Exploration Geophysics Applied to Groundwater Investigations 1965 – 1972

Some Memories

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INTRODUCTION

In the years prior to 1965 investigation programs for large-scale groundwater supplies in Australia were generally carried out by Commonwealth and State Government Authorities. These programs were supervised by Government staff and involved selecting optimum locations based on the hydrogeological knowledge of an area and then drilling and testing exploration bores to determine the location of aquifers suitable for production bore construction.

Many small-scale water supply investigations were conducted by privately owned drilling companies, sometimes supported with hydrogeological advice provided by a consultant Geologist or Engineer, who either offered this service additional to their Company's principal line of work or had left Government service and set up as a consultant. The most popular on-site technology used to locate sites for drilling water bores for private use was water divining. This arguably remains so today.

The readily available recorded use of geophysics for groundwater investigations in Australia were few and for me the most notable were studies by BMR (Bureau of Mineral Resources, Geology & Geophysics) in WA and at Alice Springs.

I have been asked by the ASEG to record my knowledge of the early transition years when evidence was produced to show exploration geophysics was providing valuable assistance to both large - scale and small - scale groundwater investigation programs. During the period 1967 - 2009 I spent the majority of my work time studying, applying and teaching exploration geophysics for groundwater, engineering and archaeological investigations. The following is based mainly on my memories acquired during the period 1967 - 1972.

MY INTRODUCTION TO GEOPHYSICS

In late 1963, having completed the first year of a Science degree at Sydney University, I no longer wanted to major in chemistry. My geology lecturer Dr Charles Phipps answered my query "I want to be involved with geology but I don't want to be a Geologist" by telling me to chat to the Geophysics group at UNSW led by Dr Laric Hawkins. After that chat I was both inspired & hooked – geophysical exploration was for me.

In 1964 I enrolled in a Physics/Mathematics degree (including 2nd year Geology) at UNSW and completed the Honours degree in 1966. Laric drew my attention to an offer by the NSW Water Conservation & Irrigation Commission (WC&IC) to pay University expenses for a student to complete the Graduate Diploma (Geophysics) at UNSW during 1967. I applied and was accepted. This resulted in me being appointed to the position of "Hydrogeologist", to work as a Geophysicist, commencing January 1968 and bonded to the WC&IC for 3 years.

I should add that during my time at UNSW I heard the most wonderful and impressionable lecture I have ever attended. Professor Runcorn spoke at a public meeting on the subject of Continental Drift and Plate Tectonics – the romance of which then bound me to geophysics for life.

NSW WATER CONSERVATION & IRRIGATION COMMISSION – HYDROGEOLOGY/GEOPHYSICS GROUP

PERIOD 1965-1969

A major development in the advancement of exploration geophysics applied to the search for groundwater occurred in 1965 when the NSW Water Conservation & Irrigation Commission decided to incorporate the use of the seismic refraction technique to their already established program to evaluate the groundwater resources of the major NSW river systems. Commission staff realized that the seismic refraction method offered the possibility of mapping variations of the alluvial content within the river systems and so more economically target drill site locations. Also, calculation and interpretation of refraction data were now greatly simplified, in contrast to previous methods, after Hawkins explained the Reciprocal Method of seismic refraction acquisition.

The WC&IC formed a truck mounted multi-channel seismic refraction system, supported by a drill rig to drill shot holes to house a small explosive energy source. Field staff included a seismic observer, a driller/shotfirer and off-sider. The support line crew were often staffed by local casuals living in nearby country towns.

Professional input was Initially provided by WC&IC Hydrogeologists. In 1966 the WC&IC offered to pay university expenses for graduates to take the newly established Graduate Diploma in Applied Science (Geophysics) at UNSW to be followed by employment at the WC&IC to work on their geophysical programs.

Joe Odins completed the Diploma in 1966 followed by myself in 1967, both joining the WC&IC the year after completing the Diploma. By 1969 there were four of us appointed as Hydrogeologists but working mainly on the geophysical programs – Joe Odins, Helen Andrews, Brett Haines and myself.

Coordination between the Hydrogeologists, the field crews and we geophysical “Hydrogeologists” generally ran very smoothly. The latter would join the field crew during data acquisition staying in nearby country towns.

On completion of each period of data acquisition the data would come back to the Sydney office and after interpretation depth sections were drafted by the drafting staff. These would be included in later reports completed by the Hydrogeologists.

A Volkswagen Kombi-van mounted geophysical well logging unit was also formed to complement the bore hole construction programs.

During my time at the Commission, I was mainly involved with working on the seismic programs within the valleys of the Lachlan and Murrumbidgee river systems.

My long-lasting memories on the job include:

1. The seismic refraction unit operated very efficiently and I enjoyed my time whilst being part of the team. This was largely due to the planning led by Bill Williamson, Maurice Hind and Joe Odins. The Seismic Observer Alan Ferguson did an exceptional job with field management.
2. The field surveys showed me the effectiveness of the seismic refraction method over varied terrain as well as an appreciation of the land holder’s needs and concerns about water supplies and the operational issues of working on country properties.
3. I will never forget laying seismic cable within fields containing numerous dead & dying sheep. The 1968-9 period was one of drought over much of in-land NSW and one farmer on

the Murrumbidgee flats informed us they simply couldn't afford the money needed to euthanize the animals.

Working at the WC&IC provided me with valuable experience in the acquisition and processing of seismic refraction data and in the conduct of field surveys. At the end of 1969 I left the Commission and in early 1970 I joined Australian Groundwater Consultants, mainly to gain more varied experience.

ESTABLISHMENT OF THE FIRST SPECIALIST GROUNDWATER CONSULTANT COMPANY IN AUSTRALIA - AUSTRALIAN GROUNDWATER CONSULTANTS PTY LTD

PERIOD 1966 - 1972

In 1966 two staff Hydrogeologists left the WC&IC to form Australian Groundwater Consultants Pty Ltd (AGC). At that time there was no other company of specialist Hydrogeologists in Australia (or for that matter, I would later learn, in the USA). I worked with one of these two Principals of the company, James Johnson, who remained with AGC until leaving in the mid-70's. The other original Principal had left by the time I joined in January 1970.

At that time mineral exploration was increasing at a great rate and the Pilbara iron ore deposits were a prime target. One of the first jobs for the new company was to explore for a water supply for both the Goldsworthy Town and Mine - which exported its first iron ore shipment in June 1966. AGC commenced both seismic refraction and electrical resistivity surveys that successfully located the initial production bores within the alluvial aquifers of the De Grey River system. The geophysical work was supervised by James Johnson, with Gunter Seidel (later to move to BMR) contracted to assist James to provide the geophysical interpretation for these early investigations.

Following the success at Goldsworthy AGC was contracted by Hamersley Iron (at Tom Price & Paraburdoo), Mt Newman Mining (at Newman) and Goldsworthy (at Shay Gap) to develop their mine and town water supplies. By the end of 1969 seismic refraction and electrical resistivity surveys had been completed at Tom Price and Newman with the initial investigation and production bores constructed at target sites.

In 1969 Steven Hancock amalgamated his consulting practice in Melbourne with AGC in Sydney headed by foundation director James Johnson. In the same year AGC appointed Cecil Forbes (Engineer) from the WC&IC who would soon become the third Director at AGC.

In late 1969 James offered me a full-time position as Geophysicist and to write off my bond with the WC&IC. I accepted as this would afford me more varied experience throughout Australia.

A Memorable First Field Trip to the Pilbara: 5th February – 10th May 1970

I joined AGC on 2nd February 1970 in Sydney, landed in Perth on 5th, arrived Tom Price airport on the 6th and was driven down to Paraburdoo that day. Expected duration for my trip was 4 weeks. Mission was to conduct electrical resistivity traversing on the proposed Tom Price – Paraburdoo rail line to enable a water bore to be constructed every 5 miles along its 65-mile length. The AGC vehicle was an old Landrover utility, no air conditioning, registration UFO…, with imperfect brakes. Enquiring at the Tom Price Shell service station whether they could have a look at the problem they told me they could fit us in in late November.

On my first evening at the Paraburdoo camp site I met up with the chap I would be sharing the 2 bunk (top & bottom) room with me. Of course, his wife's mother lived opposite my family home in Gentle Street, Lane Cove, Sydney. There were many ESB's working in the Pilbara at that time.

Pulling wires along the railway route at Paraburdoo was a hot job in over 50-degree heat soon to be made harder by one of the crew telling the cook's offsider that he fed his lunch to a kangaroo who keeled over backwards and died. For the second week we were refused ice for our Esky and water container. Lunch had to be eaten well before lunch time.

Aided by air photography the electrical traversing work was successful in finding fractured aquifers in the volcanics with only the 13th bore, closest to Tom Price, providing insufficient yield having been drilled in electrically conductive shales. A second drilling attempt proved successful.

At the same time as geophysical and drilling work was happening on the railway AGC staff were supervising an oil rig (IDECO Rambler 6000) working on 2x12 hour shifts whilst constructing production bores to supply Tom Price. The aquifers are within weathered parts of the Wittenoom Dolomite formation as located from seismic work completed by AGC in 1967. This borefield is 25 miles north-east of Tom Price (at the South Arm of the Fortescue River). AGC was also supervising a drilling rig working on 1x12 hour shift at Paraburdoo (65 miles south of Tom Price) drilling investigation holes for the future town and mine.

It was not too long before I became aware that, as a consultant, I could be called on to attend any of these jobs as required and at any time, and possibly at the same time. I soon became experienced in geological sampling, running and interpreting geophysical logs (normally at mid-night or there abouts), designing stainless screen locations in the production string as well as driving the near vertical hill on the pipeline route from the Tom Price bores to Tom Price in UFO.

Due to various personnel changes this resulted me arriving back in Sydney on the 10th May, a little longer than the planned 4 weeks field trip, knowing much more about geological sampling, well logging techniques and production bore design and the temperament of drillers. Times were busy. I was back on site a week later. Iron ore and nickel booms wait on no one.

Geophysical Procedures

The geophysical procedures used during these early years at AGC comprised

- Seismic refraction traversing using the reciprocal method of calculation.
- Electrical resistivity methods – Schlumberger array traversing and vertical electrical sounding.
- Well logging. When supervising drilling projects, we had use of a unit providing self-potential, single point resistivity and gamma ray logs.

Calculation aids comprised graph paper, a slide rule and a set of Schlumberger sounding curves.

A combination of seismic refraction traversing and vertical electrical soundings provided us with depth control whilst long spacing electrical resistivity traversing provided us with variations in conductivity and layer thickness.

1970 Attitudes to Geophysics

I quickly found that the general attitude of hydrogeologists working in WA was very different to my workmates at the WC&IC. No other consultant was using geophysics for groundwater exploration in WA and the general feeling was that the best method to explore was to go straight to drilling exploration holes.

Groundwater was vested in the crown and so our surveys were supervised by the Public Works Department of WA. All meetings were attended by the client, AGC and the PWD. When we

suggested using electrical resistivity surveys in the Eastern Goldfields the PWD advised us that the WA Geological Survey were of the view that these methods were unlikely to be effective because of the very conductive nature of the surface materials. We understood their concern however the PWD permitted us to proceed, always supported by the clients.

It soon became evident that electrical methods could provide valuable aquifer information.

Geophysical Projects

During the period 1970-72 the geophysical surveys I supervised included:

WA

Tom Price Railway 13 bores each capable of producing 5,000 gallons per hour for 12 hours.

Shay Gap Town & Mine

Windarra - Nickel

Mt Keith - Nickel

Yeelirrie - Uranium

NT

Nabarlek - Uranium

Gove - Bauxite

Overseas

Den Pasar, Bali

1974 USA PGA Golf Tournament Water Supply

Ciawi P4 Animal Project, Java

Some Comments Relative to the Early-1970s Period.

1. Our mining clients were often after 3 to 5 million gallons per day of groundwater for their sites. When we were told that the metallurgists for Mt Keith required over 12 million gallons per day of potable water (< 1000 mg/l of salt) we were faced with a big ask. In 1971 both seismic refraction and electrical resistivity traversing were completed on several sections across the Lake Way drainage system in the search for a supply.

   In mid-1972 three of us went on a 2-week tour of the area between Mt Keith and Wiluna sampling all wells and bores we could find staying over nights in vacant shearing sheds. Fortunately we just happened to have sufficient beer bottles with which to take our groundwater samples. A map of groundwater salinity was produced for this large area.

   It was later decided by the metallurgists that the more saline groundwater that abounds in the area would be satisfactory for mineral processing.

2. Den Pasar Water Supply, Bali
   The Australian Government Aid Plan contracted AGC to assist in establishing a water supply for Den Pasar in 1971. Too many people were dying of gastroenteritis by consuming contaminated surface water. Included in the work was an electrical resistivity survey to locate fractured rock aquifers at depth in the volcanics that form the island. The top 30 metres of each bore would be cemented off to protect from surface water entry. A drilling company from Melbourne was contracted to construct the bores.

   The work was carried out several kilometres north of Den Pasar. We passed through many villages and employed locals to keep the people away from our lengthy electrical transmitting lines. At each village the locals were most hospitable and invited us in to see their kampongs. The children seemed amazed when they saw us and I was told that these children had not seen white skinned people before.

3. North Carolina, USA
   The President of the National Water Well Association (NWWA) had guaranteed to find a water supply for the 1974 USA PGA golf tournament to be held at the Tanglewood Golf course in North Carolina. The sponsor, Reynolds, was very keen to have that happen however after the drilling of several unsuccessful holes the NWWA President took to desperate measures – in July 1972 he asked James Johnson for assistance. James put my head in a rope by assuring that he would send someone over to fix the problem. So with a box with a few knobs on it able to take 2 reasonable size 45V batteries (TX) and a lab voltmeter (RX) I proceeded to the country that was a leader in geophysical technology hoping that statistically there must be a small chance I would come out of this alive.

   After preliminary discussion with the hierarchy of the Reynolds Company (who assured me that I should never offer them any excuses as that would not be taken kindly) I proceeded to run resistivity traverses across the hard rock terrain. After acquainting myself with the nettle bushes that abounded the edges of the course, having changed from my “colonial” shorts to reinforced jeans, I came up with four sites that showed promise. We drilled the two closest sites to where they wanted to install the tank and were disappointed that each hole produced less than required supply – but more than any of their previous bores. We then moved 50 metres away from the tank site to my 3rd site and constructed a bore that was able to pump twice the required amount. Lee Trevino won the resultant golf tournament in 1974.

   Well up to now the hospitality shown to me by my NWWA hosts had been wonderful. However I did not expect what followed: being interviewed on the Charlotte evening TV news that night, then flown to the headquarters of the NWWA in Columbus, Ohio, then flown to South Carolina (Myrtle Beach) for a conference and then Savannah, Georgia then off to Bear Lake, Maine where the soon to be next President of the NWWA had a holiday cottage. During all of this I had my 30th birthday – one I will never forget.

4. P4 Animal Husbandry Project, Ciawi, Indonesia

CSIRO and the Indonesian Government were planning to construct the leading animal husbandry project for Indonesia at Ciawi, Java. Here amongst other developments the Gooduck would be researched – a bird the size of a goose laying a goose size egg but with the appetite of a duck. Clearly a wonderful economical result.

Following the construction of a large cattle shed costing well over one million dollars (stainless steel stalls, concrete floors) they needed a water supply. A Catholic Priest from Jakarta had visited the site and determined by water divining (and perhaps by other divine means) the best place for a water supply bore was in the middle of this shed.

CSIRO requested AGC to assist so with my trusty TX and RX from the USA job I travelled to the site. Promising sites were found and the first bore drilled was successful – well away from the prized shed – and a water supply was established. But don't knock divining – please read on.

5. Mt Mulgine Mine, near Paynes Find, WA

In the early 70's I was asked at short notice to travel to the mine and evaluate the water supply conditions. The hire company dropped off the vehicle and I arrived at the site just in time to be served dinner with the caretaker, his wife and 12-year old son. Halfway through the meal the son asked me why I didn't have a spare tyre. For the first and only time I had not checked one of the most basic of needs. So totally dejected in my stupidity I wasn't in a great mood when the caretaker asked me if the real reason I had never divined for water was that I was too scared to do so.

So off we went outside – he handed me two bent wires each in the shape of an L. I was told to hold the long arm loosely in each hand and walk between the house and the adjacent shed. To my amazement the wires turned and then turned back – twice in my 30-metre walk.

The caretaker had drawn a cross in the dirt where the wires crossed. They precisely marked where the water pipes crossed my path-easily identified by their presence on the outside of both the house and the shed. I have never tried that again. I don't know why?

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