue from German to English. Can your German business partner provide me with a comprehensive German language description of a water vein?	Please see attached document which explains in more detail. (OCSE comment: this is the *Vein Water System The Additional Water Source* document, Appendix 5)
6	The Quantum Water website refers to Alfvén waves. I understand these relate to plasma physics and magnetics fields and can be generated within the corona of our sun (reaching frequencies of Hz at Earth with very large wavelengths), or more generally within any conducting fluid in the presence of a magnetic field: a) As the freshwater in a water vein would not be a very good conducting fluid, vein water would not give rise to Alfvén waves. Is this deduction correct? b) Does Darcy's law apply to the flow of water in veins? c) Is ACE or Your German business partner able to provide me with the mathematical equations that describe how Alfvén waves from our sun influence the flow through water veins? d) Is ACE or Your German business partner able to provide me with the mathematical equations that describe how Alfvén waves from our sun concentrate freshwater in water veins?	Please see attached document which explains in more detail. (OCSE comment: this is the *Vein Water System The Additional Water Source* document, Appendix 5)
	Are Alfven waves associated with the formation of the water veins (from underground pressure and heat, or from cosmic wave impact); or are the Alfven waves associated with the electromagnetic field technology used to detect the water in the veins.	Alf[v]en Waves are associated with the formation of the water veins. In addition - Jacque Dirac already mentioned in 1927 that there are magnetic bodies that are filled with water; other scientists have also been working in this field.
	Follow up question: There is a mention of other scientists working in this field, so could you please send their names or citations	

	Question put to Quantum Water Corporation Ltd [and provided to ACE Drilling]	Answer from Quantum Water Corporation Ltd [verbatim]
7	From ACE's marketing materials I understand that you have successful water vein wells here in Australia, including at Orange. Is my interpretation correct?	Yes this is correct
	Can you provide the bore identification number for the bore sunk as part of Project Orange?	The groundwater log number in relation the Orange bore is GW805369.
8	How many water veins have been located in NSW with this technology and how many have been successfully developed with ACE drilling rigs?	So far we have conducted our pilot trails in Orange. Please note that these pilots were intended to demonstrate the accuracy in locating water veins for our reseller (Ace Drilling PTY) and was not done under controlled scientific conditions that you would normally expect from a scientific review process.
9	ACE's marketing material briefly outlines an approach for drill site selection to improve the likelihood of striking any water source when drilling. From this material I understand that the approach involves utilising previously collected field data, remote sensing images from third party satellite providers and GIS enabled data analysis in Germany. Is this correct?	Please see attached document which explains in more detail. (OCSE comment: this is the *Vein Water System The Additional Water Source* document, Appendix 5)
10	What are the specific data inputs into your technology? (i.e. what specific geology, hydrogeology and remote sensing datasets do you and your German business partner rely upon?) – note that I am not asking about the technology employed to process the data just the specific sources of information sourced from clients and third parties by your overseas partner. My knowledge of the inputs into the technology will enable me to improve the quality of my advice to my client.	Please see attached document which explains in more detail. (OCSE comment: this is the *Vein Water System The Additional Water Source* document, Appendix 5)
11	For how long has ACE drilling been using the technology provided by your German business partner?	Since mid-January 2015
12	Is the technology used by your overseas partner patented?	No it is not patented for obvious reasons..
	Could you direct us to peer reviewed scientific papers providing evidence for 'water veins', and that the methods and technology proposed are valid?	We have not published anything about water veins or our technology as per my earlier email. The point is that our technology determines the difference between conventional ground water and vein water which is not only propitiatory, but it is also not possible for other measurement methods/technologies to determine this difference at all. Which makes our "Black Box" technology different from others as we are the only company in the world capable of precisely locating this entirely unique water system
13	In the marketing presentation ACE guarantee to drill a second well if the first well does not find a suitably fresh water supply. Does ACE guarantee to drill a third well for free if the first and second well do not encounter a supply suitable for drinking purposes?	Our terms and conditions ensure that payment is only due once a suitable supply of water based on clients requirements (minimum acceptable yield) is met. If due to difficult drilling conditions or safety concerns at a specific site where we are forced to abandon the drilling, we simply drill an alternative bore hole, whether this is a second or third bore is of no concern to us. Our objective is to obtain a result which we guarantee.

	Question put to Quantum Water Corporation Ltd [and provided to ACE Drilling]	Answer from Quantum Water Corporation Ltd [verbatim]
14	The information provided in your marketing brochure was high level and not pitched at a technical audience. From that material my assessment would be that your drill site location method is no different from those techniques already employed by practicing hydrologists, hydrogeologists and scientists (e.g. Al-Bakri and Al-Jahmany, 2013; Nag 2008) other than that your partner has automated the data analysis procedure. a) Is this interpretation correct? b) If not, without going into IP restricted detail, what special attributes distinguishes your partner's drill site location technology from standard practice (e.g. Al-Bakri and Al-Jahmany, 2013; Nag 2008)	Please see attached document which explains in more detail. (OCSE comment: this is the *Vein Water System The Additional Water Source* document, Appendix 5)
15	ACE's marketing materials suggests that successful well drilling sites can be located within one week of commissioning. This would be impressive if demonstrated with data (as per your suggestion for a field demonstration exercise) and also if the cost of the service could be reduced from $80,000 in future (as this is more than the cost of drilling one well, as per the example provided in the marketing presentation provided to me by Chris). Can the location of successful drill sites be completed within one week in all locations?	Our process states very clearly that once the client has completed an application form (on-line or pdf), submitted and authorised to proceed, we are able to conduct a remote survey and study identifying water vein targets within seven (7) business days. We do not conduct blanket studies of entire areas such as NSW. Our survey and studies are client specific along with all our guarantees. If all geological formations were linear and predictable in every situation anywhere in the world, you may establish a baseline time frame for drilling. Unfortunately the reality is somewhat different and therefore every site has its own unique drilling challenges. Time frames differ in some instances even on the same site. We will not be discussing commercials within this forum as pricing is very subjective and based on client specific requirements, conditions, concessions and price points can vary greatly. We do not operate a "one size fits all" pricing model. We recently submitted a high level proposal for the long term supply of freshwater for the city of Broken Hill at a supply rate of 50 mega litres per day within 6 months of approval, at a price point of below $50 million dollars. This was inclusive of all guarantees including; water quality meeting ADWG standards, yields and long term sustainable supplies that would provide water security over the next 100 year event horizon and beyond. Our proposal clearly states that unless we provide results, not a single dollar of public funds would be spent. The 6 months is based on authority to proceed which is purely for drilling services only! It assumes that we have already done the survey and studies, identified all the targets and been given the approvals and licenses to proceed with drilling activities. Our technology provides the fastest, reliable, scalable and most cost effective *alternative* freshwater sourcing solution for mainland Australia that guarantees results before payment is made! It is available to private, commercial and government clients and can be purchased as a full service solution "Premium water bore service" or as a "water targeting and bore placement service" (without drilling services). Assessment of each drilling contractor would be required to ensure they have the capabilities to meet our drilling requirements, details of which would be provided to organisations wishing to tender out drilling services.

	Question put to Quantum Water Corporation Ltd [and provided to ACE Drilling]	Answer from Quantum Water Corporation Ltd [verbatim]
16	In lieu of disclosing details of the technology of your overseas partner are you able to instead demonstrate the strength of the intellectual property supporting your partner's technology by disclosing to me: a) The number of scientists, physicists and technologists who are (were) employed by Your German business partner to deliver (develop) this service? b) The curriculum vitae's of the scientists and physicists who developed and provided this technology? c) An organisation chart for you overseas business partner	Due to security and confidentiality of our staff and scientific team, we are unable to provide this information.
	What are the names and qualifications of the scientists that have developed the technologies to precisely locate water veins?	
	What is the name and certifications of the German laboratory that will be used in the Premium Bore Water Service?	
17	What is the name of the satellite that is being used to undertake the hyperspectral survey?	All methods, techniques, tools or instruments used to locate water veins remains within a "Black Box" and shall not be disclosed in order to protect our intellectual property.
18	What is the depth of investigation of the hyperspectral sensor on that particular satellite?	All methods, techniques, tools or instruments used to locate water veins remains within a "Black Box" and shall not be disclosed in order to protect our intellectual property.
19	What parameters of the overall 'fingerprint' of each water vein is the technology able to identify to determine the presence of water?	All methods, techniques, tools or instruments used to locate water veins remains within a "Black Box" and shall not be disclosed in order to protect our intellectual property
20	Why is the bore life guarantee only 5 years? [5 years quoted on FAQ document on website]	This document has been superseded with a new FAQ document which has not yet been published on the website. Our bore water supply and construction are guaranteed for the life of the bore
21	It is noted that the water supply is only guaranteed for one year [as quoted on FAQ document on website] although the company indicates a "perennial" water supply will be discovered. This guarantee appears short in contrast. Can you please provide reasons for the one year guarantee	Water vein bores as part of the Premium Water Bore Service guarantees water supply for the life of the bore, or the bore is simply replace free of charge. The FAQ document you are referring too has been superseded and a new one published soon.

APPENDIX 2

16 June 2015

WRL Ref: WRL2015044DJA L20150616

Ms Suzanne Pierce
Office of the NSW Chief Scientist and Engineer
GPO Box 5477
Sydney NSW 2001

By email: suzanne.pierce@chiefscientist.nsw.gov.au
CC: chris.armstrong@chiefscientist.nsw.gov.au

UNSW AUSTRALIA

Water Research Laboratory

Dear Suzanne,

Review of ACE Premium Bore Drilling Service – 16 June 2015

The Water Research Laboratory (WRL) of the School of Civil and Environmental Engineering at UNSW Australia (UNSW) has completed a review of the Aqua Coal Exploration (ACE) Premium Bore Drilling Service as requested. WRL's Principal Groundwater Engineer, Mr Doug Anderson (the reviewer), undertook the review for the Office of the NSW Chief Scientist and Engineer (the Office).

Mr Anderson is a qualified environmental engineer with 14 years of experience in geohydrology and numerical modelling of conventional groundwater systems. He holds a Masters of Engineering Science in Groundwater Studies from UNSW. Mr Anderson has worked on groundwater related projects in a range of countries including Australia, Canada, Argentina and the United States.

This letter details the findings of Mr Anderson's review. In summary, in the opinion of the reviewer:

1. Water veins of the type described by ACE Drilling do not exist;
2. The claim that German scientists possess a technology to determine the depth, yield and quality of under-ground water at a site in advance of drilling is unsupported by evidence;
3. In the absence of evidence regarding the workings of the technology or any independent water quality sampling and testing to prove the water quality claims for "water vein" bores, Mr Anderson has no confidence that the service promoted by ACE Drilling could be feasibly provided.; and
4. Customers interested in installing water bores for water supply security should consult an experienced hydrogeologist prior to engaging a water well driller. The NSW Office of Water and the International Association of Hydrogeologists can help interested parties identify local hydrogeological expertise.

Mr Anderson has declared he has no conflict of interest in providing this advice.

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ABN 57 195 873 179 | www.wrl.unsw.edu.au | Quality System Certified to AS/NZS ISO 9001
Innovative answers for tomorrow's water engineering questions, today | Since 1959

1. Background to the Review

Aqua Coal Exploration (ACE) Drilling have an established 60-year record of accomplishment of working with Australian hydrogeologists to drill and install groundwater wells. Recently, ACE Drilling have begun to market a new premium water bore service to prospective customers, including NSW Government agencies. Subject to various conditions, the marketing material advertises a guarantee for the development of a high quality, drinking water guideline compliant, perennial bore water supply for their customers. The advertised fee for the service - to determine the depth, yield and quality of bore water in advance of drilling – is approximately $80,000 per bore.

The ACE materials indicate that the service is reliant upon a propriety technology developed by German scientists. It is claimed that the technology can detect both conventional groundwater resources (aquifers) and a new type of unconventional, perennial underground water supply, a "water vein" hitherto unknown to mainstream science. The marketing materials suggest that the technology is a software platform that makes use of various remote sensing data sets and, possibly, existing sources of hydrological, geological and hydrogeological information. The materials also suggest that successful drill sites on a property can be located within seven (7) days of commissioning.

The ACE materials make various claims regarding water veins and the properties of the perennial vein water. The review understands that these claims include, but are not limited to:

1. Vein water is completely unrelated and isolated from the groundwater flow that occurs within conventional aquifer systems such as the solution cavities in karst, the fractures in rock, and the connected pores in consolidated or unconsolidated sediments;
2. Vein water is confined within hard "*igneous - sedimentary or metamorphic*" (sic) rocks, flows in response to cosmic Alfven waves and is recharged constantly by water stored deep within the earth's crust that "*naturally makes its way up and integrates into the system from the high pressure and oscillations within the hard rock formation*";
3. Vein water can be found anywhere on earth, but typically within two hundred metres of ground surface and sometimes immediately above, below or between a conventional groundwater source (i.e. an aquifer);
4. Vein water is fresh and can be pumped without any drawdown or influence on surrounding aquifers, even those aquifers that are only metres away; and
5. Proprietary technology "*can now accurately located each system and can forecast the depth, yield and quality of the water inside the system, without the need of hydrogeological surveys, test holes or ground survey teams*".

2. Terms of Reference

WRL was commissioned by the Office of the NSW Chief Scientist and Engineer (ref: 15/12490, 15/13681) to review a number of materials over a two day period and:

a) Assess and advise on the concept of the non-conventional water system known as "water veins" and claimed properties;

b) Assess and advise on the accuracy of the claims and comparisons made between conventional and non-conventional water sources;

c) Insofar as possible comment on any unique features of technologies or approaches described in available material or literature;

d) Provide overarching comments on the approach, including engineering/scientific value and merit; and

e) Provide any other relevant comments.

3. Approach to the Review

The reviewer relied upon the following materials for the review:

- ACE Drilling Premium Water Bore Service with Moira Plains Proposal supplied by the Office;
- ACE drilling website (http://www.acedrilling.com.au, 26 May 2015 and 15 June 2015);
- Example Projects (Water Vein Example Projects.pdf) supplied by ACE Drilling;
- Quantum Water website (http://www.quantum-water.com, 26 May 2015); and
- Miscellaneous scientific literature available online and through UNSW subscription systems.

The ACE materials available for review contained a number of ambiguities. On 1st June 2015, the reviewer sought to interview ACE Drilling's Principal Technology Adviser, Mr Brian Joshi, to clarify the details of the service and the technology advertised by ACE Drilling. The reviewer provided sixteen short answer questions by email (Appendix A). Mr Joshi responded by telephone on 10th June 2015 indicating that these questions had been forwarded to their German business partner for a response. At the time of preparing this document, the reviewer had not received a response from Germany.

4. Review Findings

In the absence of clarifying detail from ACE Drilling, the key findings of this review are, in accordance with the terms of reference:

a) Assess and advise on the concept of the non-conventional water system known as "water veins" and claimed properties

The reviewer found no scientific evidence of an unconventional underground water supply called a "water vein" within the published English scientific literature matching the descriptions provided by ACE Drilling. In the experience and opinion of the reviewer, the claimed properties are inconsistent with basic geological principles, known physics for water movement through hard rock, and the thermodynamics for the postulated mode of formation of vein water. For example:

- Sedimentary and metamorphic rocks are not subsets of igneous rocks.
- Hard rocks have very low primary porosity and are effectively impermeable to the flow of liquid water. It is physically impossible to pump useable quantities of water out of hard rock unless it is fractured (a fractured rock system would be a conventional groundwater source).
- If vein water were recharged from deep underground, it would have been subjected to high temperatures and pressures and would consequently be mineralised in nature, not fresh.

The UNSW Connected Waters Initiative, one of Australia's leading groundwater research bodies, refers to "water veins" as an ancient myth (UNSW CWI, 2013).

b) Assess and advise on the accuracy of the claims and comparisons made between conventional and non-conventional water sources

No scientific evidence was provided by ACE in support of their claims and comparisons between conventional and non-conventional water sources. The reviewer requires independent field based evidence to assess the accuracy of the claims made by ACE. For the example projects listed, no evidence was provided by ACE Drilling to prove that conventional groundwater sources (i.e. aquifers) were not the source of the water supply.

To determine the accuracy of the claims made by ACE, independent water quality sampling and testing of vein water is required. The reviewer can provide the Office with details of sampling requirements and a list of suitable analyses once a suitable water-vein well location is identified

by ACE Drilling and permission for sampling from that well has been granted by the owners. For a first-pass assessment of the water quality claims no further site-specific information would be necessary.

c) Insofar as possible comment on any unique features of technologies or approaches described in available material or literature

From the available marketing and promotional materials, the reviewer was unable to deduce any unique features of the technology or the approach developed by the German scientists.

WRL's reviewer has speculated that the service may rely upon GIS enabled computer software that automates the workflow of skilled hydrologists, hydrogeologists, geologists and remote sensing experts who mine multiple sources of data to determine drilling locations (e.g. Meijerink, 2007; Nag 2008; Al-Bakri and Al-Jahmany, 2013). The claim by ACE Drilling that drill locations can be determined from satellite surveys and mining of image datasets without the need of hydrogeological surveys, test holes or ground survey teams is noted. This suggests the approach may be based upon traditional photo-geological survey techniques. Application of these techniques was once common but has dwindled with the development of geological and hydrogeological surveys and resource mapping (Meijerink, 2007).

d) Provide overarching comments on the approach, including engineering/scientific value and merit

At this time, the reviewer is unable to comment on the engineering/scientific value and merit of the approach advertised by ACE Drilling. This would require ACE Drilling to provide: (a) physically based descriptions and evidence of water veins and vein water flow, and (b) some details of the technology such as the specific sources of data input into the data mining algorithms that sets the technology apart from traditional hydrogeological mapping practice.

With regard to questions provided by the Office:

- Good hydrogeological practice for drill site demarcation would consider the data sets that are mentioned by ACE Drilling; and
- The soil-moisture detection depths of published neutron detector technologies are decimetres only and are not suitable for detecting groundwater at greater depths.

e) Provide any other relevant comments

With regard to ACE Drilling claims, and questions from the Office, regarding water veins and Alfven waves, this is a topic beyond the expertise of the reviewer. We recommend that you seek further advice on this matter from: (a) remote sensing experts, (b) geophysicists and (c) experts in magneto-hydrodynamics.

Notwithstanding this limitation, the reviewer notes that Alfven waves are a transient electromagnetic-hydromagnetic phenomenon occurring within magnetised plasma or conducting fluids (Cramer, 2001; Keiling, 2009). On that basis, the reviewer was unable to understand the claim by ACE Drilling that Alfven waves are cosmic in nature and constantly influencing the movement of water in water veins. Further, given that vein water was claimed to be fresh, and not ionised or salty, the reviewer could not understand how the movement of vein water might give rise to an electromagnetic field that would enable its detection.

Further advice may be commissioned from WRL following receipt of responses to the reviewer's questions (Appendix A) or notification of the location of a water vein bore in Australia from which the owner permits sampling and testing by an independent organisation such as UNSW and/or ANSTO.

Yours sincerely,

G P Smith
Manager

Attachments

Appendix A – Questions sent to ACE Drilling (1st June 2015)
Appendix B - References

Doug Anderson

From: Doug Anderson
Sent: Saturday, 6 June 2015 1:56 PM
To: 'Water Technology Division'
Subject: RE: Introductory email - ACE Drilling and WRL

G'day Joshi,

Thank you for the opportunity to ask you some questions regarding water veins and your premium water bore service. I have listed some initial questions and requests for you and your colleagues and partners below.

The majority of my questions require a simple yes or no answer or statement of quantities to clear up any potential ambiguities in my interpretation of the material. The other questions are intended to help me better understand the level of effort that went into developing the technology that supports your premium water bore service as you have indicated that details of the workings of the technology cannot be disclosed.

Also, from your email I understand that some of these questions might need to be answered by your overseas business partner in Germany. In such cases, if language is an issue, answers to my questions / queries may be provided directly to me in German rather than English.

Note also that I will not be able to attend my phone in the next week as I am working long hours inside a laboratory that has no phone reception. Answers to my short answer questions by email this week greatly appreciated.

Regards,
Doug

Questions:

1. ACE drilling's marketing material and the Quantum Water website describe water veins as an unconventional water source. My interpretation is that water veins do not exist in the solution cavities of karst or in the fractures and joints in rock. Is my interpretation correct?

2. I understand your overseas partner is Quantum Water. Is this correct?

3. Does ACE or Your German business partner possess photos and microphotographs of water vein material/geology that you can supply to me?

4. Is ACE or Your German business partner able to provide me with a graphical conceptual model illustrating a water vein at different spatial scales (microscopic and macroscopic)?

5. I am having difficulty comprehending the media through which vein water flows and am concerned this might be a translation issue from German to English. Can your German business partner provide me with a comprehensive German language description of a water vein?

6. The Quantum Water website refers to Alfvén waves. I understand these relate to plasma physics and magnetics fields and can be generated within the corona of our sun (reaching frequencies of Hz at Earth with very large wavelengths), or more generally within any conducting fluid in the presence of a magnetic field:
   a) As the freshwater in a water vein would not be a very good conducting fluid, vein water would not give rise to Alfvén waves. Is this deduction correct?
   b) Does Darcy's law apply to the flow of water in veins?
   c) Is ACE or Your German business partner able to provide me with the mathematical equations that describe how Alfvén waves from our sun influence the flow through water veins?
   d) Is ACE or Your German business partner able to provide me with the mathematical equations that describe how Alfvén waves from our sun concentrate freshwater in water veins?

7. From ACE's marketing materials I understand that you have successful water vein wells here in Australia, including at Orange. Is my interpretation correct?

8. How many water veins have been located in NSW with this technology and how many have been successfully developed with ACE drilling rigs?

9. ACE's marketing material briefly outlines an approach for drill site selection to improve the likelihood of striking any water source when drilling. From this material I understand that the approach involves utilising previously collected field data, remote sensing images from third party satellite providers and GIS enabled data analysis in Germany. Is this correct?

10. What are the specific data inputs into your technology? (i.e. what specific geology, hydrogeology and remote sensing data-sets do you and your german business partner rely upon?) – note that I am not asking about the technology employed to process the data just the specific sources of information sourced from clients and third parties by your overseas partner. My knowledge of the inputs into the technology will enable me to improve the quality of my advice to my client.

11. For how long has ACE drilling been using the technology provided by your German business partner?

12. Is the technology used by your overseas partner patented?

13. In the marketing presentation ACE guarantee to drill a second well if the first well does not find a suitably fresh water supply. Does ACE guarantee to drill a third well for free if the first and second well do not encounter a supply suitable for drinking purposes?

14. The information provided in your marketing brochure was high level and not pitched at a technical audience. From that material my assessment would be that your drill site location method is no different from those techniques already employed by practicing hydrologists, hydrogeologists and scientists (e.g. Al-Bakri and Al-Jahmany, 2013; Nag 2008) other than that your partner has automated the data analysis procedure.
   a) Is this interpretation correct?
   b) If not, without going into IP restricted detail, what special attributes distinguishes your partner's drill site location technology from standard practice (e.g. Al-Bakri and Al-Jahmany, 2013; Nag 2008)

15. ACE's marketing materials suggests that successful well drilling sites can be located within one week of commissioning. This would be impressive if demonstrated with data (as per your suggestion for a field demonstration exercise) and also if the cost of the service could be reduced from $80,000 in future (as this is more than the cost of drilling one well, as per the example provided in the marketing presentation provided to me by Chris). Can the location of successful drill sites be completed within one week in all locations?

16. In lieu of disclosing details of the technology of your overseas partner are you able to instead demonstrate the strength of the intellectual property supporting your partner's technology by disclosing to me:
   a) The number of scientists, physicists and technologists who are (were) employed by Your German business partner to deliver (develop) this service?
   b) The curriculum vitae's of the scientists and physicists who developed and provided this technology?
   c) An organisation chart for you overseas business partner

References

Jawad T. Al-Bakri, Yahya Y. Al-Jahmany (2013) "Application of GIS and Remote Sensing to Groundwater Exploration in Al-Wala Basin in Jordan", *Journal of Water Resource and Protection*, 2013, 5, 962-971 http://dx.doi.org/10.4236/jwarp.2013.510099 Published Online October 2013

S. K. Nag 2008, "Application of Remote Sensing and GIS in Groundwater Exploration"

Doug Anderson
Principal Engineer – Groundwater and Modelling, Water Research Laboratory
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From: Water Technology Division [mailto:premium@acedrilling.com.au]
Sent: Monday, 1 June 2015 12:42 PM
To: 'Chris Armstrong'
Cc: Doug Anderson; 'Suzanne Pierce'
Subject: RE: Introductory email - ACE Drilling and WRL

Hi Chris,

Appendix B - References:

Jawad T. Al-Bakri, Yahya Y. Al-Jahmany (2013) "Application of GIS and Remote Sensing to Groundwater Exploration in Al-Wala Basin in Jordan", Journal of Water Resource and Protection, 2013, 5, 962-971 http://dx.doi.org/10.4236/jwarp.2013.510099 Published Online October 2013

Cramer, N.F (2001). The Physics of Alfven Waves, Verlag Berline GmbH, Berlin

Keiling, A. (2009). "Alfvén Waves and Their Roles in the Dynamics of the Earth's Magnetotail: A Review", Space Sci Rev (2009) 142: 73–156
DOI 10.1007/s11214-008-9463-8

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APPENDIX 3

Australian Government
Geoscience Australia

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Office of the Chief Scientist and Engineer,

NSW Government

Attn Chris Armstrong and Suzanne Pierce

16 June 2015

Review of the scientific merit of 'drilling into and extracting water from "water veins"'

I refer to your request, dated 18th May 2015, for a review of the scientific merit of the technique for 'drilling into and extracting water from "water veins"' currently being promoted by *ACE Drilling Pty Ltd*.

Geoscience Australia (GA) was requested to review the claims made by ACE Drilling considering the following requirements:

a. Assess and advise on the concept of the non-conventional water system known as "water veins" and claimed properties.
b. Assess and advise on the accuracy of the claims and comparisons made between conventional and non-conventional water sources.
c. Insofar as possible (without having access to the technologies themselves) comment on any unique features of the technologies or approaches as described in available material or literature.
d. Overarching comments on the approach, including scientific merit and value.
e. Any other comment you believe relevant.

Additional questions were raised in further correspondence dated 2nd June 2015, which GA agreed to address:

f. Could you comment on [the method description provided by ACE Drilling], including its relationship (actual or possible) to current hydrogeophysics practice e.g. electromagnetic surveys used to detect aquifers or to track injected fluid in extractive industries?
g. Can you comment on whether this approach [proposed by ACE Drilling] is similar in character to use of cosmic ray neutron soil moisture probes and similar technologies?
h. Could you comment on whether the types of data that are referenced by ACE drilling are consistent with current or evolving research and industry practice?
i. Can you comment on what is the most likely water source that is being targeted [where it is being claimed that water veins are being targeted].

GA has reviewed the following documentation:

- Presentation from ACE Drilling, on the 'Premium Water Bore Service'. Document provided by OCSE, 'ACE Drilling Premium Water Bore Service with Moira Plans proposal(1) (2).pdf' (ACE Drilling, 2015a)
- Information made available on the ACE Drilling website (www.acedrilling.com.au) relating to their 'Premium Water Bore Service'
- 'Frequently Asked Questions' document on website, (ACE Drilling, 2015b)
- 'Responsible Water Sourcing for the Mining Industry' document on website, (ACE Drilling, 2015c).

Summary

GA considers that there is no scientific basis for the concept or existence of 'water veins' as described by ACE Drilling. There is insufficient detail provided by ACE Drilling in their promotional documentation to provide evidence for the claims being made with respect to both the existence and properties of 'water veins', or the technology used to locate this water source or other groundwater sources. GA considers that the promotion of 'water veins' as limitless water sources of good quality, available at any geographic location, as described by ACE Drilling, is inaccurate and potentially misleading for people making choices about investing money in water supply for towns or businesses.

GA additionally considers that the methodology proposed by ACE Drilling has no scientific merit. It is likely that ACE Drilling would be able to find water resources by drilling in hard rock systems to depths less than 400 metres, however the supply would not be limitless and would drawdown connected systems and potentially impact other groundwater users.

More detailed comments relating to particular aspects of the water source and the technology are outlined below.

Kind regards

Dr Stuart Minchin

Chief, Environmental Geoscience Division

Geoscience Australia

GA review of concepts and technology presented by ACE Drilling

'Water Veins'

The term 'water veins' is not used in the scientific or water supply literature. There is no evidence in science-based hydrogeology, or the broader science disciplines of geology and physics, for the properties of 'water veins' as described by ACE Drilling. Table 1 presents the specific properties of 'water veins' claimed by ACE Drilling with GA commentary on each property.

Table 1 Claimed properties of 'water veins' with GA comments

Claimed Properties of 'water veins' (related claims grouped together)	GA Comment
Water veins are a freshwater system hidden from conventional view due to its unusual properties that can only be viewed using specific scientific instruments and software. Water veins have no relation to conventional groundwater systems and draw down has no impact on groundwater systems or groundwater table.	GA can find no reference to, or evidence for, the concept or existence of 'water veins' as a groundwater source in the scientific literature. Conventional water sources are generally defined as water sources derived directly or indirectly from rainfall, for example, rivers and groundwater systems. There are a range of non-conventional water sources recognised in the scientific and water supply literature. They are generally defined as water resources that rely on human intervention to obtain water from different sources, such as desalination or treated wastewater. Groundwater systems are all connected to some extent and extraction from one will have an impact on those adjacent to it, although the timeframes of this impact will vary.
The water system travels within hard rock formations.	Groundwater science recognises groundwater systems that exist in hard rock. These can include aquifers in porous rocks, such as sandstones, and fractured rock systems, such as basalts. Water flows through interstitial connected pore spaces or through connected fractures and faults and solution features within the rock matrix. There is no other way for water to flow through rock that is accepted by the scientific community. The water volume, flow rate and quality will vary based on the site conditions.
Under high pressure, heat and subjected to geophysical forces including ultra-high resonant frequencies, water molecules change their state and are capable of moving through materials that match the resonant oscillation of its surroundings. Water veins are confined within hard rocks but flow seamlessly between hard rock formations under the influence of pressure, resonant frequency of its surroundings and electromagnetic forces.	Significant heat and pressure, beyond those generally found between 0-400 m in Australia, would be required to change the state of groundwater molecules. GA is not aware of any geophysical forces that could result in water molecules changing state and moving through materials that match the resonant oscillation of their surroundings. The system and behaviour described by ACE Drilling has never been reported or observed in geological systems, and does not seem possible based on our understanding of physics, geology and hydrogeology.

Claimed Properties of 'water veins' (related claims grouped together)	GA Comment
Drawing water from 'water veins' has no impact to catchment hydrology, groundwater systems or groundwater table. Water supply is perennial, regardless of pumping rate and draw down Recharge of water system occurs from underground, unrelated to rainfall Water veins are recharged from underground through various ways, one of which is the subduction of tectonics plates that drive seawater into the crust and mantle before being forced back up from heat, pressure and geophysical forces.	These descriptions of a water resource are not scientifically or physically based. Such a water source has never been documented within the scientific literature, nor is such a water source possible within the laws that govern the physical environment. Whilst groundwater can be present as connate water (trapped in the geological unit during rock formation, usually saline) or fossil water (very old groundwater systems that receive little or no modern recharge), these are non-renewable sources of water.
Forms part of an interconnected network of water systems which are hierarchical in nature (parent – child) and span the entire earth as one giant network of interconnected water systems.	ACE Drilling indicate that they drill to a maximum depth of 400m. This is relatively shallow geologically, and geological basins generally exist to significantly greater depths. Whilst groundwater systems can span thousands of kilometres, there is no evidence the earth is spanned by a giant network of interconnected groundwater systems, as ACE Drilling imply. 'Hierarchical water systems' generally refer to water distribution and delivery systems (often urban). Water obtained from 400 m or less depth is likely to come from one of the managed groundwater resources in NSW. A bore into these formations would be drawing water from the recognised resource and would likely impact on groundwater pressures/levels.
Water quality is exceptionally high and potable, regardless of geographic location. Due to the unusual geophysical properties of the water system, bacterial or microbiological organisms cannot exist, preserving the quality of the water at all times.	It is physically impossible for water to be of high quality regardless of geographic location. GA stresses the importance of assessing the water quality (both organic and inorganic components) of a new source prior to its use for water supply as well as the importance of ongoing monitoring to ensure that water quality does not degrade.

Water finding technologies

The ACE Drilling website states, *'As these water systems ['water veins'] are not visible using conventional tools and instruments, proprietary technologies have been developed which can now accurately locate each system and can forecast the depth, yield and quality of the water inside the system, without the need of hydrogeological surveys, test holes or ground survey teams.'*

There is no evidence in the scientific literature to indicate that 'water veins' as described by ACE Drilling represent water resources of any significance. However, GA can comment on technologies that are used to identify areas where conventional groundwater resources may be found. Note that ACE Drilling states that its *'Technology was developed to target vein water systems but is capable to target others.'*

ACE Drilling state that the technology they propose is the result of 'over 30 years of research and studies' however there are no papers in the scientific literature that provide evidence to support the methods proposed or the information stated in their promotional material.

On the slide titled *"Step 1: Requirements"* of ACE Drilling (2015a) indicates a range of hydrogeological data and sources that would be referenced in siting the bore. The types of data listed by ACE Drilling are

consistent with data that would be collated under standard industry practice, when determining a potential bore location.

A standard assessment to identify a potential location in which to sink a bore could include the following data and steps:

- Review topography, topographic maps and aerial photography
- Review existing maps of groundwater systems and geology
- Review bore log and groundwater bore databases held by government agencies
- Review all other publicly available datasets for the geographic area of interest. Some areas have had a range of surveys undertaken, for a range of purposes that may also provide useful information to identify potential groundwater sources. For example investigations for mine sites or petroleum and gas resources may provide a range of data.

Table 2 outlines ACE Drilling's available 'Technology and Science' information with GA commentary.

Table 2 Claimed technology and science for discovering 'water veins' with GA comments

Claimed Technology and Science for discovering 'water veins' and 'other' conventional groundwater resources (related claims grouped together)	GA Comment
Technology developed over 30 years in areas of Geophysics, Quantum Physics and Mathematics	GA is not aware of any existing technologies involving quantum physics for the detection and quantification of water resources. GA was unable to find any information in the scientific literature to support this technology.
Hyperspectral satellite survey conducted over sites Conduct satellite survey & study to identify water targets	The term 'hyperspectral imagery' as used by ACE Drilling is nonspecific but GA assumes it is within the range of wavelengths that is capable of being detected by existing space-based sensors. It is well known that hyperspectral imagery is used in the earth sciences and geophysics, and GA utilises this as one technology in its range of investigative tools. Hyperspectral imagery provides information about what is at, or very close to, the earth surface, but is not able to provide information about the geology, temperature, volume of a groundwater resource etc. at any significant depth. There are accepted science-based methods that employ data collected by satellites to locate regions where groundwater resources are more likely to be found. These methods can be employed by hydrogeologists along with other information to better understand where groundwater resources may be located, they are not capable of precisely forecasting the depth, yield and quality of groundwater.
Datasets mined and processed using proprietary methods and technologies	ACE Drilling indicates that "Datasets [are] mined and processed using proprietary methods and technologies". No further information is provided regarding the nature, source, or verification of these proprietary processes.
Geophysical anomalies and EMF signatures of interested resources allow precise targeting of water systems	Geophysics is the discipline of science involved in the assessment and interpretation of physical earth properties and has numerous sub-disciplines. These include gravity, magnetics, electric, electromagnetics, and seismic. Of these, the most prevalent conventional methods applied to identifying local scale water resources are electrical and electromagnetic methods. Both these geophysical methods identify potential water-bearing systems through rigorous interpretation of data by trained and experienced geophysicists in communication with other earth science disciplines. Whilst geophysical anomalies and electro-magnetic frequency (EMF) signatures can assist in the targeting groundwater resources, there is insufficient detail for GA to comment on the efficacy or precision of the proposed methodology.

Claimed Technology and Science for discovering 'water veins' and 'other' conventional groundwater resources (related claims grouped together)	GA Comment	
	No geophysical method is able to precisely target a water resource in isolation from other hydrogeological information.	
Depth, Yield and Quality of water is determined during remote survey and study	There is no evidence in the scientific literature that any geophysical method is able to precisely target a water resource. There is no way to forecast the depth, yield and quality of groundwater without employing standard, accepted hydrogeological exploration techniques. Accepted methods include information from existing bores in the region, i.e. where depth, yield and quality has already been measured, along with a detailed understanding of the hydrogeology of an area. Accepted methods may also include a simple desk-top assessment of publically available groundwater information, geophysical surveys or drilling and sampling programs, numerical or analytical groundwater modelling. Site-specific, on-ground assessments are almost always required prior to siting even a stock bore. The decision of which method(s) to use are generally based on the availability of location specific data, the potential use of the bore and the risk of not correctly siting a bore.	
Commence drilling on targets with real-time satellite relay from site to laboratory in Germany	The information provided in ACE Drilling material is ambiguous. It is unclear what is implied by 'real-time satellite relay' and there is no information about the laboratory in Germany including the role that this laboratory has in the drilling project, or the qualifications of its staff.	

Comparison to technology used in cosmic ray neutron soil moisture probes

A neutron soil moisture probe measures the quantity of water present in a soil by measuring the density of "fast" neutrons above the soil. This can be interpreted to give a measure of the soil moisture. The neutrons can originate from either a radiation source within the neutron probe, or from cosmic rays.

Neutron probes that utilise cosmic ray neutrons have a maximum measurement depth that depends strongly on soil moisture, ranging from approximately 0.8 metres in dry soils to 0.12 metres in wet soils (Zreda et al, 2008).

It is noted in the literature that while satellite based monitoring of soil moisture is able to provide global coverage, it has several limitations including 'a shallow vertical penetration depth of millimetres to centimetres, limited capability to penetrate vegetation or snow, sensitivity to surface roughness...' (Zreda et al, 2012).

From the information available, the approach proposed by ACE Drilling uses a space-based (i.e. satellite mounted) hyperspectral sensor. Hyperspectral sensors are very different from the neutron soil moisture probes. Hyperspectral sensors collect images from multiple spectrums across the electromagnetic spectrum. Each image represents a relatively narrow band of wavelengths and multiple images, across multiple bands, can be combined to form a complex hyperspectral image that can provide a high level of detail of the target area. However, the level of detail available depends on the precision and the spatial resolution of the sensor (i.e. the area of the pixel that is captured). Like the neutron soil moisture probe, hyperspectral sensors are only able to provide information about the Earth's surface down to very shallow depths, not to the depths at which ACE Drilling will drill to target water veins (400 m). Additionally, it appears that there is currently only one satellite mounted hyperspectral sensor in operation, the Hyperion sensor on the EO-1 Satellite. The sensor was developed as a technology demonstration, however the relatively low signal to noise ratio for the sensor means the data is of a significantly lower quality than imagery obtained from airborne hyperspectral sensors (such as the AVIRIS system) and as such 'data collected under less optimum conditions [than data collected during the summer season] ... allow mapping of only the most basic mineral occurrences and mineral differences' (Kruse, 2002).

Water sources potentially being targeted

ACE Drilling indicate the water veins they are targeting travel within hard rock formations. Groundwater systems exist in a range of hard rock formations including porous rocks (e.g. sandstones) and fractured rock systems (e.g. basalts) and it is probably these groundwater systems that are being targeted. In many cases in NSW, extraction from these systems is managed under water sharing plans.

One of the example projects provided by ACE Drilling indicates a water vein target was located at a depth of approximately 96 m near Orange in NSW. Without any details of the bore number, location or bore logs, it is difficult to say with certainty which groundwater source was targeted. However, using available geological mapping and an understanding of the NSW water management framework, it is possible that this bore was located in the Orange Basalt Groundwater Source or the Lachlan Fold Belt MDB Groundwater Source, where the main groundwater source is associated with interconnected joints and fractures.

Guarantees proposed by ACE Drilling

ACE Drilling give their U-PVC cased bores a 5 year lifespan (ACE Drilling, 2015b). This appears quite short. GHD (2010) states 'There are few if any, documented cases of PVC casing collapse due to old age, and therefore PVC is expected to last at least 50 years. There was no correlation with depth of a bore and decreasing life expectancy.'

ACE Drilling guarantee the water supply for one year of bore life (ACE Drilling, 2015b), which appears short when offering a 'perennial water supply'.

Overarching comments

Based on the limited technical detail available on the methods proposed for finding water in the Premium Bore Water Service, GA considers there is no scientific merit or value in the proposed water finding technology. The technical terms in the document reviewed are used inappropriately, and several of the claims made by ACE Drilling appear to be misleading.

Based on the current scientific understanding of geology and hydrogeology, the water resource ACE Drilling claim to be able to find does not exist. Additionally, the technology that ACE Drilling claims to utilise is not capable of finding groundwater resources in the way they describe.

It is quite likely that ACE Drilling would be able to strike potable quality water on most properties, by drilling in hard rock to a maximum depth of 400 m, when informed by the freely available geological and hydrogeological data and maps. However, the water resource accessed would be neither recharged from underground, nor an unlimited resource. The resource would drawdown if the extraction rate exceeded the recharge rate. Where recharge occurs, they are recharged by rainfall or flow from adjacent water resources. and extraction would have the potential to impact on other groundwater resources and potentially surface water resources. As stated previously, groundwater systems that exist in hard rock can include aquifers in porous rocks and fractured rock systems. Any water found by ACE Drilling in hard rock formations would be drawn from systems such as these.

GA would reconsider this view if ACE Drilling are able to provide additional technical detail regarding the proposed water resource and water finding method, supported by peer reviewed evidence of its efficacy.

To address the concerns raised in this review, ACE Drilling would need to provide the following information, at a minimum:

- The name of the laboratory they are working with in Germany.
- Peer reviewed scientific papers providing evidence for 'water veins', and that the methods and technology they propose are valid.
- The name of the satellite they use to undertake the surveys they are marketing.

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Ref: J1691.2L
2 July 2015

Office of the NSW Chief Scientist and Engineer
GPO Box 5477
SYDNEY NSW 2001

Attention: Ms Suzanne Pierce, Senior Manager

Dear Suzanne

Premium Water Bore Service

As requested in your letter (ref. OUT15/T150701) of 2 July 2015, I have reviewed the claims made by Premium Water Bore Service concerning a "*new water technology*" and "*water vein systems*". I have also reviewed the information provided on the *Premium Water Bore Service* page on the Ace Drilling website and the *Premium Water Bore Service* "fact sheet" downloaded from the Ace Drilling website.

This letter presents the outcome of my review.

Summary

In my opinion the claims made by *Premium Water Bore Service* concerning "*water vein systems*" and a "*new water technology*" are without foundation.

I can find no scientific basis for the existence of "water vein systems" and they are certainly outside my experience and in conflict with the knowledge that I have acquired in 35 years of practice as a hydrogeologist.

Neither the *Premium Water Bore Service* page on the Ace Drilling website nor the *Premium Water Bore Service* "fact sheet" contain any references to sources in the scientific literature regarding the novel groundwater flow mechanism described; in my opinion this lack of even claimed scientific support severely undermines the credibility of the claims made regarding this mechanism.

No internal research and development documentation is provided or cited.

I have carried out my own review of the fundamental phenomena claimed to be the basis *for water vein systems* and cannot find any support for the existence, let alone properties, of these systems.

Detailed Review

This section reviews in detail the claims made in two promotions: the *Premium Water Bore Service* page on the Ace Drilling website [1] and the *Premium Water Bore Service* fact sheet downloaded from the Ace Drilling website[2].

[1] http://www.acedrilling.com.au/premium-water-bore-service/

The Premium Water Bore Service Page

How it Works

Water vein systems are a natural phenomenon which traverse through hard rock formations at high pressure and ultra-high resonant oscillations, making it easy to pass through all types of rocks such as granite, and form part of an interconnected network of water systems which are hierarchical in nature (parent – child) and span the entire earth. The water systems are confined within hard rocks (igneous – sedimentary or metamorphic) and are totally unrelated to conventional groundwater systems (aquifers, fractures, faults, cavities etc.). The flow and direction of the water inside the system is influenced by cosmic waves (Alfvén waves) which have a constant influence on the earth. Water vein systems are also under constant recharge from water deep within the earth's crust that naturally makes its way up and integrates into the system from the high pressure and oscillations within the hard rock formations. As these water systems are not visible using conventional tools and instruments, proprietary technologies have been developed which can now accurately locate each system and can forecast the depth, yield and quality of the water inside the system, without the need of hydrogeological surveys, test holes or ground survey teams.

The water vein system has a vital role to play in Australia's water security as it is truly the first diverse water system (unrelated to rainfall) to be discovered in almost 40 years since the introduction of desalination plants. The system also has a sustainable source and yield, where the water quality is naturally potable in nature and the system can be accessed using traditional water boring technologies and equipment. It is by far the most exciting breakthrough in both the water and drilling industry in over four decades and provides the greatest reassurance for mainland water security which is cost effective, easy to implement and highly scalable.

The Premium Water Bore Service Fact Sheet

The fact sheet begins with four paragraphs addressing some aspects of water resource sustainability in Australia – *The Water Crisis, All Fingers Point to the Clouds, Water Security* and *What Are We Doing About Water Security*. It does not present the full picture and none of the statements are referenced, but it appears to be largely based on published material and I do not have major problems with the statements made in these paragraphs.

The fifth paragraph is different.

Is There A Solution?

One thing is for sure, there is no single solution to solving this problem. Pushing the boundaries of science and technology and of our understanding of freshwater sources, has resulted in the discovery of a different type of water system known as **water veins**, which traverse through hard rock formations at ultra-high frequencies. A team of leading scientist from Europe who have been studying this natural phenomenon for over 30 years have now unlocked the secrets behind these hidden water systems and have developed proprietary technologies which can accurately identify them, similar to the way in which a finger print can identify a person.

What is known about this water system is that it exists naturally in hard rocks and forms a hierarchical structure (parent and child), like a network of interconnected waterways which span the entire earth. The water system moves at ultra-high frequencies through hard rocks, making it impossible for any microbiological organisms to form or exist, and thus ensuring the water is always potable. The water system is also under constant recharge from underground sources, making both the source and yield reliable and sustainable, unaffected by external factors such as climate change or rainfall. The significance of this discovery means that for the first time we have access to an alternative freshwater system, independent of rainfall, which can provide sustainable supply, yield, and quality without impact to ecosystems, and fulfils the UN's working definition of water security.

Some of the claims are common to the two promotions, but there are also differences (for example, the "fact sheet" does not refer to Alfvén waves).

I note that neither the *Premium Water Bore Service* page on the Ace Drilling website nor the *Premium Water Bore Service* "fact sheet" contain any references to sources in the scientific literature regarding the novel groundwater flow mechanism described; in my opinion this lack of even claimed scientific support severely undermines their credibility.

[2] http://www.acedrilling.com.au/water-supply/

Furthermore, no internal research and development documentation concerning the *"new water technology"* and the *"proprietary technologies"* for investigating water vein systems is provided or referenced.

Comments Concerning the Scientific Basis of the Claims

> *Water vein systems are a natural phenomenon which traverse through hard rock formations at high pressure and ultra-high resonant oscillations, making it easy to pass through all types of rocks such as granite.*

It is not clear what is meant by *high pressure*. It could mean almost anything, but the following examples give an idea of the credible range.

- The fluid or pore pressure in groundwater systems is commonly expressed as metres of total water head above (or below) some datum, which could be Australian Height Datum (AHD), the ground surface, or the top or base of the aquifer. Total head is the sum of elevation head and pressure head, and is a useful measure when assessing the direction and rate of groundwater flow in an aquifer. The pressure head could also be expressed in kilopascals (kPa), usually relative to atmospheric pressure. This is more useful when considering, for example, groundwater encountered when advancing a mine adit or excavation.
- It is unusual to encounter total heads in natural groundwater systems that are more than a few metres above local ground level. Initial heads in the deeper parts of the Great Artesian Basin were (anecdotally) about 30 metres above ground level. This is equivalent to a pressure of 300 kPa at the ground surface, and 3,300 KPa at the base of the bore (assuming a 300 metre bore depth.)
- Pore fluid pressures of several thousand kPa relative to atmospheric pressure have been encountered in deep mines, often with damaging if not catastrophic consequences.
- Fluid pressure in high pressure water mains may be up to 5,500 kPa (the Oberon-Leura pipeline in the Megalong Valley)[3].

Unfractured granite is a crystalline rock with very low hydraulic conductivity; values in the order of 1×10^{-10} to less than 1×10^{-13} ms^{-1} could be expected[4]. Even under the highest pressures identified above, flows through any significant thickness of unfractured granite would be so small as to be unmeasurable.

Ultra-high resonant oscillations. Again there is no indication of what this is supposed to mean, if indeed it means anything. I can only assume that it means ultra-high frequency (UHF) oscillations, or waves, that are at one of the natural (resonant) frequencies of the rock mass. Since the waves are supposed to pass though hard rock formations, I have to assume the reference is to mechanical waves not electromagnetic waves, as UHF electromagnetic waves are attenuated over very short distances in solids. The following information about mechanical waves is relevant:

- Seismic waves, as generated during earthquakes and other crustal movements are mechanical waves.
- Hydrodynamic waves are a particular type of mechanical wave transmitted through fluids; ocean waves are an example.
- Mechanical waves transmit energy not mass, which can only be locally translocated at a discontinuity or interface.

[3] **Barret, Denis 2008**, Nomination of Fish River Water Supply Scheme as a National Engineering Landmark, s5.2.3.4, p38 https://www.engineersaustralia.org.au/sites/default/files/HRP.FishRiver_Water_Supply

[4] **Freeze J. and Cherry R.A. 1979**, *Groundwater*, 604pp, p29. Prentice Hall, New Jersey

- The attenuation (loss of energy) of mechanical waves, seismic waves being an example, in rocks and unconsolidated sediments is complex and depends upon a number of material properties. It also depends directly on the frequency of the waves. For mechanical waves in *any* medium, high frequencies are attenuated in shorter distances than lower frequencies.
- Large dense objects have low resonant frequencies.

Clearly, the use of scientific terminology is vague and inconsistent. Put simply, *ultra-high resonant oscillations* cannot move water through rock.

> *…and form part of an interconnected network of water systems which are hierarchical in nature (parent – child) and span the entire earth.*

It is not clear what is meant by this statement. Hierarchical systems are not necessarily parent-child systems, but I have assumed that the systems envisaged start with large channels that branch into smaller channels that branch into yet smaller channels etc., etc., in the manner of an urban water supply reticulation network.

The obvious difficulty with such a system is that tapping into one of the extremities is going to result in obtaining rather restricted flow.

> *The water system is also under constant recharge from underground sources, making both the source and yield reliable and sustainable, unaffected by external factors such as climate change or rainfall.*

Scientific argument over a possible plutonic origin for groundwater (in Australia it has been mainly in relation to the Great Artesian Basin, but also other groundwater resources in Australia and elsewhere) goes back over a century. It was substantially resolved, in favour of a meteoric (rainfall) origin for groundwater recharge, by about 1920[5]. Personally, I do not know any hydrogeologists who support a plutonic origin for more than a very small proportion of groundwater, in very specific geological settings.

In my opinion, this statement is simply not credible.

> *The flow and direction of the water inside the system is influenced by cosmic waves (Alfvén waves) which have a constant influence on the earth.*

Alfvén waves are magnetohydrodynamic waves that may be generated within conducting fluids subjected to a magnetic field. Any movement within a conducting fluid (plasma) that is in the presence of a magnetic field will generate electrical currents. These currents will then interact with the field to produce mechanical forces that act back on the fluid[6]. In 1970 Hannes Alfvén won a Nobel Prize for his discovery of these waves in 1942[7] and his subsequent work on them. Alfvén waves have since become important in the study of laboratory, space and astrophysical plasmas, of which the sun's corona is a well-known example. Alfvén waves have also been detected within the liquid, iron rich core of the earth, and cause torques acting on the mantle and measurable changes in the rotational period of the earth.[8]

[5] **Habermehl M. A. 1982**, *Investigations of The Geology and Hydrology of the Great Artesian Basin 1878-1980*, Bureau Of Mineral Resources, Geology And Geophysics, Report 234, Australian Government Publishing Service, Canberra

[6] **Nature Physics Portal** 2006 http://www.nature.com/physics/looking-back/alfven/index.html

[7] **Alfvén H. 1942,** *Existence of Electromagnetic-Hydrodynamic Waves*, Nature 150, 405–406

[8] **Jault D. and G. L´egaut 2005,** *Alfven waves within the Earth's core, Fluid Dynamics and Dynamos in Astrophysics and Geophysics*, Andrew M. Soward, Christopher A. Jones, David W. Hughes, and Nigel O. Weiss (Eds), CRC Press

Alfvén waves may propagate through space, and may influence phenomena in the Earth's atmosphere, such as the aurorae.[9] However, I can find nothing in the scientific literature that even suggests that Alfvén waves of solar or interstellar origin can affect, much less drive, processes beneath the Earth's surface, and I would not expect to find such references.

I can find no references in the scientific literature to Alfvén waves having any influence on water movement in the Earth's crust, and nor would I expect to find such references on the basis of my own scientific knowledge.

In my opinion this statement is utterly without foundation.

Conclusions

This review has found that neither the *Premium Water Bore Service* page on the Ace Drilling website nor the *Premium Water Bore Service* "fact sheet" contain any references to sources in the scientific literature regarding the novel groundwater flow mechanism described. No internal research and development documentation concerning the "proprietary technologies" for investigating *water vein systems* is provided or referenced. Given the lack of references, I have carried out my own searches and have not found any scientific basis for the existence of *water vein systems*.

I have also carried out my own review of the fundamental phenomena claimed to be the basis for *water vein systems* and cannot find any support for the existence, let alone properties, of these systems.

These systems are also completely outside my own experience and in conflict with the knowledge that I have acquired in 30 years of practice as a hydrogeologist.

In my opinion, "*water vein systems*" do not exist.

For and on behalf of
C. M. JEWELL & ASSOCIATES PTY LTD

CHRIS JEWELL

[9] **Fernando Simões, Robert Pfaff, Jean-Jacques Berthelier, Jeffrey Klenzing 2012,** *A Review of Low Frequency Electromagnetic Wave Phenomena Related to Tropospheric-Ionospheric Coupling Mechanisms,* Space Science Reviews, Volume 168, Issue 1-4, pp 551-593

APPENDIX 5

VEIN WATER SYSTEM

The Additional Water Source

http://www.scene.org/~esa/merlib/riess.html

The late Stephan Riess gave us a theory of "primary" water generated in the rocks.

(from: Thinking of Water by Bob Fryer (published in The American Dowser, Winter 1990, v30, n1, pp55-56)

In the early 50's, a geo-chemist, metallurgist, mining engineer and dowser named Stephan Riess theorized that a vast supply of water ran under the Mojave desert large enough to supply the needs of all the people in southern California. Riess's conclusions were corroborated by a study done by civil engineers. Their findings revealed that there was as Riess called it, primary water travelling in the deep rock fault system under the desert that had nothing in common with the water in the alluvium sedimentary aquifers. This rock fissure water was also so pure that chlorination was unnecessary, and it ran like deep, life-giving veins in the earth.
He felt instead that the largest quantities of water underground were formed from the elements within the earth, and constituted primary water that had never seen the surface of the earth before.

A southern California magazine, Fortnight, ran a 2-part article in 1953, and diagnosed why such a discovery was ignored by local politicians. There was simply too much money to be made in the vast water transport systems planned that California's financial and political leadership had to ignore Riess's discovery.

It is certainly far more economical to pump water vertically up 450 feet than to pump and transport it laterally for 450 miles!"

The fact that Mr. Riess and a few other individuals like Mr. Anton Rieder and Mr. Schroeter had developed some kind of sensitivities or otherwise capabilities with which they could locate underground water sources, some of them with a success rate of upto 90%; was the starting point for us to explore the scientific background and underlying realities and factors for these phenomena. All known theories and explanation given for the existence of the water resources as well as for how these few individuals could locate some of them, did not satisfy us.

At some places one can observe the fascinating situation where water simply appears and flows out of granite. Physically this can only be possible if the vibration frequency of the rock/material is very similar to, or the exact same, as that of the water.

In this open borewell in a desert of India a horizontal water vein that is located very close to the surface of the ground, slowly fills up the well with a non-fluctuating flow. Its frequency is nearly the same as that of the relatively soft granite in which it is flowing.

The landowner, a local farmer, dug out a very large open borewell in order to utilise the water. As this vein has only very limited water quantities, one can nicely observe the water ingress into the well, which is coming only from one side of the well.

At times the water remains in this open well for several weeks, directly exposed to the sun and temperatures of more than 40 degrees Celsius.

The people there, and our team as well drank water directly from the well after it had been sitting there for more than 4 weeks; it tastes relatively sweet and was nicely cool at all times. No one had any health issues; we did the same test at other such wells as well with the same results.

Our research has shown that the source for many waterfalls are in fact water veins; including ‘Santos Angel’ Falls (cover picture).

In the picture on the left we also see the only material through which vein water can’t flow - Columns Basalt – it is too hard and it’s frequency is to different from those of water veins.

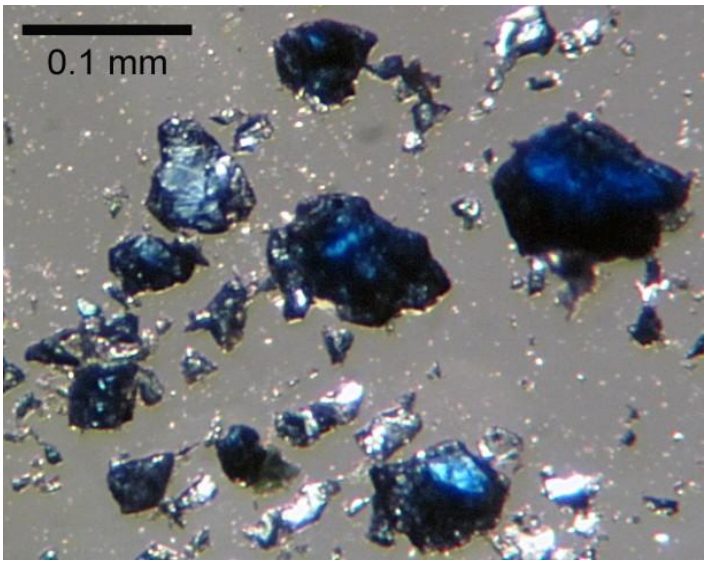
One of the most vital questions in this entire context is – Where does this water come from; what is the original source?

Until recently there was no conclusive answer available. American scientists have established that some minerals can hold water upto a sizeable percentage of their own weight. In addition, seismologist Brandon Schmandt of the University New Mexico has established that regularly observed irregularities can only be attributed to the existence of vast water reservoirs deep within the American Continent.

The velocity of propagation of the seismic waves changes dramatically at the depth of approx 500 to 700 kilometers; and that without any changes in the chemical composition of the strata itself!

The scientific explanation for this situation seems to be the due to the humongous pressure of the sheer weight of the upper strata, especially the mineral called ‘Ringwoodit’ changes it molecular structure (Kristallstruktur?); but does not change its chemical composition.

Due to this change in its structure the mineral can bind a lot of water molecules; which means that the water is not in the usual liquid form available in this depth, but is bound/linked with the mineral. It is estimated that these water reserves are far more than those available on the earth’s surface, incl. ocean water!

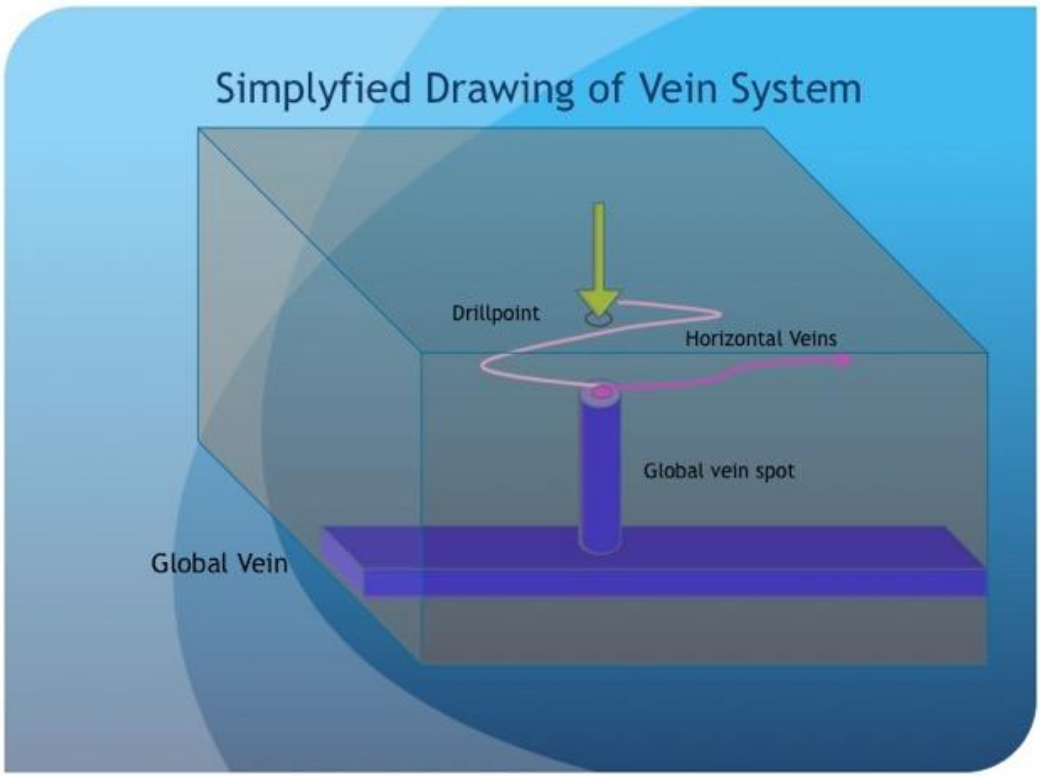


Ringwoodit

This so far explains only the location of this water. It does not yet explain how the water has come into existence at this place.

In September ’14 some results have been published of the scientific work conducted by Mr. Ilsedore Cleeves, working with the University Michigan, in Ann Arbor. By way of conducting Deuterium-Analysis it has been established that all the water on earth stems from a very cold source, the temperature of which being hardly above the absolute zero point. As the time of creation of the solar system is well known, this means that the water must be older than the solar system!

This also means that the water has reached earth directly out of the cosmos; and that this connection is highly likely to still be intact.

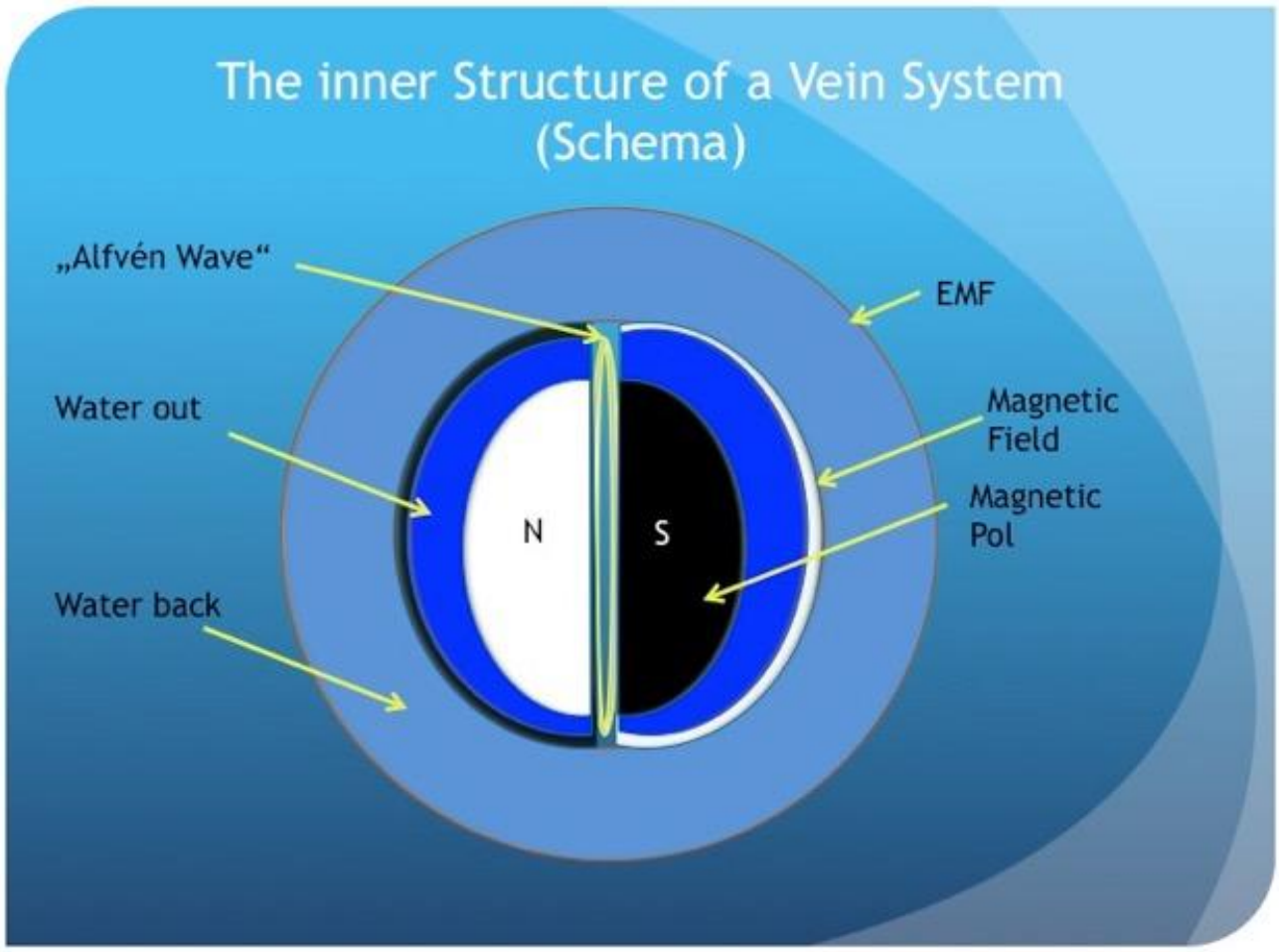


Simplified Drawing & Explanation of the Basic Structure of Water Veins inside Earth

Our proprietary technology for locating water veins is designed to identify specific characteristics/properties of vein water. Groundwater on the other hand can be located with commonly available technology as it has a very high microwave resonance. In the process of our surveys & analysis for water veins we do not analyse changes or anomalies of the seismic, magnetic or electromagnetic situation of the strata.

Global Water Veins are created by very large magnetic fields (not shown in the diagram). So far most of these veins have been located in the range of 1 to 100 kilometer below earth surface; with the pattern that deeper veins are larger and contain more water than veins that are located less deep. With our technology we can locate spots that are located in irregular patterns, at which this vein water can be accessed near earth surface, many between 50 to 500 meters. Depending on the pressure and water quantity within the spot, horizontal veins can emanate from these spots.

In specific conditions a spot can even be accessed directly at the surface, where the water will be present all year long; irrespective of any weather or ground water conditions within the area. (Photo to the right: a vein directly at the surface)



The above diagram provides a simplified overview of the basic structure of water veins. For the purpose of an easier understanding the magnetic situation in the center of the vein has been displayed disproportionately.

The basic principle of the structure is:

The space between the poles ‘N’ & ‘S’ is being created by Alfvén-Waves; because of this phenomena the magnetic poles cannot connect. In most vein systems this space does also contain some water, which has some properties different from other water within the system.

In the vein system shown here, the uprising part of the water is being positioned around the magnetic center. It is obviously being surrounded by counter polarised magnetic fields, which also keep the water in place in the process. In addition, these kind of veins do also have an electromagnetic ring around the entire structure.

Alfvén-Waves are known to have a specific velocity of propagation. In addition to a vertically positioned magnetic part, which has a particular transversal frequency; they also contain another, longitudinal part. This part, however, does not propagate in the same direction of the Alfvén-Wave as such, but in a particular angle instead; and it is basically similar to a sound wave.

Alfvén-Waves usually arise when magnetic field lines are being bordered by a plasma field. We call the waves in the veins Alfvén-Waves because the basic structure is the same; although the longitudinal part consists of photon impulses that have a very high frequency. As a result, information can be transmitted with and within the structure and the high pulse sequence ensures a high degree of stability of these connections. One could therefore call them ‘cosmic Alfvén Waves’, as they require photons in order to expand throughout the cosmos.

Example Projects

The following three examples depict some recent drilling projects with short descriptions that will help to understand the overall situation and the way our bore-well projects are conducted.

Despite a negative geological and hydrological prognosis, we located two different water veins in this plot in Spain. The water vein that we accessed was at a depth of approx. 160 meters, under and within layers of sheer bed rock. As a result of the pressure within the vein the water rose by 115 meters within the borewell; i.e. it could be accessed at just 45m below surface

Between this water source and the local ground water is a very large, extremely hard layer of granite which can be discerned in the picture from the rocks that were discharged by the drill. This means that it is impossible that any surface water, which may accumulate in some areas as ground water during rain intensive seasons, could have reached to the depth where the water was located!

The remote survey conducted for this site in India indicated the drill point right in between a dry open well (35 meter deep), a dried up hand pump (50 meter deep borewell) and another hand pump which gives only saline water (borewell depth of 55 meter); within a distance of less than 15 meters from each of those existing wells.

Drilling was conducted to a total depth of 148 meters in order to utilise maximum possible water quantity; however water was already struck at a depth of just 30 meter below surface and the water level inside the well is at 15 meters. Especially the starting depth of the water (30 meter) astounded everyone present, given the presence of 3 nearby wells, all of which deeper than that, but without any potable water at all.

The well delivers 15,000 liters per hour (approx 360.000 Liter/Day) of drinking water; which means that this one well is enough to provide drinking water for the entire population of the village. The water was tested directly at the site as well as in certified laboratories and found to be of excellent drinking water quality.

This project was commenced in California, USA approx 250 kilometer south-east of San Francisco. Since several years the entire region is suffering under ever increasing draught and rapidly dwindling ground water resources; because of which many farms are closing down and are up for sale. We identified a spot and potable water was accessed in a depth of 58m; approx 13,000 Liter/Hour are available at this site.

Final Remarks

One fundamental element regarding our proprietary technologies for locating and analysing water based on satellite and photographic images of any area is the fact that pictures/photos do contain all information of everything present in the photographed area; whether it is visible or invisible. Our technologies enable us to qualify the information and with particular procedures, including with specifically developed mathematical formulas, determine the quality and location (including the depth below surface) of the water vein and the water that it contains.

In this context it is also important to realise that 'Darcy's Law', being an empirical parameter, can provide only limited information with regards to the flow of the water within the veins; as the resistance of materials is only of little impact within veins due to the very high similarity of the vibration frequency of the vein and the material itself.

To our knowledge there are no other scientists, companies or individuals working with any kind of technology that would be comparable or similar to our proprietary technologies.

VEIN WATER SYSTEM

Quantum Water Corporation Ltd.

APPENDIX 6

Additional advice received from Water Research Laboratory, 9 July 2015

I have considered the email response, *Re: Vein Water System (Answers to Questions)*, from ACE and Quantum Water dated 29th June 2015 and provide this supplementary response to accompany WRL's review letter with reference WRL2015044 L20150616:

- I have read through the email. It is my opinion that responses to the majority of my very specific questions are not provided and the brochure to which I am referred does not answer the specific questions I asked;
- I found it concerning to read that names and CV's of the scientific team that developed the service can't be released due to security concerns; and
- WRL's previous advice on this matter remains unchanged.

In addition, I provide the following comments on the brochure that was attached to the email:

1. Photo on page 2 captioned as demonstrating water flow from granite: This photo is unclear, obscured by shadow and provided without scale and regional photographic and geological context. Quantum Water suggests that the vibrations of compounds in water and rock from incident energy causes water flow through solid rock. This is inconsistent with my understanding of thermodynamics and wave motion. In classical physics water flows because of pressure differences. The rate of water flow is proportional to the resistance (hydraulic conductivity) of the flow medium. The resistance of a material to water flow is proportional to the effective diameter of the pore-space or fracture within the flow medium. Solid, tight rock such as granite has a very high resistance (low hydraulic conductivity) because the pore-space of the material is very small and largely disconnected. Unless fractured, granite rock effectively precludes the passage of water. A fractured granite mass would be a conventional groundwater flow system, not a water vein system. See also point 7.

2. Photos of a well on page 3 and captioned as demonstrating a reliable water supply: This would be true for any groundwater well in any conventional aquifer. No evidence of any of the claimed attributes of vein water are provided.

3. The reference to Santos Angel Falls being fed by a water vein: In my opinion this is unscientific and unsupported by evidence. It would be logical to conclude that Santos Angel falls is fed by rainfall falling on the plateau of Auyan-Tepui. If Quantum Water's claim is correct, the water pressure in the water vein would need to be some 2000m above sea level. I would be happy to review the unreferenced research by Quantum Water demonstrating that Santos Angel Falls are fed by vein water.

4. The work of Ms Ilsedore Cleeves: I am not an astrophysics expert, however, it is my view that this work has been misinterpreted by Quantum Water.

5. Descriptions on page 5 that water veins are a magnetic phenomenon: Note that Quantum Water's technology for detecting water veins is stated not rely on the sensing of any electromagnetic, magnetic or seismic signals (see point 7 below).

6. Groundwater detection by Microwave Resonance: Quantum Water assert that groundwater can be located with commonly available technology as groundwater has a very high microwave resonance. To the best of my knowledge microwave radiometry can only be used to sense water table depth to about 3m, and only when a-priori information about climate and soil type is available.

7. Descriptions of water vein physics on pages 6 and 7: Regarding comments on Darcy's law it is evident that Quantum Water are asserting that the flow of water in veins is associated with Electro Magnetic Fields (EMFs) and Alfven waves. It is suggested that water can flow through solid, tight rock apparently unimpeded by the laws of classical physics (see point 1 above). Note also that Quantum Water describes Alfven Waves as comprising of high frequency photon impulses. I interpret this to be a suggestion that water veins are a quantum phenomenon that might be detected with photon or particle detectors. If the statements provided by Quantum Water were supported by evidence, this matter could be examined further by a physicist.

Additional advice received from Geosciences Australia 9 July 2015

We have examined the document "Vein Water System – The Additional Water Source" and consider that the document does not provide any further support for the concept or existence of 'water veins'. The information provided is presented in a scientific manner, however it does not adhere to an acceptable use of the scientific method or the standards of evidence required by science. The scientific method relies on the ability of data or information to support a hypothesis by following closely linked, logical steps, and by being repeatable. The information provided includes some interesting geological and geophysical observations and facts, which are irrelevant when considering the occurrence of water within 400 m of the Earth's surface, the maximum estimated depth of the 'water vein' system targeted by ACE Drilling. As stated in earlier advice, the methods purportedly employed by Quantum Water are not repeatable or testable, as they are not willing to release the details of those methods. Below are some detailed comments on particular statements in the document.

The document states (p2) that "At some places one can observe the fascinating situation where water simply appears and flows out of granite. Physical this can only be possible if the vibration frequency of the rock/material is very similar to, or the exact same, as that of the water." This statement is incorrect. Whilst unweathered granites are generally poor aquifers because they have very low porosity, groundwater will still travel through fractures in granite. Highly fractured granite can, in fact, make a reasonably good aquifer, due to the relatively high permeability imparted by the fractures, and fall into the category of aquifers referred to as fractured rock aquifers. The ability of fractured rock aquifers to transmit reasonable quantities of water largely depends on the interconnection of these higher permeability fractures. For example, the Young Granite groundwater source in NSW is a managed groundwater system with water bearing zones generally associated with the fractures and weathered zones within the granodiorite body. The average bore yield in the water source is about 4 litres per second and yields of up to 50 litres per second have been obtained (Kumar, 2013). The photos in the document and text stating it is a 'soft granite' is indicative of a highly weathered granite, which can act as a reasonably good aquifer.

The document describes the presence of 'ringwoodit' (p4: sic, ringwoodite). Ringwoodite occurs 520 – 660 kilometres below the earth's surface between the lower and upper mantle and is a high-pressure phase of Olivine. The mineral has a high water content. The research appears to have discovered that downward-flowing mantle material is melting as it crosses the Mohorovicic discontinuity, the boundary between the transition zone and the lower mantle layer (approximately 660 km below the earth's surface), and that this melting indicates the presence of water in the down-flowing material. While this work is published in the peer-reviewed scientific literature, the water vein document provides no information as to how this may be connected to water within 400 m of the earth's surface. There is also no explanation of how the research into downward flowing mantle material might explain the upward recharge of 'water veins' from underground. In these regards, the presence of water in the mantle is not logically or methodically linked to the presence of water within 400 m of the earth's surface, nor is it logically or methodically linked to upward recharge of 'water veins'. Additionally, the water present at depths of 520 – 660 km

below the surface is not readily accessible. The deepest hole drilled on earth to date is 12.2 km deep (Facts Hunt, 2015). Whilst the presence of water in the mantle, and within the crystal structure of various minerals, is a widely accepted scientifically demonstrated truth, it is wholly unclear how this is related to 'water veins' at all.

In the Final Remarks section (p8) Quantum Water Corporation Ltd refer to Darcy's law as being an empirical parameter. A scientific law, such as Darcy's law, is a statement about an observed phenomenon using repeated experimental observations. Darcy's law is in fact an equation that defines the ability of a fluid to flow through a porous media such as rock. Darcy found that the amount of flow between two points is directly related to the difference in pressure between the points, the distance between the points and the ability of the porous media to impede the flow. In addition to describing groundwater flow, Darcy's law is also used to describe water, oil and gas flow in hydrocarbon reservoirs. Darcy's law was proposed by Henry Darcy in 1856 (Darcy, 1856) and has been the basis of hydrogeological understanding since, supported by countless peer-reviewed published scientific papers, and informs the scientifically recognised and accepted understanding, use and management of groundwater systems around the world.

If the water vein system travels within hard rock formations, as ACE Drilling have stated, then Darcy's law will describe the ability of that water to flow through the hard rock system. The "vibration frequency of the… material itself" will not influence the flow of water.

References:
Darcy, H. 1856. *Les fontaines publiques de la ville de Dijon*. Paris: Victor Dalmont
Facts Hunt 2015 http://www.factshunt.com/2013/06/kola-super-deep-borehole-worlds-deepest.html Viewed 7th July, 2015.
Kumar, P. B. 2013. Young Granite Groundwater Source Status Report 2012, NSW Office of Water, Sydney.

Advice received from Professor Suzanne O'Reilly
6 July 2015
Occurrence of "water" in the deep Earth: relationship to shallow and surface water.

Analysis of data provided by the office of the NSW Chief Scientist and Engineer.

Water in the Earth's mantle

In the last decade Geoscientists have developed many instruments, methodologies and technologies to probe the nature of the deep Earth. These include:

1) Direct observation of deep-seated material that has been brought to the surface either very rapidly (hours) by magmas rising from the mantle, or more slowly (e.g. – 20 million years or more) by tectonic processes,
2) Experimental duplication of conditions deep in the Earth,
3) Remote sensing using geophysical techniques that include a range of seismic methods, and magnetotelluric, magnetic, thermal and gravity techniques.

It has been demonstrated from these approaches, that significant water may occur in the Earth's mantle, to at least 650 km and possibly below. This deep water in the mantle has two major origins:

1) *primitive* water that was incorporated early in Earth's 4.5 billion year history as it formed from planetary particles and later from bombardment by water-bearing comets. Such water was the main source of water that formed the oceans at the surface as the Earth evolved and differentiated
2) *recycled* water contained in surface rocks that are taken down to depths of up to 450 km (and possibly more) at collision ("subduction") zones of Earth's tectonic plates. Examples of modern subduction zones are beneath the Himalayas, the Andes and other circumPacific regions.

Nature and behavior of water-bearing minerals at depth

This deep mantle water is not in the form of "free" H_2O, but is bound in mineral structures, commonly as the element hydrogen (H).

Many water-bearing minerals are common and stable at the surface and in the Earth's crust (generally about 30-40 km deep). Such minerals can dehydrate (release water) when their host rocks are subducted from shallow regions, as they become subjected to higher pressures where different minerals are stable. This released water from dehydration does not form veins or streams of free water, but (i) may react with other minerals, thus forming new water-bearing minerals that are stable under the new conditions or (ii) may dissolve into partial melts of the surrounding or overlying rocks where the melting point has been lowered by the dehydration reactions (called

“dehydration melting”). These melts can be detected seismically at depth if they form large volumes, and some melts may travel to the surface and be erupted, or they may be injected as sills and dykes through the Earth’s crust above the regions where they are generated. Large volumes of water have not been shown to accumulate as veins or underground rivers through this dehydration process.

Water-bearing high-pressure minerals (such as Ringwoodite) may be transferred to regions (still in the mantle) where the dense crystal structure is no longer stable. They will then dehydrate but free water does not form. There are a series of reactions that hydrate the minerals in adjacent rock volumes, forming other types of water-bearing minerals that are stable under the new, lower pressure, conditions. Melts may also be formed at these depths, due to dehydration melting, but again, significant volumes of free water are not formed in these circumstances.

Relationship of deep water to shallow and surface water.

With the present (extensive) knowledge of the distribution and residence sites of water in the deep Earth, it is not evident that there can be any relationship of this deep “water” (contained in mineral structures mainly as hydrogen), to the water veins referred to in the article “Vein Water System – the Additional Water Source”. Large volumes of free water have not been shown to travel up to the subsurface in veins from 40 – 600 km deep; it forms hydrous minerals (including amphiboles, micas, serpentines, clay minerals etc.) that are stable at low-pressure conditions, or it may be dissolved in magmas that then crystallise hydrous minerals on cooling.

Structure of veins referred to in article

The structure of the veins shown in diagrams is very puzzling, and does not conform with any knowledge that I have, of the nature of water reservoirs and their properties in the Earth’s crust. Significantly more detail would be required to comment further. Such detail would include simple parameters such as scales of these features, as well as methods of detection used to define these properties.