CSIRO in Western Australia
Musings of Some Former Staff

Disclaimer

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CSIRO Alumni
WA Chapter
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FOREWORD

That science is a profoundly human activity is too often hidden by its neutral outward surface. When we scientists report our work in scientific papers there is frequently a sense of understatement as we strive for objectivity and rigour. Yet science draws from many wellsprings of human creativity and inspiration, as everyone involved in it knows deeply. Sometimes when one of its practitioners stands in front of an audience or a camera and speaks from the heart something may be heard of the exhilaration, but I regret that too little of this wonderment is made evident to those outside our domain. The accounts in *Musings* go a good way towards redressing this gap by revealing the human side of science in a significant segment of the most important scientific agency of our country, CSIRO.

The stories that follow are spirited personal ones, focused on the daily and the year-by-year experiences of working in the Western Australian arm of CSIRO during its earliest and then its rapid growth phases. Three aspects stand out to me. Firstly, doing science is fun! These stories pull aside the curtain of earnestness that dominates many public perceptions of the scientific community. Life for a CSIRO staff-member is frequently a sequence of amusing and entertaining events. This is not to say that disappointments and tensions never occur – life is a balance of yin and yang, after all – but the joy of working with passionate people in exciting and ground-breaking endeavours comes through superbly in these tales.

The second theme to emerge from the *Musings* is that CSIRO's Western Australian laboratories were full of 'characters'. There is a decent argument to be had as to whether or not the earlier eras of our Organisation allowed more such idiosyncratic individuals to prosper than is the case today, but that is for another place. What matters here is that these stories are full of high-spirited activities and personalities. My favourite comes from Peter Hick. It concerns one Bob Millington, an old friend of mine from Alice Springs who happened to be visiting the Perth laboratories at a time when everyone had been told to tighten their belts. The mischief-makers decided that this instruction demanded a response. Given that Bob had the same surname and initials as the Chief of a sister division in Canberra, a requisition form for a Cessna 206 with an attached Hasselblad camera was slipped into the system late on a Friday afternoon, with the apparent endorsement of 'RW Millington'. The purchasing officer went so far as to obtain quotes before other staff-members smelt a rat. After a newspaper spilled the beans, the trick was out. As Peter comments, "We never got our plane!"

Finally, these stories are imbued with pride. Everyone writes with satisfaction and fulfilment about the value of the work that they were doing, an outlook permeating stories not only from senior scientists but also from those whose efforts were devoted to administrative and technical support. Within this shared aspiration and pride lies the persistent strength of CSIRO. The team spirit and the sense of communal purpose, I believe, are as important today as is so evident in the *Musings* from past times.

CSIRO approaches its centenary in a decade or so, and I dare say that more formal accounts of the Organisation will be prepared as that notable event draws near. The reports herein are not intended to be official or balanced or comprehensive. Their strengths are elsewhere, in the emotional, the everyday, the human and the informal, and in this manner they will stand as evidence behind the formal histories. Read them and enjoy their colour, candour and vitality.

Steve Morton
President, CSIRO Alumni

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PREFACE

As Chair of the WA Chapter of CSIRO Alumni, in 2010 Adrian Peck invited all members to suggest projects for the Chapter. Peter Hick proposed the preparation of an informal history of CSIRO's activities in WA with a focus on the human stories behind the science in the various labs and field stations in Western Australia. This proposal was enthusiastically received by the Committee. It was recognised that a rich history of individualism and ingenuity was a hallmark of the growth-period of CSIRO in WA. Anecdotes of the activities of the diverse characters and the unique problems associated with the isolated western third of the continent will be lost with the passing of time and failure of memory.

Of course, somebody had to take responsibility for gathering the stories and preparing them for publication. The Committee placed this burden on Peter Hick and Adrian Peck – both with experience in preparing papers for scientific journals and reports for industry partners, but little previous experience of what we hope you will find to be an enjoyable record of events in the life of the staff of CSIRO in WA.

In the absence of any funding for this project, and with uncertainty about the size and demand for the intended document, we called for contributions of any sort, knowingly deferring any decisions about publication. On advice, we believe that the editor's disclaimer allays any unintended concerns.

The primary aim of this project has been to capture the stories that reflect everyday life in our labs and field stations before memories of unrecorded events are lost. As a brief example, some of us remember Reg Rossiter, a former OIC of the WA Labs and a very conscientious scientist – one knew when Reg was on leave because he would come to work in shorts and thongs instead of his normal shorts and long socks! Sadly Reg and many other pioneers of CSIRO's research in WA are no longer with us so their first-hand stories are not available to us. Moreover, many members of the Alumni with long experience and continuing interest in CSIRO feel that they are now not able to write their stories. Arrangements have been made to interview some of these people and these oral histories should be available to members of the Alumni sometime in the future.

The Committee suggested that the scope of material for this project should not be restricted to direct scientific programs, but to include the staff and work of support groups (administration; library; computing; chemical analyses; workshops and other site services; etc), and stories from social events – cricket matches; tennis competitions; athletic events; Christmas Parties etc. No restrictions were placed on the style or length of contributions, but it was recognised that some editing and formatting would be necessary. The objective was to collate recollections by former staff at all levels and most definitely not to prepare an official record of CSIRO activities in WA -- we expect that CSIRO will arrange such a history at some time in the future.

This collection of stories primarily covers the period from 1945 to the end of the 20th century. We note that ground-breaking work in fisheries, especially the fledgling crayfish industry, was done in the 1940s, and we have faith that there will continue to be events and characters that are worth recording in a future edition of our Musings.

Peter Hick and Adrian Peck
August 2013

1. SOME HISTORY

BEFORE CSIRO[1]

Before Federation in 1901, some problems in Australian agriculture had been identified and several attempts were made to introduce a co-ordinated scientific approach to these, but none succeeded. The Federal Government introduced Bills in 1909 and 1913 to establish a Bureau of Agriculture, but these Bills failed, principally because the states were still fearful of Commonwealth meddling. However, in 1916 the Commonwealth Government, spurred on by the urgency of the War, set up an "Advisory Council of Science and Industry". This was based on a British model, and some regard this as the origin of what we consider to be "our Organisation". However, the official record (Currie and Graham, 1966, *The Origins of CSIRO*) shows that only minor consideration was given to problems of the western third of our young nation.

In 1919 Federal authorities agreed to establish a Forest Products Laboratory in Perth to look at Western Australian eucalypts after trials of Tasmanian eucalypts for paper pulping in 1915 showed that poor results were produced. They sponsored Mr I H Boas to study forest industries and research facilities overseas, and on his return he persuaded various WA newspaper owners to contribute £600 to purchase a paper making machine. But, the Federal authorities would not adopt Boas' full plan to set up a laboratory on a scale that could deal with forest industries requirements and after setting up a small Forest Products Laboratory in Perth, he left for Victoria.

Vilnis (Bill) Balodis compiled a history of the Division of Forest Products in 2008 and quoted work of Benjamin in 1959 who wrote, "Boas foresaw, the model papermaking plant not only served a very useful function in teaching us the rudiments of papermaking but was also of great propaganda value". Samples of white paper, made from pink karri and red jarrah, were sent to state Forest Departments asking for funds, with a promise that their woods would also be investigated. The fund-gathering scheme operated for a few years, but in 1923 the Forest Products laboratory of the Institute of Science and Industry was moved from Perth to Melbourne. That lab also closed in 1928 and the papermaking machine (which is restored today in Melbourne) was transferred to the Division of Forest Products.

THE BEGINNINGS OF CSIRO IN WA

The Forest Products experience may have been typical of the changing roles and expectations. But things were changing, and acts were passed that resulted in the first meeting of the Council for Scientific and Industrial Research (CSIR) which was opened by Prime Minister Bruce in June 1926. A feature of the act was the creation of State Advisory Committees with the duty of "supervision" and "disbursement of funds" and to ensure equality of representation of the smaller states on the Ministerial Advisory Council before the Federal Government.

In his extensive review of the biological divisions of CSIRO in 1972, Eric Underwood said that "for its first decade the Advisory Council largely confined activities to problems of the agricultural and pastoral industries, especially to those involving pests and diseases". These were the horse-and-buggy days and that fact is evident in the scope of investigations that were specific to problems in Western Australia. They included why gold was found in quartz; how to control insects in grain; improving leather quality and tanning products from eucalypts; Kimberley horse disease and cattle tick; suitable pottery clays; and the use of waste timber from Jarrah forest logging.

[1] Contributions by several people

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In the First Annual Report of CSIR (1927) it is stated that a Conference of agricultural experts was called by the Council. This meeting included representatives of all State Departments of Agriculture and several Universities. They formed the opinion that, "in view of the number and magnitude of the problems concerning the agricultural and livestock industries of Australia, Commonwealth participation in agricultural research is desirable." The CSIR Report stated "there are many problems which are national in range or scope and which require concentration, effort and highly specialized equipment for their solution. Such problems were considered to be specially suited for investigation by the Commonwealth. The State Departments of Agriculture and the Universities recognised the limitations of their staff and facilities for agricultural research of the magnitude and continuity required, and they gave strong support to Commonwealth participation.

The States were by no means abrogating their rights to undertake agricultural research in favour of the Commonwealth. The 1927 Conference recommended that CSIR should undertake investigations "of a more or less fundamental character" and which are "national in scope", whereas those of a more or less "local character" and which "involve the application of local knowledge" should remain with the States.

EARLY DAYS[2]

In 1945 the then CSIR (renamed CSIRO in 1949) was requested by the State Fisheries Department to investigate the biology of the most important WA marine fisheries – crayfish, whales, salmon and herring to better manage the development of the industry and the conservation of these species. This request resulted in the appointment of Keith Sheard in 1946 to work alone in the Zoology Department at the University of WA.

By 1952, the Division of Fisheries and Oceanography was represented in WA, and operated Fisheries Research Vessel FRV Warreen. This vessel was built in Williamstown for CSIR and used as a trawler for fisheries research in Tasmania in the late 1930s. It was taken over by the Navy in about 1942 commissioned as HMAS Stella, and in about 1946 returned to CSIR when it was based in Fremantle for research in the Indian Ocean.

About 12 biologically oriented scientists were housed in the Zoology Department of UWA headed by Professor Harry Waring. Keith Sheard was nominally the leader of the CSIRO group, while the Hydrography section was led by Rex Spencer. This group of people were housed in temporary premises at the southern end of the UWA campus at Crawley along with staff from the Division of Soils (led by Robert Smith) and Division of Entomology (under Murray Wallace). These buildings were previously occupied by the Dutch Officers Club which was HQ of the Catalina Squadron that patrolled the Indian Ocean from Crawley to Colombo during WW2. Other CSIRO staff were housed within the UWA Institute of Agriculture that was headed by Professor Eric Underwood, a strong supporter of CSIRO and a member of the State Committee.

Most of the CSIRO group housed at the Institute of Agriculture were staff of the Division of Plant Industry and were locally led by Reg Rossiter a local graduate. Also housed in the Institute building was Norm Stenhouse of the Division of Mathematical Statistics who was

[2] Contributions by several people

supported by a couple of Assistants equipped with Marchant calculators. They handled the statistical computations for most of the CSIRO research staff.

Dom Serventy transferred from the Division of Fisheries to head a newly formed offshoot of the Division of Entomology that was called the Wildlife Survey Section (later to become the Division of Wildlife Research). This group initially occupied a house in Caporn Street adjacent to UWA but as its activities expanded it moved to occupy a house on the banks of the Helena River in Helena Valley that was converted for laboratory and field operations.

Alan Beck of the Division of Animal Health was accommodated in the State Animal Health Laboratories in Smyth Road, Nedlands, which were demolished to make way for the Hollywood High School (later to be renamed Shenton College on a new site in Shenton Park). Erik Munk Petersen, who transferred from the Division of Animal Health Parkville (Victoria) was also located within the Institute of Agriculture where he was later joined by Norm Adams.

In 1954, two buildings were erected by CSIRO on UWA land immediately south of the Institute of Agriculture. These laboratories and offices were expanded and modified a few times to cope with staff growth. By 1968 these facilities were replaced by the first group of buildings on the Floreat Park site. A grant of 25 acres (10 ha) was arranged by the State Premier (Sir Charles Court) who was anxious to see CSIRO expand its presence (particularly in minerals research) in WA. The Floreat Park site was part of the WA University Endowment Lands for which the University received alternative land grants from the WA government.

A group from the Division of Mineralogy was transferred to WA from Fishermans Bend (Victoria) in about 1962. This group was led by Wilf Ewers. Initially this group was housed partly in one of the Chemistry buildings on the UWA campus, and partly in the Zoology Department of UWA at the north end of the campus. On completion of Stage 1 of the Floreat Park laboratories, both groups were transferred temporarily to the Floreat Park site pending the building of Stage 2 when the HQ of the Division was relocated to Floreat Park with Arthur Gaskin as Chief, and Wilf Ewers OIC of the Laboratories. In 1972, Stage 2 of the Floreat Park site was completed and occupied by the Division of Mineralogy.

ADMINISTRATION AND GROWTH[3]

By the middle of 1954, with the completion of the first CSIRO buildings in Western Australia on the UWA campus, behind the Institute of Agriculture, Myers Street, Nedlands, most of the staff from the various Divisions spread around Perth had moved into the new laboratories and offices. This included officers from the Division of Entomology, Division of Mathematical Statistics, Division of Plant Industry, Division of Soils, and Division of Wildlife. C. Schuster, of the Division of Forest Products, remained off- site, and Fisheries staff, which was the largest group in WA at that time, remained housed on the University campus near Kings Park.

The administrative staff comprised Hector Potger, (Chief Clerk) Jack Brophy (2nd in charge), a clerical assistant, Kath Power and two typists. They had been occupying rented accommodation at Museum Street, Perth before moving to the UWA site that became the central administrative unit of the newly formed WA Regional Laboratory. The first Officer-in-Charge was Reg Rossiter, from Plant Industry and Maurice Mulcahy from Soils was his deputy.

In November 1954, Jack Brophy was appointed as Chief Clerk. Over the next 5-6 years, staff numbers increased rapidly. They were bolstered dramatically by the arrival from the

[3] Contributed by Des Baccini and John Brophy

eastern states of the new group from the Division of Applied Mineralogy, who were housed in the Chemistry Department at UWA, but received administrative support from the WA regional office. The staff increases in WA were mostly within the Plant Industry and Soils groups. Plant Industry also had staff operating at Kojonup, Kelmscott and later, Bakers Hill, field stations outside the metropolitan area. The Floreat office was required to provide an administrative service to staff at those locations.

The expanding Wildlife group, under Dom Serventy, was forced to move out into a rented house in nearby Caporn Street, Nedlands because of lack of space and the need to house ailing birds and animals brought in by the public to be cared for by technical assistant, Lexie Nicholls. When the Wildlife group moved to Helena Valley they provided their own administrative staff operating independently from the Floreat administration.

With no possibility of extensions to our CSIRO buildings on site and with a keen desire to be separated from UWA restrictions and control, Jack Brophy became deeply involved in negotiations with the WA State Committee, State Government departments and CSIRO Head Office, which resulted in the successful acquisition of the University endowment land near Perry Lakes in Underwood Ave, Floreat Park. This became the first land owned by CSIRO in WA - it officially cost the CSIRO "1x peppercorn." It became known as the "WA Laboratories".

During the next few years, staff numbers continued to grow at a fast rate and the Organisation was pressured by the WA Government to have at least two Divisional headquarters based in this State. A new building was erected on the Floreat site to house the newly formed Division of Mineralogy; the Chief of this Division, Arthur Gaskin, had moved from Melbourne to live in Perth. This new Division, comprising 85 staff, had branch laboratories at Canberra, Melbourne and North Ryde and required it's own administrative staff unit at Floreat to operate separately from the WA Regional Office. With the establishment of a Divisional headquarters on the Floreat site, the administrative and financial control of the site library and engineering services became attached to the Division of Mineralogy.

The Floreat office under Jack Brophy continued to provide administrative services to the other staff in WA until about 1973 when a second Divisional headquarters, the Division of Land Resources Management, with Ray Perry as Chief was created on the Floreat site with it's own administrative staff under Divisional Administrative Officer, Pat Keogh.

With two Divisions located at Floreat Park labs, administration of the site was run jointly and informally between the two Chiefs and the two Divisional Secretaries on a day-to-day basis. At this time the administrative group under Jack Brophy was moved off the Floreat site to premises in Kings Park Road, West Perth and given a new role as WA Regional Administrative Office (RAO) with responsibility for payment of salaries and accounts for all WA staff. Changes in CSIRO's administration throughout Australia in 1985, led to the abandonment of Regional Administration, and the administrative staff were relocated to new offices on the Floreat Park site.

THE STATE COMMITTEE

The Science and Industry Research Act was introduced into Federal Parliament by the then Prime Minister Billy Hughes in 1926. The Act provided for the establishment of the Council for Scientific and Industrial Research which included the appointment of a national advisory body, the CSIR Advisory Council with representatives from all the States of the Commonwealth, supplemented by the Executive (full time) of CSIR. In 1949 the Science and Industry Research Act was amended by an Act of Parliament and CSIR became the Commonwealth Scientific and Industrial Research Organization, CSIRO.

The first Western Australian State Committee (WASC) was established in 1927. It consisted of 9 members from the University of WA and various State Government Departments, and was chaired by Mr B. Perry. John Brophy, as the Secretary of WASC, recalls it comprised Academics from the UWA and the WA Institute of Technology (later Curtin University of Technology) along with leaders from Industry, Governments (State and Commonwealth) and the Agricultural and Pastoral Industries, Engineering, Science and Business. Members were nominated and approved by the Chair of the WA State Committee and endorsed by the Premier of the State. Following the creation of Murdoch University and Curtin University of Technology, further members were recruited. Initially, the Chair was drawn from the Heads of University of WA, WA Government Departments and leaders of Industry (particularly the Pastoral Industry), but with the expansion of the mining industry, representation on the Committee broadened.

The WA State Committee continued to function until it was disbanded following the recommendation of a Government-appointed Review Body, chaired by Professor Don Watts (formerly VC of Curtin University in WA and later VC of the University of the Northern Territory). This was a retrograde step for Western Australia whose State Committee was highly regarded and effective in its operation.

One of the members, Laurence Brodie-Hall, later Sir Laurence, was installed as Chairman of the Committee in 1962. In his memoirs, Brodie said "during my 10 years as a member of the State Committee, I thought of ways in which it could be made more productive, and when in 1972 I was offered the Chairmanship, I accepted. However, my acceptance was with the proviso that “it should become more formal, and meet bi-monthly on fixed predetermined dates, that its objective should be to investigate the research needs of the key areas of Western Australian Industry, that a report should be prepared by a sub-committee of experts on the subject being investigated and submitted to the Chairman (and Executive) of CSIRO with the request that it become an agenda item for consideration by CSIRO Advisory Council at the next meeting following receipt of the report."

"Brodie", as he was commonly known, provided dynamic leadership of the WA State Committee. He personally canvassed for new members of the Committee including Bruce Kirkwood, Chairman of the SEC (State Energy Commission), Noel Fitzpatrick, Director of the Department of Agriculture, Bob Hillman, Director of Public Works, Professor Robert Street, Vice Chancellor of the University of WA and several other community leaders. In fact everyone Brodie approached agreed to join the Committee.

Brodie reserved to himself the position of Chair of each Project Committee whilst John Brophy, acted as Secretary to each project. The following is a list of WA State Committee Reports prepared under Sir Laurence's Chairmanship.

- Proposals for environmental studies into some aspects of natural resource utilisation in South Western Australia.
- Proposal for marine environmental studies off the West Australian coast.
- Systems analysis studies in resource management for Western Australia.
- Long term trends in Agriculture in Western Australia
- Understanding the near-surface environment of the Kalgoorlie Region to aid mineral exploration and water management.
- Research problems in Western Australian sheep fertility.
- Observations into cloud seeding in Western Australia.
- Review of forests and forest products problems.
- Studies in tropical ecology and a multi-disciplinary approach to arbovirus in Western Australia.
- Applied Physical oceanography - A preliminary study in Western Australia's

needs and future research programs.

- New land use options for the South West of Western Australia.
- Fresh fruit and vegetable production for North West Australia
- A proposal for a national water supply technology demonstration centre in Western Australia.
- A submission to the Committee of enquiry into CSIRO.

FLOREAT PARK

The successful acquisition of an area of University endowment land near Perry Lakes on the corner of Underwood Ave and Brockway Road, Floreat Park was a turning point in the history of CSIRO in Western Australia. CSIRO had a home at last. It was, at first sight, natural bushland east of Reabold Hill and Bold Park, and only minutes from Perth's famous beaches.

However, the beautiful bushland site does have a fascinating history and it overlooks the site of the former main stadium of the 1962 Empire (Commonwealth) Games to the north and McGillivray Oval to the south. The history of the McGillivray oval is significant as it is the site is where Perth had its second airfield built about 1927 and the Brooklands Race Track covered part of the site. It was also known as the "West Subiaco Airfield" it had a colourful but largely unrecorded history. It was used by joy-riders and amateur barn-storming pilots who used to race their tiny fabric aircraft around the track at tree top height against cars and motorbikes. Large crowds were regularly in attendance despite the boggy sandy road access over the Shenton Park Hill.

It is rumoured that international air heroine Amy Johnson refused to land there in 1930 because its main permanent occupier was the German Consul Herman Christian Ittershagen who was also the local Lanz tractor dealer. Ittershagen ran his German-built Lanz tractor business from the airfield and he flew his little 40 HP Klemm (VH-ULU) aircraft from the site to service his Bulldog tractors throughout the wheatbelt. He even had floats fitted to the Klemm to allow water landings. He claimed a same-day delivery of tractor parts and repairs. His pilot was Harry "Cannonball" Baker, who flew the Klemm in the Trans–Australian Air Race in 1930. However, anti-German feeling in the years following WW1 and leading up to WW2 saw his planes damaged and hanger burned down when war with Germany looked likely. The Government dug up the airstrip to make sure it was unusable as there was a fear (most likely unfounded) that Herman would have let his German friends know of its location and its history was removed from maps and documents. The bush quickly regenerated although the careful observer can walk through the bush on the CSIRO site and still see some remnants of the history and the limestone rocks that marked the edge of the race track and the airfield.

THE FIRST CHIEFS BASED IN WA

The first Divisional Chiefs in WA, Ray Perry and Arthur Gaskin, Chiefs of Division of Land Resources Management and Division of Mineralogy respectively were appointed to Perth at about the same time, and moved into the Floreat Laboratories. Ray was from the Division of Land Research in Canberra which had been restructured following a review of Land Use and Soils Divisions. The Officers of those two Divisions located in Perth were amalgamated to form the Division of Land Resources Management (LRM)

Wilf Ewers remained in his position as OIC of the Division of Mineralogy at Floreat while Arthur Gaskin transferred his office from Melbourne to Floreat Park, where he remained until his retirement. The consequent increase in staff numbers, facilities and finance enhanced CSIRO's presence in WA and, having two Chiefs on site in Floreat Park, support *for* WA was markedly increased.

Along with Ray Perry's relocation to Floreat came additional professional communication staff including a photographer, Bill Van Aken, a journalist, Justin Murphy and Admin Officer, Bob Rummery and cartographer, Maurie Woodwood who contributed to the professional skills on the Floreat site. It was not long before Ray Perry and his group organised an open week at Floreat which attracted hundreds of members of the public who toured the Laboratories and met staff at work.

Such was the success that monthly visits by community leaders, another of Ray's initiatives in conjunction with the State Committee, opened the Floreat Laboratories to a broad group of industry and government leaders. The visitors would be met and introduced to staff, and escorted to a number of Laboratories where Officers would provide an outline of their research activities. This led to many Industry contacts being established and maintained.

The two Floreat Chiefs became permanent visitors to the WA State Committee meetings, and at the final Meeting before the Committee was disbanded, they jointly proposed that Sir Laurence Brodie-Hall's contribution to CSIRO in WA be recognised by establishing an annual Lecture to be known as the Brodie-Hall Address be funded by CSIRO. It is worth noting that the Brodie-Hall Address this year (2013) will commemorate the 50th Anniversary of the Division of Mineralogy in WA.

2. PEOPLE

GEOFF ANDERSON[4] (1957 to 1992)

One of the farm assistants who played tennis said to me one day "My father-in-law is retiring soon from his position as farm manager at CSIRO's Glen Lossie Research Station at Kojonup. It would suit you nicely and the conditions are much better than here". His comments appeared to be correct and I decided to apply.

There was a great deal of interest in the position and applications came in from most Australian states and many of them were from men with diplomas from leading agricultural colleges. My advantages were West Australian farming experience, previous research station background and my Honours Degree in Science. I do not know if this was an influence or not, but I went to UWA at the same time as the officer in charge of Glen Lossie, Eric Watson. He interviewed a short list of applicants including me and reported to the head scientist of CSIRO in WA, Reg Rossiter, that I was clearly the person they wanted. Reg felt that he should check this assessment and came to see me at Wongan Hills. We looked around the station, had a good discussion and then returned to my house (and office) for morning tea. Maureen and I had entertained the previous night and there were some tasty leftovers. When Maureen brought these in, Rossiter exclaimed with pleasure and tucked in appreciably. He mentioned that morning tea for years afterwards. Did I impress him? Or did the morning tea affect his judgement? Whatever, I got the job! He provided staunch support for me for the rest of my career and I mourned his death when it came shortly before I retired.

A high school friend of mine, Noel Fitzpatrick worked for the Agriculture Department and came to Wongan Hills Research Station now and then. Later he became the Director of Agriculture. He offered me a three-month-old sheepdog pup and duly brought me my second "Toby". He was a black and white border collie/kelpie.

We moved to Glen Lossie in May 1957 and I soon recognised the subtle advantage of working conditions with CSIRO. Each week I discussed the running of the farm side of the station with Eric Watson, then had a free hand on the management of the farm. Eric was a Research Scientist living on the station and conducting his own research program. We both reported to Rossiter in our Nedlands laboratories.

There were five Technicians responsible to various Scientists from our Nedlands Headquarters living on the station and I had a farm staff of five. The technicians were initially Arthur Rogers, John Beresford and Peter Lapins; later on Gordon Michael and Robin Barron joined them. Eric was a happy-go-lucky fellow with a university reputation for pranks. We got on extremely well most of the time. An exception was when we differed about a farm assistant appointment. Eric was religious, an enthusiastic and preaching Baptist. He persuaded me to appoint an extra man on to the farm staff without advertising the position. Nowadays this would be frowned upon and even then it was a bit unusual in CSIRO. After a

[4] Compiled by Peter Hick from an autobiography "The Risks and The Rewards" (ISBN 0-646-37992-5 Printability) written by Geoff in 1999 after he retired from CSIRO. I have taken the liberty of selecting those parts of Geoff's book that are relevant to his great contribution to the early days of the Division of Plant Industry and some brief biographical back ground.
Geoff was born in Adelaide in January 1926, the youngest of seven children to his fourth-generation Australian parents. In that same year his family moved to Perth and after a failed real-estate venture the family moved to farming in the Red Hill area; later they bought a farm in the Jenncubbine district in the height of the depression. Geoff attended Northam High school and then enrolled to do medicine at UWA. Fortunately for all of us at CSIRO he drifted toward zoology gaining a BSc with honours and came to the notice of Eric Underwood. After a time back home farming and at the Agriculture Department at Wongan Hills, he joined CSIRO.

while I noticed that jobs took longer if he was one of a pair of men doing it. It transpired that he was also a keen Baptist and was trying to convert some of the others to his beliefs. However, he started carrying a Bible and reading to them in their lunchbreaks, pushing pamphlets onto them and leaving religious literature around. Some of the men complained to me so I reprimanded him and told him to restrict his religious activities to his own time. However he continued until I said "If you won't work to my rules you will have to leave." When he reported this to Eric, both Eric and I got very stirred up and I was ordered not to dismiss him. I replied that if I was not allowed to run things my way I would refer the matter to Rossiter and other senior staff and would resign if they agreed with Eric. (I had already discussed it with some of them and knew how they felt.) In the end Eric backed down, the man went and life returned to normal except for a few months of coolness between us.

Eric was responsible for the maintenance of the houses on the station. These were mainly of bungalow style with verandas on two or three sides. The walls and roof were made of asbestos. When Jim Grogan, an Irish farm assistant reported a leaking roof, Eric climbed up to see what repairs were needed. Now Eric was a very big, strong man weighing over 110 kg. This weight was too much for one section which broke and he fell through, luckily landing on a veranda. He was not hurt much but his fertile imagination came up with a joke to play on the superstitious Jimmy. Eric found a very large gravel stone, which only he could carry, and staggered with it to the spot below the gaping hole in the roof. When Jimmy came home and saw this he jumped to the conclusion that it was a meteorite and he rushed to report this very strange happening to me. But I was "in the know" and solemnly sent him off to see what Eric thought of it. 'Begorrah. it's even got moss on it' said Jim. Eric agreed it was most unusual and promised to report it to the Bureau of Meteorology. The other farmhands soon found out and blew the bubble; poor old Jim was very red-faced and quickly realised how gullible he had been. We only ragged him over it for about a month!

Kojonup was a pleasant little town and we settled into the social life by joining the tennis and golf clubs. We became friendly with a lot of the locals particularly with teachers, bank officers, chemist etc. There were frequent social events between this group and the technicians from the station. Eric and Peg Watson, Arthur and Rene Rogers, and John and Pam Beresford between them had 12 boys but no girl, so, when our Anne-Marie arrived, she caused a ripple of excitement as the first girl born on the station.

Some of the most memorable events during our stay there were the biennial field days when farmers were invited to the station to see and hear what each of the scientists were doing. At the biggest of these, in 1960 I think, approximately 700 individuals attended. These included farmers and their wives, bank managers, Agriculture Department officers, stock agents and townspeople. This number took us by surprise as 200 was a more usual number. Each speaker had prepared 6 by 4 foot visual aids which were placed in a frame on the back of the farm truck from whence they could be seen and read by the visitors at ground level.

One speaker, an ebullient Welshman Haydn Lloyd Davies, presented a talk about infertility in sheep, a serious problem at the time. He mounted the truck wearing plus fours, a tweed coat and cap and carrying a shepherds crook with which to indicate important points on his graphs. I was on the truck too for various reasons and my dog, Toby, who went everywhere with me was underneath. Haydn started his talk confidently and was soon in full flight, striding back and forth banging his crook on the floor for emphasis. He was really quite impressive until Toby, sensing the excitement of the presentation, decided to start chasing his tail below the speaker. Well, the audience started laughing and poor old Haydn lost his composure and had to refer to his notes. During the lull, Toby lay down but as soon as Haydn got back to banging with his crook, Toby became excited and started turning circles again. Some of the crowd went into hysterics and Haydn, very red-faced, finished off quickly. Toby was very pleased with himself; he had never had such an appreciative

audience before (nor since). Haydn stalked off muttering to himself and it was only months later that he could see the funny side of it.

Another amusing event that day was that the very long car in which the Director of Agriculture was travelling, was the only one to get bogged in a Glen Lossie's creek! We had anticipated possible problems there and had a tractor standing by so the car was quickly extricated. On the serious side we learned that moving such a crowd around by car and utility was too time consuming. Thereafter we had trucks with hay bales for seats and buses to minimise the length of the cavalcade.

I had always hankered for some land of my own and as our finances improved I was on the lookout for opportunities. At Kojonup I bought a 10 hectare hobby farm and ran a few sheep and cattle there. This was close to Glen Lossie so it was convenient for me to check on the livestock after work and do any necessary jobs in the weekend. Later I sold this and bought a 400 hectare block half way to Boyup Brook. Jim Mazza, an old friend from St Georges College, then and still a solicitor, bought a half-share. With an old tractor and plough I started preparing the land for cropping. Just then I was asked to move to Bakers Hill to develop a new research station, so Jim found someone to buy my share and I started looking for land close to Bakers Hill.

I suffered a serious setback while at Kojonup when I was helping my brother-in-law Terry Caulfield to shear sheep on my hobby farm. I stumbled while dragging a sheep backwards and felt the unmistakable agony of a slipped disc. Terry had to finish the few remaining sheep by himself then take me home to a nice firm bed. The doctor, Ted Bevan one of our card-playing group (whose daughter ended up working at Floreat for a while) agreed with my diagnosis and confined me to hospital for 2-3 weeks traction. In traction some weights are attached to the feet of the patient and suspended by pulleys at the end of the bed. This stretches the spine and allows the damaged disc to move back to the correct position. The treatment worked well and I recovered completely in a few weeks.

My family and CSIRO friends insist that I confess to the following embarrassing story. Toby sometimes travelled in the boot of my car which was well aerated. One evening I came home in the dark from my farm, garaged the car, went inside for a wash, had my tea and in due course went to bed. In the morning Toby was missing and failed to come when I called and whistled. I went out to the block thinking I had left him there and I searched and made enquires around the town. Another night went by and the mystery deepened until I remembered putting him in the boot! Was he relieved to get out! And he had not even dirtied the boot. What a good dog and what a stupid Geoff. In time I have become even more forgetful but that took some beating for a long time!

There is another little story from Glen Lossie which I like to tell about my good friend John Beresford. John acquired a sheep for rations. He had never killed anything before but he decided he must dress this sheep. The dastardly deed was performed in John's backyard probably with advice from Arthur Rogers his next door neighbour. The recommended treatment for a freshly slaughtered sheep is to hang it outdoors overnight in a well aerated jute bag. John hung it from a tree in the small paddock next to his house. When I came out next morning it was there and temptation got the better of me. I hid the carcass in a small dairy shed 100 metres away in the furthest corner of the paddock and waited for developments. Soon, John came out rubbing the sleep from his eyes. When he had rubbed them a second time he realised that his prize carcass was missing. He raced back into the house, I don't know why, then ran along the fence line, every so often looking from left to right. He had assumed that a dog had carried it off until he reached the shed where he quickly found it. His body language when he emerged was very clear until he spotted me; then it changed instantly from (Who did this? to I know who did this!) I will never forget the incredulous look on his face when he first realised it was gone!

In 1962, our scientists decided that travelling to Kojonup was too time-consuming and that a station closer to Perth would have several advantages. A decision was made to purchase land at Bakers Hill, 47 km east of Perth. I was asked to go there and establish the new station. It was named "Yalanbee Experiment Station and I moved there to a new house early in 1963. Three bungalow-style houses were subsequently transported there from Glen Lossie as farm staff were transferred.

There had been a lot of interest and support shown for the research carried out on Glen Lossie and the Great Southern farmers were therefore not amused when it became known that most future research would be transferred to a new station at Bakers Hill.

Reasons given for the move were that new soil types were needed and that many Glen Lossie paddocks were no longer suitable because so many previous fertiliser, cultural and grazing treatments had made many sites unsuitable for further work. While this was partly true, there were other less publicised aspects. The distance of Glen Lossie from Perth annoyed scientists who begrudged the time spent travelling, which sometimes meant they had to stay overnight in Kojonup. There were other problems too; pasture samples for chemical analysis often required really fresh material and Haydn's growing program of Animal House feeding trials required daily attention by him and/or his technical staff. Bakers Hill was only one hour from the Floreat Park laboratories which meant that technicians could travel there, take samples or do other duties for a few hours and return home in daylight hours.

I had been asked to transfer to Yalanbee and was happy enough to do so. My work had become rather repetitious and I looked forward to even more responsibility and authority. The challenge of establishing a new station was one I could not resist. We regretted leaving our circle of friends behind but knew that we would soon make new ones. Actually two or three families whom I had known before going to Forrestdale were still there and they welcomed Maureen and the family readily. Some experiments in progress could not be terminated overnight. Most of Glen Lossie was sold quickly and some staff were moved to Yalanbee while two older men elected to stay behind and retire when everything was wound up.

My responsibilities as ‘Station Supervisor' included clearing the land, having houses moved from Kojonup, establishing crops and pastures having farm buildings, fences and water supplies set up and supervising farm staff and contractors. The youngest and most recently appointed farm assistant came with me as there was a house available for him and he had recently married he was keen to move. I made him Senior Farm Assistant which proved to be an excellent choice; he developed quickly into a very capable leader of the new team as it expanded with Yalanbee’s requirements. His name is Gerald Watson and he continued still as a Senior Technician at the Floreat Park Laboratories completing nearly 50 years with the organisation.

The Baker's Hill landscape is somewhat variable - more so than those selecting the site of the property realised. There are steep hills, the tops covered with large granite boulders, gravelly mid- slopes timbered with white gum, red gum and jarrah, and lower slopes (poorly drained in places) and timbered with wattle, casuarina etc. Blackboys are scattered throughout and native poison plants of the oxylobium and gastrolobium species are prevalent in some areas. As these are highly toxic to sheep and cattle (kangaroos are immune) every plant must be eradicated before grazing can commence. Many plants are killed by the cultivation which is necessary before pasture can be established. This cultivation also brings to the surface a horrifying assembly of gravel stones ranging in diameter from 15 to 50 cm and a multitude of tree roots. Days and days were spent carting the roots and stones into heaps and grubbing out the poison plants. I had to employ casual labour to cope with these demands. A Scotsman was warned in advance that he would be

sharing in these dirty and monotonous chores and only stayed a few weeks. His parting words were "Damn stones, roots and poison plants! This was the only work I could get when I arrived in Australia 30 years ago; I had hoped that one day I might graduate to something better!"

The position of Yalanbee is high in the landscape and the Goldfields Water Supply system has insufficient pressure to service some areas of the station. The ground water is excessively saline so bores and wells were seldom useful. Therefore, I had large earthen dams constructed to collect surface run-off. Sometimes in high positions it was also necessary to construct wing drains to direct the water into the dams. Exploratory drilling was usually required to determine whether sub-surface clay was sufficiently impermeable to hold water. Dams are often built above mid-slope as those on lower slopes may become salt after a few years.

When there was adequate pasture at Yalanbee, sheep were transferred from Glen Lossie. Eventually, because detailed measurements were to be made on the sheep, lan Southey a technician from Glen Lossie arrived to take over all sheep work from me and the farm staff. Relieved of this responsibility, I asked approval to take on some experimental studies. It was also decided to employ an administrative assistant to allow me more time for my new interests.

I had always taken a keen interest in many of the research projects on the various stations and was able to make relevant comments about some of them to the responsible scientist. It had become apparent that I could contribute in ways other than running the station. CSIRO had a plant introduction section headed by a senior scientist, Eric Bailey. He had made several trips overseas mainly to the Middle East, Southern Europe and South America collecting a variety of grass and legume species to test in our soils and conditions. He planted these first few seeds in rows and harvested the resulting seeds by hand. As seed supplies increased he concentrated on the most promising species. They were grown in small plots and examined for resistance to pests and diseases in several regions of South Western Australia and some were sent to the Eastern States for evaluation there. He also evaluated the yield potential by cutting and weighing the vegetation twice a year to simulate grazing. Unfortunately, this was where his work stopped.

I suggested to Reg Rossiter that here was a suitable extension of Eric's work for me to perform. The ultimate tests of a new species are how it regenerates after grazing and how livestock perform on it. When he agreed, I started a program sowing areas of vetch, clover and grass species which had withstood Eric's evaluation. These were then grazed in individual plots so that both sheep and plant performance could be measured. Some proved disappointing, others thrived and were reported in scientific journals and were recommended to the Agriculture Department for regional testing.

These papers were my first individual contributions to International scientific literature. Reg Rossiter and Eric Watson also offered me the opportunity to take part in experiments they were conducting on Yalanbee. It was useful for them to have me on the spot where I could regularly check on the stock and also participate in soil and pasture measurements. I gained closer insights into working in groups. Each of these projects resulted in publications with me being named as a co-author. Thus my transition from Station Supervisor to Experimental Scientist gradually occurred.

Our head office, The Western Australian Regional Laboratories, was based in Floreat Park; it included several other Divisions besides ours which was named the Division of Plant Industry. Our research scientists together with their support staff were based there. Experimental scientists worked on some projects of their own but always supervised by a research scientist. Research Scientists often had several lines of research and if one or

more of them were based on Yalanbee he, his experimental scientist and technicians would visit the station as often as necessary to take measurements and make sure things were going to plan. At other times just the support staff would come, and occasionally, one or more farm or livestock assistants would be requested for extra help.

Cooperation between me and my staff and the research teams from the WA Regional Laboratories was essential and in most cases was readily achieved. However, our Welsh scientist sometimes felt himself to be above the chain of command accepted by all the others of keeping me fully informed of his projects on the station. It led to some antagonism between me and his station based technician. This was unfortunate as it spoiled the previously happy cooperative attitude and tended to create a' them and us' situation.

Another function of mine was to assist the inexperienced lessees of new conditional purchase blocks in the area with advice on pasture species suitable for their land, fertiliser rates and establishment methods. As we had just completed experiments on these aspects on Yalanbee, I was able to pass on the latest information. I recommended that in the clearing process, a few trees per hectare should be left for shade and appearance and also to use water deeper in the soil profile and hence prevent the water table rising and salinity development.

In the 1960s the importance of trees in the landscape was being increasingly recognised and CSIRO's awareness of the potential for the development of soil salinity on heavily cleared lower slopes was growing. However, it is difficult to conduct pasture experiments with large trees present so, little by little, and against my better judgement, some of the parkland appearance I had achieved with my initial style of clearing was lost by further tree removal. We attempted to compensate for this by planting thousands of trees where we could. Unfortunately it proved to be a losing battle as time and testing revealed that Yalanbee, though high in the landscape, was particularly prone to salinity development and large areas became affected. I was personally involved in attempts to combat this situation and set up the first experiments with trees for salinity control. Though input from many other scientists was used, our efforts on our own property were only partially successful. We can only hope that other farmers learned from our disastrous experience.

At Yalanbee we continued the CSIRO practice of holding field days as at Glen Lossie because they provided an excellent avenue of communication between farmers and scientists. Our division received funding from several organisations such as the Australian Wool Board and good public relations was important. Wool Board members and some scientists from our eastern states Divisions sometimes attended. There was a lot of preparation to be done for field days and about twenty scientists and technicians from the laboratories would come to help and to hear the addresses. We never achieved the big crowds like the Glen Lossie record and Toby never got to perform again.

Another activity carried on from Glen Lossie was the manning of an official meteorological station. This recorded wind run, rainfall, maximum and minimum temperatures, barometric pressure, evaporation etc. The instruments were read at 9 am each morning and at the same time, wind direction, cloud cover and type were assessed. These records were sent to Perth for the scientists' attention and copies went to the Commonwealth Bureau of Meteorology in Melbourne. It was quite a chore and, until I was given an assistant, I would do routine office work until it was time to 'read the weather'. After that I could check on the activities around the station or attend to my experiments. Old Toby accompanied me on my rounds and mustered the sheep for me if necessary. Eventually he became very frail and with great regret had to be put down. I buried him on a stony knoll surrounded by wildflowers; he had been a great pal to me and the whole family.

Working with Graham Arnold, David Bennett, Ernie Biddiscombe and other scientists over the next few years greatly enhanced my understanding of a range of research programs. In addition I attended seminars on a variety of subjects and learned a lot more. Graham was interested in all aspects of sheep and pasture research. I helped him with glasshouse trials at the laboratories and in field studies both on Yalanbee and on farmer's properties.

David was using advanced computer programs to establish the residual value of phosphate fertilisers in years subsequent to the original application. We set up trials on farmers properties, selecting soils ranging from clays at Narrogin, through loams and gravels in the central wheatbelt to yellow sands as far afield as east of Northampton. I applied eight rates of superphosphate at each site; rates adjusted for the previous fertiliser history of each individual site. Each treatment had four replications so there were 28 sub-plots. Pasture growth on each was measured with an electronic capacitance meter then harvested by mower to obtain actual yields.

So every six weeks through winter and spring I would travel around making the measurements. After these trips the samples would be taken to the sorting laboratory. This was a large room staffed by two or three assistants. There were ovens to dry the samples, scales and large benches on which pasture species could be sorted into the individual clovers, grasses and other species if required. When large batches arrived, those who had taken them would sometimes have to help the girls get the work done before more arrived. Although the jobs were tedious and boring there was a radio to listen to and general conversation and gossip to be passed around. Heather Parkes organised priorities assisted by Jan Briegel and Olwyn Brown and conversations ranged far and wide unless cricket was being broadcast.

Ernie Biddiscombe, a colleague with whom I had collaborated at Yalanbee on field trials with annual grasses, came to Graham Arnold with a request for my assistance. He proposed to establish experiments between Manjimup and Pemberton to compare the performance of three perennial grasses (Fescue, Phalaris and Cocksfoot) on clay, loam and gravel soils of the Great Southern Region. I duly joined his group of Arthur Rogers, David Briegel and Ernest himself. I had a major influence on site selection and establishing the stands and later with collecting samples. I well remember with Arthur, grinding away in the blazing sun drilling holes to one metre through clay and gravel so that root penetration and influence of water-logging could be compared. At that distance from Perth, we were forced to stay down for at least two nights at a time in order to get the work done. At sampling time, we needed to include girls from the sorting laboratories to make up a decent team.

Four papers including early evaluation and going right through to regional trials and including CSIRO and Agwest work were finally published and helped establish a line across the South-West corner of the State beyond which perennials were not recommended.

Meanwhile a major change was taking place at the West Australian Regional Laboratories. Staff from existing Divisions were being combined into one group to be known as the Division of Land Resources Management with a Chief (Ray Perry) based in Perth. This Division was to de-emphasise straight agricultural productivity research and diverge into more environmentally sound ways of managing the soils, water and plants of the region. Most of the scientists were asked to make changes to their research priorities in this direction leaving Agwest to continue work on agricultural productivity. Some of the old group resented being asked to change and there was only reluctant acceptance of these new objectives.

For me, Ray Perry's attitude to research revitalised my work outlook. Much of the work I had done for Arnold, Bennett and Biddiscombe had not really satisfied me; it lead in too many different directions and some of them were not sufficiently practical for my liking.

When Perry asked for new initiatives I had one in mind. I proposed that we start researching the integration of trees into agricultural systems. One aspect that I suggested to Ray was the growing of pines in established pasture and the establishment of clover pasture into thinned stands of pine. I had seen examples of this in New Zealand and had realised the potential of the system for our South-West.

Advantages of mixing trees and pastures include the provision of shelter for pastures, soils and livestock, increasing the use of ground water hence decreasing the likelihood of salinity development and ultimately providing an alternative income from the sale of pine logs. In wet and windy conditions, freshly shorn sheep and new born lambs suffer hypothermia and many can die in exposed paddocks. However, under a stand of spaced trees or behind a few rows of trees, wind speeds are reduced and the wind chill effect on wet bodies is greatly reduced.

In winter, exposed pastures suffer a growth setback each time a severe frost occurs: under trees, temperatures are warmer and frost effects are much less. Also, in summer shade from trees has benefits for livestock. Reduced wind speeds mean less topsoil is blown away; soil erosion is reduced. A disadvantage of having a lot of trees in pasture is that too much shade reduces pasture production. We had no scientific data to determine suitable spacing of trees which might achieve maximum overall benefits. We had a lot to learn.

There were several detractors of my proposal. Some pointed to the likely reduction in light reaching the pastures as the trees grew larger, others believed that soils became too acid for pastures under pines. I maintained that the effect of shading would depend on tree number and the extent to which the trees were pruned. Others argued that clover seeds would not germinate in a soil covered with a layer of decomposing pine needles. While I could not fully convince all of them, my argument was generally accepted that as scientists looking for environmentally friendly systems of agriculture, we should be doing the necessary studies.

Another aspect I suggested was the need to determine where trees should be planted on a slope for maximum effect in maintaining desired depths of water tables, and whether pines or eucalypts were most effective to achieve this. No one knew the answers and I wanted to get them. I suggested small plantations of trees on a uniform slope with bores drilled so that measurements of depth to water table could be taken on a monthly schedule as the trees grew.

Ray Perry liked my ideas, in fact they were among the very few he accepted from the large number submitted by scientists senior to me. Incidentally, when I told my supervisor, Graham Arnold, that I intended to submit my ideas to Ray and his advisory committee, Graham protested that my career was well protected by his patronage. Nevertheless I sensed that here was an opportunity for me to take a big step forward and I took it. This new work represented a very big challenge which I was prepared to take. Of course I needed to convince Ray that I had fully considered the practicability of my plan and how we could finance it. I was friendly with foresters Frank McKinnell and Frank Batini of the WA Department of Conservation and Land Management (CALM). Both of them were eager to learn about the impacts of agriculture on forestry while I had the opposite perspective. They had only superficial knowledge of agriculture and I had very little experience of forest practices. We believed that we could make a useful team. While they went through their formal channels of seeking approval for the proposal and for funding from their Research Advisory Committee, I pleaded for CSIRO funding. Frank Batini suggested a joint application to the Commonwealth Development Bank for funds.

We prepared a case and in due course they granted us $20,000 because they applauded our initiative in attempting to combine environmental benefits with sustainable productivity.

They agreed that agricultural production systems that would avoid the forms of soil degradation occurring under conventional practice, warranted their support.[5]

The CSIRO Officers Association is the body which represents the scientists in protecting their terms and conditions. The Organisation has a team of managers collectively known as Head Office. In their wisdom these people frequently review the conditions, duties and salaries of all staff. In many cases their decisions are seen to be unacceptable by the various groups to which they apply. In particular, the scientists say we earn CSIRO's reputation for high quality research while Head Office says that may be, but we know what is best for you. Therefore the Officers Association and the Technical Association have been set up to fight for their members' rights.

Two or three years passed fairly routinely and I was keeping up nicely with writing up the results for publication and replying to the requests for copies of my earlier papers. One day the President and Secretary (Brian Whelan and Margo Willing respectively) of the Officers Association came to see me. They told me that a serious problem had arisen. The annual elections were almost due and they were having difficulty finding replacements for their positions. One person was known to want the presidency but was considered so unsuitable by other members that they were going to resign en masse if he took over. Brian had already served for three years and was under pressure from his supervisor to make more progress with his work. They pleaded with me to fill the position.

I was reluctant to accept, because I had not served on the committee and had only a general awareness of recent happenings in the association. I did realise that I owed something for advice it had provided during a claim for re-classification which I and others had benefited from. They assured me that I would be strongly supported by the members and that I would be able to handle the extra work involved. As the president was also the WA delegate to the National Committee there was an obligation to attend four meetings per year in the eastern states. This meant giving up weekends to travel to them. Travel was by business class so that delegates could study the agenda on the plane. A delegate was permitted to pay the difference on two economy seats and take his wife if he so wished. I went home to discuss the matter with Val before accepting.

I soon found there was a great volume of correspondence to handle each month and material requiring a vote at the National committee meetings needed to be discussed first at our local meetings. The committee member who had wanted the presidency was a rabblerouser who constantly argued over minor points so our meetings often tried my diplomacy and patience to the limit.

At the National conferences we worked quite hard. We flew to the host city on the Friday afternoon or night and met for eight hours on the Saturdays and for four hours on the Sundays before flying home again. The highlight of the weekend was a first-class dinner at a restaurant recommended and arranged by the host delegate.

[5] *Geoff went on to run large scale field trials become a world-recognised leader in the field of Agro-forestry and continued his contribution to that science well after his retirement both in academic institutions and in private industry. He travelled the world extensively and was very generous with his knowledge and time. His contribution to CSIRO's sporting achievements are also covered in his book and as captain of the CSIRO Golf team with Rudi Horwitz, Mike Krencev, and Ron Couper they won the coveted "Commonwealth Department's Shield". Geoff also made contributions at all social and scientific levels in the organisation as he quietly went about his business in an efficient and effective manner. As an example I have also extracted the following section from his book. This copy is unauthorised and as he said "that's naughty" but I think in this case he might just approve!*

During my pre-retirement year, because CSIRO was unable to replace me, I had been endeavouring to obtain external funding so that the research could be continued. I had approached the Wool Corporation, the Australian Wheat Board and CALM with negative results for various reasons. CSIRO offered to appoint me as an Honorary Research Fellow to pursue this matter and to arrange the take-over if I succeeded. I retained my office, secretarial services, and use of an official vehicle on the two days a week that I was expected to come in. This suited me nicely. It not only allowed me to retire by stages but left me time to develop a small business I planned.

The arrangement worked well. Curtin University agreed to take on my research and the hand-over was effected smoothly during the year. On my side I was able to complete the compilation of about twelve of my research papers into one volume. Copies of these were sent to colleagues in other states, New Zealand and the USA.

Some universities also requested copies to use as aids to teaching agroforestry which was becoming a growing trend. On retirement, the usual dinner was held at which some amusing incidents during my career were repeated with embellishments and some serious speeches of commendation were delivered. I was presented with a very nice fishing rod and reel. There was also a couple of informal lunches; one organised by the Yalanbee staff at which the' piece de resistance' was yabbies from the dams on the station, the other by my close associates at the laboratories. We all enjoyed ourselves and regretted that, for me, they were coming to an end.

DES BACCINI[6] (1954 to 1969, 1971 to 1980 and 1991 to 1993)

In November 1954, aged 19 years, I successfully applied for a new junior clerical position which was allocated to the admin unit because of the increasing numbers of research and technical staff being added to the WA laboratory and around WA regionally. About 2 years later, Jack Brophy was appointed as Chief Clerk, and because it was then decided there should be only two clerical positions in the admin group, I automatically became 2nd in charge in an office of two clerks.

In late 1969 having worked 15 years in the WA administration I decided to enhance my career by successfully applying for the position of Administrative Officer at Katherine Research Station on a permanent basis and left WA in October1969.

Later I was successful in my application for the position of Divisional Secretary of Mineralogy and returned to the Floreat site in July 1971 after a two year absence. With the establishment of a Divisional headquarters on the Floreat site the administrative and financial control of the site library and engineering services became attached to the Division of Mineralogy.

In November 1980, Arthur Gaskin approved my 2 year transfer to the position of Centre Secretary at the CSIRO overseas aid project in Bogor, West Java, Indonesia. However, my stay in Indonesia was extended to 6 years so that I could assist with the closing down of the project and handing over the management of the buildings and equipment to our Indonesian counterparts in December 1986. Because of my extended stay overseas I had to forego my position in Mineralogy and consequently on return to Australia I was transferred to a vacant position, Laboratory Secretary, Division of Tropical Animal Production, Rockhampton, Qld.

In December 1992 the position of Laboratory Secretary, for the newly formed Laboratory for Rural Research (LRR), Floreat Park was advertised and I was appointed by the Officer in Charge, Frank Hingston, and I returned to Floreat in February 1993. LRR staff, from Animal Production, Entomology, Soils and Forestry, were accommodated in a new building on the west side of the Floreat site and within two years underwent the inevitable name change to become the CSIRO Centre for Mediterranean Agricultural Research (CCMAR) with Mick Poole, from the WA State Department of Agriculture, appointed as Head of Centre and myself as Centre Secretary. The CCMAR administration acted independently from other admin units on site.

[6] Contributed by Des Baccini

JIM BARROW[7] (1961 to 1992)

I came to CSIRO in Perth in October 1961. This was not my first appointment in CSIRO. I started work with CSIRO in Armidale, NSW, in March 1954, where I was appointed as what was then called a Technical Officer with a Bachelor's Degree in agricultural science from Melbourne University. While I was in Armidale, I acquired a MSc externally from Melbourne and also a PhD from New England. I was then awarded a CSIRO postdoctoral Fellowship for one year which I spent at Rothamsted in the United Kingdom. I mention this background because it colours my impressions of Perth. While in Armidale, I met and married Lin, and when we left there, we had a 20 month old daughter.

We first visited Perth in late September 1960 on our way to England to take up the scholarship. I was impressed, and so, when offered the opportunity to return to Australia to work in Perth, I grabbed it. We returned to Australia by ship, as you did in those days. By this time, our family had grown with the addition of a son born in England. The ship called in at Fremantle where I met my future colleagues, but we continued to Melbourne and Sydney so we could visit our relatives. Perth and the Eastern States were then a very long way apart. We returned to Perth by air, with the whole family travelling first class, as was the rule in those days, on a DC6. It seemed huge. It would be many years before we could afford for the family to make another visit to relatives.

I immediately felt at home in Perth. I liked the suburbs with their wide expanses of front lawn, without any front fences, and with their sprinklers quietly playing on a summer's evening. Those were the days! I liked the staff at CSIRO, and they seemed to like each other. The group was small and there was quite a bit of social interaction. When they met, the wives all hugged each other – not a form of greeting I had been accustomed to. (The research staff were exclusively male in those days, so "significant others" were all female.) Mind you, the weather was a bit of a challenge. Twenty-one years in Victoria, seven years in Armidale, and one year in England were not very good preparation for a Perth summer. And that first summer was a pretty hot one. But I enjoyed it; Lin didn't.

At that time, the CSIRO labs were located within the University of Western Australia grounds. The main buildings were in the area now occupied by extensions that were made to the School of Agriculture in the 1990s. Only a few of the rooms were air-conditioned – mostly the laboratories, and so it was a bit of a challenge to get much work done on a hot summer's day. I was located in a "temporary" building that had been erected during the war – the First World War! It was where the science library now stands. Although the laboratory was tiny and crowded, we were able to do good work in it. One of the rooms was small; I had an air-conditioner inserted into the window, and we were able to use this room as a constant temperature room.

When we arrived in Perth, we did not have much money and the little we did have was needed for a deposit on a house. It was therefore some time before we could afford to buy a car. Fortunately Jack Brophy had organised rented accommodation for us quite near the Cottesloe shopping centre. This meant that we could walk to the shops. A further advantage was that I could get a ride to work with Tom Shaw who lived in Fremantle. We decided that we would rather like to live in the Floreat area, but reckoned that blocks were too expensive as they were over £1200 each. We went a little further to Wembley Downs where the blocks were only £1000-£1100. It took a little while to choose a block, and get a house designed but construction time for a house in those days was only 12 weeks. We moved to our new house in about July, some eight months after arrival in Perth. It was pretty bare. I spent the next several years painting it, building furniture and establishing the garden. Not the way things are done these days.

[7] Contributed by Jim Barrow

The Perth and Armidale laboratories of CSIRO were devoted to pasture research. Those were the days when wool was still very profitable and much scientific effort was devoted to growing good pastures. In both cases there was emphasis on finding and selecting better plants for pastures and in diagnosing their nutrient requirement. In Armidale, with its year-round rainfall, the search was for better perennial plants; in Perth with its Mediterranean climate, the search was for annual plants. And in both cases there was emphasis on plant nutrition, in Armidale because graziers had been reluctant to use any fertilizers, in Perth because of the extreme poverty of WA soils. But the way the work was organised was different. Pasture sampling involved placing a wooden frame on the plot and cutting the pasture within the frame using a portable shearing machine. The frames were specified as having an area of 12.5 square links (everything was in Imperial measure; there were 100 links to a chain, about 8 inches or 200 mm.) I think the plots must have been 2.5 links by 5 links – very close to 0.5 m by 1 m. In Armidale this was specialist work. Two men were tasked to do it, and each week a meeting of research staff would decide who had access to their services for the next week. Female assistants were not permitted to do field work; how would they manage if they needed to go to the toilet? They remained in the laboratory handling samples.

In Perth it was quite different. Assistants were assigned to individual research officers and when there was field work to be done. Informal arrangements were made, with people "borrowing" extra assistance as needed. I remember making trips to Kojonup to help with field work – and I remember celebrating Linley's 21st Birthday there. (Linley Cole as she was then, later Linley Thornber). Everybody took turns at using the portable shearing machines and that included some of the female assistants who thought it was rather good fun. And when they needed to go to the toilet, guess what, they managed just fine. (My work was initially with dairy pastures which had become very patchy and I decided that the fairly small frames were not a good way to sample them. I used a forage harvester to cut a much larger proportion of the plot.)

One of the interesting consequences of being sited at the University was that there was no place to garage CSIRO vehicles overnight. It was therefore ruled that individual employees should take the vehicles home and garage them there. As several of us lived in what were then considered the northern suburbs, the one who lived furthest north (John Beresford who lived in Doubleview) had that privilege. On the way in to work, he would pick me up in Wembley Downs, then Alf Humphries in Floreat and finally Peter Ozanne also in Floreat. On the way home the sequence would be reversed.

1960 was pretty much the effective dividing line between BC (before computers) and AC. They had a computer at Rothamsted in 1960 (which was pretty esoteric). It could not really do much and it was the domain of specialists. In the early 1960s the only computer accessible to us was one at the University. To use it, you had to write programs in Fortran and these were punched onto cards by a specialist operator using a fairly large, machine. You then took the cards across to the University and fed them into the computer through a card reader. Output was not directed to a printer but to another card punch machine and you took these cards to another machine that printed them. When CSIRO moved to the new laboratory in Floreat, I think use of the university computer continued. I think it was several years later that a computer laboratory was established at Floreat. It was in the basement and took over an area that had been used for storing pasture sampling equipment. This laboratory provided a communication with the BIG computer that lived in Canberra. It was probably much less powerful than an ordinary laptop of these days. Programs had to be written in Fortran and were, as before, fed in using a card reader but output was to a "line printer". It was very tedious. Jobs were organised in "batch mode". This meant that you sent a program down the line and waited for an hour or two for it to be processed, only to find in many cases that you had left out a comma or made some other trivial mistake, which you then had to find, correct, and try again. There were also small stand-alone computers

on which you could run BASIC programs. These were slow but had the advantage that the "grammar" was corrected instantly. I learned to use them in order to try out bits of the programs. It was not until (I think) 1981, that we gained access to the first personal computer. It was a “Cromemco” and sat in a very large box. Input was from a keyboard and was visible on a tiny monitor. Programs were stored on large floppy disks. It was marvellous.

A characteristic of the research staff in Perth when I arrived was that there were many "Erics". There was Eric Bailey, Eric Bettenay, Eric Greenwood, Eric Watson, and Eric Holm. Best remembered is probably Eric Watson because of all the stories associated with him.

Eric's research work was concerned with soil fertility and he was also Officer in Charge at Glen Lossie, the field station at Kojonup. As such, he thought it would be convenient to have a motorbike in order to readily get around the station without using a bigger vehicle. However, when he put in a requisition for a motorbike, it was knocked back. He therefore put in a requisition for a "Pasture Plot Inspection Machine", which was of course a motorbike. That worked just fine, until the auditors made a visit to Kojonup and were surprised to find what to them was a motorbike even though there had been no paperwork authorising its purchase. To make them even more suspicious, the motorbike had been purchased from "Watsons Garage" in Kojonup, which was in fact the name of the local garage. Eric was officially reprimanded though, I suspect, secretly admired for his ingenuity.

Perhaps it was because the CSIRO offices were not air-conditioned that it was accepted that things slowed down in summer. Many of us took our annual holidays then, so the Christmas parties were rather like a school break-up party. When we were at the University site, proceedings began with a softball match held on the foreshore near Steve's pub. This was followed by a fairly well lubricated lunch on the CSIRO site. Everyone was very relaxed. Later, when we moved to the Floreat site, I think the tradition of a softball match was continued for some time. However, the highlight of the Christmas parties soon became the "annual report" delivered by Doris Leadbetter the librarian. These could perhaps be considered as a local form of the "Ignoble Prize" – highlights of non-achievement through the year. I particularly remember one person being awarded a prize specified for conspicuous lack of bravery at sea! It was alleged that he had panicked while in a boat even though the water was scarcely more than knee deep. I also remember that same person being awarded a special sporting prize for being the only person in history to be dismissed three times for a duck in the one cricket match. You had to be rather careful to make sure that Doris did not hear about your little mistakes.

Epilogue

In 1991, my scientific achievements were acknowledged by promotion to Chief Research Scientist (II), the highest ranking available to Research Scientists (as distinct from administrators) in CSIRO. Some nine months later, I was approached by the Chief of my Division who invited me to retire. CSIRO had become very dependent on moneys received from agricultural industries and especially the wool industry. With the decline in the wool profitability, this income was no longer sufficient to sustain activities. I declined to retire and CSIRO then make me redundant. This meant that I had the benefit of receiving a year's salary as a lump sum.

I continued to do scientific work. Initially my reason was that I had several commitments I had taken on - such as the editing of an 800-page book for a plant nutrition conference. As the years went by, I attended CSIRO less frequently, but continued to work from home. I write this, nearly 19 years after my "retirement", and note that I have published nearly 40 papers over the interval. These include work in cooperation with colleagues in Germany,

Chile, Denmark, India and New Zealand. In 2002, 10 years after my "retirement" I was acknowledged as a Highly Cited Author, one of about 10 in Western Australia.

GREG BARTLE[8] (1966 to 2001)

My memories of the early days of CSIRO at Floreat Park cover a period from about 1966-1971, prior to the formation of the Division of Land Resources Management. CSIRO had not long moved into new labs at the Floreat site. It was a much smaller site than now. There was the main four story building; an animal house and surrounding holding paddocks; a Caretakers cottage; pot and soil storage rooms; root washing area, and plant grinding room above the store. Four glass houses and two parking areas on the eastern end of the main building.

The main building held mainly people from the Division of Plant Industry with Graham Arnold as Officer in Charge. Reg Rossiter, the former OIC, played a large part in the direction of the science. On the top floor there was a typical laboratory layout with a semi-enclosed office in one corner, benches and sinks and support staff desks in the laboratory; not very private at all. There were several constant temperature rooms on this floor.

The first floor held the Division of Soils, led by Maurice Mulcahy, with the chemistry laboratories and soil mapping offices. The ground floor held Jack Brophy's admin offices, the typing pool, purchasing, the library, maths and stats, and I think a small group of entomologists. The lower ground floor had the canteen, cold room, dehydrator (ovens) room, bag storage (for pasture collection) and a large pasture sorting laboratory. Pasture sorting was a particularly boring job but Heather Parkes, Jan Cunningham (later Jan Briegel), Olwyn Brown, Betty Herschfelt, Jenni Bartle, Jeannie Brown and Anne Murray seemed to enjoy the challenge.

The Division of Plant Industry had three external research properties. Glen Lossie at Kojonup was closing down in 1966 to be replaced by a research station (Yalanbee) at Bakers Hill. On the Swan Coastal Plain north of Wanneroo there were two small research stations at Pinjar. There was also a small lab at Kelmscott run by the plant introduction section that evaluated and bulked up newly introduced pastures that were sourced from overseas. I think Rose clover was introduced here.

The Division of Plant Industry was the largest group of scientists in the Floreat building. A typical unit would consist of a research scientist (RO or later RS) usually with a higher degree and experience (although PhDs were not so common in those days), an experimental officer (EO as they were known) with basic degree and less experience, and a technician with various qualifications, diplomas certificates etc. Most technicians were agricultural college graduates. There was a strong emphasis on plant nutrition. The research was focused towards pasture and crop production both at Glen Lossie and then at Bakers Hill. The use of stock both in the paddock and animal house was looking at the quantification of pasture production, nutrition and usage rather than animal production. Many pot trials were conducted in the glass houses, looking at production, establishment and survival and nutritional requirements of pasture and crops.

The two small research stations at Pinjar looked at production from tropical and sub-tropical grasses and legumes. They were on Spearwood and Bassendean sands that are very infertile with little organic matter. The production was based around non-limiting fertilizer and water application. Very large yields were produced, but stock did not particularly thrive. Snakes certainly did, and were a constant source of concern for the staff who worked there.

The laboratory was a fairly happy place in those early days. There was no pressure on scientists to source external funds. The process was for scientists to submit their budget (always overdone) to their Chief of Division who would then allocate the funds as he thought fit. We were all "permanent" staff and salaries were paid from the federal budget or from

[8] Contributed by Greg Bartle

industry funds generated through agricultural production levies. There was a process for approval of experiments where a “pre-schedule” was presented to the peers at an internal forum where it would be subjected to a great deal of scrutiny. It was interesting to see the various biases and prejudices come to the surface at times. Healthy debate was the norm.

The data from most experiments in those days needed to pass strict scrutiny by the statisticians as there had to be sufficient randomisation and repetition for the data to be statistically significant. In these earliest days one could hear the clatter of Marchant and Olivetti electric/mechanical calculators as the prime means of data analysis. The ground floor housed staff of the Division of Mathematics and Statistics. Their work related to the establishment of research statistical principles and the analysis of experimental data to prove reliability.

Pipe-smoking Clive Boundy was the senior mathematician and ruled by bluff and bluster with a booming voice that belied his other finer attributes. Approaching the two senior statisticians for the first time was rumoured to be a fairly daunting affair for the younger scientists. The first computer arrived about 1968 and was run by Geoff Adam of the Division of Computing Research. It was housed in a large room-full of things which daunted many of us who knew nothing of computers and FORTRAN gobbledegook. Data entry was by way of punch cards. So one entered data onto special forms, handed them over to the elite punch card girls Sheryl Trotter, Anne-Marie Mason and Irene Piercy to access the regurgitated miracles.

A wide range of chemistry analyses were available from the labs, and workshop, lab staff were always churning through piles of samples, and an auto-analysis apparatus was a leading system that was developed on site. Tom Shaw was in charge here but many other trained chemists worked in the labs including Zig Titmanis, John Hill, Terry Power and Vit Gailitis.

The Typing Pool was a large room where all manuscripts and hand-written documents were handed into the head typists, Trish Benwell or Helen Warrener for distribution to the girls who all initially used manual typewriters. Later electric typewriters had their short moment of glory before they and the typing pool vanished as PCs became the norm and scientists became typists! Many of the girls (Gail Knight, Doris Burnham, Jill Trevaskis, Cathy Crampton, Rosemary Harper, Christine Everett, Kathy Allen) went on to less odious jobs in the Organisation but their ability to decipher some of the hieroglyphics was legendary. Many drafts were handled as well as day to day correspondence. There was quite a turn-around of staff so hard to remember.

Jack Brophy ran the admin section, ably assisted by Des Bacini. Jack had great connections with head office and a real skill for getting things done quickly and in the interests of staff and organisation even if it did cut across protocol. Processing of purchasing was handled via mail through Melbourne in those days. One wondered if the cost of this processing was often more than the article involved. The wheel turns and after having local administration for many years it is ironic that currently, some 45 years later most processing of purchase orders is again handled through Melbourne although with electronic media the process is a good deal speedier.

Non Professional staff would have to “sign on” the time book in the mornings and off at night. Tom McNab was the keeper of the time book in my time, and the hours were 0845-1706, no variation. He was known to snatch the book away from under the pen if you were late mainly as an act of defiance and usually with a wry grin. Tom was a “ten quid pom” and many a technician, when receiving their travel allowance from him, would offer him a tenner to go back! Tragically, Tom had a massive heart attack on the front steps of the building and, sadly, died immediately leaving us without one of life’s true characters.

Scientists were not under pressure to move on with their research projects or to chase dollars in popular areas, and many had become world specialists in their fields. Most would submit applications for (and receive) overseas tours fairly frequently to stay in touch with research in their disciplines and young experimental scientists were often seconded to the headquarters of their Division in the eastern states to further their experience. There was a regular seminar program designed to keep the rest of the site informed of recent work.

The library was run by a larger-than-life lovable extravert Doris Leadbetter. Library services were very different then. Staff would see a routing list of new journals, books etc and fill out request forms. At least two of the library staff would bring the materials around on trollies and pick up the finished and due books. Doris had a wonderful way with words and a devilish spirit. At each Christmas party she would give 'awards', a character "roast" if you like. People would be cringing awaiting their turn as any minor misdemeanour would not escape her ears and embellishment to maximise embarrassment was the order. However, it was all in good humour.

Olive Drake-Brockman was the first tea lady. I think the tea was brought around initially but very shortly that changed to going down to the tea rooms on the lower ground floor. A lot of useful conversation took place at these times. The Children's Christmas party was a popular event for staff offspring and they would look forward to getting their gift from Santa via the gardeners lawnmower skilfully dressed as Santa's sleigh.

CSIRO fielded many sporting teams. There was a strong social club with volunteers collecting fees annually – like getting blood out of a stone I believe. Eventually with volunteers we installed a lovely grassed tennis court, oval with turf wicket and a bowling green. We fielded competitive cricket, hockey, soccer, Australian rules football, basketball, and table tennis teams. At one stage, even Yalanbee had enough staff to field a cricket team in the local comp. There are many stories to be told about these affairs and the antics after (days before drink-driving dangers were recognised) but that is another chapter.

It must have been early in the seventies when a change started to creep into CSIRO. Terms such as "review", "change of direction", "outsourcing", "outside funding" etc began to surface. A review of WA laboratories and the appointment of a Chief based at Floreat (Ray Perry) saw a change in direction and a new Division of Land Resources Management formed. The need for change was not well supported by the older establishment and those with a desire to stay in the agricultural stream were relocated to other Divisions. The Division of Soils was absorbed into LRM. These were not popular moves at the time, but looking back, the organisation was not going to survive on its current course.

DAVID BENNETT[9] (1961 and 1970 to 1984)

Clover Disease, or How I got my PhD

In the early 1940s ewes grazing clover dominant pastures in Western Australia produced fewer lambs than would normally be expected. They also suffered from other reproductive disorders, such as prolapsed uteri. Lambing rates from affected ewes continued to be low. The cause of these problems was thought to be phytoestrogens in the clovers, of which there were a number. A subgroup, known as the isoflavones, were considered to be the most likely, as they were found in quantity in many of the clover varieties used in Western Australia.

From field observations, farmers and scientists suspected that there were differences in ewe infertility between varieties of subterranean clover. But experiments to establish this were impossible due to the scale of the necessary experiments. So bioassay, the measurement of responses by living tissue or organisms, was used; beginning with laboratory animals, guinea pigs and mice. However, the results did not seem to correlate with the field observations of farmers and scientists.

In May 1961, I was appointed as an Experimental Officer in the CSIRO Division of Plant Industry, Canberra, after working as a Technical Officer on various King Ranch properties, both in the Northern Territory and NSW. Shortly after my appointment, my boss, Fred Morley, suggested that I might like to spend the next six months working for Haydn Lloyd Davies in Western Australia. Happy to oblige, I arrived in Perth and was introduced to the staff and the Glen Lossie Field Station at Kojonup, where I helped with a number of experiments.

Shortly after my arrival we were visited by Don Lamond of the Division of Animal Production, who described an experiment that he had performed using the uterine weights of spayed maiden ewes as a form of oestrogenic bioassay. Haydn immediately decided to use the technique to measure oestrogenic effects of different varieties of subterranean clover. So we set up an operating theatre in the shearing shed at Glen Lossie and proceeded to spay a group of maiden ewes, and then feed them on two different varieties of clover, one of which was suspected of being high in oestrogens and the other low. We sold the experimental sheep to the Kojonup butcher and attended the slaughter in order to collect the uteri. That night, having cleaned up the uteri and weighed them, it was quite clear that our suspicions had been confirmed. I can remember Haydn getting very excited, saying “Boy, you don’t realise what we have found tonight!” We performed further, larger trials, which involved taking a truck load of experimental sheep down to the Albany abattoir, because there were too many for the local butcher. Then I returned to Canberra.

Fred Morley, who was a veterinarian by training, thought that more research was required to sort out some problems that had arisen. The first one was that the results of bioassays using laboratory animals had given different results to the sheep bioassays. After further experiments in association with officers of the Division of Animal Production involving measurements of the different isoflavones, we found that the two water soluble isoflavones (genistein and biochanin A) that were active in guinea pigs and mice (extracted from the clovers and injected into the muscle of these animals) were virtually inactive in sheep. But a virtually insoluble (in water or body fluid) isoflavone that was inactive in laboratory animals (partly or mainly due to its insolubility it stayed at the sight of the injection) called formononetin, was well correlated with the activity found in clovers. It turned out that formononetin was broken down in the rumen to another oestrogenic compound, called equol, which was then absorbed from and caused clover disease.

[9] Contributed by David Bennett

One final problem remained and that was some aberrant results with clovers containing genistein and biochanin A. We had adopted another, less destructive form of bioassay using the increase of teat length in wethers (castrated male sheep). Because responses were faster in teat length we could reduce the length of bioassay. When we did so clovers containing these two isoflavones showed activity. Late one night, while I was working on my PhD thesis I plotted the length of feeding time against activity. The graph showed that as feeding time increased activity of clovers containing these two rapidly declined. This indicated that, as the rumen microflora got used to the clover diet they adapted, and broke down genistein and biochanin A. This was a Eureka moment for me and I realised that my PhD was in the bag! All I had to do was complete the thesis and submit it.

From then on varieties of subterranean clover low in formononetin were selected and these were recommended for sowing. As the nitrogen content of the soil from nitrogen fixation by the clovers built up, so clover dominance of the pastures declined, which also helped to resolve the problem for farmers.

ERIC BETTENAY[10] (1960 to 1986)

Eric Bettenay made his mark on CSIRO in Western Australia and is internationally recognised for his contributions to Soil Science, a point well made at the 1979 International Soil Science Congress of which he was a principal contributor and organiser. His work covered nearly 40 years and has laid the foundation of land management, salinity and hydrological understanding of the ancient Western Australian landscape. Eric was happiest when in the bush and he used his vast knowledge and sense of humour to unselfishly enthuse and delight a wide range of his colleagues.

Eric was born in Perth in 1927 and was brought up on the family orchard at Roleystone in the hills overlooking the fast-growing city. He attended Perth Boys and Modern School but was happiest when away from academia, and left school early to work on the large Illawarra orchard. Fortunately he was persuaded to go to Muresk to study Agriculture as, in 1944, the College was about to reopen after a period of closure for military purposes. This he did, and it must have suited him as he achieved high marks that enabled him to enrol (provisionally) at UWA from where he graduated in Agricultural Science with Honours in 1951. Eric speaks warmly about the 4 years of his University life where he lived with and befriended a young CSIRO entomologist, Murray Wallace at a house they shared close to the UWA in Hardy Street, Hollywood. Alec Mahon was also living at this house at this time.

It was through Murray that Eric was introduced to CSIRO when the chance came for some of the final year UWA soil science students to join a CSIRO project to study the soils of CSIRO's Field Station Glen Lossie at Kojonup. Thus Eric participated in his first soil survey in 1950. There followed an invitation from CSIRO for him to join a combined group that was

[10] Prepared by Eric Bettenay with the help of Peter Hick, all photos belong to Eric or Bill Van Aken.

set up to evaluate soil-suitability for release of land for Soldier Settlement Schemes in the South Stirling range, north of Albany. His lecturer at UWA was an ex-CSIRO soil scientist, Laurie Pym. The only CSIRO member of the Division of Soils, since he arrived in WA in 1945, was Robert Smith. Both Laurie and Robert recognised Eric's special talents in this field. At that time, CSIRO's labs in WA were located at UWA and staff worked very closely with the UWA Institute of Agriculture which was led by Prof. Eric Underwood.

On the completion of his degree Eric was offered a temporary Technical Officer position in the Division of Soils, to join a survey in the southeast Stirling Range area. In a letter to his Chief in Adelaide, Robert Smith requested that Eric should also be included in a survey of the Mount Manypeaks area to provide a second traverse party in support of soil scientist Tjeerd Poutsma. Eric was included in the team "to make more efficient use of the camp and transport facilities before the weather breaks in May". He recalls the survey with great affection, and Smith went on to record that he "was a good bushman and a cheerful surveyor in the camp"

The camp at Mount Manypeaks in 1952 may have lacked some of the comforts. With Eric are, Ray Doyle, Tjeerd Poutsma and Mike Hewson (standing)

The Chief of Soils Division at that time (JK Taylor) agreed to Bob Smith's request and commented on Eric's suitability and "single blessedness" and appointed Eric to a temporary position on £620/year. In a following letter he mentioned that a permanent position would soon be available and that with every appointment a consideration should be given that the appointee should have the potential to be "a Senior Research Officer and pedological thinker – survey is just a Technical Officer's job. The fact that we use Research Officers for survey is because we have too few of the other category". He went on to say "Bettenay does seem to be a useful and solid kind of worker who could develop, given the right kind of training, into something perhaps better than a Technical Officer"

The post-war land managers were crying out for soil surveys. Eric justified the faith put in him by the Chief of Soils Division, and followed the South Stirling survey with more to the

north of the Range, he defined the spatial limits of the alluvial soils of the Carnarvon irrigation area as well as surveys on the Swan Coastal Plain and the WA Wheatbelt. He had a sound understanding of soil and plant relationships, probably further developed by a long working relationship with Bill McArthur, during a study of soils of the Capel-Boyanup and Peel-Harvey regions in the mid-fifties.

Robert Smith had commenced work on the soils of the Swan Coastal Plain in 1952, following work of others including Beadnell (1940) and Pym (1952). Eric and Bill drew together all previous work and with the laboratory expertise of Frank Hingston and Glyde Turton produced a report titled "Development and Distribution of Soils of the Swan Coastal Plain" which is still the basis of land use and planning today. Successful farming enterprises followed and mining companies based their exploration and development strategies for the vital heavy mineral sands industry on the explanation of the soil development of this work. The bulletins produced by Eric and Bill are still a pleasure to read. Eric earned an MSc for the work in 1960; there was no doubt of his being a "pedological thinker"!

The emphasis of finding more land suitable for agriculture to maintain the Government's desire to see "a million acres a year cleared" was changing. Salinity was of increasing concern as large tracts of formerly productive land were lost due to increasing soil salinity. The Chief of Soils Division at the time (CG Stephens) told Eric not to get involved in this controversial area unless he could do something "important". The link between clearing of native vegetation and rising saline ground waters was not well understood and politically unpalatable to a country that was benefitting from wool and wheat production for world markets.

Eric had initiated the adaption of a Proline drilling rig following ideas of Keith Northcote and Cedric Wells in Adelaide (fundamentally a posthole borer mounted on a Land Rover), to investigate some of the deeper soil profiles on the Swan Coastal Plain. Before this time, all soil profile inspections had to be dug by shovel or hand auger. The Proline could take undisturbed soil cores and also dig holes to expose the deeper stratigraphy, hydrology and root penetration to depths up to 15 metres.

Around this time Australia was in the grip of a "credit-squeeze". A recession in today's terminology, and unemployment was high. Frank Hingston's brother in law, Wally Russell had just completed an apprenticeship as a Fitter and Turner at the Midland Railway workshops, but like so many, was unable to find work. His mechanical skills were recognised and he was employed as a technical assistant and soon became expert in getting the very best results from the Proline and made significant contributions to the acquisition of more complex drilling systems and eventually the complete redesign and construction of the LinKen rig built by Lindsay Derriman and Ken Wright in the Floreat Workshop. Wally, though without any formal science training became indispensable to both Eric and the Soils Pedology group. He quickly learned the importance of detailed chemical, physical and biological aspects of soils and had an exceptional understanding of native vegetation and the natural environment. He stayed with Eric for the next 25 years reaching the Senior Technical ranks and is credited by many to have made a very professional contribution.

Wally Russell, Eric's long-time technician, doing some fine tuning of the Land Rover-mounted Proline drilling rig in the Johnson lakes survey in 1967

The Belka Valley, south of Merredin provided Eric with the opportunity to do something "important" and this work was instrumental in improving the understanding of hydrological systems in the ancient weathered Archean plateau. He was able to show that the intake zones for recharge to aquifers beneath the valley floors could be at a great distance, and he showed the hydraulic pressure that could be established in these confined aquifers. This started investigations by other scientists such as Bill Blackmore into the hydrological and physical characteristics of the soils and aquifers that were measured at many other sites. David Williamson began hydrological studies at Meckering and detailed studies of paired catchments at "Yalanbee*".* Higher rainfall areas of the Wellington Dam catchment were also "important". Eric and Wally selected and described 5 sub-catchments that were used to quantify the effects of clearing of native vegetation around Collie.

As the survey and drilling of experimental catchments near Collie might take 6months Eric proposed that a house in the town could be rented from the State Housing Department and collectively paid for from travel allowance. Collie was suffering a downturn in coal mining activity and State Housing was delighted to rent one of their many unoccupied houses. Three years later the house was still the base for a wide range of scientific and some unscientific activities. Many feasts of marron, trout and red-fin perch were complemented with steaks from Dardanup and red wine from Cowaramup.

Eric had "pedological thinking" but implicit in this is the understanding of slow processes. Also he was able to think outside traditional landscape-forming processes and was always aware that extreme events would have significant and counterintuitive consequences. He could often explain the irregular by the extreme. Aeolian landscapes fascinated Eric and his explanations of these phenomena are good examples.

Since the time of Federation a call by the States for a generic soil survey of the whole continent was unanswered. In 1927, CSIR had indicated that this was a priority but nothing eventuated until the early sixties when CG Stephens directed Keith Northcote to devise a specific soil classification system that would accommodate the complete range of the unique Australian soils. This he did and divided Australia into 10 mapping sheets to be called the "Atlas of Australian Soils". Much of 3 of those sheets covered Western Australia and the WA Pedology Group, led by Maurice Mulcahy took responsibility for this area and delegated the organisation to Eric for the mapping of Sheets Five and Ten. Much of the southwest had been mapped and only needed to be adapted to the universal description system. The rest had to be visited and mapped. A team from CSIRO and UWA was formed and a convoy of Land Rovers and a Bedford Truck left for the desert in 1967. Mapping was done along the "highways, roads and barely tracks" built by Len Beadell as part of the "Gunbarrel Road Construction Company". They went as far as Alice Springs and all points west, with fuel caches being provided at Warburton and Blackstone Ranges.

On one of Len Beadell's highways during mapping for the Atlas of Australian Soils

More than likely, this trip influenced Eric to expand his pedological interests into subtle processes that had gone into the formation of profile stratigraphy. The Wiluna hardpan is a good example of a study that was undertaken for the sake of understanding, but eventually led to an improved exploration model and better use of water in the landscape. Eric and Max Churchward also discovered, by chance, the source of large clay nodules in lakeside lunettes. They and others had been puzzled by their occurrence in the light gypsiferous Morrel soils that had clearly been derived from the dry lake beds in the eastern Wheat-belt. A very strong willy-willy blew toward and over them from the lake and the clay nodules fell from the sky. Clear and fortuitous evidence of an unusual pedological process!

When close to retirement, Eric took on a significant mentoring role and was instrumental in guiding several studies using his practical and pragmatic approaches to encourage and develop junior scientists. His knowledge of the desert terrains saw him play an integral part and guiding hand to Ian Tapley in the Canning Basin studies that made use of the latest multi-spectral and active radar sensors to provide images of the ancient buried landscapes, for which Ian was awarded his PhD.

Wally Russell, Peter Hick, Ian Tapley and Eric near Sahara 1, central Canning Basin, 1986

Eric had a wit and dry sense of humour that often went straight over the head of the hapless few that bore the brunt of his remarks. He created apt names for various people that clearly suited and most stuck. An instance recalled by Wally was on the Atlas mapping trip when a half empty fuel drum was bouncing on the back of the truck and sounded like an African "tom-tom". Several times Wally stopped and climbed up on the tray to reorganise the load in a vain attempt to reduce the irritating noise, but to no avail. On the suggestion that he stop and try again Eric quite bluntly said "Come on Wal, we can't stop for every Tom-Tom, Dick-Dick or Harry-Harry!"

Eric's retirement has been dominated by his love for tennis, the beach and his family. He also helped his son Greg establish a vineyard in the Margaret River region.

JOHN BROPHY[11] (1952 to 1985)

Following 3 years of service as a wireless mechanic in the RAAF in WW2, I enrolled in the Science Faculty at UWA. Then in 1951 I joined the Commonwealth Public Service before joining CSIRO in January 1952 on the day CSIR became CSIRO. I became the fourth member of the administrative staff in WA, which was housed in offices at No 1 Museum Street in North Perth (now built over by the State Library). Ultimately, I became the WA Regional Administrative Officer providing Administrative support for all staff in WA, and for 16 years I was Secretary of the WA State Advisory Committee. I retired from CSIRO in 1985

I was associated with several land acquisitions for CSIRO:

- 25 acres of prime land at Floreat Park and the planning and construction of the WA Regional Laboratories to house Divisions formerly located on the University of WA site at Crawley. The Floreat laboratories were gutted by fire when almost completed, necessitating major reconstruction and rescheduling;
- Plans for relocating the University site laboratories;
- The sale of the Glen Lossie Field Station at Kojonup, the acquisition of land at Bakers Hill, and the development of the Yalanbee Field Station for the Division of Plant Industry;
- The purchase of land at Marmion and construction of the Marine Laboratories for the Division of Fisheries and Oceanography;
- The purchase of 2 separate areas of land and buildings for the Division of Wildlife Research at Helena Valley;
- In 1997/8 I was awarded an MBE for services to CSIRO
- In 1982 I chaired the Organizing Committee for the 16th International Biochemistry Congress which involved 1000 visitors from around the world being accommodated in Perth, and transported to various venues along with arranging sponsorships to offset costs. A visit to Japan was undertaken to promote the Congress.

[11] Prepared from material provided by John Brophy

BARRY CARBON[12] (1964 to 1980)

I started as a technical assistant at the CSIRO WA laboratories then on the UWA campus in January 1964. I turned up on the first day with half a science degree and a neat sports jacket to meet my boss Frank Roberts and technical colleague Ken Power.

It was a hot day and Frank sent me outside with a shovel do some digging around the plots of introduced grasses. The next day I wore more appropriate clothing. I think that was the first of innumerable lessons in my enjoyable 17 years at CSIRO.

Frank and others like Alf Humphries were asking questions about the suitability of introduced perennial plants to the extreme wets-and-drys of the Mediterranean climate of southwest WA. This was an era before we began to appreciate the extent of modern climate change, and even sustainable farming didn't get much of a look-in amongst increased stocking and compensatory gains in heavily stocked pastures; CSIRO was wrestling in the balance between being scientists or servicing the community.

As well as Frank and Alf, I learned a lot from great scientists like Reg Rossiter, Jim Barrow, Tom Shaw and then Graham Arnold when he arrived in WA from Canberra. Equally I learned a lot from technical colleagues like Ken Power and Greg Bartle and Ann Murray. I worked through a science degree part time, followed by some post-grad maths, and then a 'conversion degree' to agriculture. In 1970 I was sent off to Canberra with my young family for a year of training at CSIRO's Black Mountain campus.

In Canberra, I did some work with others on the interaction between grazing and pastures of the region but the great learning experiences were bonuses on the side. John Philip and Adrian Peck of the Pye Lab kindly educated me in meteorology. And two displaced souls that shared my office took this neophyte through the first steps of computer modelling and systems analysis. It turned out that CSIRO had a computer modelling capacity such that the Americans had requested the validation modelling of unmanned flights to the moon. Subsequently CSIRO had decided that computer modelling was not real science and disbanded the team. No-one got fired those days so these two displaced scientists languished in this back office at Black Mountain for those who were not quite locals.

The Canberra experience changed my career and by mid-year I gave visiting lectures at ANU on my fledgling modelling of water balance for pastures, crops and forests. On returning to Perth the skill allowed me to change a then Master's thesis on plant soil water relations to include modelling along with the field work.

Along the way I had been given a series of promotions to research status, and began in Perth under the converted Division of Land Resources Management led by Ray Perry. Again there was lots of learning, this time about research and the customer, but subsequently about leadership. With vast rangelands research experience, Ray was

[12] Contributed by Barry Carbon, AM, Fellow of the Academy of Technological Science and Engineering, Fellow of the Environmental Institute of Australia and New Zealand, recipient of the medal of the International Institute of Impact Assessment, Australian centenary medallist, since leaving CSIRO was leader of Alcoa of Australia environment function. Alcoa's pioneering work on successful rehabilitation of native forest on previous mined land has been recognised in Alcoa being the only mining company admitted to the United Nations 500 Club for Environmental Achievement. Barry was subsequently Chair and Chief Executive of the WA Environmental Protection Authority, then Chief Executive of the Commonwealth EPA and concurrently Supervising Scientist for the Alligator River Region and inaugural chair of the Standing Committee for the National Environment Protection Council, then Director General for the Queensland EPA and Parks and Wildlife, then CEO for the New Zealand Ministry for the Environment, and Secretary for Environment for New Zealand. Since standing down from full-time employ, he was inaugural Chair of the WA Waste Authority. He is now Chair of Bauxite Resources Limited, and an environmental consultant.

determined to do some things differently and to challenge scientists with new horizons. One challenge was to focus on science specifically for resource decision making, and 'Program G was born'. Established scientists like systems scientist David Bennett and soil scientist Bill McArthur in the program were not interested in the hassles of the leadership role, and it fell to me. We attracted social scientist Geoff Syme away from animal psychology, economist Jon Thomas and operations research PhD grad Duncan Macpherson. With support from Greg Bartle and Ann Murray, with Paul Downes and Peter Sewell we set out consciously to work with others to do useful things.

With UWA we did some exciting things about water and electricity user behaviour, with the WA Department of Agriculture we did some things with decision models for fertiliser use (and with the Water Authority subsequently for decision support for major water resources). With WA land planners we established coastal dune science that was and is a foundation for urban expansion. With the Water and Land Planners we contributed science to management of groundwater reserves and the lakes and water bodies that are contiguous with those aquifers. With other parts of CSIRO we contributed forest science to hydrological understanding of catchments. Interestingly now is that it was a big step in faith in pragmatism to study root and leaf distribution, plant water stress and to estimate transpiration in native forests and introduced mine rehabilitation. Some were as questioning of the Program G approach to science as were those who decided against operations research with computers in Woomera pre-1970.

I left CSIRO in 1980 to enter first the world of mining rehabilitation and soon after the world of environmental protection. Whatever contribution I have made since I left was firmly rooted in the science that I grew with in CSIRO.

Certainly not all of the work that we did with CSIRO was successful, but I cherish the things we did that made a difference. I cherish the people and the experience and I hope that CSIRO is the growing experience today that it was for me.

RON COUPER[13] (1965 to 1986)

I was employed by the West Australian Government Railways in 1942 as an Apprentice Turner & Iron Machinist. On completion of my apprenticeship in 1947, I was kept on as a tradesman and then 4 years later as a Toolmaker.

In December 1965, while on long service leave, I applied for a position of Toolmaker with the Division of Mineralogy and was offered the position which I accepted. I commenced with the Division on 1 Feb 1966 at the Chemistry Department of UWA working directly with Dai Davies)from the Division of Chemical Physics at Melbourne) on drilling by water jet research, later with diamond scratching under load and lateral movement. A short time later I was appointed to Laboratory Craftsman level 1.

In October 1966 the Division moved to Floreat Park where I had a room on the lower ground floor with a lathe, milling machine, etc. A new workshop was designed and built over the road from the new Mineralogy Building in 1967. It was then a challenge to fully equip the workshop.

In 1968 Dai Davies returned to Chemical Physics in Melbourne. I then assisted Wilf Ewers (OIC) making furnaces combined with high pressure equipment. We then did interviews for new staff. The first was Bill Bouwer, followed by Terry Harrison, Brian Alsworth and our first apprentice Mark Dyson (son of the late Norm Dyson from Fisheries) – a talented boy.

Brian Alsworth then took over from me assisting Wilf Ewers as well as working in the workshop to leave me to run the workshop

In approximately 1971 Bill Bouwer was seconded to the mineral preparation section next door. I delegated Mark Dyson to Brian Alsworth so I could do the ordering of equipment, stores and parts for the many different projects. As well I worked for all the research staff -- Terry Harrison concentrated on the electronics and wiring of specialist apparatus produced in the workshop

Over the years there many pieces of equipment were made in the workshop, notably high temperature and high pressure vacuum equipment, high temperature furnaces (1900 C), X-Ray safety equipment, stage for the MRC Electron Microscope (50 x 50 mm x10 XYZ movement at 1.5 micron steps) in conjunction with Ric Vigers who did the electronics himself.

The Floreat site was very sport conscious with many competitions such as bowls, tennis, cricket and soccer – the facilities for all these sports were on site

At the suggestion of Wilf Ewers a golf tournament was arranged (he was a member at Cottesloe Club and I was a member at Wanneroo Club) and held each year in early December – the winner had to hold the BBQ at their home the following year -- 3 times at my place with some 60 Adults and Children. These were great fun.

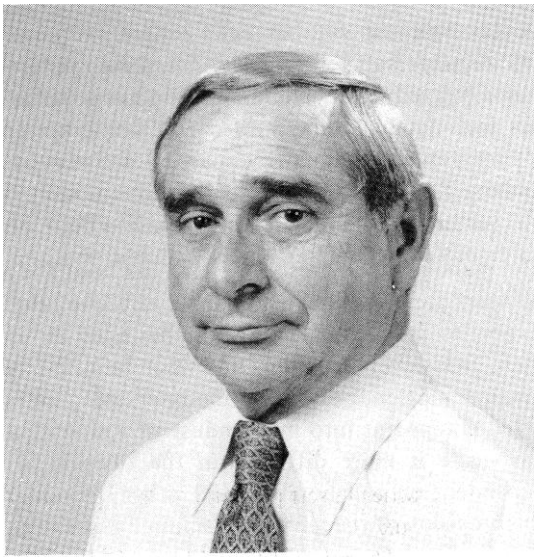
After almost 21years with CSIRO I decided to retire in December 1986 as an STO2. Many thanks go to Arthur Gaskin and Wilf Ewers for my promotions and increments. I left CSIRO with great memories of a wonderful place to work.

[13] Contributed by Ron Couper

ARTHUR GASKIN[14] (1978 to 1983)

The Division of Mineralogy produced reviews of their current research work in 1983 and again in 1985. A very reliable library source says that these two documents were the most requested for interlibrary loan of any of our publications. Compare this to the glossy publicity reports of the later years that ended as expensive rubbish.

Following are some selected parts from Arthur Gaskin's introduction to the 1983 volume that are relevant to the WA laboratories:



A.J. Gaskin Chief, Division of Mineralogy

"At the end of 1970 the CSIRO Executive decided to bring together most of the staff of the Organisation concerned with mineral exploration and the nature of ores, fuels and industrial mineral deposits to form the Division of Mineralogy, a member of a group of Divisions then being established as the Minerals Research Laboratories; a group which eventually became the major part of the present Institute of Energy and Earth Resources.

This Research Review is designed to illustrate the scope of research activities in the Division of Mineralogy, providing more detailed and extensive accounts of projects and fields of interest than the more condensed references that have appeared in Annual Reports of the group laboratories with which the Division has been affiliated. The Review consists of a series of articles grouped in a manner that should allow readers to identify both their main fields of interest and the individual workers concerned with specific topics in these fields. Whilst the articles are representative of the scope of the Division's research program, the list is not intended to be exhaustive. Other topics currently being studied have not yet reached a stage that warrants reporting at this time.

The headquarters of the Division are at Floreat Park in Perth, where 15 research workers supported by experimental and technical staff are housed. A group of similar size is accommodated at North Ryde in Sydney and a further 6 research staff form part of the Baas Becking Laboratory in Canberra. Most of the techniques essential to modern research in mineralogy and geochemistry are available to all sites, exceptions including equipment for advanced mass spectrometry which is housed in the Sydney laboratories and the facilities for biological research at Canberra.

[14] Prepared by Mike Thornber from reports and notes

Government support has been progressively reduced in recent years, and resultant problems in maintaining staff numbers and facilities at levels essential for first-class research have created increasing reliance on funds from industry and other sponsoring bodies. Sufficient overall support has fortunately been provided to date, to preserve reasonable levels of activity within the limits set by available laboratory space. Some alleviation of the long-standing space problems at the Sydney site is being achieved through the construction of two general purpose laboratory blocks, but accommodation difficulties persist at Perth and Canberra.

The main cause of these problems has been the need to house and service the range of large and complex facilities now required for effective progress in the fields of mineralogy and geochemistry. Access to specialized equipment has been an essential feature of the participation of CSIRO in these fields ever since the time when reflected light microscopy represented the necessary stage of instrumentation, but during the intervening half century the introduction of increasingly sophisticated equipment into most industrial and academic laboratories concerned with minerals research has made it more difficult for the Division to maintain this advantage. We are now more dependent on collaboration with other Divisions of the Organization, and on industry support, for the provision of the advanced facilities that can expedite progress in specific areas of investigation.

We are particularly indebted to the Division of Mineral Physics for access to mass spectrometric facilities used in the initial development of our techniques for applying lead isotope ratios to base metal exploration. We look forward to future collaboration in the mineralogical field using high energy particle beams from the accelerator now being installed in that Division. Apart from such specialized equipment our own laboratories provide access to many of the facilities needed for modern mineralogical and geochemical research, including a variety of electron optical instruments, X-ray fluorescence, polarographic and atomic absorption equipment, direct reading spectrometers using inductively coupled plasma sources, devices for thermal analysis, the examination of fluid inclusions and the measurement of thermo-electric and magnetic characteristics, hydrothermal rigs and the usual range of sectioning, polishing, grinding and separating equipment that is essential for effective work in this field.

Most of the projects currently being undertaken in the Division are more or less directly relevant to the development of techniques and concepts for use by Australian industry in locating new mineral deposits or extensions of known deposits. These projects forming part of the 'Exploration' program of the Institute are further grouped into two subprograms, one dealing primarily with the origin, nature and location of ore-bodies and other occurrences of economic minerals, the second dealing mainly with the development of geochemical methods of exploration.

Activities within these subprograms are to a large degree interdependent, the work on exploration methods being especially influenced by the data and concepts provided by the first subprogram. Since geochemical exploration methods are usually dependent upon the detection of indicator elements associated not only with the composition of an ore-body, but with most other aspects of its origin, effect on surrounding rocks and subsequent geological history, thorough studies of these factors can obviously produce information of vital importance to projects on the development of search techniques. Data from the work on techniques can, conversely, produce valuable leads for projects on ore-bodies. Isotope ratio studies have provided an example of the high degree of interaction possible between; subprograms. Initial work on ores showed connections between specific patterns of isotope ratios and processes of ore genesis, thereby leading to the development of an exploration technique, the results of which have proved important to the subsequent extension of studies on the genesis of particular ore-bodies. Similar instances are not uncommon throughout the range of projects in the Exploration program. Decisions on

whether projects are primarily concerned with the nature and origin of deposits, or with exploration methods, therefore tend to be rather arbitrary.

The selection of project topics is largely influenced by discussions between staff members of the Division and of the mineral industry taking into account current activities in other research groups such as in the Universities and the Bureau of Mineral Resources. These define possible applications of the available specialized facilities and expertise to problems of potential economic importance, preferably to the national economy, though the nature of the subject is such that projects usually have to be concerned initially with specific investigations on particular deposits or techniques. Projects often evolve unpredictably as initial research discloses unexpected, but productive lines of investigation, a trend which reflects the disparity between present levels of knowledge of mineralization processes and the extreme complexity that is typical of most deposits. A project initially aimed at defining the factors controlling the distribution of phosphorus in the Pilbara iron province, for example, produced a core logging technique of general interest to industry and then a method for expediting exploration for high grade iron ores.

The duration of projects is also commonly unpredictable, ranging from short term tactical exercises that can produce the required data in periods of up to 3 years, through medium term, which in CSIRO usage means about 10 years, to long term investigations comprising the particular subjects that form the core research of the Division. Projects on exploration techniques are generally derived from concepts developed in core research, where continuing background effort is being largely directed towards the advancement of knowledge of the nature and genesis of deposits, with special emphasis on the mineralogical, structural and isotopic features of ore-bodies, the geochemistry of the weathered environments in which these occur and the chemical, physical and geobiological factors involved in mineralizing processes.

The Division enjoys a very close relationship with the industry it serves. Besides the financial support, either directly or through funding bodies such as the Australian Mineral Industries Research Association and the Western Australian Mining and Petroleum Research Institute, companies have been very generous in providing access to the research materials essential to many of the Division's projects. These costly materials, which include exploration drill core and mine samples, could not be generated by the Division itself, yet they are essential to the successful pursuit of many of our research projects. The Division is neither equipped nor manned to obtain much of the basic geological information that sets the context for our primarily laboratory-based research. Our industry collaborators have been particularly helpful in this respect, often providing geological and other information on a confidential basis, well before its release to the public.

An aspect of the work of the Division that is not shown by this review is the considerable contribution that many of its staff has made to the community of professional scientists in the fields of geology, mineralogy, geochemistry, chemistry and physics. Members serve on committees of local, Australian and international professional societies and institutions, are involved in service to Government bodies at State and Federal level, take an active part in teaching at Tertiary and other levels and contribute to a range of community interest groups. Many of the projects are conducted in collaboration with research workers from the BMR, State Geological Surveys and Universities, and staff are involved in joint supervision of students pursuing post graduate research projects.

Staff are encouraged to integrate relevant geoscientific information and to transfer it to the mineral exploration industry. Their activities in organising symposia, workshops and field conferences have become well known. Particular services to the geoscience field are provided by staff engaged in editorial and refereeing duties for Australian and international

scientific journals, and those serving on international Committees such as the Commission for New Minerals and Mineral Names, the Meteorite Nomenclature Committee and various sections of the International Geological Correlation Program.

Within the Institute of Energy and Earth Resources, the Division of Mineralogy contains a concentration of mineralogical and geochemical skills relevant to the work of other Divisions, and collaborative studies have developed in topics as wide-ranging as salinity in ground-waters, pollution, and Landsat imagery. Joint projects with CSIRO Divisions outside the Institute have enabled mineralogical techniques to be applied to problems in agriculture and animal nutrition and have allowed new techniques, such as metal-ceramic bonding, to be applied to minerals research.

A review of the Division, to be conducted immediately prior to my retirement later this year, will provide a committee of representatives of industrial and academic circles with the opportunity of examining our achievements and current status, guided by submissions from local and overseas members of the profession. Recommendations from this committee regarding the future constitution and direction of the Division will then be presented to the CSIRO Executive for subsequent action.

One of the issues to be addressed by the review committee is the long-standing debate about the relationship of the field of work of the Division to that of the BMR, although the matter has been largely resolved to the satisfaction of the two Organizations during the past year. In May 1982, a joint statement was prepared on the 'Rationalization of Minerals (Exploration) Research between BMR and CSIRO' and a 'Minerals (Exploration) Research Liaison Committee' (MERLCO) was established, comprising the Directors and Chiefs of the two Organizations. In the two MERLCO meetings that have taken place since then, a set of working arrangements has been established to ensure that future research programs would be jointly considered and agreed upon before implementation and that particular efforts would be made to identify specific research areas where complementary or collaborative work would be undertaken. Only a few such areas have become apparent to date, but the means to achieve a rational distinction between the respective activities of the various research teams involved now at least exists and a greater degree of collaboration will clearly ensue, even though opportunities for rationalization in the economic sense appear to be limited at this stage.

In concluding this introductory section, I would like to acknowledge the important contributions made to the production of this publication by the editor, Wilf Ewers, by Ray Binns and Russell Hudson for the organization of the volume, by Colin Steel who illustrated and collated the text, and by Helen Warrener who set the type. If this initial effort is favourably received and Divisional circumstances permit, further issues will probably be forthcoming at more or less regular intervals."

I have highlighted the reference to the Divisional Review which did take place. This review was carried out and the findings commended the Division on the work that was being carried out. Arthur who was suffering terminal cancer at that stage was extremely gratified by the findings of the independent review committee. The death of Arthur Gaskin in October 1983, and the retirement of Wilf Ewers marked the end of the "early days" of CSIRO minerals research in the west. Mike Thornber

ROBERT GERRITSE[15] (1983 to 1998)

In the newly formed Division of Groundwater Research, Ray Perry and his second in command Adrian Peck decided to broaden the scope of research in DGR beyond classical hydrology and salinity to include research inputs into Australia's water problems from hydrochemistry, hydrogeology, isotope hydrology, plant physiology, resource economics, social psychology, computer simulation and modelling and mathematics. Various people were appointed to fill these disciplines from 1980 to 1983. First off were Jon Thomas (resource economist), John Marshall (botanist), Eric Greenwood (plant physiologist?), Ed Wronski (hydrologist), Munna Sharma (soil physicist), Henry Allison (mathematician), Eric Bettenay and Max Churchward (pedologists), Geoff Syme & Blair Nancarrow (social psychologists). And then five new positions were filled over the period 1982-1983: Jeffrey Turner (physical chemist, isotope hydrologist), Greg Davis (mathematician), Alan Curtis (groundwater modeller) all from Australia, Chris Barber (hydrogeologist) from the Water Research Centre in Stevenage (UK), and finally me (physical chemist – aspiring hydro- and soil chemist) from the Soil Fertility Institute in Haren, the Netherlands. The Soil Fertility Institute was dissolved soon after I left, and was merged with various complementary Institutes in Wageningen. But, as I was told later, this had nothing to do with my departure.

Most of the five new researchers must have had the feeling of running around like headless chooks in their first year (at least I did), possibly wondering where they had got themselves into and how to get some form into this new job. There was no clear local management structure other than the two 'gurus' chief Ray and co-chief Adrian, their 'adjutants' (David Williamson and Colin Johnston (research assistants to Adrian), Margaret English (Ray's secretary), Pat Keogh (administration), Bob Rummery (communications), Bill van Aken (photography), Anne McKenzie (graphic designer and pilot), and (Ray's hobby horses) the social psychology and resource economics units.

Some structure developed over the following few years. Chris Barber developed associations with waste management authorities in Perth and showed first signs of management ambitions, possibly following his former position as group leader at the WRC in Stevenage. Projects were developed and further stimulated or thrown back for redevelopment. Associations between the 'five' and other researchers began to develop. All researchers went through a phase of proposing green papers for their projects, which were discussed extensively within the Division and then finalized as white papers. Alan Curtis, with his military background, was particularly active and effective in getting all this going and maintaining momentum. Researchers then had to go out and attract funding for their 'white papered' projects. This funding aspect was new and a rather strange experience for the older researchers. Suddenly they were asked to earn their keep! Every project had to be costed in advance with at least 30% recovery of salary components. Over the years this percentage increased slowly to full recovery and projects with industry were charged at three times salary + on-costs. Thinking back the first 3 to 5 years must have been an interesting study object for social psychologists, particularly on how to best develop creative and financial potential and management structures of a multidisciplinary research group. This development, however, just happened as things bubbled up from the group and were then given mostly appropriate stimuli from the Chief and Assistant Chief (at least that is how I experienced it) and was not researched and went undocumented. Management training was given during the process and possibly gave some insight to people about what was happening and how to react. It all made me think of my exposure in Europe to the Tavistock method of 'leaderless' management training. Through role playing games you are made to experience vividly how you function in a group and how that affects the group and its interactions with other groups. Consultants observe, but only provide brief interventions for the group's consideration.

[15] Contributed by Robert Gerritse

My initial brief was to find anything worthwhile other than salinity to contribute to water research in Australia and seek out some relevant field sites. A few hints were given such as nutrients (eutrophication), organochlorine pesticides (OCs were being phased out, but many others were trialled, and long-term environmental behaviour was often unknown), waste disposal, septic tanks and many related areas. I was given a small corner office in a room, which had the potential of a laboratory. No provisions had been made for a laboratory or technician. When I discussed this with Ray Perry, I was left feeling a bit like Oliver Twist. 'You have got a room and we have given you the problem areas to develop and we have a central laboratory (then run by Monty Janz) and workshop (run by Lindsay Derriman). Do you want more!!!' The central laboratory was then pretty basic and not always easy to use. Once I needed access to a high speed centrifuge; the crucial rotor could not be found. Eventually it was found to be in use as somebody's doorstop! Yes I did want more: liquid- and gas chromatographic equipment to develop specific methods for analysing major and minor ions, pesticides and other organic pollutants; a spectrophotometer for colorimetric analysis of phosphate and some trace metals (Fe, Mn); a TOC analyser; a differential pulse polarograph for ultra-trace analysis of metals; a quartz double-still for ultra-pure water; a list of smaller items and an assistant. Ray agreed and all this was purchased over the next three years with the help of research proposals that were part funded by CSIRO with (sometimes) matching funds from government and industry (EPA, Public Works Department – later Water Authority, Universities, Alcoa, Bayer). And over the following 15 years, results on a range of projects were published as journal papers (29) conference papers (19) and reports (31). I was assigned a technical officer in 1985 (John Adeney, poached from Kath Bowmer of the CSIRO Griffith lab).

After mulling things over for about a year, I settled into a few little niche projects that slowly grew into things (I felt) worthwhile pursuing.

A chromatographic method with UV detection for trace analysis of bromide together with chloride, nitrate/nitrite and sulphate was used extensively to follow changes in the chloride to bromide ratio from recharge to groundwater and surface water. Bromide was found to be sufficiently biophylic to be measurably affected by degradation or formation of organic matter relative to chloride and a few interesting papers resulted. Bushfires left a clear footprint through release of Br and a subsequent lowering of the Cl/Br ratio. Bromide was also added as a tracer to follow effluent from septic tanks in the Darling Range and quantify rates of denitrification. Dissolved oxygen could also be measured as a separate peak. Analysing water extracts from Bassendean Sands, I once noticed that, on standing in stoppered glass flasks, concentrations of nitrate as well as oxygen slowly decreased to zero. But this did not occur in stoppered polyethylene flasks. As the water extracts had been centrifuged at high speed and membrane filtered, I must have stumbled on abiotic aerobic denitrification by extracellular enzymes. Aerobic denitrification has been regularly reported in the literature and is now accepted as occurring widely in nature. The exact mechanism(s) are however far from solved and I still regret not having been able to develop this observation into a research project with a molecular biologist. Implications for treatment of wastewater could have been interesting.

A project for the Water Authority into the behaviour of organochlorines (OCs) showed that because of odd behaviour of their Henry coefficients, volatility of heptachlor was orders of magnitude greater than that of dieldrin, explaining the rapid disappearance of heptachlor after spraying in moist areas and often high concentration in the atmosphere of houses that had been sprayed against termites. Dieldrin was a lot 'safer' in that respect and more persistent, yet was banned and taken out of production, while heptachlor was continued to be used until the late 1980s, when use of all OCs stopped.

	
John Adeney sampling the water column down to about 5 m in the Murray River.	Sediments cored from Lucky Bay in the Swan-Canning estuary at 4-5 m depth by Vas Hosja.

Impacts of residential urban areas on groundwater quality were extensively studied for the Perth situation, and with the help of Chris Barber and John Adeney led to a seminal report in a Water Resources series. This report formed the basis for many further studies into environmental impacts of septic tanks and also on impacts of agriculture on water quality. The expertise of the social-psychology group was put to use for surveys of consumption of nutrients and other chemicals by house holders and their potential impacts on waterways. In particular the contribution to nutrient inputs of pets and other animals in residential and (semi) rural areas was quantified. The Ellen Brook catchment was studied and a model was developed for describing exports of phosphorus, nitrogen, organic matter and also cadmium into the Swan River. Relationships with soil type were explored after an extensive survey with help of pedologist Bill McArthur.

Anthropogenic contributions to phosphorus and a range of heavy metal in sediments of the Swan-Canning and Peel-Harvey estuaries were investigated. John Adeney developed ingenious water column and sediment samplers (see photos) and the Water and Rivers Commission supplied an expert diver (also phytoplankton researcher) for coring sediments (Vas Hosja). Coring the sediments in the Swan estuary was not easy as depths at the chosen locations were more than 4 m and light hardly penetrated beyond 2 m because of relatively high levels of dissolved organic matter. Poor Vas surfaced many times because of loss of orientation and associated nausea and then vowing never to do this again. But he persevered and without him we would not have succeeded in piecing together the sediment and water column chemistry. Work on the WA estuaries was given a fair bit of media coverage, which culminated in a poorly managed (by me!) write-up on the front page of the West Australian on 24/7/1994. This article in the West did not earn me any brownie points.

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CSIRO attacks Swan clean-up

By Carmelo Amalfi

AUSTRALIA'S top science organisation says the State Government's clean-up of the Swan and Canning rivers has failed to tackle the cause of 90 per cent of one of the main pollutants.

A five-year study by research scientist Robert Gerritse of the CSIRO found that Government environmental efforts were focused on the wrong part of the Swan River because most of the pollution was in fertilisers entering almost continuously from Ellen Brook, about 30km north-east of Perth.

In April, Environment Minister Peter Foss announced grants worth more than $1.7 million to develop methods to improve water quality in the Swan and Canning rivers.

Dr Gerritse said although new State Government measures might provide a quick-fix answer, no long-term solution would be found until agricultural activities over poor sandy soils near the brook were banned.

He said the only research project dealing with land use problems in the catchment was rejected by the WA Estuarine Research Foundation, which was established by the Court Government last year in response to blue-green algal blooms in the rivers.

Some of the projects adopted by the foundation involved the development of ecological models of the rivers, examining the presence of sea grasses near Fremantle and finding how algal blooms were triggered.

Dr Gerritse's five-year study has looked at phosphorus and heavy metals in sediments deposited in the river system over the past century.

He found that concentrations of phosphorus, which has been blamed for choking algae outbreaks in the river, increased sevenfold and those of lead tenfold, between 1950 and 1990.

He blamed most of the phosphorus on fertilisers and said phosphorus levels appeared to be still increasing despite efforts since 1970 to slow land clearing near the brook.

His study, which involved the use of radioactive dating techniques and chemical analyses, cast doubts over claims by WA water authorities that only about 35 per cent of the phosphorus reaching the Swan was from Ellen Brook, with most of the rest from the Avon and around the metropolitan area.

Dr Gerritse said that Ellen Brook contributed at least 90 per cent — making it the main source of phosphorous pollution in the Swan River, even though the amount of water from the brook was diluted 10 times after joining bigger flows from the Avon River.

The Ellen Brook water was nearly 90 per cent concentrated, dissolved phosphorus believed to be leaching from paddocks, hobby farms and market gardens.

"From a management point of view, unless the Ellen Brook catchment is cleaned up, nothing you do downstream will stop these levels climbing," Dr Gerritse said.

Last night, Mr Foss said he was hesitant to comment on work that seemed to go contrary to present ideas about where most of the phosphorus in the Swan came from.

● The causes, page 10

Smiling newlyweds: Former prime minister Bob Hawke and bride Blanche d'Alpuget smile for guests and photographers after their wedding in Sydney yesterday.

Hazel parties on Bob's big day

Sydney

YES, he cried.

Former prime minister Bob Hawke, 66, married his biographer Blanche d'Alpuget, 51, in Sydney yesterday in a ceremony as slick and media-managed as any of Mr Hawke's election speeches.

There were security guards, former Cabinet colleagues Michael Duffy, Ros Kelly, Lionel Bowen and Kim Beazley, and the famous tears.

Speaking just after the private ceremony at the Ritz-Carlton Hotel in Double Bay, Mr Hawke brought up the issue himself.

"Did I cry?" he asked, grinning at his new wife. "Yes, I had a couple of tears in my eyes, which Blanche said was quite nice. But I had a new experience today — I started to water from the nose a bit as well."

He denied the couple had sold their story.

Mr Hawke's former wife, Hazel, marked the occasion with a "Freedom Party" at the four-storey Sydney mansion she and Mr Hawke built after he retired from politics.

Mr Hawke's new wife asserted herself when photographers eager for her to look their way began calling "Mrs Hawke".

"I'm Blanche d'Alpuget," she said sternly. "Always."

The service was conducted by Mario Schoenmaker, leader of the Independent Church of Australia into which the bride herself hopes to be ordained as a priest.

Her outfit was a traditional creation of cream lace bodice and matching long taffeta skirt.

The 150 guests included Mr Hawke's three children and Ms d'Alpuget's son.

● Alston, page 13

CSIRO was becoming increasingly corporate in the 1990s. Ray Perry retired in 1987; the position for a new Chief was advertised internationally and Adrian Peck became Acting Chief until 1988. The name of the Division changed to Division of Water Resources Research and came to include labs in Adelaide, Canberra and Griffith. Adrian was very busy. Line management structures slowly crept in with the development of clear programs across states with their program leaders, project leaders, researchers and assistants. By the time Graham Allison took over as the selected Chief in 1988 these structures were well on their way and were amplified (particularly the interstate aspects) by the creation of and funnelling of most of the funding made available to CSIRO by the government through Cooperative Research

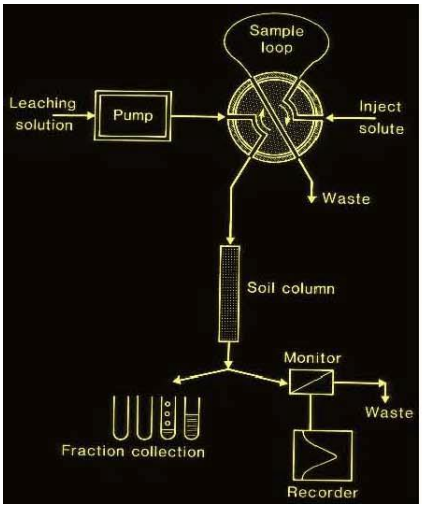
Centres (CRCs initiated in 1989) and Centres of Excellence (e.g. Graham Batley's Centre for Advanced Analytical Chemistry or Environmental Contaminants Research, as it is now called). With increasing funding by industry and matching funding by government, CSIRO was becoming a multi-million$ industry. Chiefs now led 'executive teams', with professional advisors on media, finance and human resources. The name of the Division was changed slightly in 1989 to Division of Water Resources. Graham Allison decided to remain in Adelaide and appointed OIC's at the Division's other sites. Jon Thomas became OIC in Perth. Meetings proliferated and often came up with clear 'ways forward' to be plugged into a next meeting. There was no room for off-the-cuff publicity. Everything had to be carefully managed so as not to upset stake-holders and to avoid nasty litigation and secure long term income. After the front page coverage in the West Australian, I was politely told by Graham Allison to toe the line or get out. Later Graham Allison, ironically, got caught up in some nasty litigation himself and relinquished his Chiefship, which was taken over by Geoff Pickup in 1995 and by Graham Harris in 1997. The name of the Division had then become just simply Division of Land & Water and included sites of the former Division of Soils in Adelaide, Canberra and Townsville and the Centre of Environmental Mechanics in Canberra.

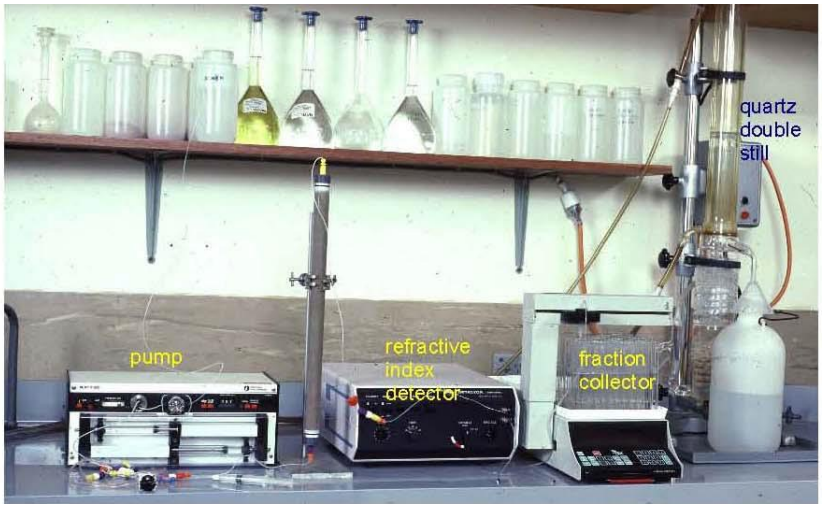
After the media saga I got involved, jointly with Peter Thompson of the Division of Fisheries at , in projects on nutrient limitation of algal blooms in the Swan-Canning estuary. These projects were funded by the Coastal Zone Program of CSIRO, which was coordinated by John Finnigan. Seven Divisions were involved in this Program, started in 1991 with an initial budget of $2million. A few interesting multidisciplinary meetings in Hobart resulted. The Coastal Zone Program was ended in 1999, but was kept alive until 2006 through the CRC for Coastal Zone Estuary and Waterways Management.

Together with Peter Thompson of the Division of Fisheries at Marmion, I got involved in projects on nutrient limitation of algal blooms in the Swan-Canning Estuary funded by the Coastal Zone Program of CSIRO and coordinated by John Finnegan. Seven Divisions were involved in this Program, conceived in 1990 with an initial budget of $2million. A few interesting multidisciplinary meetings in Hobart resulted. The Coastal Zone Program was kept alive from 1999 to 2006 through the CRC for Coastal Zone Estuary and Waterways Management.

At a more fundamental level, I developed a flow system with miniature saturated columns of soil (or, when clay content increased, mixtures of soil with an inert filler) for measuring the sorption kinetics of solutes (chloride, bromide, oxyanions, pesticides, heavy metals, isotopically labelled water) from breakthrough curves registered online with a flow-through detector or offline in collected fractions of effluent. Results were obtained for phosphate, glyphosate, triazines, cadmium in a range of soils and were then compared with numerical simulations, from which sorption rates and distribution coefficients were estimated.

The column-flow method was applied to predict movement of phosphorus from sewage effluent in Rottnest Island's calcitic soils and in soils of tree farms near Albany. Also the effect of flow rate on dispersivity in soils was investigated and an empirical equation for predicting breakthrough times of phosphate from soils was tested. The method was also used to compare breakthrough of Cl, Br and D_2O from columns of different soil types. Differences were measured, particularly when clay content increased. Effects of charge (Cl, Br) and size exclusion (Br) and stationary water (D2O) were noted, particularly for unsaturated flow. Direct funding for this type of work was, however, difficult to obtain and mostly piggy-backed on funding for the then more politically relevant projects on eutrophication and algal blooms.





After 1994, I went through a succession of program leaders and my research focus dropped. In 1998 I opted out of CSIRO through a redundancy program and left with fond memories of CSIRO and all the people I was privileged to meet through CSIRO and have discussions with in the period from 1983 to 1998.

In recent work (yes, there is some life after CSIRO!) build-ups of Cl and Br in profiles of clayey soils above aquitards were measured with differential movement of Cl and Br, linked to effects of charge- and size exclusion.

PETER HICK[16] (1966 to 1968 and 1970 to 2001) and WORKMATES

In 1966 I spent a year at Kimberley Research Station working on a joint CSIRO/WA Department of Agriculture beef cattle pregnancy diagnosis trial. I assumed that my career would continue to be based on my Muresk qualifications and deep interest in veterinary aspects of cattle production. I had literally spent much of my time in the Kimberley sticking my skinny arm up the backsides of cows that had been fed on a high oestrogen diet of cotton seed, to determine ovary irregularity and early foetal abortion. However, in December 1966, while home for Christmas, I saw a newspaper ad in the "West" for a technical position at the new Floreat Park Labs of CSIRO so I dropped in an application and soon I was being interviewed by Eric Bettenay for a job with the Division of Soils. At the end of the short interview Eric said "give us a ring in a couple of days", which I did, and he rather sarcastically replied on the phone, "well, there weren't too many applications, so I suppose you've got the job!" A little taken aback, I was still to learn of Eric's dry and pragmatic sense of humour. Eric and I became lifelong friends; later he encouraged me to take on further studies, supervised my Masters and helped with my PhD. We also shared ownership of two yachts, drank some very good red wine and had many adventures together.

At Floreat, soil scientist Max Churchward was perpetually draped over a strange little military green device that looked like a pair of glasses worn backwards with a couple of two-bob-sized lenses propped above piles of air photos. The air photos looked to have been attacked by a graffiti-artist with grubby blue and red pencil marks randomly scribbled all over them. So my first introduction to a stereoscope, and in effect remote sensing, was probably treated with some cynicism as I heard the arguments between Maurice Mulcahy and Max and Bill MacArthur who were trying to convince Maurice that they should actually buy every photo in a flight line run instead of every second photo. This was a waste of money according to Maurice who argued that because of 60% overlap redundancy "you already have the coverage you needed to make a map of the landscape". Maurice seemed unmoved by the argument of the advantage of stereoscopic 3D coverage given by the overlapping parts of air photos. I am not sure if Maurice (who in the late 1960s was OIC of the WA Labs of the Division of Soils) had an optical problem. I do not think that he ever saw a stereo image despite his significant contribution to unravelling the mysteries of the ancient Western Australian landscape. He was the boss and this was his management style, developed as a senior officer in the Royal Navy. The senior scientists, Bill, Max and Eric had a significant victory when at the start of new soil mapping project they actually purchased all the intervening photos that gave stereoscopic coverage and paid a staggering $500 for a Topcon Mirror Stereoscope.

When I joined the Division of Soils in 1967 we were definitely in the air photo interpretation era and I remember well Eric Bettenay, acquired a very grainy low-resolution picture from one of the recently launched geostationary weather satellites. We spent hours looking at this first ever view of the whole of WA. We could see the salt lake chains becoming rivers, the extent of agricultural clearing and salinisation, the Darling fault reaching the south coast, the swirls and patterns in the ocean that we later knew to be the Leeuwin Current and, "how close is Timor!"

The Division of Soils was one of the oldest of CSIRO's many Divisions. It had started in 1927 in Adelaide and had undertaken major work in all aspects of understanding the primary Earth resource. The Atlas of Australian Soils is one such achievement that had an influence on the WA group that was formed just after the War, and was a very significant national application of interpretation of aerial photographs. The work of Bill McArthur and Eric Bettenay on the Swan Coastal Plain is probably the most widely adopted example of how

[16] Contributed by Peter Hick and some of his workmates.

the understanding of the landscape effects and what makes living in WA so great. Daily-used terms such as the “Spearwood”, the “Karrakatta” and the “Bassendean” soils were coined by these two. The first member of Soils Division in WA was Bob Smith in 1945 who was joined by Glyde Turton in the Lab and then also by Bill, Eric, Frank Hingston and later by Maurice Mulcahy, Max Churchward and Geoff Dimmock. Wally Russell also joined to provide technical support in the late 1950s and although trained as a fitter and turner he developed a rare and deep understanding of landscape, vegetation and soil properties, not to mention classical music and fine wine!. The Soils group diversified into chemistry, with Murray Chapman and Jack Keay, and soils physics streams with the appointment of David Williamson and later Adrian Peck, Peter Yendle and Denis Hurle

After a short break of a couple of years while I tried farming again, I returned to the group on the invitation of Maurice over a glass of sherry. I was back with Bill, Max, Eric and Wally Russell doing soil regolith and vegetation surveys throughout the length of the state. The stereoscope and grubby blue chinagraph wax pencil always complemented the hand auger and spade. I worked for 4-5 years in the mid-seventies mainly with Bill and Max on the Murray-Hotham drainage basin, that involved mapping the entire catchment with detailed soil mapping in 7 sub-areas.

Bill McArthur and the Pedology Group

Bill was a wonderful teacher and his knowledge of all spatial aspects of landforms, anthropology and pedology was freely given and gratefully accepted. Not only did he teach me how to interpret landscapes from photographs, but also he introduced me to the wonders of ecology. We spent many hours photographing plants and wildlife and searching for native artefacts and remnants of natural history. We collected native seeds, and with the help of the CSIRO gardener Norm Jervis we germinated thousands of seedlings in the glasshouses. Most of the large native shrubs and towering eucalypts that are now so important a part of the CSIRO Floreat Park site came from those seedlings that Norm and I grew in one of John Beresford’s glasshouses. Bill was also a lover of good food and fine wine and some of our visitors to the field would be somewhat amused (but always impressed) with table cloths at smoko, chilled chardonnay with a freshly-caught trout at lunch and his legendary rare fillet with shiraz for dinner, all from the back of a Land Rover. Bill had joined the RAAF and was a navigator and flight crew in the Pacific during the WW2. On discharge, he went to UWA as a mature student. He was a “gentleman” in every sense of the word.

The Soils Pedology Group was very much in the remote sensing business although we did not realise it at the time. Wide recognition of the importance of such work as the soils of the Swan Coastal Plain, the genesis of the ancient lateritic landscape and the pervasive effects of agricultural soil salinity was evident. We were also starting to move into more commercial aspects of the science (rather grudgingly by some) and began several projects that were funded from external sources, such as fertiliser, agriculture, mining and timber companies as well as the water supply agencies. The benefits of these initiatives were reflected in our resources and travel opportunities. Bill, Max and Eric were all rewarded with reasonably rapid promotion and overseas sabbaticals.

In the early 1970s the Chief of the Division of Soils was Gordon Hallsworth. He was based in Adelaide and rarely visited the West, but when he did, he seemed well pleased. Wally and I were quite excited when on one visit he mentioned to Maurice that he was thinking of retiring soon but before going he wanted to tour the rapidly expanding iron ore provinces in the Pilbara. And he added, “by the way, while I was recently in the UK I raced down the motorway in the luxury of one of these Range Rover things”, and he felt that this form of travel was appropriate for him on his planned Pilbara Trip.

Maurice (MJ as he was affectionately known, or Dr Mulcacky when he was out of favour) wandered into our lab and in his usual style "umphed" a few times and said to Wally and me "Take our old Land Rover Station wagon down to the Rover dealer (Faulls), and get a trade-in price on one of these new Range Rover things, eh". In the early 1970s, Faulls was run by one Johnny Jullian who was on pretty good terms with us but he was worried that he had been obliged to take 6 of these expensive, and in his opinion, highly unsuitable vehicles. He was very keen to do business with us as he reckoned he would never sell one at $6000, which was 50% more expensive than the top line Land Rover of the day. In early 1973 we had an order in and before long we had our Range Rover.

Maurice gave us stern warning to look after this as it was only bought to cart revered dignitaries like Gordon around but we took it to Collie and on the first track that we encountered we picked up a log that ripped open the bottom of the radiator and knocked off the oil filter. So we were stranded in the bush without oil or water. Serious embarrassment! However, major under-body protection was fitted and extra fuel range capacity and dust sealing was soon added. Although we set the vehicle up to suit the forthcoming Pilbara trip, which incidentally was successfully completed without incident, that vehicle became a most useful field vehicle that saw extensive surveys throughout the state, especially in the Pilbara, Goldfields and Kimberley. Other technological marvels of the era were the Engel Fridge and the Honda generator. Eric used to refer to the history of field work in the past as being "BF" (before fridges) such was the effect on the level of comfort of our field work. The small quiet generators also provided camp light and charging for batteries that were run down keeping copious quantities of another marvel of the times, canned beer, cold.

As a well-resourced and well-balanced group, the future looked great and we would have been happy spending the rest of our lives doing soils surveys close to trout streams in the summer and near the picturesque gorges of the Kimberley or Red Emperor spots in the Pilbara during the winter. We completed soil surveys of national importance, our section of the Atlas of Australian Soils principally based on air-photo interpretation and local specific importance of the Collie, Murray-Hotham catchments, soil fertility studies throughout the entire wheatbelt, the Woodchip Lease areas, selecting the Murdoch University site, Mt Keith-Yeelirie nickel and uranium provinces, the proposed Karratha town-site, and the Strelley and George catchments in the Pilbara. Always, with a pile of photos and a trusty stereoscope close by. What more could you want?

Ray Perry's LRM

Change was afoot; the new order was upon us. The turbulent Whitlam years led to an agreement being hammered out with the State Premier (Sir Charles Court) that "two CSIRO Divisions must have their headquarters in WA". The reorganisation following the Underwood review was the creation of a "Western Australian Division" to be called the Division of Land Resources Management. The appointment of a locally-based Chief (Ray Perry) was an organisational tsunami that rocked the foundation of all that we knew and very comfortably understood in CSIRO at Floreat. Ray was a rangelands ecologist and brought with him groups from Alice Springs and Deniliquin. The demise of the strong and influential pedology group from the Division of Soils was regretted in many quarters, especially in the State Government departments who in some cases picked up the slack. The loss of that capacity is poignantly and officially noted in Lee's History of the CSIRO Division of Soils. However, WA did get its two Divisions and experienced significant growth in the land management and minerals streams as well as fisheries, oceanography and wildlife. It must be to Ray Perry's credit that he recognised the potential of evolving technology and while in the US in 1976 took the time to visit Stanford University where a young expat West Australian post-doc, Frank Honey was working with Professor Ron Lyon. Ray met with Frank in rather informal circumstances and invited him back to Perth to start a "remote sensing" group. Frank Honey has become synonymous with remote sensing, especially in WA.

Frank Honey and Ian Tapley

Frank Honey was nothing short of an amazing guy, Ray gave him incredible freedom and resources to develop and lead the group. His first achievement was to produce a suite of software that could process the data that came from the Landsat Satellite that we would first have to order from the US. This program, named "Eyeballs in the Sky" after the potty crabs in the "Perishers" comic strip, initially required the processing power of the huge Dec10 at the UWA Computing Centre but we eventually took delivery of a half-million dollar roomful of computing gadgetry which included a washing machine-sized storage disk with an amazing 30 megabytes of space. People used to line up just to look at the 12 inch, 7 track tape drive slowly going around! Scientists flocked from all over Australia and beyond to look at hand-coloured line-printer output showing the unravelling of the mysteries of the land and water.

However, it was about this time that Ian and I discovered the full meaning of the magic term "ground-truthing". All this stuff that was being rolled out in prodigious quantities had to be checked on the ground, or the air, or from a boat – bloody heaven! Ian, who had returned to CSIRO in Alice Springs from service in Vietnam, had a wide experience before coming to Perth in aircraft deployment and acquisition for studies in the rangeland conditions in the NT. His "light-bulb moment" was probably when he first saw a grainy picture from the 1981 Shuttle Imaging Radar, and since he has gone on to become an internationally-recognised expert in the application and interpretation of imaging radar technology.

Together we set up a pair of Hasselblads (these were the cameras that Frank had managed to acquire and had been developed and successfully used on the manned lunar missions – nothing but the best). We made mounts and devices that enabled us to fit spectral and thermal radiometers (wonderful little boxes of magic) to all manner of land, airborne and seaborne platforms. The old Range Rover had frames and contraptions bolted all over it and Kevin Radford used to shake his head in disbelief at some of the things that we proposed to fit into his aircraft.

It was about this time when we were doing quite a bit of wetland characterisation and we discovered the benefits of helicopters. We teamed up with the RAAF who had significant flying hour requirements for crew training and were itching to do something useful. We had built various "Heath-Robinson" structures and aircraft mounts in ever-forgiving Lindsay Derriman's well-equipped workshop. However, the opportunities afforded from the freely available and ideally suited RAAF Iroquois to make thermal and spectral measurements and photographs from places that few others could get permission to fly, were tremendous. Rumours abound; we were never caught pulling craypots at Rottnest from an Iroquois, but we did eventually receive a stern warning from the CO about the amount of cleaning the aircraft required after "bloody CSIRO flights". As we often landed on beaches there was the usual amount of sand that wound up in the aircraft. On one occasion we landed on what appeared to be a dry swamp bed near the Gnangara pine plantation (we may have needed some Christmas trees for the upcoming festive season and there was also some issue with the need for the chain saw in the aircraft as well), but alas it was dry powdery peat and this time the chopper turned black and filled with fine peat dust.

What eventually upset the apple-cart was when we were doing dye studies of an ocean current near one of the coastal islands. The dye was a bright-purple fine powder that can be traced in very small concentrations by its fluorescent properties. The plan was to slightly rupture the protective bag, drop it in the ocean out of the open-doored chopper and study its dispersion over time by the local current. Fisheries had boats in the area taking measurements and we had an array of cameras and instruments in the chopper. Unfortunately the RAAF guy with responsibility for opening the bag did so a little early, and little too much, and the contents instantly filled the chopper and covered all its occupants with bright purple dye powder that turned out to be almost impossible to totally remove.

The only serious incident occurred one lovely summer's day when we were making spectral observations of chlorophyll over the Swanbourne sewerage outfall and some part of the apparatus that we had extended out from the floor of the chopper started to disintegrate and the source of a sudden vibration changed the demeanour of our usually laughing and joking pilot to stony silence. As I was alongside him peering down a drift-sight periscope, I think I seized the gravity of the situation from the look on his face (or maybe the smell coming from his trousers) and that in all likelihood we had caused some damage to the tail rotor. Thanks to the instant reaction and the thorough training of the ex-Vietnam pilot, the nose went down into a steep dive and we immediately gathered speed and control and made a beeline for the famous and beautiful nude beach of Swanbourne (not that we were that interested in the view at the time). We made a very hard but safe landing and after extensive checking nothing could be found wrong with the aircraft, but there were bits missing from our camera gear. Very Lucky!

In 1982 Captain Eric Moody was commanding a London to Auckland British Airways Boeing 747 carrying 263-passengers when it encountered an ash plume from the erupting Mount Galunggung in Java, Indonesia. Frank had looked at daytime imagery of the eruption but this was not able to separate the plume from cloud. A subsequent eruption a month later, while Nic Andronis and I did the 3am acquisition that coincided with chosen flight path from Indonesia, we made a fortuitous discovery. When we enhanced and ratioed the thermal bands, a strange looking cloud streaming toward WA from Java was revealed. Qantas engineers were in the office next day!

Monitoring of rangeland degradation and ecosystem function is a classic use of remotely sensed data and was developed by Ian Tapley, especially with his experience of vegetation monitoring at spatial scales of thousands of square kilometres. The Ashburton River country was chosen at the end of Hooley's Stock Route in the late 1860's and became a very special place to us all over 100 years later. This stock route commenced at the last northern civilisation out-post, the Geraldine Mine, near Northampton and opened up the north to the prosperity that Australia has earned from sheep and cattle. The route was chosen by Edward Timothy Hooley who pushed 2000 sheep up to the Pilbara in the winter of 1866 where, near the end, he selected a beautiful pool and the adjoining river country on the Ashburton as his home. His efforts on the Ashburton were not as successful as the next owners, the Forrests, as tragically three of his stockmen were speared by the locals and his young wife Jane and daughter Sarah narrowly missed the same fate. The "punitive retribution", known as the Battle of Minderoo, followed with the inevitable slaughter of many of the local aboriginals. The Hooleys left the Ashburton property and Minderoo was taken over and extensively developed by the Forrest family (Alexander the explorer and John who later became "Lord" and Premier of WA. Grandson and mining entrepreneur "Twiggy" Forrest still owns and cherishes Minderoo). Sheep and cattle numbers grew in the late nineteenth and twentieth century, the huge wool clips, clothed and warmed our European cousins and the bully beef fed our soldiers, but the fragile vegetation suffered.

It was at Minderoo while monitoring that vegetation, and alongside that famous pool, that Ian Tapley and I often made camp and enjoyed the wonderful hospitality of Don and Judy Forrest and their youngsters Andrew and Jane. Years of over-grazing in the region and some of the successful regeneration and erosion mitigation made by the Forrests at Minderoo meant it was a great location to validate vegetation trends indicated by the Landsat satellite data. The other great bonus was the fact that Minderoo had a Cessna 182 that Judy Forrest was happy to fly for us with all our bits poking out the open windows at freezing altitudes, and to land us on short bits of claypan to calibrate our radiometers!

Minderoo had one of the biggest and best shearing sheds in the Northwest. It had 12 stands and was made of oak that was brought to Australia from the UK in prefabricated form, probably in the 1890s. Despite surviving numerous cyclones it mysteriously burned down in

about 1980 and a magnificent new shed was built on the same site overlooking Minderoo pool. I believe that it still has the tyre marks on the roof as one of the locals christened the building by running his aircraft landing wheel along the roof during the first shearing cut-out party.

During our regular winter sojourns we always camped at the big pool that could tell so many sad and some very happy stories. We would often find a large hollow log and at the end of the night sit it on the fire forming a huge chimney that would roar all night until it burned completely away. On one occasion Ian and I decided to stop at Minderoo after a long trip north, and as it was Easter Friday we called in to see Don with a coldy in the Engel. Don had just slaughtered a beast and was happy to see us as it was stinking hot and another couple of pairs of hands were always welcome. Before long we had the beast cut down, sliced and packed and into the cool-room, and I even rolled up roasts that Don presented to the senior stockman, Mick I think was his name, who had never seen a flap rolled roast before. He dryly commented that "That's the bit we give to the dog". That night we filled a wheelbarrow with coals from the campfire and had a marvellous BBQ of still twitching fillet steak on the veranda of the beautiful "Minderoo" homestead. Not a normal Good Friday meal but very enjoyable. Not so enjoyable was the next day as we had a heap of punctures to repair and belting a tyre bead-breaker is not a great hangover cure!

Wednesday BBQs

Much of the basis for the strong collaboration ethic stemmed from an institution that was instigated in the late 1970s shortly after the appointment of Ray Perry and Arthur Gaskin, the other chief on the site with responsibilities for the Mineral division, namely the famous Wednesday BBQs. These BBQs, under the trees with the magpies, became an informal feature of the way that business was done in the Western Australian Labs of CSIRO. It was where problems were sorted, where external relationships and collaborations flourished, all with the clarity of rigorous argument, rare sirloin and red wine. At these functions, a technical assistant could tell the chief to "pull his head in" (and vice versa!). The Friday night "Beer Club" and monumental Calcuttas and Melbourne Cups and Sunday morning tennis also contributed a very strong social influence at a time when Booze Buses were unheard of!

It was probably from an idea that was sown at a BBQ, in response to a budgetary dictate that "we would all have to tighten our belts until the next financial year", that we decided that we should buck the trend and buy an aeroplane. We were told by the administration in bureaucratese that "there would be no new capital items purchased unless it had cross-divisional support and could be shown that it was an essential component of an existing capital item". It was fortunate that a close colleague and mate Bob Millington was down from Alice and even more fortunate that he had the same name and initials and similar signature to the Chief of a sister division in Canberra another "RW Millington". We contrived that if we slipped a requisition form into the system late on a Friday afternoon with most of the paperwork looking reasonably official, we might just get away with buying a Cessna 206 "as an attachment to a Hasselblad Camera", especially with the apparent (forged) endorsement of the Chief of another Division. It went as far as the purchasing officer getting quotes before the astute bean-counter Kevin Eatt smelt a rat and decided to let the press know about this. Next morning's "West" spilled the beans with an accompanying cartoon the subterfuge was out. We never got our plane!

We did however manage to pick up a replacement Range Rover from another Division who had a policy of replacement of a "lightly-used" vehicle at a fixed time and mileage. We put a proposal to Pat Keogh, our Admin Officer, that we would save the Division a bundle in replacement cost if we grabbed the trade-in and then sold our old one at auction. The deal was done and we got our second "second-hand" Range Rover. The old one by this stage had holes drilled in nearly every panel to take some instrument or device that we could

attach and despite its shabby and tired appearance the actual cash outlay was very small so Pat turned a blind-eye to the irregular transaction.

Another thing I found out about Ian on that trip was his predilection to lighting fires. In an attempt to replicate the traditional native method of land management by patch burning that creates a mosaic of burn ages, he would chuck a lighted match out the window whenever he saw a thick patch of spinifex. I used to lie in my swag at night wondering when a wind change from whence we came might engulf us all in flames. But it never happened, and as Ian would say that "like harlots they always go out at night!"

The target of this trip was one of the only reliable natural water sources in the central Canning Basin, a place that few have ever seen called Dragon Tree Soak. The last 20-30 miles in to the soak required traversing a series of very big dunes. It was getting dark and although we had HF radio contact between the two vehicles we had approached the soak from different points and somehow Frank and Eric had missed the soak by one dune and driven passed it along the adjacent dune. We were getting a bit concerned and decided to run the Range Rover up to the top of the nearest dune and hope that they see the headlights, which they did after a while. This did rather make us realise how alone we were with probably not another sole within 500miles.

It was on one of these trips that we had planned a short run up into the Kimberley and while just north of the Devonian reef on Napier Downs a tyre burst causing Mike to lose control and both the Range Rover and trailer rolled injuring Ian, and to a lesser degree Mike. Eric Bettenay and I were waiting for Ian and Mike further up the road when Sam Lovell, a local aboriginal tour-guide and friend of ours, caught up with us and told us what had happened. Ian asked Sam and his wife Rosa to find us and then managed to apply staples to his badly injured leg (using a special Queensland brand of over-proof anaesthetic). The bandaged wound sufficed until we got back to medical help at Derby next day and he and Mike flew back to Perth; another very lucky occasion. This was the only car accident that we ever experienced in the "millions" of miles that we did in over 30 years of field work.

Next day he was in his element navigating us across the dune fields from Percival Lakes to Telfer before traversing along Len Beadell's Talawanna Track to Balfour Downs. Ian and I learned much from Ray. History in some quarters may have not been kind to Ray and his management style, but from our perspective he was an outstanding Chief and great mentor. In my life at CSIRO I worked under 13 chiefs and Ray stands out in my memory for his ability to communicate complex issues with great simplicity. One quote that sticks with me is a reference he once provided that referred to the scientist in question as having "spent his whole life pushing doors marked Pull." My contact with Ray continued long after his retirement and we worked on solving some problems together with the Kailis group.

Minesite Rehabilitation

More shuffling of Divisions and repositioning of CSIRO's priorities saw the formation of a new group of mining and exploration Divisions and the appointment of Bruce Hobbs as the Chief in 1992. My first reaction was that I should look for another Division to grace with my talents. I had been doing mainly environmental work with a strong marine remote sensing emphasis. Bruce had an interesting style of management, and was reported as saying my door is always open, "but if you enter, bring two things, first, the written reason why you wish to see me, and second your written resignation, I will decide which I accept". After some months of feeling out on a limb in a Division that did not have any interest in the work that I was doing, I decided to knock on his door with both letters in hand. "Stick at what you are doing now and within 12 months I will have something new for you to do" was his reply.

Unconvinced and mildly surprised, I concentrated on writing up earlier work, I consolidated my industry network and more significantly, I improved my sailing skills. After 12 months I

went back into his office and Bruce apologised saying I should wait a bit longer. By this stage I was looking at other options. However, I did not have to wait much longer for Bruce turned up unannounced in my office with an offer to join the National Minesite Rehabilitation Program with assurances that they needed a remote sensing team. I immediately liked Tony Milne, the Adelaide-based leader, and he gave our small but skilled group great support and opportunities. We developed our "remote sensing for the mining environment" business model which was well planned, effective, and well accepted by industry. It was clearly Bruce's "new paradigm". But more importantly, we were back hanging things out of aeroplanes, helicopters and boats, going to fantastic locations throughout the country and taking our findings to the world.

From then until my retirement 10 years later, the group grew and flourished. We produced significant work in all aspects of quantitative remote sensing as it applied to measuring environmental consequences of the mining and resources industries. We used hyper-spectral airborne systems to measure the dust from iron ore production (that has effects on health), hydrological changes and contamination from evaporative salt ponds, leakage from uranium extraction and mineral sand mining, rehabilitation and ecosystem functioning of revegetation after bauxite mining, and the pervasive effects of acid drainage leaching and dewatering from mining. We used spectrometers to measure light disorientation of turtle hatchlings near oil rigs, and optical fibre attachments to measure the colour of pearls inside their living hosts. We tracked oil spills and assisted the development of satellite imagery that is now being distributed daily to land managers, telling of the effects of weather and climate. But most importantly for CSIRO, we made money! Ian Tapley took responsibility for the group when I retired, but soon realised that I was having even more fun, and soon he followed!

It was clearly time in 2002 to hang up my stereoscope (although Max is still using his and I get mine out occasionally) but this is about the only constant that stayed with me over my 30-plus years from a TA to SPRS. I knew this when I was ushered into a room one day by an eager young scientist who was keen to show me the latest 3D processing system, and, he said, if I sit in front of this massive image display system and wear a special pair of glasses I will be able to see the landscape details with the hills and trees standing up above the valleys and rivers". Wow! So now I am sailing a lot more and again working with my livestock back where it all started, sticking things into the down-wind end of cows.

FRANK HINGSTON[17] (1953 to 1995)

"We seem to have a compulsion these days to bury time capsules in order to give those people in the next century or so some idea of what we are like." Alfred Hitchcock

A Quest to Achieve Something

My contribution to the history of CSIRO in Western Australia is confined to the projects in which I was involved. In discussing these projects I have attempted to provide an outline of why the research was undertaken, the main findings and their relevance. The programs have often been collaborative, involving other CSIRO scientists and staff from Western Australian Government Departments and the University of Western Australia. In some instances I have played a supporting role where I hope I can say I have succeeded in "making a contribution". In others I have been a major player, and in still others I have worked independently.

Writing about my career reminds me of the dilemma of Lionel in the TV series "As time goes by" when he was faced with the prospect of publication of his book "My life in Kenya". Will it be excruciatingly boring for most potential readers? Nevertheless I have attempted to summarise my peripatetic journey through a series of research programs.

From the beginning I had hopes of using my newly acquired chemistry degree to make a useful contribution to research in the area of applied science. I believed that CSIRO would provide me with the opportunity of doing this. Such is the enthusiasm of youth and so began my quest.

I first became aware of the research organisation known then as the Council for Scientific Research (CSIR) when working as a cadet laboratory technician in the Chemistry Department at the University of Western Australia. At the time David Koch, a postgraduate student employed by CSIR, was developing a process for extracting potassium salt from the mineral alunite (aluminium potassium sulphate). It was just after the Second World War (1939-1945), potassium salts were needed for agricultural fertilizers but in short supply, and alunite could be obtained from salt lake deposits in Western Australia. I believe David went on to greater things working in CSIR (later to become CSIRO) in the eastern States.

Later during my BSc course, I was employed for a short period by Dr Bradbury (a Research Officer in CSIR) to help in synthesising genistein. Genistein is an isoflavone which has similar physiological effects to hormone estrogen. Significant amounts of genistein had been identified in subterranean clover which was implicated in low lambing rates of sheep grazing on clover-rich pastures.

Early Days in CSIRO

After graduating from the University of WA with a BSc in chemistry, in 1953 I was appointed as a Technical Officer in the Division of Soils of CSIR. A year or two later the organisation changed its name to CSIRO. Headquarters of the Division of Soils was in Adelaide. The staff in Western Australia comprised the OIC Bob Smith (who was absent on leave when I joined and did not return to the Division), Glyde Turton, Laurie Pym, Bill McArthur, Eric Bettenay and Tjeerd Poutsma. This group was housed in a small laboratory on the UWA campus near the Institute of Agriculture. They were engaged in studies of the distribution and pedology of soils in the southwest of Western Australia. As a Technical Officer, I began by assisting Glyde Turton, the senior chemist in the group. The pedologists spent a large proportion of their time in the field studying the soil distribution at Manypeaks, Rocky Gully, in the Swan Valley and, on the Swan Coastal Plain. Soon after I joined the group Maurice Mulcahy was transferred from South Australia to take over as OIC, Geoff Dimmock was

[17] Contributed by Frank Hingston

transferred from Tasmania, and Max Churchward joined the group from the Organisation's Regional Pastoral Laboratory at Deniliquin in NSW.

Other Divisions represented in Western Australia included staff from Plant Industry, headed by Reg Rossiter, Plant Introduction, headed by Eric Bailey, Mathematics and Statistics headed by Norman Stenhouse. Division of Fisheries staff in Western Australia included Keith Sheard and Graham Chittleborough who were located in the Zoology Department of UWA. Reg Rossiter is legendary for his studies relating to the pasture establishment and production in Western Australia. Eric Bailey introduced clover species suited to local climatic conditions. Norm Stenhouse taught many of us the basics of statistics. He was also responsible for advising on planning statistically sound experiments and analysis of the experimental results for research groups stationed in WA.

Offices and laboratories were located in the main Institute of Agriculture building and in a prefabricated building near the Institute. The prefabricated building was constructed during the Second World War (1939-1945) as part of the Catalina Flying Boat Base. This building was shared between the Soils Group, Rex Spencer and Athol Middleton from Division of Fisheries, and a laboratory for Agriculture students supervised by Don Drover, the soil science lecturer in the Institute of Agriculture. The Plant Industry, Plant Introduction and Mathematics and Statistics groups were housed in the main Institute of Agriculture buildings. The laboratory equipment and facilities available at that time were rudimentary to say the least. The offices and laboratory were hot as Hades in summer and cold in winter. After several years in the prefabricated buildings, several temporary buildings to house most of the CSIRO groups were constructed on the south side of the Institute. The laboratory facilities were much improved in these buildings. Then in the early 1960s CSIRO staff from Plant Industry, Animal Production, Soils, and Mathematics and Statistics were again relocated to new purpose built laboratories at the Floreat Park site.

My first task was preparation of soil samples submitted by the pedologists. This involved sieving to separate gravel from fine earth (> 2 mm) and crushing clay samples with an iron mortar and pestle. Not a very inspiring beginning! After a month or so I graduated to analysing soil profile samples and developing improved analytical procedures. The laboratory methods then in use were time consuming and based on techniques which would be considered very basic by today's standards. Added to this the temperature in our laboratory commonly changed over a 15 degree range in a single day. This lack of temperature control caused problems with some of the equipment and techniques. Output from our very basic colorimeter was projected from a spot galvanometer onto a metre length scale viewed in a darkened room. Samples and reagents were weighed on an analytical beam balance which unfortunately behaved badly. If everything went well about eight analyses for total phosphorus might be achieved on a good day. However, the technique in use was very temperamental and this severely limited the output of data for the soil samples returned by the survey staff. Analysis of lateritic samples from Rocky Gully involved their dissolution in aqua regia or fusion in sodium carbonate to produce solutions for classical gravimetric analysis and colorimetry. This is a very labour intensive and time consuming process. The most up to date piece of equipment we obtained at this time was a basic flame photometer. My computing was done using a slide rule or logarithmic tables. Nowadays analysis would be done using atomic absorption and x-ray fluorescence equipment in a fraction of the time we spent in analysing samples. How times have changed!

During this early period I took the opportunity to learn what I could from the literature about soil chemistry, clay mineralogy and pedology, so that I might make the laboratory characterisation of soil profile samples more relevant.

The insight that Bill McArthur, Eric Bettenay and Maurice Mulcahy gave me into pedology during my participation in field excursions to many locations in the south west and the

wheatbelt was invaluable for interpreting laboratory data. I am grateful to them for making the more routine part of my work much more rewarding. Their work illustrated the importance of knowledge of geology and physiography in understanding the occurrence and distribution of soil types. They also described how the occurrence of particular plant species, the topography and interpretation of aerial photography provided the basis for mapping the distribution of soils which they identified from auger holes across many transects and described in detail from examination and sampling from soil pits.

Examples of the application of this broad range of knowledge are provided by their studies at Capel-Boyanup, Merredin, York and Pemberton. At Capel–Boyanup on the Swan Coastal Plain this involved recognition of the relationship of the soils to the geological ages of the dune systems along the coast and the prior stream patterns on the depositional plain. In the Merredin area the emphasis was on patterns of alluvial and colluvial deposition associated with past and current drainage patterns, soils formed on the truncated material of the Tertiary lateritic landscape and soils formed on lunettes around salt lakes. At York the studies centred on soils developed on the pallid and transitional zones of the Tertiary lateritic landscape exposed by erosion and soils forming the yellow sand plain derived from destruction of the ferruginous zone. In the Pemberton area nature of the soils was related to the geology of the bedrock and the occurrence of laterite. The forest types in this region were largely dependent on the nature of the soils, *Eucalyptus diversicolour* occurring where the soils were on more basic bedrock and *Eucalyptus marginata* on lateritic soils on granitic gneiss. Soil mapping conducted in these areas, in the region around Dandaragan and in previous work at Manypeaks, Rocky Gully and the Swan Valley combined with broader ranging reconnaissance in the state was incorporated in the Soil Map of Australia produced by the Division of Soils. The maps and details of these studies enable assessment of soil suitability for the agricultural and forestry industries. Perhaps as importantly they later provided the basis for a wider consideration of land resource management and environmental issues. The studies were also a starting point for development of studies of the occurrence and possible strategies for amelioration of salinity.

A colleague once remarked to me that when he was asked what he did for a living he replied "I dig holes and after I describe what I have dug up I fill the holes in". Clearly this is far from an accurate description of the pedologist's role in studies of soils as the discussion above demonstrates!

"It is apparent that no lifetime is long enough in which to explore the resources of a few square yards of ground"
Alice M. Couts

<u>Study of the Effect of Tannins and Other Polyphenols in Eucalypt Leaves and Litter on Soil Formation</u>

One of the first attempts I made to contribute to understanding of the chemical aspects pedology was in a study of podzolisation. The hypothesis put forward in a number of reports in soils literature by Dr C Bloomfield from Rothamstead and a number of overseas research workers to explain leaching of iron in soils was that organic compounds in leaf litter played a significant role in the process. Following a visit to the laboratory by Bloomfield I began a study to investigate this hypothesis further by identifying water soluble organic compounds in jarrah and marri leaves and litter that were capable of dissolving and chelating iron.

At the beginning of the project I was able to assemble a fairly primitive set of equipment for paper chromatography but to have access to other equipment I enrolled for an MSc (part time) in the Chemistry Department of UWA. This enabled me to use liquid-liquid extraction to separate compounds from the aqueous extracts from leaves and litter. It also gave me access to x-ray and infra-red equipment to help in identification of the separated compounds.

The aqueous extracts of green leaves and freshly fallen leaves and leaf litter from jarrah and marri trees were found to contain a mixture of polymeric tannins and polyphenols. Extracts from green leaves contained gallic acid, ellagic acid, leucoanthocyanidins and a range of flavonol glycosides all of which form chelates with iron and aluminium. Leucoanthocyanidins hydrolyse under acid conditions to produce the flavanols (pelargonidin, cyanidin and delphinidin) which, as their names suggest, are the coloured compounds in many flowering plants. Flavonols (kaempferol, quercetin and myricetin) and their glycosides are yellow compounds commonly present at significant concentrations in the leaves of plants. Similar concentrations of tannins, leucoanthocyanidins and flavonols were present in freshly fallen leaves and green leaves. The brown leaves in litter contained significantly less of the flavonols than the fresher materials. In experiments with iron oxide and solutions of leaf litter leachates, gallic acid, ellagic acid and commercial tannic acid (all buffered at pH 5. 0 and pH 6. 0) showed that under conditions where oxygen was not excluded these solutions dissolved small amounts of iron oxide. Under reducing conditions the solutions the amount of iron dissolved was significantly enhanced and stable iron-polyphenol complexes were formed. The difficulty with study of weathering, mineral dissolution and leaching in soil formation is that the effects are small and the results of these processes are only observed in the long term.

Tannins and other polyphenols readily oxidize and polymerise. Some tannin compounds are adsorbed onto clay minerals, while others are mobile and leach through sandy soils. Evidence for the leaching of tannins through soils is given by the brown colouration of stream water observed issuing from the sands of the Swan Coastal Plain.

An interesting outcome of the study was the identification of suites of polyphenols comprised of leucoanthocyanidins, flavonols, gallic acid, ellagic acid and tannins characteristic of leaves from different eucalypt species (a kind of fingerprint for identifying particular species). The results of this work were reported in a paper written in collaboration with Ted Hillis of the Division of Forest Products.

For the time I spent on this study the odour of the chemicals used in chromatography impregnated my clothes and hair. I assume the persistent chemical odour was far from pleasant!

Cyclic Salt and Salinity in the Southwest of Western Australia

The possibility that widespread salinity in Western Australia might be related to accession of “cyclic salt” was suggested by reports in the literature by Wood and Wilsmore as early as 1923. Woodcock *et al* (1953) added credence to this hypothesis by their study of the formation of salt aerosols in the atmosphere from bursting bubbles formed on whitecaps in the ocean, and oceanic spray from the breakers on the shoreline. The salt aerosol thus formed the source for the salt in rainfall over the land. At about the time I commenced the preliminary study of the salts in rainwater precipitated at several sites in Western Australia, Eriksson produced an extensive review of cyclic salt data for the northern hemisphere in 1952 and 1960 and in 1958 Hutton and Leslie published data from South Australia.

To investigate the cyclic salt concept for Western Australian conditions, rainwater was sampled from a limited number of sites from 1953 onward as recorded in a Divisional Report in 1958. As reported in 1976 the study was extended to monthly sampling at 65 sampling sites. In a later study (1982 and 1983) in the Margaret River area a further 5 sites were sampled. Analysis of rainwater showed that the mean annual concentration of salt decreased from about 15 mg chloride per litre at sites about 4 km from the coast to 4 mg chloride per litre at sites as far as 300 km inland. Rainwater sampled daily at Floreat over a 3 month period in winter showed that during passage of rain fronts the salt concentration was highest in the initial showers and decreased in the later showers. Variation in the mean

annual chloride concentrations in rainwater sampled from year to year can be attributed to this factor and differences in wind direction and strength encountered in different seasons. Salt concentrations decreased from the south west coast in a clearly defined manner with distance from the coast and the annual accession varied with annual rainfall. Annual accession calculated as sodium chloride ranged from approximately 40 kg per hectare in the north of the South West Coastal region and increased to 250 kg per hectare on the South Coast. In the South West Central (semi-arid) region, where salinity was most evident, accession was around 30-50 kg per hectare. Could this small input of salt be enough to result in the extensive salinity observed in the landscape?

You may recognise some of these faces: Frank Hingston, Jon Thomas, Adrian Peck, ?, Andrew Mensaros (Minister for Water Resources), Ken Kelsall (Water Authority) and Brian Whelan

In an attempt to answer this question a number of factors were considered. There is no geological evidence in the literature for past oceanic incursion into the areas affected by salinity, no sedimentary rocks from past geological eras which might have contained salt and weathering of the igneous basement rocks could not be a source of the amounts or composition of salt found in studies of soils, deeply weathered laterites and salt lakes. Therefore it is reasonable to assume that the salt originated through accumulation of cyclic salt transported inland by westerly winds from over the Indian Ocean. The major factor favouring this postulate is the fact that the West Australian Plateau is known to have been a land mass over millennia even from the time it was part of Gondwana Land. The climatic conditions over the long periods that would be required to accumulate the quantities of salt found in the landscape are not known with certainty. However it is believed that for a long time in the past climate was similar that prevailing currently. The semi-arid conditions of the inland in the south west, subdued topography and occluded drainage systems all favour salt retention. Further, the deeply weathered Tertiary laterite in the landscape provides a sink for storage of accumulated salt. Estimates of salt storage made by Geoff Dimmock, Maurice Mulcahy and Eric Bettenay in the Bakers Hill area and by Colin Johnston and Bill McArthur at Dryandra and Popanyinning in the Murray River Catchment illustrate the large amounts of salt stored in deep weathered soils. The amount of salt accumulated increases with the decrease in average annual rainfall and the depth of soil profiles. In any particular region accumulation would be expected to depend on the balance between the input of cyclic salt in rainfall and export in drainage. The saline drainage into longer rivers extending to the semi-arid inland is evidence that some salt is exported. Hence net accumulation to the extent observed would require input to have occurred over very long period, probably many thousands or hundreds of thousands of years. In the coastal region west of the Darling Scarp salt input in rainfall is greater than inland but the topography and higher rainfall results in greater export and relatively little net accumulation.

Studies by Eric Bettenay of the distribution and development of soils around Merredin established the nature of the modification of deeply weathered Tertiary landscape. A detailed investigation of the groundwater aquifer in the Belka Valley by Eric, Bill Blackmore

and I provided physical parameters of the system and data on the salt concentration and chemical composition of the groundwater. These studies showed intake of rain water around rock outcrops at the upper parts of the landscape entered an aquifer system consisting of a sandy clay aquifer confined by a very dense clay layer. The salinity increased gradually to reach concentrations similar to and greater than in seawater (described as “pig pickling” concentration) at outlet seepages in the valley floor. Measurements from transects of bores drilled across the valley showed that the groundwater was under pressure due to the aquifer gradient. However, because the gradients were relatively low and the measured hydrologic conductivity of the aquifer was also low, water movement was estimated to be very slow.

The fact that the water in the aquifer became increasingly salty from intake to outlet indicated that less salty water must be extracted from the aquifer. The mechanism for this process is highly speculative and presents difficulties for interpretation. Water uptake through tree roots is possible but the salinity of the water in the aquifer is a problem. Another possibility is that salt-sieving might occur with the dense clay confining layer functioning as a membrane retarding the passage of salt allowing less salty water to leak into soils above the aquifer. The salt-sieving process can be compared with that in desalinization of water by pressure filtration through semi-permeable membranes in commercial desalinisation.

As the origin of the salt in the rainwater is considered to be from oceanic spray the ionic proportions should be identical with those in seawater. Therefore the relative proportions of individual ions to chloride were determined in order to compare the ionic composition of rainwater sampled from sites located throughout the southwest. At some sites there were slight excesses of sulphate, calcium and potassium over the proportions expected for sea salt aerosols. These could be explained in most areas by local contamination of the samples by dust. However, significant excesses of sulphate and calcium found at the Floreat site (Perth) and at Kalgoorlie due to air pollution arising from industrial activity.

Chloride was used as the reference ion to compare the ionic composition of water in the aquifer with that in rainwater. Analysis of aquifer water showed that the proportions of the other major ions sodium, magnesium, calcium, potassium, sulphate and also minor components bromide, iodide and borate closely mirrored those in rainwater and seawater. This observation supports the concept of cyclic salt accumulation.

The saltiest aquifer water also contained significant concentrations of ferrous iron, aluminium and silicate due to anaerobic and acid conditions in the aquifer. This observation gives a clue to the current process of weathering occurring at depth in the landscape. It appears that carbonic acid concentration builds up in the saturated zone dissolving iron and aluminium. Iron is maintained in the ferrous state, due to the anaerobic conditions, and at the lowered pH the concentration of soluble silica, largely in the form of silicic acid, is high. On exposure to air the iron in solution precipitates forming the iron oxide sludge commonly observed at saline seepage sites. Silica is precipitated from solution when the pH is increased and may lead to formation of silcrete.

Characteristics of the aquifer in the Belka Valley are repeated in other valleys in the wheat belt. However salinity problems occur over a wider range of landscape situations in the region stretching from the semi-arid inland towards the higher rainfall areas to the west. Saline seepage occurs on hillsides both in the sands of the lateritic uplands and in soils over weathered bedrock. In areas where native deep rooted vegetation has been cleared for agriculture, salt stored in subsoil is mobilised due to disturbance of the balance between rainfall and transpiration. This mobilised salt adds to salinity of many ephemeral streams feeding into the river systems of the south west. Studies of water supply catchments at

Collie in the southwest by Adrian Peck, David Williamson and others provide data on the mobilisation of salt stored in the soil.

Another aspect of the "cyclic salt" story arose when aerosol salt transported inland by strong winds from over the Indian Ocean was postulated to be the cause of vine damage in the Margaret River area. In a study Jeff Galbraith and I conducted, a number of aspects of the problem were examined. Estimates were made of the range of airborne salt particle sizes in the aerosol. Collectors were fabricated and installed at vineyard sites to monitor the effects of wind direction, distance from the coast and the size of simulated leaves on the amount of salt impaction. The results indicated that newly emergent smaller leaves collected the greater amounts of salt than larger (older) leaves, most salt impaction on the leaves occurred during periods when winds were from the north-west to south-west. Wind speeds in excess of 7.5 m per second were correlated with the particularly high amounts of impaction. These results were in accordance with the aerodynamic theory of aerosol particles trapped by obstacles. For laminar flow, the efficiency of trapping of particles by impaction depends on six dimensional variables: diameter of the particles, characteristic dimension of the obstacle, wind speed, kinematic viscosity of air, air density and particle density. The key aerodynamic characteristics are the interception parameter, Reynolds number and Stokes number for the system. As a close approximation for this study the collection efficiency is given by the Stokes number, which is proportional to the diameter of the particles squared, multiplied by the wind speed and divided by the characteristic dimension of the obstacle. Small newly emergent leaves in our study trap more of the salt aerosol per unit area than larger fully developed leaves and are therefore at greater risk of salt damage.

It was concluded that newly emerging vine leaves in particular are subject to physical damage due to exposure to strong winds from the ocean. When combined with salt impaction this is likely to be responsible for the vine damage observed in some seasons.

The results of measurements of cyclic salt impaction raise some interesting but highly speculative questions about the contribution that this might make to salt accession. In Jarrah forested areas, where the leaf area index (area of leaves per unit of land area) is commonly about one, I have calculated that the mean salt accession by impaction is probably much less than the year to year differences in annual accession in rainfall. The situation inland is even more uncertain but the effect of impaction would be expected to be even smaller because as the LAI is much less and impaction values decrease rapidly with distance from the coast.

Specific Adsorption of Anions

"I would like to start by emphasising the importance of surfaces. It is at the surface where many of our most interesting and useful phenomena occur. We live for example on the surface of the planet. It is at the surface where catalysis of chemical reactions occurs. It is essentially at a surface of the plant that sunlight is converted to a sugar. In electronics, most if not all active circuit elements involve non-equilibrium phenomena occurring at surfaces. Much biology is concerned with reactions at a surface." – Walter H. Brattain (Nobel Laureate for his work on electronics)

"Specific" and "non-specific" adsorption of ions at the solid-liquid interface of soil minerals are among the most important reactions occurring in soils. With this in mind, I commenced a study of anion adsorption. This study was among the most challenging of the projects I undertook during the time I was in the Division of Soils.

Some of the participants at the International Soil Science Society Conference, 1968. Glyn Bowen, Alan Posner, Jim Quirk, Keith Norrish, Bruce Tucker, John Hutton, Graham Aylmore, Max Raupach, Wilf Ewers, Kevin Tiller, Jack Keay, Bill Blackmore, me and many others.

Anion adsorption has particular relevance for agriculture because fertilizers containing phosphorus, sulphur and trace elements such as molybdenum, selenium and boron are added in anionic form to soils. The availability of these nutrients depends on their interaction with clay minerals including the oxides of iron and aluminium. When these studies were commenced theoretical work on cation exchange was well established and studies of specific adsorption of cations were in progress. Although empirical methods were in use to estimate nutrient availability in soils, more detailed understanding of specific adsorption of anions was desirable to evaluate the residual effects of applied fertilizers.

My first study of anion adsorption was of borate on soils and clay minerals. This was prompted to some extent by the possibility that borate which is a component of salts in saline areas might be retained and accumulate to toxic levels when other salts are leached. Later, during a year-long period in the Division of Soils HQ in Adelaide, I extended my interest in anion adsorption to study of silicic acid adsorption on aluminium oxide. In both these studies I noted that maximums in adsorption isotherms varied with pH (acid and alkaline conditions) and were greatest around the pK of the conjugate acids of the corresponding anions (a measure of the dissociation of the acids). However, the complexity of the mixture of clay minerals and other components of soils prevents detailed analysis of the reaction at the solution/mineral surface. I decided therefore to extend investigation of the chemical processes involved in adsorption to experiments conducted under more controlled conditions. Stable adsorbates with measurable properties were required and artificially prepared iron and aluminium oxides in the form of goethite and gibbsite were ideal for my purposes. Goethite and gibbsite occur naturally in soils so their behaviour provides an appropriate model for investigating adsorption reactions occurring in soil.

As studies of the surface properties of goethite were in progress in the Department of Soil Science at The University of Western Australia I took the opportunity to begin a comprehensive project to study specific adsorption of anions under the supervision of Professor Jim Quirk and Alan Posner.

Reactions of anions at the solid /solution interface involve non- specific and specific adsorption. Anions of strong acids such as hydrochloric, perchloric and nitric only adsorb at mineral surfaces with a net positive charge. This process is considered to be “non- specific” and is analogous with cation exchange at negatively charged sites. In contrast, anions from weak acids are adsorbed “specifically” on mineral surfaces irrespective of the net surface

charge. The amount of the anion adsorbed is out of proportion to its solution concentration relative to non-specifically adsorbed anions and is dependent on the identity of the anion. The amount of specifically adsorbed anions taken up at the solid/liquid surface is relatively unaffected by the presence of high concentrations of non-specifically absorbable anions in solution.

Details of the investigations into the nature of specific adsorption are in my thesis "Specific adsorption of anions on goethite and gibbsite" submitted to the University of Western Australia. In summary measurements were made of the surface area, crystal morphology, net surface charge and changes in net surface charge of the oxides. The anions examined were chloride, sulphate, fluoride, molybdate, selenite, arsenate, orthophosphate, pyrophosphate, tripolyphosphate and silicate. The experimental measurements included adsorption and desorption, net surface charge, zero point of charge (ZPC) i.e. the point at which the surface has no net charge and the shift in ZPC due to specific anion adsorption, infrared absorption spectra, rates of reaction and isotopic exchange and effects of temperature and competition between specifically adsorbed anion species.

The theory for adsorption at polarisable (mercury) and non-polarisable (oxide) surfaces and of coordinate complexes (ligand exchange) was drawn upon in an effort to develop a generally applicable theory of anion adsorption from the data obtained. It was postulated that in contrast with non-specifically adsorbed anions which are held at the outer Helmholtz plane, specifically adsorbed anions were held at the inner Helmholtz plane at the solid/liquid interface. To provide evidence of the nature of the bonding of anions to the oxide, the surface charge and changes in this charge due to adsorption were investigated.

Many difficulties were found in producing a comprehensive theory of the reactions at the solid/liquid interface. These may be due in part to specifically adsorbed anions being essentially in a "metastable" state at the solid surface i.e. the anions are in a state between being held in a layer at the solid/solution interface and formation of an insoluble compound. Surface charge changes and the opportunity for "mono-dentate" and "bi-dentate" bond formation complicate analysis of the ligand reactions involved. However the results of my study of adsorption of anions at the solution/oxide surfaces have been widely accepted judging from the citations in the soil science literature. One of my earliest papers on the subject was recorded as a classic in "Contemporary Classics in Plant, Animal and Environmental Sciences" (Barrett, 1986). This is a minor claim to achieving something!

Soils obviously differ from the model system as they are mixtures of clay minerals and organic matter and therefore present a much more complex situation than the goethite and gibbsite model systems. However, a survey of the soils literature dealing with adsorption of phosphate and other nutrients present in the form of anions indicates that the principles derived in this study apply widely. The retention and availability of nutrients applied as fertilizers is affected in the same general way by pH and the surface area of clay minerals. Both soil testing and the process of uptake of nutrients by plant roots involve understanding of competition between specifically adsorbed anions. As specific adsorption occurs at a wide range of mineral surfaces and for a wide range of anions the study should find application in other areas of science.

The National Soil Fertility Program(NSFP)

In the mid 1960s the Division of Soils embarked on a program to apply their expertise in soil characterisation to the response of wheat crops to fertilizer at a wide range of sites in Western Australia and in the Eastern States. The Australia-wide program was initiated by Gordon Hallsworth (then Chief of the Division of Soils). In New South Wales the program included 47 field experiments and was directed by John Colwell. In WA over 40 field experiments were conducted in collaboration with the State Department of Agriculture and a

commercial fertilizer company (CSBP). CSIRO's part in this program mainly involved the soil survey staff and analysis of soils and plant material by chemists under the direction of Jack Keay. The Division of Mathematics and Statistics group provided advice and assistance with analysis of the data obtained over several cropping seasons. I participated to a minor extent in experiments and collated the mass of data that were accumulated.

A major development in the laboratory at this time was the introduction by Jack Keay of automated techniques for chemical analysis. This innovation enabled the efficient processing of the large number of soil and plant samples produced in these and later projects. The development of faster computers that had occurred by that time facilitated the compilation and analysis of the large volume of data produced in this project.

Although a great deal of useful information was collected in these experiments, analysis of the data proved to be a formidable task. Multivariate statistical analysis was used to disentangle the various environmental and nutritional factors that correlated with wheat yields.

Soil analysis for bicarbonate extractable phosphorus was of most value for predicting responses and other factors such as date of sowing and rainfall were correlated with wheat yields. Responses to application of phosphorus and nitrogen were defined for the range of experimental sites located over a significant range of the soil and climatic conditions in the wheatbelt.

Tim Grove and I conducted an off-shoot of the NSFP program to investigate the response of clover pasture to phosphorus, nitrogen and sulphur fertilizers on the Swan Coastal Plain south of Perth. This project was complemented by a series of glasshouse trials with surface soils to determine the response of clover to applications of trace elements. The responses and uptake of Cu, Zn, Se and Mo were related to soil tests.

This photograph was taken during a meeting of the Executive of CSIRO hosted by Ray Perry and Arthur Gaskin at Floreat held soon after the Division of Land Resources Management and the Division of Mineralogy were established.

Division of Land Resources Management

During the early 1970s the Division of Land Resources Management (LRM) was formed with headquarters in Floreat, and Ray Perry was appointed Chief. From what I understand, Ray's concept was for the Division to focus its research on all aspects of land management including the social and economic aspects.

The Division was made up of staff from the Division of Soils, Division of Plant Industry, Division of Animal Production and Division of Entomology research groups stationed at

Floreat with the inclusion of the Rangelands Research Group stationed in the Northern Territory. A new research program was established to deal with social and economic issues. This program included Jonathon Thomas, David Bennett, Geoff Syme and Barry Carbon. Later a program headed by Frank Honey was established to research the application of satellite remote sensing data.

I was allocated to the Forested Lands program headed by Maurice Mulcahy. This program included Glyde Turton, Geoff Dimmock, Tony O'Connell, Tim Grove, Nick Malajczuk, Neil Bougher, and a number of technical staff. Shortly after the formation of the program Maurice left the Division to take a senior position in the WA Environmental Protection Authority. I was appointed to head the Forested Lands Group to undertake research relevant to managing these lands. Prior to formation of the program experience in forestry research was confined to Glyde Turton who conducted field experiments on the nutrition of *Pinus radiata* growing on lateritic soils and Nick Malajczuk who was investigating the role of *mycorrhizae* in relation to the Western Australian Department of Forestry and the CSIRO Division of Forestry's work on *Phytophthora cinnamomi.* The rest of the newly formed group were engaged on plant nutrition and soil research connected with the National Soil Fertility Program.

Forest Ecosystems of the Southwest of Western Australia

Research centred on the ecology of the forests was chosen as being the most useful contribution the program could make to management of the forested land. The first projects undertaken were in collaboration with the State Department of Forestry in an experimental area which had been subject to an intense fire. The objective of this study was to determine the effect of fire on the forest ecosystem. Nutrients transferred to the soil in ash were measured. Regeneration of understorey species, particularly the nitrogen fixing plants *Acacia pulchella* and *Macrozamia riedlei*, was monitored. Estimates were made of the amount of nitrogen fixed by these species to replace that lost by burning.

In common with many areas of forested land throughout the world the Jarrah forest grows on nutritionally poor soils. Growth and survival of the forest ecosystem is crucially dependent on conservative use of nutrients within plants and nutrient cycling. It was decided therefore to concentrate projects undertaken by the Management of Forested Lands Group on nutrient cycling processes. As the basis for these studies, plant species in the experimental areas were surveyed, nutrient concentrations and their distribution within plants were determined and estimates were made of available nutrients in soils. Inputs to the system through nitrogen fixation and rainfall, cycling through litterfall and canopy leaching and outputs through controlled burning, wildfires and harvesting were estimated. Uptake of nutrients in boles and branches of the tree species was calculated and compared with the extractable nutrients in soils. This overall analysis of the system provides the basis for assessing the effects of harvesting, thinning and fertilizing the native forest. The analysis also provides useful guidance for rehabilitating forest areas that have been mined for bauxite.

A similar approach was taken to analyse the Karri forest ecosystem and nutrient cycling processes important for land management in the southern forests. The analysis in this case provides relevant information for rehabilitation of the forest after clear-felling for woodchip production.

In each of these forest types the distribution and nitrogen fixing activity of *Acacia* and *Bossiaea* species, *Macrozamia reidlei* and *Allocasuarina fraseriana,* was given particular attention. The role of ectomycorrhizal development on the fine roots of jarrah in increasing uptake of nutrients, particularly phosphorus, was also subjected to intensive study. Tim Grove, Tony O'Connell and Nick Malajczuk researched nitrogen fixation by organisms in litter and the role of decomposing litter and harvest slash on the nutrient dynamics in the

forest floor. These researchers expanded their studies to plantations of *Eucalyptus globulus* after I retired.

Establishment of the Laboratory for Rural Research

In 1981 the Chief of the Division of Land Resources Management, Ray Perry, was transferred to Canberra to make an Australia wide assessment of research in CSIRO relating to the water industry. I was then assistant Chief so in his absence I was appointed Acting Chief (a caretaker role) for a year. On his return the Division of Land Resources Management (LRM) was disbanded and a Division of Water Research was established. A number of groups in LRM were transferred to other Divisions. The Management of Forested Lands group was transferred to the Division of Forest Research and members of the Division of Forest Research stationed at Kelmscott were transferred to the Floreat Laboratory. For administrative purposes it was decided to form the CSIRO Laboratory for Rural Research (LRR) encompassing the groups from Forestry, Plant Industry, Animal Production and Entomology. LRR's mission was to undertake research on the problems of rural industries in the Mediterranean climatic region.

I was OIC for Forestry and the OIC's for the other groups were Neil Turner, Barry Purser and James Ridsdill-Smith. A new purpose built laboratory was constructed on the Floreat Site to house LRR. I spent a great deal of time with the architects during planning of layout of laboratories paying particular attention to ensuring more recent safety standards were met. I was the Chairman for the laboratory committee for the first three years. This responsibility was rotated later to Neil Turner then to Barry Purser for three year periods. I served a further three years before I retired. The Chairman organised the office administration and facilities while the OIC's of the Divisional groups were responsible to their Divisional Chiefs for their research programs. The LRR Committee met monthly to discuss administrative matters and possible collaborative projects between the Divisional groups.

Here are some more faces you may recognize. James Ridsdill-Smith, Joe Landsberg (Chief of Forestry and Forest Products), Frank Hingston and the Chiefs of Entomology and Animal Production.

Modelling Plantation Growth and Water Use

'In earth and water will you grow,
In air will your leaves speak as you reach towards the fire of the sun,
We respect and admire you,
O tree, and all trees, for you represent both
Peace and Power – though you are mighty you hurt no creature,
Though you sustain us with your breath, you will give up your life to house and warm and teach us.
We give thanks for your blessing upon our lives and upon our lands.
May you fare well in this chosen place.

"Awen"' "Druid ceremony for planting a tree"

The research program to test the applicability of a process based model of tree growth (BIOMASS) was commenced in the early 1990's. The program was supported by a grant from the Rural Industries Research and Development Corporation (Project: CSF-41A). Bunnings Treefarms and the Western Australian Department of Conservation and Land Management (CALM) arranged access to a number of plantations and the staff of the Busselton branch of CALM assisted with sampling to determine the distribution of biomass among the component parts of the trees. The modelling program was supplied by Ross McMurtrie from the Division of Forestry and Forest Products in Canberra.

The objective of the program was to adapt the existing process based model for tree growth developed for modelling the yield of *Pinus radiata* on a site limited by water and nitrogen to simulate yield and water balance at five plantations of *Eucalyptus globulus* growing in the southwest of Western Australia. The plantations had been established on farmland in areas where the mean annual rainfall ranged from 600 to 1400 mm and potential evaporation ranged from 650 to 400 mm. As the fertility of the soils at all plantation sites was moderately high any effect there might have been due to differences in nutrient availability were not simulated. This omission was justified by the high levels of available nitrogen and phosphorus shown by soil and tissue analysis.

Inputs required for operation of the model included daily values for maximum and minimum temperatures, rainfall, vapour pressure deficit and total solar radiation. These measurements were continually logged by automatic weather stations. Monthly measurements were made of stem diameters and leaf area index. Litterfall was collected and measured monthly, soil water measurements were made using a neutron probe, leaf area index (LAI) and leaf water potential measurements were made at the same interval.

Details of the results are contained in the final report to the Rural Industries Research and Development Corporation. The model proved useful for analysing the factors that govern soil water uptake and assessing the risk of losses due to drought. Measurements of soil moisture made to the depths of root penetration (as deep as 6 m). The plant-available soil water contents and seasonal variation estimated by measurement was well simulated by the model. Several of the plantations suffered from drought stress during our studies.

Measurements of the proportions of biomass in leaves, branches and stems were made at each of the plantations in order to allocate carbon fixed by photosynthesis. Good agreement between simulations of seasonal growth and diameter growth measurements made on the trees at each plantation.

A major outcome of this study is the identification of the factors influencing growth and water availability in the plantations. Rainfall amount and seasonality combined with depth of soil available to store moisture over the dry part of the year are clearly of prime importance. From the modelling point of view I believe the results show that simulation based on the series of relatively simple and fundamental subprograms can produce good agreement with measurement. Manipulating parameters such as rainfall, leaf area index or perhaps carbon dioxide levels in the atmosphere could provide an assessment of effects on growth and survival of plantations under changing environmental conditions.

Bits and Pieces

As might be expected, there were times when various lines of research other than those described above were considered. Sometimes these were pursued to a pilot stage or circumstances dictated that the work was better undertaken by others. A few examples of these projects are outlined below.

Around the time that the building at Floreat was extended to accommodate the Division of Mineralogy a Division of Soils group headed by Maurice Mulcahy considered a collaborative

research project on the role of soils studies in geochemical exploration. It seemed that understanding of geomorphology and soil distribution could be useful, especially in areas where the geology was obscured by lateritic and related depositional soils. I was included in the group which made a reconnaissance trip to Mount Keith, viewed the soils and landscape in that area and sampled soils for analysis. I spent a period of time acquainting myself with the literature on geochemical prospecting techniques but as it turned out this "toe-dipping" exercise was not investigated further. Research relating to geochemical prospecting was more appropriately pursued by Charles Butt, Russell Hudson and others in the Division of Mineralogy.

In another instance, the proposal to establish an industrial complex at Kemerton in the south west of WA raised the question of whether this would pose a problem for the surrounding area due to emission of fluoride. To assist in providing relevant information for the WA Department of Conservation and the Environment, Geoff Dimmock, Jeff Galbraith and I conducted a limited study of the surrounding soils and vegetation. The effects of low concentrations of fluoride in air on tree species were also studied in order to determine the sensitivity of pine and native species to airborne fluoride.

Glyde Turton made a study of the effect of sewage effluent, which had undergone secondary treatment, on growth of pines at a site near the Beenyup treatment plant. This study showed that the minor elements copper and zinc were retained on the solids separated during secondary treatment of sewage water. The treated water contained high concentrations of phosphorus and nitrogen. When the treated water was applied to a stand of pines serious deficiency symptoms were evident. These symptoms were corrected by adding minor elements including copper and zinc to the treated effluent. As part of the study, I analysed both the soils under the treated area and the ground water for ammonium, nitrate and phosphate. These analyses showed that ammonium was retained in the surface layers of soil; nitrate leached to the water table and phosphate was progressively adsorbed on the deep yellow sand and was not detected in the watertable. These data were not published but the results could have been significant if there was a proposal to use effluent from a secondary treatment plant to replenish the ground water in the Gnangara mound. In particular the presence of nitrate in the groundwater could have been of concern. However in view of the current plan for sewage water to be given "tertiary" treatment before being injected into the groundwater this observation is probably less relevant.

Bowing Out

My quest to achieve "something" during my career was, in retrospect, a little ambitious. However, like Miguel de Cervantes character Don Quixote de la Mancha I have steadfastly pursued the quest. History will decide whether this has been in vain.

> *It is in the nature of things that research is superseded almost as it is done. This is as it should be! Most of us cannot claim to have discovered a new star, or plant, or animal species, or made any other spectacular contribution to the world of science. We can only hope that our contributions add to the sum of knowledge.*

In the words of an esteemed colleague, who was quoting Henry David Thoreau:

> *"The mass of men lead lives of quiet desperation and go to the grave with the song still in them".*

DENIS HURLE[18] (1972 to 1982)

I came to Western Australia to go to a friend's wedding, and more-or-less accidentally ended with a job in CSIRO at Floreat Park. I resigned by mail from Australian Iron and Steel where I was employed as a computer programmer, stayed in Perth and had my (limited) belongings sent over to minimise the cost of relocating.

The reason I was employed with such alacrity was that in 1972, CSIRO in Perth had a telephone line link to the mainframe Control Data Corporation (CDC) computer in Canberra. The link was called CSIRONET. As a consequence, CSIRO Perth computing power was vastly enhanced, and many of the research programs of the Division of Soils and Division of Plant Industry were requiring more sophisticated data storage and processing software. Being a recent graduate from the CDC Institute with experience in scientific programming helped somewhat in getting the position.

I was employed in Adrian Peck's group in the Division of Soils. In those days the group comprised Adrian, David Williamson, Tom Bromilow and me. Our main project was the investigation of the salinity problem in WA, working in close collaboration with pedologists Bill McArthur, Eric Bettenay, Max Churchward, Geoff Dimmock and others. The Division in Perth was headed by Maurice Mulcahy.

The salinity research program was initially centred on field investigations that were being undertaken at 'Yalanbee' the Bakers Hill research station some 60 km east of Perth in a medium rainfall area of the Darling Range. Three small catchments (the East Catchment, the West Catchment, and the Subdued Drainage) had been instrumented with stream gauging stations, rain gauges and pluviometers, evaporation pans, neutron access tubes and shallow and deep groundwater observation piezometers. The East Catchment was mostly uncleared and the Subdued Drainage catchment was cleared for pasture and grazing. After monitoring for a few years, naturally vegetated the West Catchment was cleared to determine hydrological changes.

Aside from all this, I can remember the mushrooms that grew and we collected on Yalanbee after the first rains in autumn. I used to stay at the Bakers Hill Hotel and the group used a Volkswagen Kombi van that was specially fitted out for monitoring and included a large water tank for storage of the radioactive neutron probe. The monthly field monitoring usually took three days to complete. In those days I, or Tom Bromilow, did the field work alone, although the Farm Manager (Gerald Watson) knew of our general whereabouts. It didn't help a lot during the wetter periods when the Kombi inevitably got bogged trying to access some of the monitoring equipment. One time I had the Kombi as well as the farm 4WD vehicle bogged and we had to get Gerald with the farm the tractor to pull them all out.

As well as establishing the data collection and processing system, I also undertook the monthly monitoring of the catchments. An important part of the data collection system was the use of the punched paper tape 'Event Recorder' system. These recorders were used by other CSIRO Divisions around Australia and were a precursor to the later electronic data loggers. The data collected on the paper tape was processed by computer to give a time trace of the variables measured (such as rainfall, stream flows etc.), but at the time of my joining CSIRO, the software for the processing had not been written. One of my early tasks was to develop this software, and together with Richard Blyton from the Division of Land Use Research spent considerable time in Canberra Black Mountain Laboratories completing such.

The primary objective of the Yalanbee study was to determine the water and salt balances of the catchments. However the works were also used as a precursor to establishing a more

[18] Contributed by Denis Hurle

sophisticated and larger, but similar research program in the Collie River catchment. This river provides drinking water for people and stock, and water for irrigation of the Swan Coastal Plain near Bunbury. State Water Authorities were concerned about increasing salinity of water supplied from Wellington Dam on the Collie River, and a joint submission from the WA Government and CSIRO resulted in a grant from the Australian Water Resources Council to undertake hydrological studies in that catchment.

As a result of starting the Collie project, the group under Adrian was expanded significantly with the transfer of Munna Sharma from Deniliquin, and the employment of, Maurice Height, Peter Yendle, and Colin Johnston. Initial investigations at two significantly different rainfall areas in the Wellington Dam catchment were undertaken by drilling and carrying out soil and vegetation investigations. Many holes were cored to bedrock (or refusal of penetration), under the supervision of Adrian or David, but with field work done by Peter Hick and Wally Russell with the drilling team headed by Jim Moynihan.

Five experimental catchments were selected: a pair named Wights and Salmon in the relatively high rainfall region near Wellington Dam, and three in the lower rainfall region east of Collie (Lemon, Dons and Ernies catchments). In each catchment, five sites were selected for instrumentation, each with a rain gauge, three neutron access tubes for measuring soil moisture changes, a deep (cored and sampled) observation borehole which was completed as a piezometer, and a shallow observation piezometer slotted through the overlying soil horizon. Each catchment was equipped with a Public Works Department (PWD) gauging station, pluviometer and stream sampler, as well as an Event Recorder which was being trialled by the PWD.

At this point I should note that the Collie Experimental Catchments (CEC) study was undertaken jointly with the Public Works Department (PWD) of WA, under the auspices of and partly funded by the AWRC. PWD personnel I mostly worked with included Keith Barrett, Ian Loh, Rob Stokes, and Brian Saddler.

Equipment, particularly vehicles, was upgraded for the Collie Project. We ridded ourselves of the ‘forever bogged’ VW, and acquired a specially fitted out Toyota Land Cruiser together with a PTO winch and never got seriously stranded again. Peter Yendle was our dedicated field data collection officer, and (unfortunately) alone was tasked with monitoring the Bakers Hill and Collie catchments (and later the Del Park bauxite mining catchment). I think Peter spent one day on each of the five Collie catchments, two days at Bakers Hill, and one or two days at Del Park, and a day or two travelling, each month.

I did some field work in Collie, some drilling supervision to relieve the others and a little bit of data collection. We rented a State Housing Commission house in Collie town while we were installing the catchment instrumentation. From what I remember it was mostly used by Jim Moynihan, Tom Bromilow, Peter Hick, Eric Bettenay and Wally Russell. We also stayed at the Collie Club Hotel numerous times. We stayed in rooms within the old pub itself until motel units were built at the Club in 1975. The Collie Club hotel later expanded by construction of a motel, and the pub kitchen closed to public trade. In its place a Chinese restaurant was operated; nowhere near as memorable.

In those days you (along with all the other boarders) had to be at the breakfast table at 6.30 am – no later! There was just one big breakfast table. The cook was a small, plump Italian lady who had previously done a lot of cooking at shearers quarters. And boy, did you get breakfast. Cereal first, then all of two fried or scrambled eggs, two thick sausages, a slab of steak, bacon and lamb chop, chips and toast -- all on one huge plate. You were also encouraged to have seconds.

When breakfast was finished you were presented with your lunch to take to the field – half a loaf of bread made into sandwiches with mixed fillings, (last night's roast lamb, pork or chicken), salad, some cold roast potatoes, and a bottle of orange juice or water.

The five uncleared CEC's were monitored approximately monthly over 1973, 1974 and 1975 and in 1976, selected catchments were cleared (either partly or fully) for agricultural purposes. The cleared catchments and their uncleared pairs were then monitored (albeit on a reducing frequency) until the mid-late 1990's.

In 1974, considerable public opposition was mounting to clearing within the forested western Darling Range. This was directed initially at wood-chipping operations in the Pemberton region and later at Alcoa's bauxite mining operations near Jarrahdale, Del Park and Wagerup. A group called the Campaign to Save Native Forests was formed to spearhead this opposition, and among other things, used unproven scientific 'facts' to raise public support for their cause.

Our group in CSIRO was supported by Alcoa to monitor hydrological responses of a small catchment to bauxite mining. We installed a network of monitoring bores over a small catchment (Del Park – 80 ha) and monitored groundwater and streamflow before and following mining on parts of the catchment. After mining had ceased, the mined out areas were rehabilitated and reinstated with the piezometers. Pre-clearing groundwater levels on this catchment indicated relatively quick responses of (deep) groundwater to surface forcing by rainfall and evapotranspiration. This was contrary to the expected low rates of water transmission through a 10 to 20 m thick unsaturated clay profile.

Groundwater responses lagged rainfall by almost zero to about 100 days. These results indicated that there were preferred flow paths from the surface to the deep groundwater. Furthermore, the rapid decay of the groundwater following seasonal rainfall reduction was possibly due to increased evapotranspiration from groundwater, not due to redistribution of groundwater to the unsaturated zone, or to groundwater flux divergence away from the area.

This was the premise for undertaking the 1982 dye experiment. The experiment showed water did in fact flow down preferred pathways formed by root channels. Excavation of a pit to about 7 m showed that some of these channels contained live roots and hence evaporative demand was satisfied by trees accessing the deeper groundwater.

My work in CSIRO was supplemented by involvement with other research projects. Three particular projects were participation in CSIRO's involvement in the review of EIA reports for the Australian Government in order to provide export licencing. Projects assessed included:

- *Some Aspects of the Environmental Effects of Wood Chip Felling in South Western Australia undertaken in 1974*
- *Yeelirrie Uranium Mine Export Licence Review*

Not long after completing the dye experiment (the work was written up as a Divisional Technical Paper by Colin Johnston) and I left CSIRO to join the world of environmental consultants. Being experienced in groundwater modelling and hydrology, I joined Australian Groundwater Consultants (AGC) as a senior consultant, and later a shareholder, and implemented a lot of my experiences in CSIRO into the consulting industry.

This ended my ten years of experience with CSIRO, which was enjoyable and formed the basis of my further career.

PHIL JACK[19] (1952 to 1954)

Employment by CSIRO Division of Fisheries and Oceanography was my second job; I lasted only a few months in the first before the TB mass X-ray program put me into Sir Charles Gairdner Hospital for the usual 18 – 25 months or so of the day. John Brophy came to the rescue with a placement in the Oceanography lab in the UWA grounds adjoining Agriculture – in those days, the Institute of Agriculture. It was 1952. We used to see Prof Bayliss setting out from his home – in Myers Street, I think, on his way to the Chemistry Department.

Dave Rochford was Chief of the Division of Oceanography in the recently opened Cronulla labs, and in the Perth branch we had Rex Spencer still living in Everett St Nedlands, Harry Jitz, Athol Middleton, Kitch Godfrey, Clive Wirrell and Norm Dyson.

The branch role included sea water monitoring programs off Albany, Geraldton and west of Rottnest in studying the Leeuwin Current, and estuarine surveys of the lower SW mainly the Swan River and Peel-Harvey Estuaries.

These days *Standard Ocean Water* is defined by its electrical conductivity, but in those days we had "Standard Sea water" from some magic spot off Norway, and we did salinity by Mohr method (silver nitrate titration) using 50 mL samples so we must have disposed of lots of silver.

When Harry deputised for Rex, his arrival was often heralded by his booming out an operatic favourite before he lit his pipe and settled at his desk in our crowded room – there were no personal offices. If the tenor solos were indulged, others had their own peccadillos; one used a spare spot in the store room to make a dinghy in his lunch breaks! Another had a vegie patch at a secret wayside garden on the Great Southern – tended on the way to the Albany offshore 'dips' (sampling). Most memorable to me was another's use of the office ute to take his young bride on their honeymoon – to one of the ocean monitoring points, of course.

It was during observations of the Swan River Estuary in those days that we noted the pronounced stratification following runoff. Some years, as during winter 2010, it never happened and the blue marine water persisted through the profile. We used to be sort of on the *qui vive* on the way to work to be the first to see the brown-water sign of run-off. This very stable layering of the marine water under the relatively fresh has been beautifully demonstrated with underwater photography by Jorg Imberger's group at UWA in the last 25 years. The depth of the sharp thermocline/halocline interface is commonly <0.5 m.

Twenty-four-hour 'takes' were sometimes included in our sampling and I have vivid memories of a night shift near the Causeway when I had to row to the middle of the river and do a profile sampling. In the utter darkness I heard the '*phush'* of a dolphin breath and, mammal be damned, convinced myself that it was a shark. Thank heavens the river is not wide there and I was smartly back in our dimly candle-lit shed trying to keep warm and awake for the next hour.

The perennial lament in the press of algal pollution in the Swan-Canning – often emphatically claimed to be toxic – is alarmist; but indicators seem little changed over the years. The nutrient levels don't seem much different though the sources and loadings are better understood.

I had good times too in the Cronulla labs and in Hobart where the Division is now headquartered.

[19] Contributed by Phil Jack

Not acid rain! We did regular surveys of Lake Macquarie from Cronulla and on one of these "dips" we thought we had lots of trouble with the dear old pH meter giving us values around 4 at several of the sampling stations. We returned with the samples as usual planning to get proper values on another instrument at the lab; but they were confirmed and we recalled the shiny brass propeller and other metal bits on the bottom of the survey launch.

We learned that a sulphuric acid plant on Cockle Creek running into Lake Macquarie had had a significant spill – 80 tons was rumoured!

I ran the small lab of the Hobart division for a few months in 1954-1955 with an inspirational fresh-water biologist, Alan Weatherly, where I did scuba diving for the first on a sampling "dip" at St Helens, discovered the hazards of driving on ice and had the honour of a one-to-one with the Chairman of CSIRO, Sir Ian Clunies Ross, on one of his personal visits to Divisional branches.

One cannot omit mention of the Derwent Hunter in a CSIRO oceanographical memoir. She was the Division's survey vessel for 10 years from ~1950. *She* - I hope I convey a nautical air – was a 27 m, sorry, why do the sailors persist with feet, a 90 ft schooner built in Tasmania in the forties from Huon Pine and Bluegum; a lovely sleek looking ship. I missed the adventure of a life time when offered the cook's job on one of her month long cruises to Fiji. I shouldn't have told them I couldn't cook.

The CSIRO Research vessel "Derwent Hunter" (source unknown)

HUGH KIRKMAN[20] (1978 to 1998)

I was at Marmion Marine Laboratories (Labs) from 1978 until 1998. The Labs was a happy place to start with under Bill Weibe. We were tasked to work on reef ecology. I had come from CSIRO Cronulla and quickly Dave Smith, Alan Pearce, Graham Major, Ian Cook and Bob Griffiths followed. Shirley Jeffrey was the Division's Chief but until Bill Weibe left we were shielded from the continued reorganisation and changes so common in CSIRO. My work revolved around the large kelp growing off the coast at Marmion, and I completed my PhD working on kelp although one chapter was about seagrass. As a team we worked well together and many papers were accepted particularly when Bob Johannes and Chris Crossland arrived to strengthen the team.

About this time we started to compete against Floreat in an annual triathlon which we generally won, sometimes with two teams. Bob Griffiths was our star performer in the swimming leg.

Bruce Phillips took over from Bill Weibe as OIC at the Labs, and Lindsay Joll, Peter Jernakoff and Bill Wood added to its scientific strength. The support staff included Jill Downey the OIC's secretary, Dave Wright, Simon Brain, Jill Thomas, Craig Manning, and Dave Evans.

It was about then that the CSIRO Division of Fisheries began to change. New goals, new leaders and more emphasis on earning funds for research from external sources saw directions change. The Labs had two main projects then, one under Trevor Ward the local OIC, and the other a team that I helped to form. Sjaak Lemmens and John Neilsen were added to my team while Scott Langtry, Bruce Wallner and Gary Kendrick were added to that of Ward and Charles Jacoby. Ward's team were engaged in developing mesocosms at the Labs and, after world tours and workshops led by the main proponents, the mesocosms were built together with an extension of the Labs which were the envy of all WA marine research organisations. The Labs lost the lucrative and prestigious Coburn Cement project at that time and were investigated by the rest of the Division for a year or so.

[20] Contributed by Hugh Kirkman

BILL MCARTHUR [21] (1950 to 1982)

Bill McArthur was born in August 1922 and raised on a family farm at Millicent, SA along with six siblings. He left school early (yes, those were the Depression years) and worked as a laboratory assistant at nearby Mt Burr Research Station until 1941. With the advent of war, Bill joined the RAAF and served as a navigator in Catalinas on the WA coast and in Beaufort light bombers out of New Guinea and in the Pacific.

During the post-war era, under the Commonwealth Rehabilitation Training Scheme, Bill gained a science degree in geology and botany at the University of WA. His honours degree, based largely on the ecology of Garden Island, kindled a lifelong interest in soils and associated landscapes. On joining the CSIRO Division of Soils, in 1950, he worked on the soils of the Swan Coastal Plain and developed a general model proposing the principals of soil distribution for this vitally important part of Western Australia. With Eric Bettenay and Frank Hingston, the knowledge gained from that work enabled the expansion and rational development of post-war agriculture on the Swan Coastal Plain. The work is still used as the basis for catchment studies and adaptive management.

Bill married Moira (a member of the pioneering Packham family of the Tammin district) and had two sons (Geoff and Colin). He was transferred to Armidale, NSW in the late 1950s, where he turned his attention to soils developed on volcanic rocks of the Dorrigo district. As well, Bill developed an interest in the study of plant/soil relationships. On returning to the West in the early 1960s, he put this experience to good use as a leader of the National Soil Fertility Program. He also brought back with him a passion for trout fishing.

Bill introduced to all who worked with him the great pleasure that could be had from field work. He was fastidious in the preparation of everything he ever did and the advantages of 5-Star comfort and cuisine, while deep in the bush, are indelible memories of everyone who ever “roughed” it with Bill. It was probably due in some degree to the advent of more sophisticated technologies such as car-fridges, small generators and bottled gas, but the delicacies that were shared from, and around, the campfire changed the whole culture of field work. The travel allowance enabled Bill to build up an enviable array of camp comforts that graced trout streams, desert dunes and Kimberley canyons.

During his 30 years at CSIRO, Bill studied soil patterns in several parts of the southwest of Western Australia. Of note, he established an understanding of soil patterns (and trout streams) in the Pemberton area. This work, along with his earlier coastal studies, formed the basis for future investigations along the southwest coast of the continent. At the time, much debate was raging about effects of the wood-chipping industry on the forest, and Bill undertook to determine the relationships of forest and soil distribution that could influence forest management for the woodchip license area. Also at this time he developed a keen eye for aboriginal artefacts and was called upon by the WA Museum to explain how certain landforms and soil-forming processes could be used to date aboriginal settlement. The carbon dating work at Devils Lair in the Margaret River area pushed back the aging of those artefacts significantly. Bill was also responsible for the Kimberley section of the Atlas of Australian Soils that is covered more specifically by Eric Bettenay in his section of this collection.

[21] *This contribution is drawn together by Peter Hick and Greg Bartle from notes compiled by Max Churchward, Adrian Peck and Bill’s son Geoff McArthur, as well as anecdotal comments by his long-term colleague Eric Bettenay*.
Within CSIRO in Western Australia there were some people that unobtrusively and incrementally made a huge contribution nationally, locally and in the day to day enjoyment of our work place. Bill is mentioned in many of the personal contributions compiled by others.

Bill had been coerced into the National Soil Fertility Program (NSFP), a large multidisciplinary rural industry funded project. He made a very good job of it but it was not where his heart lay and he had been arguing with Maurice Mulcahy (the WA officer in Charge) that a more strategic study of the soils and weathering processes in a large catchment, such as the Peel-Harvey, would be a better use of his time. The NSFP style of project was the trend of the day and there is no doubt that Bill's influence on the selection of sites did ensure that he was never far from a fishing spot be it trout or salmon. On one sortie to Esperance, the freezer was filled with fish fillets.

With a bit of help from Max Churchward, Bill did convince Maurice that a Murray-Hotham catchment study should proceed as there was now much evidence that what was happening with the status of the Peel-Harvey estuary could be linked to the nature of the whole catchment. What Maurice thought should be a 3-6 month project looking at pathways of nutrient flow, somehow lasted for over 3 years and provided the basis for understanding weathering of the lateritic surface, and the release of ancient salts that had built up in the deep profiles. This work highlighted the importance of areas of remnant vegetation such as Dryandra, Tuttanning and Marradong that are now all reserved. The scarcity of deeply dissected valleys of the western Scarp had removed the threat to dam the Murray, and the large tract of jarrah forest that was threatened by dieback now had a strategy for its protection based on soil genesis. This mapping both at large and small scales still provides the basis for most management decisions in the catchment.

To do the work, bases were set up at Dryandra (in an old forestry hut), and at Lynford, a large property that had excellent shearing quarters. Both sites became well known for extravagant culinary exploits. At Dryandra a hide was set up to observe the morning rituals of Mallee Fowls turning and checking their eggs that were buried at the centre of a mound of leaves to maintain the right temperature. Also numbats were observed in one of the very few natural habitats that they had left. Each evening in the summer, the acrobatic little bee-eaters could be seen performing their colourful displays whilst a Stone-Curlew screamed. Bill taught his colleagues not only about soils but also about plants and animals, and over a red wine at night discussions continued on how it all fitted together.

Another innovative project developed by Bill and Max, was to study the physical properties and genesis of two catchments, one inland from the newly gazetted town of Karratha, based on the rich red soils of the George River catchment, and another in the sandy granite Strelley River country inland from Port Hedland.

The organisational changes associated with formation of the Division of Land Resources Management were both dramatic and fortunate for Bill. At the end of Maurice Mulcahy's time as OIC, Bill was Maurice's deputy. The demise of the Pedology Group at the insistence of the new Chief (Ray Perry) did open new doors. Bill soon realised that some of the opportunities could be very practical, and it enabled him, with Greg Bartle, to look again in much more detail at the west coast dune systems, particularly in relation to industrial and urban development. This work had a very immediate client but in no way was the science compromised.

Following the demise of the Pedology Group in 1972 Bill, joined group "G" under the leadership of Barry Carbon. There was absolutely no dedicated soil work in this group at that time and it must have been difficult for Bill after moving away from his colleagues and no clear future. Greg started work with Bill in the Walpole district where they finished off some drilling for Bill's "Marri Woodchip" project.

Greg Bartle recalls that he had only ever seen Bill in the laboratory where he was always immaculately dressed, often with cravat and moleskins and 'nary a hair out of place', even when driving his beloved MGB. Over their working life together, Bill earned Greg's utmost

respect and admiration for his knowledge, principles and persistence let alone his valued friendship. Bill was the complete package when it came to natural resource evaluation. With his knowledge of geology, soils, botany and wildlife he could show perceivable and believable links between all and this was the underlying principle to most of his work. Greg and Bill became close friends and spent several private times together trout fishing (tuition by Bill) and they continued in regular contact after Bill's retirement.

Through the haze of restructuring of the Division came the notion that work on the stability and fragility of coastal sand dunes and some means of predicting this as an aid to planning, would likely be supported. With usual optimism Bill developed a simple system based on soil profile development associated with periodicity (i.e. period of standstill) which related to dune stability. This was observable by stereoscopic photo interpretation of vegetation patterns, and validated by ground truth. Greg recalls this joint work as one of the most productive, educational and enjoyable periods of his working life.

Bill and Greg applied these principles to the North West Metropolitan Corridor, the Southwest Metropolitan Corridor, Lancelin Military Training area, Garden Island, and the Two People Bay Nature Reserve on the south coast culminating in large-scale (six 1:100,000) map sheets of the Landforms and Soils of the South Coast of Western Australia. Bill and Greg mapped the coastal dunes and contributed, with Max Churchward and Peter Sewell, to the inland mapping. Also in non-coastal areas they were asked to do natural resource evaluations of the Bindoon Army Training Area and (with John Marshall) the Northam Military Training Area. Results of all of these studies were published with associated maps.

By riding the bumps of reorganisation, accepting change and getting on with matters, Bill ended up continuing the sort of work he enjoyed and contributing greatly to his discipline and to the lives of others.

In 1982 Bill retired from CSIRO as an active and very fit 60-year old and he continued to work between tennis commitments as a private consultant, particularly in relation to the forest plantation industry. As well, he carried out soil mapping for a number of Government authorities and for the Navy back at Garden Island where his early work was revisited. During this time Bill was also author of 'Reference Soils of South-Western Australia', a publication sponsored by the WA Branch of ASSSI. This was a very large task that Bill completed to his usual very high standard. Numerous sites were selected and visited for soil description, soil samples were taken for chemical and mineralogical analyses, the data were collated and appropriate maps were prepared. Ever the professional, it seemed that Bill understood little of the word 'retirement'. He maintained an active interest in natural patterns be they soils, landforms or vegetation and for this he was greatly respected.

Bill passed away on 23 July 2007, about 3 months after being diagnosed with cancer, Moira having passed away several years earlier. Bill truly left a lasting legacy for all those who had the pleasure of knowing him.

ALAN PEARCE [22] (1981 to 2006)

"Discovering" the Leeuwin Current

Satellite remote sensing has played an increasingly important role in our understanding of the characteristics and behaviour of the Leeuwin Current -- the dominant south-flowing ocean current along the Western Australian coastline. Thermal satellite imagery was used to support the very "discovery" of the Leeuwin Current in the early 1980s, and has been widely used in subsequent studies of the Current and eddies within it.

While the existence of a warm tropical current had been postulated as early as 1897, based on biological observations at the Houtman Abrolhos Islands, it was only with the advent of "new" technology in the 1970s that the southward flow was finally confirmed and in 1980 named the Leeuwin Current by CSIRO oceanographers George Cresswell and Terry Golding. While measurements using moored current meters and the trajectories of free-drifting satellite-tracked buoys played the initial role in this work, satellite thermal infra-red images soon provided conclusive evidence for the Current. Sea-surface temperature (SST) images obtained by Richard Legeckis (NOAA/NESS) and George from the Advanced Very High Resolution Radiometer (AVHRR) on board the TIROS-N and NOAA-6 satellites clearly showed the stream of warm water running southwards along the edge of the continental shelf, rounding Cape Leeuwin and heading eastward into the Great Australian Bight, as well as mesoscale (~100 to 200 km) eddies and meanders spinning off into deeper water.

Soon after I was transferred from the CSIRO marine laboratories in Cronulla (a southern suburb of Sydney) to join the Coastal Ecology Group at Marmion in Perth in early 1981, Frank Honey (from the CSIRO Division of Land Resources Management) and Bill Carroll (Western Australian Institute of Technology, or WAIT, now Curtin University) proudly showed me some of the early thermal infrared images of the waters off Western Australia. These had been downloaded from the recently-established satellite reception facility which had been set up at WAIT under Frank's and Bill's joint leadership, largely because Frank's interest in thermal remote sensing had been stimulated by a post-doc period at Stanford University in the United States.

We owe a debt of gratitude to Frank and Bill for their foresight in insisting on keeping all the received satellite tapes as an archive for future use. As a result, by 1987 a catalogue of over 1200 passes had been stored on magnetic tapes. The earliest orbital pass in the catalogue is a NOAA-6 tape dated 20 August 1981. This archive is apparently the longest AVHRR archive in the southern hemisphere, and again it is due to the efforts of people such as Ron Craig at Landgate that these early passes are now safely stored on modern storage media and so still available for use into the future.

Initially, it took a little imagination to distinguish the current patterns showing the warm jets and swirls in the ocean from the land and the irregular white patchy clouds, as the pictures were geographically distorted (remapping techniques had not yet been developed) and in many cases the thermal contrasts were weak. However, we were all excited by the potential of being able to see the recently-discovered Leeuwin Current in near real-time. Remote sensing promised some real opportunities, and I was fortunate in being with a group at the leading edge of remote sensing applications in Australia.

As I was basically an oceanographer and had little technical understanding of the intricacies of remote sensing, I was heavily reliant on the expertise and the generous goodwill of Frank Honey and his group at the CSIRO Floreat laboratories. I never worked out how Frank was

[22] *Summarised by Peter Hick from the WASTAC History being compiled by Richard Smith and Henry Houghton. Reproduced with the permission of Alan Pearce (alanpearce@iinet.net.au).*

able to persuade his "Land Resources Management" overseers to support ocean remote sensing. The group had a dungeon which sported an HP1000 computer, 10-inch 1600 bpi magnetic tape drives, a RAMTEK colour display monitor and a massive HP disc drive the size of a bar-fridge. Despite a heavy workload on his system, Frank kindly allowed me Thursday afternoons and as long into the evening as I chose to work, to conjure up coloured sea-surface temperature (SST) images which showed the main features of the Leeuwin Current and its variability.

Initially, the facility was only able to receive and record every 2nd AVHRR line of data (and indeed only 1768 of the 2048 pixels across a full scan) on the 1600 bpi tapes, but gradual developments in the hardware and software by both Frank's team and Bill's students soon produced full datasets and some very fine images of the Leeuwin Current. They graduated to 6250 bpi tapes, and then more exotic (and much smaller) tape archives such as the Exabyte system, and the archive store continued to grow.

The effort was greatly aided by funding grants from organisations that saw the potential benefit of a better understanding of the ocean current systems along our coast. Fishing Industry Research Trust Account (FIRTA) awarded Frank and Bill a 3-year grant that was taken over by Peter Hick and Doug Myers, to monitor water temperatures along the south coast of Western Australia and their relation to tuna catches. Nobody had quite anticipated how much cloud there would be along the south coast for so much of the time, and I seem to recall some reticence on the part of the fishing community to reveal the true locations and extent of their catches, but some of the results were sufficiently encouraging to warrant further research.

Frank Honey left CSIRO to pursue his commercial interests, and Fred Prata (a research fellow at WAIT) joined CSIRO. Fred had developed software specifically for processing satellite images of the ocean, with the rather tantalising acronym of PESST ("Procedure for Estimating Sea Surface Temperature"), and was able to undertake both geometric remapping and calculation of the "true" SST from the brightness temperatures in the AVHRR bands 4 and 5. Fred ported the software to the Floreat system, which was a huge boost to our work as we were beginning to derive temperatures for coastal areas of the State where no *in situ* measurements were available.

Fred obtained a research grant from the Marine Science and Technology Grants Scheme under the Australian Department of Science, to derive a monthly SST climatology of the Leeuwin Current region from 1982 to 1987. The monthly images clearly showed the development and behaviour of the meander/eddy structures associated with the Leeuwin Current, and I remember Fred absolutely *insisting* that we all (including our technical assistant, Janice Carrier) wear white cotton gloves so as not to spoil the glossy colour prints of the Leeuwin Current produced during the project!

One of the questions that regularly arose in the work was how accurate the satellite-derived SSTs were. Using surface temperature measurements from CSIRO surveys between Fremantle and Rottnest Island as well as from a recording thermograph installed on the Rottnest ferry, we showed that the "best" two of the variety of SST algorithms then available yielded temperatures with a bias of about 0.2°C from the *in situ* measurements and an RMS error of 0.6°C. However, a few samples had temperature differences of over 2°C, and more recent research has failed to fully resolve these (generally rare) anomalies.

By now, micro-computers were coming on the scene, and David Jupp and his group from the CSIRO Division of Water and Land Resources on the eastern seaboard developed mBRIAN, a package of hardware (as I recall, a WYSE 286 PC) and software for studying the Great Barrier Reef (hence the acronym for Barrier Reef Image ANalysis). Fred and John Wells soon adapted PESST to run on this system, developing what they termed "mNOAA".

WASTAC

At about this time, the idea of consolidating the WAIT satellite reception facility on a more structured basis and with more adequate resourcing was gaining ground. The concept was supported by Ray Perry (the Chief of CSIRO Groundwater Research) and Henry Houghton (Department of Land Administration), and the Western Australian Satellite Technology and Applications Consortium (WASTAC) came into being. Fred Prata was the inaugural secretary. Consequently, reception of NOAA imagery into the future was assured, but for our Leeuwin Current work we needed more computer time than could be spared on the Floreat facilities.

Again industry stepped in, and I was able to get funding (again through the fishing industry and supported by the Department of Fisheries) to purchase our own WYSE computer and an early version of mNOAA. Unfortunately, both Fred and John left CSIRO at about this time, Fred going to CSIRO Division of Atmospheric Research in Aspendale, and mNOAA languished somewhat, but some support from a CSIRO/UWA Collaborative Research Grant with Bruce Hatcher at the University of Western Australia funded Jim Davies to bring mNOAA to a fully working system. It was wonderful. We could now produce our own AVHRR images of the Leeuwin Current in our offices at Marmion, using them to interpret features of the current system at various locations along the coast as well as extract digital SST blocks or transects across the Leeuwin Current for more quantitative work. Sadly, mNOAA was never developed sufficiently to become a commercially marketable package, so I (as the only user) became the world expert in mNOAA! It produced some memorable colour images in the unique VECTRIX graphics display format, and subsequently our local Marmion computer guru Gary Carroll (in fact, Bill's son) wrote an invaluable computer program to convert these images to the more modern GIF format -- they now have a new life, and we continue to use many of the pictures from the 1980s and 1990s in our publications.

Research Advances and Applications

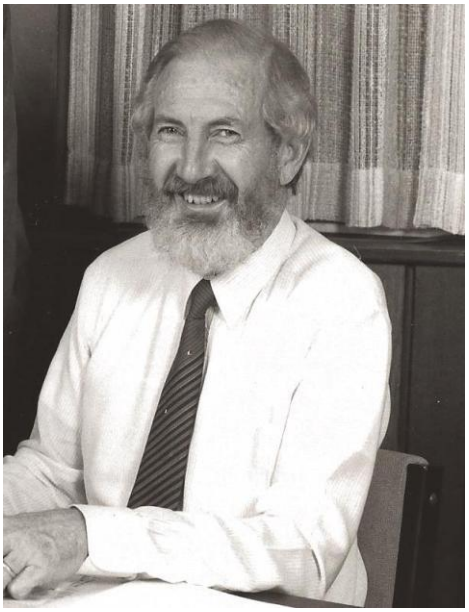
Much of our subsequent research into the current system along our coast over the past 2 decades has used WASTAC satellite imagery to supplement surface-based measurements. Perhaps one of the more interesting studies was a collaborative effort with Ross Griffiths of the Australian National University, in which the flow and eddying structure of the Leeuwin Current was closely simulated in laboratory model studies using a rotating water tank with opposite heated and cooled walls. The identification and naming of the Capes Current (with Chari Pattiaratchi of UWA) and the Ningaloo Current (with Geoff Taylor, of whale shark fame) was strongly aided by satellite SST colour images combined with SST transects across the continental shelf. These northwards-flowing inshore counter-currents are dominantly driven by the persistent southerly winds which prevail during the summer months, and may play an important role in the recruitment of some commercial fish and invertebrate species. Likewise, Barry Hutchins' (WA Museum) observations of the annual arrival of tropical fish larvae in the coastal waters off Rottnest Island suggested that the settlement there can be attributed to tongues of warm water from the Leeuwin Current penetrating across the continental shelf both north and south of the island, clearly visible in the satellite images.

George Cresswell (based at the CSIRO Marine Laboratories in Hobart) has continued his multi-faceted studies of the Leeuwin Current. I have always admired George's almost unique ability to pull together data from a variety of sources and come up with a convincing (and often ground-breaking, at least in local terms) description of the current system. A good example was his study of eddy structures along the south coast of Western Australia, combining Acoustic Doppler Current Profiler (ADCP) underway current measurements from the RV *Franklin* with SST images to reveal the structure of the eddies and deduce the

current speeds -- exceeding 1.5 m/s (3 knots) along the shelf break and also showing surprisingly high velocities in the eddies spinning off to the south.

With the availability of web-based remote sensing data and the development of ocean colour and satellite altimeter techniques in recent years, ocean applications have expanded, particularly in examining the role of Leeuwin Current eddies in ocean productivity and the oceanic migration of rock lobster larvae prior to settlement/recruitment along the coast. Testament to this is the number of papers in the special issue of Deep-Sea Research (2007: The Leeuwin Current and its Eddies) which use one or other of the various remote sensing products in describing the eddies off Western Australia.

ADRIAN PECK[23] (1970 to1988)



I graduated in physics and maths from UWA and was working as a vacation student at the Weapons Research Establishment in South Australia (developing equipment for cameras to track the Blue Streak and Black Knight rockets during testing at Woomera – a useful introduction to control systems) when I was told of an advertisement for a position in the Agricultural Physics Section of CSIRO's Division of Plant Industry at Deniliquin, NSW. I put in an application and was asked to go for a preliminary interview with Jim Quirk at the Waite Institute in Adelaide. Jim was not a CSIRO man, but he was well known by the Deniliquin group and later he was at UWA. It is interesting that this preliminary interview was not with one of the soil physics group of the Division of Soils in their lab across the road from the Waite Institute! I have very clear memories of that interview, with Jim drawing water retention curves etc for sands and clays on large sheets of butchers' paper.

The next step was an interview at the lab in Deniliquin. There were two scientists in the Agricultural Physics Section: Dan de Vries, a short-term appointee from The Netherlands, and John Philip who had trained as an engineer and worked on irrigation in Queensland before joining CSIRO. My interview with these people opened my eyes to challenging mathematical and physical problems in heat, water and solute transport in soils, and in microclimatology. I must have said some of the right things as I was appointed to CSIRO as a Technical Officer and began work at Deniliquin early in 1957. Not too long after my appointment, all TOs with degrees were moved to the new classification of Experimental Officer.

At that time, John Philip was developing the theory of infiltration of water during flood irrigation and, together with Dan de Vries working on simultaneous movement of heat and water in soils, and the modification of the microclimate resulting from irrigation in an otherwise arid region. There was interest in the latter work in response to proposals to cut a channel from one of the Gulfs in South Australia to Lake Eyre (the bed of which is beneath sea-level) as a means of modifying the climate of inland Australia. Both theory and data collected around irrigation districts in northern Victoria showed that measurable changes of climate were limited to a downwind distance roughly the same as the downwind dimension of the irrigated area or the water surface of a lake.

[23] Contributed by Adrian Peck

My primary role in CSIRO at that time was to set up and conduct experiments on simultaneous movement of heat and water transport in columns of glass beads as simple models of soils. Part of the work was measurement of thermal properties of the 'soils', which are fairly dependent on moisture content and provided a relatively simple method of measuring the moisture content of soil. Dan de Vries generously included me as a co-author of two papers on measurement of thermal properties of soils that were published in *Aust. J Phys*. – my first mention in the scientific literature.

I settled in to life in Deniliquin playing cricket in a local team, acting in a couple of shows put on in a local hall and nearby towns, going to the movies on Saturday nights with Max Churchward who was also at Deniliquin at that time (both of us single men), and fishing the local rivers and irrigation channels. One evening I watched the first Russian satellite cross the sky.

John Philip was an inspiration and great mentor for me. After I had been at Deniliquin for about 18 months, Dan de Vries returned to The Netherlands, John left for on an extended overseas trip, and the Division of Plant Industry decided that that would be a good time to move the Section to Canberra. In reality, the move was of John (*in absentia*) and me together with a large collection of reprints and a very modest amount of equipment in the back of a Holden ute. In his absence, John asked me to go through the reprints and classify them so that it would be easier to retrieve articles relevant to particular studies. I did a lot of reading and some of this material inspired me to set up experiments on effects of temperature and air pressure on water retention in soils. Before John had returned from overseas I had completed some experiments and drafted my first paper.

I must have shown some potential, because John arranged a Divisional Overseas Studentship for me, and through his contacts I was admitted as a Research Student at Clare College Cambridge. With my wife and 2-year old son we sailed from Sydney on the P&O ship 'Strathnaver' calling at Melbourne and Perth then onto Singapore, Colombo, Bombay, Aden, and Egypt before disembarking in the UK at Tilbury on the outskirts of London. I found accommodation at Cambridge and began work early in January 1961. My first experience on arriving at the School of Agriculture and needing a toilet was to ask a man (clearly technical staff) where it was and to receive a long look before some instructions. Later I learned that there were three sets of male toilets in that building – one for students, one for technical staff, and one for professional staff (lecturers to professors). Class distinction in the UK was very much alive. The man I spoke to had to guess what I was! In truth, I cannot recall which set of toilets I was sent to – any set would have been welcome at that time.

The group in the School of Agriculture was led by Ernest Childs who had PhDs from Cambridge in both physics and agriculture and focused his research on drainage of agricultural land. Childs was both on the University staff and Director of the (UK) Agriculture Research Council's unit of Soil Physics that had a lab on the outskirts of Cambridge where I did much of my experimental work. My supervisor was Edward Youngs who was in the US for the first few months of my time at Cambridge, but we had agreed that my thesis topic would be effects of air entrapment during infiltration to 'soils' being represented by a standard sand ('Leighton Buzzard'), 'slate dust' or a material of small gravel-sized particles that were themselves porous (simulating aggregated soil). I attended some of Childs' lectures and others on methods of numerical solution of differential equations. In that environment, one also learns a lot from other PhD students and the steady stream of short-stay visitors that Childs attracted.

Across the road from the School of Agriculture was the School of Botany where John Marshall gained his PhD some years before joining the CSIRO staff at Floreat Park. Nan Anderson was there too. She was completing her PhD. I cannot remember seeing John at

Cambridge, but I do remember Nan who joined the Division of Environmental Mechanics in Canberra when I was working in that group; she had once abused me for parking in the bay reserved for the Prof of Botany whilst I dashed in to Agriculture to collect some mail!

I enjoyed life in Cambridge playing cricket in three different competitions (one weekend and two inter-lab games after work during the week). After some time I recall asking myself the question 'what did I come here for – to become a cricketer or was it something else'? One night I was invited to a party in King's College by a research student I knew from UWA days, I had to break out by climbing around a locked gate across the pathway crossing the Cam to 'The Backs' where my car was parked. They were the days when all students at Cambridge were required to wear their gown after 6 pm, and College staff known as Bulldogs patrolled the City looking for victims.

Although my Studentship was strictly for two years, I managed to get an extension for a few months, submitted my thesis and left Cambridge in May 1963.

My wife and I (now with son and 15-month old daughter) returned from the UK by ship, and sat at dinner one night with a young Scottish couple who were migrating. In conversation they asked where we had lived in the UK. I told them we had been at Cambridge, and they asked what was there? I told them a University and a jam factory (Histon's), and they assumed I had been working in the jam factory!

Back in Canberra, I researched solute dispersion during flow in soils and aquifers (again represented by glass beads) and measured thermal properties of (real) soils for an oil company that was designing a heated oil pipeline in Victoria. (Curiously I had been supposed to be involved in a similar project at Kwinana whilst working for BP as a vacation student during my UWA years, but for some reason I was redirected to other things.) As time went on, I developed projects on measurement of water retention and flow in soils, and patented an instrument that was manufactured under licence to CSIRO – the principle was fine, but there are great practical problems of manufacture and the device found little real-world application. Another project was lab and field study of infiltration during furrow irrigation – John Philip had developed theory for this geometry, and Tjeerd Talsma of the Division of Environmental Mechanics introduced me to field work.

My first involvement with soil physics in WA was whilst working in Canberra, when I measured water retention properties of 'Spearwood Sand' and 'Bassendean Sand' at the request of Frank Roberts and Barry Carbon who had field trials at the Pinjar Research Station on the Swan Coastal Plain.

In 1969/70, I spent 12 months at the University of Wisconsin giving a few lectures, working on redistribution of water in soil following infiltration, and developing methods for scaling water flow in sloping aquifers. It was a sobering experience to give seminars to an audience that included authors of classic texts that I had studied. Together with a local professor, I reproduced experiments on soil moisture movement after infiltration that provided results which were inconsistent with current theory. Of course the results were genuine, and the theory needed to be amended.

The war in Vietnam was stirring protests in the US and after demonstrations at UW (including the fire-bombing of an old building), several students were killed at Kent State University and I had a National Guard soldier immediately outside my lab window. Was his rifle loaded with live ammunition as it had been at Kent State? I don't know!

On the way back from the US in 1970, I visited labs in the UK and Israel. Within an hour of checking into a hotel in London, I went for a walk and had to dodge a police car that was speeding along the footpath with siren blaring. Next morning, whilst waiting for a train, a

policeman ran through the station telling everyone to get out as there was reported to be a bomb in the station. It was a false alarm at the time of IRA terror attacks in London of which only a few were reported in the press.

I was well looked after in Israel visiting several places including Tel Aviv, Jerusalem, Bethlehem and Haifa. Israeli research has always been at the forefront of soil physics and hydrology. Some of my transport was by car and we picked up a soldier who sat in the back seat with a machine gun. When I asked to stop at one site to take a photo in occupied territory, I was told it was too dangerous. From Haifa, I was taken to sites close to the border with Lebanon, and after we were well away from that area I was told that there had been shell-fire close to the site just the week before.

Soon after returning from the US, I joined the Division of Soils in Perth. Part of my motivation for the move was a feeling that I had sat at the feet of the master (John Philip) for long enough, and now it was time for me to stand on my own two feet.

Before I took up the position in Perth in August 1970, I had letters from Gordon Hallsworth (then Chief of Soils Division) and Maurice Mulcahy (OIC Soils in Perth) stressing that the work was to study soil physics in the field – they were well aware that much of my experimental work to that time had been with glass beads that were very carefully chosen to be spatially uniform, and I had little experience of the challenges of field work. I still have copies of their letters.

My task at Perth was to lead the soil physics/hydrology group, and my brief was *'to investigate changes in hydrology and soil and groundwater salinity following clearing of native vegetation for agricultural and pastoral development. This project is to involve the instrumentation of paired catchments to determine the complete salt and water balances*.'

Soon after settling in at Floreat Park, Eric Bettenay and David Williamson took me on a tour of their studies in the Belka Valley and Meckering sandplain. The soils and landscapes of these study areas were not unfamiliar to me as I had lived at Koorda in the northeast wheatbelt for a few years as a schoolboy, but I was seeing the landscapes with the benefit of some knowledge of hydrology. I was also taken to see work at the CSIRO farm near Bakers Hill ('Yalanbee') where David Williamson had recently instrumented a pair of small catchments under native vegetation, and installed observation bores in another area.

One thing that surprised me about the Floreat lab was that in those days a lady came around every month or so to clean the phone! And of course we had somebody from the library coming to each office every week or so to deliver books and journals that had been requested by initialling a small sheet attached to each book/journal when it was on display in the library. This library service was not new to me as a similar arrangement existed at the Black Mountain site in Canberra.

Back in the lab at Floreat, I settled in to reading the literature and correspondence about salinity studies in WA and throughout the world. Amongst this material, I found that back in 1951 (when I was still at high school!) a case had been put to the CSIRO Executive for the appointment in WA of a person with experience in 'watershed hydrology', and pretty well outlining the tasks set out in my letter of appointment. Furthermore, I was impressed (depressed?) to find a copy of correspondence from the Director of the WA Chemistry Centre to the WA Government advising that there was <u>no evidence</u> that replacing native vegetation with agricultural crops and pastures was responsible for the increases of soil and stream salinity in WA that had been reported from the early 1900s. It is arguable that the Director was correct because at that time the long-held hypothesis that clearing resulted in increased salinity had not been tested by carefully controlled experiments – that is, there was no hard evidence.

Before I arrived in WA, a proposal for instrumentation of small catchments in the Collie River Basin above Wellington Dam had been submitted by CSIRO and the WA Public Works Department (PWD) to the Australian Water Resources Council (AWRC – a branch of the Federal Department of National Development). This proposal reflected the concern of PWD engineers about a trend of increasing salinity of water flowing into Wellington Dam, and resulted from discussions involving PWD, Maurice Mulcahy and Eric Bettenay. Funding for the instrumentation of several small catchments as proposed was approved by AWRC in 1971. In detailed planning I suggested some changes to the original proposal and these were accepted. In particular, on the basis of calculations (using the simplest of models) of how long it may take to leach salts from the soils, I proposed that a pair of catchments should be instrumented in the higher rainfall area close to Wellington Dam. After clearing of native vegetation, I expected that there would be an increase of stream salinity followed by a decrease as salt stored within the soil was leached by rainfall from storage in the regolith and lost from a catchment by streamflow. My calculations suggested that within about a 10 year period of data collection (including about seven years post-clearing), in the high-rainfall region of Wellington Dam it should be possible to detect some decrease of salt flowing from a small catchment. The data that we gathered over more than 10 years showed that salt discharge did not decline so quickly, which I hypothesise to be a direct result of most water moving through preferred pathways (root channels and recently weathered bedrock) in the regolith. The presence of these pathways became clear later from CSIRO's extensive drilling program in the experimental catchments and elsewhere in the southwest.

Whilst drilling and installation of equipment in the Collie catchments was proceeding, I was looking at possibilities for further analysis of existing information, and realised that chloride balances (inputs and outputs from an area) could be computed for some WA catchments. I chose several catchments in each of uncleared and farmed areas where PWD had many years of records of daily streamflow and monthly chloride concentration. With these data, and the computational skill of Denis Hurle, we computed the annual chloride output from each catchment. Chloride inputs were then computed from average rainfall (Bureau of Meteorology data) and Frank Hingston's published map of the geographic variation of chloride concentration in rainfall in WA. The different ratios of chloride output to input for uncleared and (at least partly) cleared catchments were striking and provided convincing evidence of impacts of clearing for agriculture on stream salinity.

I was puzzled by the lack of evidence of salinity in streams that drained some very large catchments, and on one occasion Eric Bettenay and I took a day in the field to sample a few streams in the Darling Range. It was during school holidays and my son David came along to climb down stream banks and collect water samples for us. The CSIRO vehicle had been booked out in my name, and soon after the trip Jack Brophy called me to his office. He was investigating a report by a member of the public that two women had been seen with the driver in a CSIRO vehicle! That was the 70s; both Eric and David had long hair, and I suppose that not many women were involved in field work at that time. It makes me wonder whether members of the public still report sighting women in CSIRO cars!

In the early 1970s, there was widespread concern that Alcoa's bauxite mining operations in the Darling Range may affect the quality of water captured in dams that had been constructed for Perth's public water supply. Sir Laurence Brodie-Hall was both a Director of Alcoa and Chair of the WA State Committee of CSIRO so a visit to some areas of possible mining east of Jarrahdale was arranged. Brodie turned up in his chauffeur-driven Rolls and invited Maurice Mulcahy and Bruce Beggs (then Conservator of Forests in WA) to join him whilst 'other ranks' followed in a CSIRO vehicle. We were allowed to listen to the hi-fi music emanating from the Rolls, but not to get too close and definitely not to touch! The tour proceeded along forest tracks that got narrower and narrower whilst the Conservator of

Forests insisted that he knew the way to get through to Albany Highway. Of course the convoy finally got though, but it was quite a site to see a Rolls on such tracks.

As our Collie catchment work was moving ahead and attracting some interest, Brodie wanted Alcoa to fund CSIRO to instrument and operate several experimental catchments in forested areas over a range of rainfall zones where bauxite mining may take place. At that time Alcoa was the only bauxite mining company operating in WA, and CSIRO refused to take this offer as it came from a single company rather than a consortium of bauxite miners! How things have changed! Subsequently Alcoa engaged the UK Institute of Hydrology to provide hydrological advice. I knew the two staff members who came to Perth and the CSIRO catchment studies team shared our knowledge with Alcoa's visitors!

As often happened in those days, whilst there were debates about funding at a higher level, CSIRO and PWD began work on one small catchment (Del Park) near Dwellingup where a stream gauging station was established and drill-holes were cored prior to installation of monitor bores on a 200 m grid. After some time, this catchment was mined for bauxite and data were accumulated for comparison with predictions of a simple model that I had developed. When mining was soon followed by reforestation, in that environment there was no evidence of any significant impact on stream water quality.

Although there was no exchange of funds, Alcoa arranged for the excavation of a pit to a depth of about 7 m within the Del Park catchment. During the preceding winter, Denis Hurle and Colin Johnston had irrigated the excavation site (at the same rate as rainfall) with water to which a dye and other tracers had been added. The pattern of staining on the pit face showed very irregular wetting due to the presence of weathered root channels (some of them wider than a finger). These conduct water downwards when a perched watertable develops beneath the interface of the shallow but very permeable surface soil and the pallid zone clays. Perched water tables often develop during the winter when there is a sufficient excess of rainfall over evapotranspiration. This pattern of water movement in the regolith is a key to understanding of the mechanisms of accumulation of soluble salts in the deeply weathered soils, the rapid response of the deeper watertable following rain, and the rate of leaching of these salts after the groundwater level rises following a change of land use.

Field work at the catchment scale is very different from lab experiments on columns of glass beads, and I turned my thoughts to the characterisation and implications of spatial variability of soil properties, particularly their hydrological properties. During a short stay working in the Environmental Sciences Division of the Oak Ridge National Labs (ORNL) in Tennessee, I realised that effects of spatial variability on the soil water balance could be investigated by a marriage of methods for scaling soil hydraulic properties and a soil-plant-atmosphere model that the ORNL people had developed. Subsequently, Bob Luxmoore of the ORNL group spent some time in Perth using the model that he and others had developed to simulate the water balance of forested and cleared land under Collie climatic conditions.

In 1976, before the experimental catchments in the Collie River basin were cleared (therefore before we had evidence of the effects of clearing, which was the original objective of the work), the WA Government legislated to control clearing in the catchment of Wellington Dam. Perhaps the large difference between chloride balances of farmed and forested catchments that Denis Hurle and I had published in 1973 influenced the decision makers.

The catchment salinity work ('program') proceeded along several lines ('projects') and received continuing support from CSIRO during evolution of the Organisation (initially a program within the Division of Soils, then within the Division of Land Resources Management, and later the Division of Groundwater Research) in WA. During this time, I was funded by CSIRO and other organisations to visit experimental catchments and non-

irrigated salinity studies in the USA, Canada and Thailand and to attend international conferences in Athens, Edmonton, Cambridge and Budapest. Comparing our work in the southwest of WA with somewhat similar programs in the USA and Canada, I maintain that we achieved a greater understanding of the process of storage of soluble salts in soils, the effect of vegetation on groundwater recharge, and the role of shallow and deeper aquifers in the development of dryland salinity in our environment. But much remains to be done: we did not develop a capacity to provide methods for prediction of salinity risk, diagnosis of causes of salinity at particular locations, or successful management of farms and catchments in which salinity has developed or could develop. The management of land and stream salinity remain environmental problems that affect many members of Australian society. In the non-irrigated areas of southwest WA, the economics of farmland operations do not encourage application of those methods of salinity management (primarily drainage) that are used in many irrigated areas of Australia and elsewhere.

In 1980, a group of eminent salinity scientists from around the world came to Perth (with financial assistance from the WA Government) for a high-level seminar and workshop. Papers presented at that seminar were reported in a special edition of *Agricultural Water Management*, and in 1987 results of the catchment studies were reported in a special edition of the *Journal of Hydrology* of which I was a joint Editor (with David Williamson). Later I was invited to present a paper at the 50th birthday celebrations of the US Salinity Laboratory.

During my employment by CSIRO, I served as an invited member of Editorial Advisory Committees for the Australian Journal of Soil Research, Journal of Contaminant Hydrology and the Journal of Hydrology. I was the Chair of a sub-committee of the International Association of Hydrological Sciences that prepared a publication “Consequences of Spatial Variability in Aquifer Properties and Data Limitations for Groundwater Modelling Practice” (a contribution to the International Hydrological Program of UNESCO). Locally I served periods as Chair of the WA branches of the International Association of Hydrogeology and the Australian Society of Soil Science (Inc) and was a co-opted member of the Hydrology group of the WA Branch of the Institution of Engineers Australia.

I had received accelerated promotion since my move to Perth, and after the formation of a Division of Groundwater Research in WA, I was made Assistant Chief to Ray Perry, and then Acting Chief after Ray retired. Later I was an unsuccessful applicant for the position of Chief when a new Water Division was created. On reflection, I believe that CSIRO made the right decision since I am not the kind of person that was required to lead Divisions within the Organisation at that time. So I accepted a separation package and after a week or two began work with a firm of groundwater consultants in Perth.

For some years, I had thought that it would be interesting and enjoyable to work as a consultant after my CSIRO career ended, but it was quite a change to find myself examining core samples on site during the night shift of drilling for a mining company. After working for the consultant company for about two years, I was appointed Chair of the WA Water Resources Council that provided independent advice to the Minister for Water Resources. As Chair, I was also a member of the Board of the Water Authority of WA. These positions took a few days of each week, and whilst my employers were keen to use my positions in their advertising material, I was told that these tasks would have to be in my own time. So I decided that I would set up my own small consultancy and for about 20 years I provided advice to mining companies, Government agencies and private land developers.

As somebody said to me at the time that I left the organisation, ‘there is life after CSIRO’. In my experience, consulting is an occupation practiced by many talented people, but there is rarely the opportunity to follow-up on puzzling observations, and thereby expand understanding – i.e. to take the next step and undertake the desirable research.

I owe a great debt to CSIRO, both the Organisation that supported me during my evolution from raw graduate to productive scientist, and the support from all the people that I worked with. When Ray Perry was my Chief, he sent a group of his staff (including me) to a series of lectures on '*Business Systems Analysis'* that impressed me in many ways, but particularly the importance of identifying all the tasks that are necessary to generate the product of an organisation. (In CSIRO's case I consider the 'product' to be the development and application of methods to generate information, the interpretation of this and other information, and the development of understanding, and knowledge – all of this to be suitably documented and communicated.) The production of valuable science by CSIRO always has and always will need a broad range of staff that includes not only scientists, but assistants, office staff, librarians, workshop staff etc. I am eternally grateful to my fellow staff in CSIRO who stimulated and supported me throughout my career.

Some contacts with CSIRO have continued since I left the Organisation in 1988, and contacts with a group of former staff of the Floreat Labs have evolved after I was asked for advice by one person who was very unhappy about the way he had been 'invited to resign'. We met for a chat over lunch, and in a Pilbara airport soon afterwards I bumped into another ex-CSIRO colleague who was consulting for one of the major iron-ore miners. So I invited him to join us for another lunch, and later others were invited to come along to similar events. This informal lunch group has continued to meet several times a year and the number of invitees continues to grow. Several of the members are now on the Committee of the WA Chapter of the CSIRO Alumni and these luncheons have become a convenient time to discuss Alumni business.

I reflect that my early work in CSIRO was directed towards plant production through better understanding of the water and energy balances of earth's surface, and the transport of water, solutes and energy in the soil and the lower atmosphere. In those early days, spatial variation of properties of soil and vegetation were ignored in seeking to understand processes in a one-dimensional vertical column including soil and lower atmosphere. Moving on to WA, the focus was on water and solute balances over the area of catchments in which the spatial variation of properties of soil and vegetation cannot be ignored. My old mentor John Philip referred to such problems as being within the realm of 'trans-science' in the sense that and the fundamental transport processes are in accord with well-established (quantitative) physical theory, but the variation of properties of the media in which transport takes place are such that their characterisation over the area of even a small research catchment is essentially impossible. John would certainly have regarded catchment hydrology as being an example of trans-science whilst from his engineering background he would have recognised the real-world need for quantitative models of the response of streamflow and quality to rainfall or a change of land use. I contend that those who follow us in research must strive to develop the science of catchment hydrology and believe that we have made some progress along that direction during the time I worked for CSIRO.

WALLY STERN[24] (1951 to 1967, WASC 1969-)

From 1951 to 1957 I was one of three Science/Technical people at the CSIRO Katherine Research Station. At the start of 3 months leave in 1956 (continuous tropical service doubled leave entitlements) my wife Maida and I travelled from Darwin to Fremantle on the State Ship Kalinda, calling at most ports along the way. We had our Morris utility on board. Each morning on this trip I found a quiet corner in the lounge and typed the final draft of my Master's thesis on a portable typewriter. On arrival in Perth, I called at the CSIRO WA Laboratories, paid my respects to the OIC (Reg Rossiter) and enquired whether they could help me find someone to prepare the thesis for submission. I think I was directed to John Brophy who, at that time was the assistant to the administrative officer. This was duly organised while we explored the southwest of the state, and I submitted the thesis when we eventually reached Sydney.

In 1960 I joined the Canberra group of the Division of Land Research and Regional Survey. My brief was to work on the crop/environment interactions of the major crops being tested at the Kimberley Research Station (KRS). The supervisory committee included representatives from the Commonwealth Department of National Development and the WA Public Works Department – and I needed to liaise with them regularly as well as the WA Department of Agriculture. The Kimberley Research Station was on the opposite side of Ivanhoe Station with Bandicoot Bar on the Ord River between them. Crocodiles often basked on the bar known as Ivanhoe Crossing near Ivanhoe Station where there was an airstrip for Connellan's small planes. Vehicles crossed the Ord River at Ivanhoe Crossing on their way to Wyndham.

KRS had several houses accommodating families, a school, single men's quarters and a mess – it was a village. A generator in the mechanic's workshop provided electric power at designated periods for about 8 hours a day. There was no telephone – only radio transceivers operating within specified periods twice daily; when storms were approaching, sessions often had to be abandoned. This was manned by a clerk (was it Humble?) employed by the WA Government. The nearest town was Wyndham some two hours away by road (not always passable), and Kunnunurra (at that stage unnamed) was basically a large works camp with a hostel for engineering staff.

In setting up the series of studies, I liaised with members of the CSIRO Division of Soils, Division of Environmental Mechanics, Division of Meteorological Physics, Division of Physics, and with instrument companies. Although some equipment was commercially available, at this time more specialised equipment we needed such as neutron moisture meters, net radiometers, and various other monitoring devices that were in development. To record data continuously, chart recorders were used – data loggers were not yet in vogue. We needed a large drying oven to use continuously, and imported one from the UK; we needed 24 hour power, so power lines were erected to KRS from the powerhouse being built at the future townsite. Imagine the joy of the folk at the KRS village – especially the wives and the people running the mess.

I borrowed, bought and scrounged equipment from all over the place and established depots in Brisbane and Perth. The support provided by CSIRO Administration in Perth (particularly John Brophy) was absolutely marvellous. Nothing was ever any trouble – if I needed equipment or supplies John always knew somebody, or where to find it and get it at reasonable cost. We needed a caravan to set up in the field – he found one and despatched it to KRS; we needed to hire people – John interviewed them and recommended appointments. He always arranged transport from Perth Airport – planes from the eastern states always arrived late in the evening and going north they always left either early in the

[24] Prepared by Adrian Peck from notes provided by Wally Stern.

day or late in the evening. Several scientific colleagues came to visit our site to help us set up the equipment and do test runs; John Brophy helped in the travel arrangements. When equipment needed to be returned for repair, John handled this and we could rely on him to see that it reached its destination and was returned to the field as quickly as possible. If I happened to pass through Perth on a week-end, John would pick me up and take me to his home.

When one of my assistants needed an operation (because he had lifted a 44 gallon drum) followed by a long recuperation period, John found a place for him in the Perth labs until he was fit to return to the field. Incidentally this man met his future wife in the pasture lab during his recuperation period.

A couple of years after becoming Foundation Professor of Agronomy in the School of Agriculture at the University of Western Australia in 1967, I was appointed to CSIRO's WA State Committee (WASC). It was then under the Chairmanship of Sir Ernest Lee Steere who had many interests and commitments, and the Committee was not very enterprising. Then in the early 1970s, Laurence Brodie-Hall took over as Chair and things began to hum. I happened to Chair his first "task force" which was concerned with the rehabilitation of bauxite mining sites in the Darling Range; other members of this task force were the Conservator of Forests, and Brian O'Brien, then Chair of the WA Environmental Protection Authority.

Brodie used the report to get some action, the outcome being a new Division of CSIRO based in Perth – headed by one of my former colleagues, Ray Perry. As reports continued to roll out from Brodie's task force approach, John Brophy became increasingly involved with this activity and it is through his enthusiasm and giving his time voluntarily, that the Brodie-Hall Lectures have become an established item in the Perth science calendar.

HONOR THOMPSON[25] (1958 to 1965 and 1972 to 1981)

I commenced with CSIRO at the end of 1958 when the Organisation was located in the University of WA grounds at Crawley. In 1965 I resigned to start a family, which was prior to the new building being opened on the Floreat Park site. In 1971, I undertook some temporary jobs at John Brophy's request and returned to a permanent part-time position in 1972, which eventually became full-time. Please note that I have always called Jack Brophy by his correct name of John and this is how I will refer to him as I find it difficult to call him Jack.

This part of the informal history is mainly regarding my experience at the Nedlands CSIRO Laboratory on the University of WA Campus. As I was part of the administrative staff it will be from a different perspective to most other contributors, but I hope it will give an indication of what it was like to work at Nedlands prior to the move to the new Laboratory at Floreat Park in 1965.

I was first employed as a "shorthand typist" with CSIRO in late 1958, it was the first job for which I applied and I did not even know what CSIRO actually did, or what the acronym meant. I was recruited by John Brophy, who was the Administrative Officer responsible for the Laboratory. Of course I called him 'Mr Brophy" as we did in those times and it was a long time before I could bring myself to call him by his first name, despite him urging me to do so.

I started in the typing pool, which consisted of 3 typists and a head typist, all of whom I remember well. I felt I had hit the jackpot with the job, the CSIRO work was very interesting and it was a friendly place to work - I enjoyed it from the beginning of my employment. The working environment was informal and as the staff numbers were small everyone knew each other.

We had many fun times socially, including softball matches on the Crawley foreshore, swimming in the lunch breaks at City Beach, Christmas parties usually with one of the scientific staff playing Father Christmas, plus other events some of which I am sure would now be regarded as "politically incorrect". I particularly remember Haydn Lloyd Davies, a Research Scientist with the Division of Plant Industry, playing Father Christmas, a role which he did well and seemed to really enjoy.

The Laboratory consisted of a number of Divisions including Soils, Plant Industry, Wildlife, Mathematics and Statistics, Fisheries & Oceanography, Entomology and Mineralogy (located in the Zoology Department of UWA). Some of the Divisions, due to lack of space on the University Campus, had premises away from Nedlands, including the Kojonup Field Station which was a farm staffed by the Division of Plant Industry where Eric Watson was Officer-in-Charge. This was later sold and relocated to Bakers Hill just 100 km east of Perth. The site was named Yalanbee, an Aboriginal word meaning "Much Grass".

The Division of Wildlife was located in an old house in Caporn Street, Nedlands adjacent to the University Campus, due to lack of space in the main laboratory. When I was in the typing pool we had a roster for working one day a week at Wildlife for Dom Serventy, the Officer-in-Charge. Unfortunately none of us particularly enjoyed working at the old house, it was very cold in winter, hot in summer, and had very limited coffee and tea facilities, which were considered most important. My main memory of Dom Serventy is that he dictated correspondence at great speed, and although I was very fast at taking shorthand, he left me behind on occasions. The Wildlife group expanded under Dom Serventy and moved from the Caporn Street premises in Nedlands to a new property in Helena Valley.

[25] Contributed by Honor Thompson

At one time office space was so scarce in the main Laboratory that as Secretary to Reg Rossiter and John Brophy, I was given a very small space in Des Baccini's office, which was close to the offices of both my bosses. Hopefully Des didn't mind sharing his office space temporarily.

After working in the typing pool for a period I became Secretary to John Brophy and Reg Rossiter, who was then Officer-in-Charge of the Laboratory. He was an exceptionally nice person, relaxed, unassuming and thoughtful. My duties included driving him to the dentist, or doctor, and waiting outside until he was ready. I was never quite sure why I was expected to do this, but he was so nice I didn't mind. As time went on I realised it was not unusual for a Secretary to be a chauffeur for their employer, a duty which was never mentioned at business college! One of my duties when in the typing pool was collecting tea money from all staff and it was never an easy task, despite the small amount involved. Reg Rossiter did make me smile though as he took out his contribution from his little money purse and slowly counted the coins prior to reluctantly giving it to me; it was as though he was handing over his lifesavings!

John Brophy was, and is, very much a people person and his management style helped make the Laboratory an excellent place to work. He had a good relationship with staff and always managed to get things done, even if he had to "do it now and answer questions from Head Office later". He had a healthy disregard for Canberra bureaucracy, an attitude which did not change in all the time I worked with him, and I suspect it was the same until he retired. John was a follower of the VFL, I think Carlton, and I remember that if he needed to visit Melbourne on business he did his best to arrange the trip when his team was playing. I asked him once to do a reference for me so that I could borrow money from the CSIRO Credit Society to buy a car (strange times!) and he compared me in the reference to being as reliable as Alex Jesulenko, one of Carlton's great footballers. That was probably almost the highest praise he could bestow on me to demonstrate my reliability.

One of my memories of the early days at CSIRO involved Eric Greenwood from Plant Industry. As he lived not far from me in South Perth, he very kindly gave me lifts to work. One very wet morning he had to brake suddenly at a crossroad near the Perth Zoo and the car skidded straight across the lawn of a corner house and through a low brick wall onto the front verandah. The occupants of the house were not amused -- hardly surprising! However, there were no injuries and the car fortunately was still drivable (just). By the time we arrived at work we were almost able to laugh about the incident.

Employment conditions for women in the Commonwealth Government when I worked at CSIRO in Nedlands were quite different to the present time. I married at 21 and was forced to give up permanent staff status and return to work as a casual. Hard to believe now, how things have changed! I worked for another year and then left to start a family – no maternity leave then. At this stage the Floreat Lab was not completed, therefore I did not work in the new building until returning for short temporary assignments in 1972.

In 1973 John Brophy asked if I would work three mornings a week for Professor Eric Underwood, a part time member of the CSIRO Executive who was located at the Floreat Park Labs. He was a fascinating man and I really enjoyed my time with him. Once again a person who was incredibly fast at dictating correspondence and he was a real test for my shorthand skills. John Brophy then asked me to work for him part time 5 days a week. It was a big decision from my point of view as I enjoyed the 3 mornings with Professor Underwood, but John could be very persuasive! I worked for John at Floreat as part of the Administrative team. This group, which was renamed the Regional Administrative Office, moved to office premises in Kings Park Road, West Perth and I worked for John there until I returned to Floreat as Executive Assistant to the A/Chief of the Division of Mineralogy,

Russell Hudson. I was pleased to return to Floreat as being located in West Perth tended to make one feel disconnected from the main Laboratory.

I loved working at CSIRO, both Nedlands and Floreat, and was never quite sure I had made the correct decision when I left to go to private industry. However, circumstances had arisen where it seemed like the right time to experience working in a different environment, particularly with a company that collaborated with CSIRO in several areas and I knew it well. It was ironic that after working with World Geoscience in West Perth for less than a year the company moved to a building on the CSIRO Floreat site; I felt as though I had returned home!

Following 5 years with World Geoscience I obtained employment in the State Government, but I have always retained very fond memories of CSIRO where I worked for a total of 23 years.

MINERALS R[26]ESEARCH IN WA (The WILF EWERS team, 1963 TO 1983)[1]

Origins

CSIRO mineral scientific work in WA commenced when Wilf Ewers moved from Victoria in 1963. Soon after he was joined by Ted Davis and Jim Graham from CSIRO in Melbourne. Alan Fletcher was the first WA appointment by Wilf.

Wilf Ewers at that time; this photo may have been taken in Melbourne because he is wearing a wooly jumper under his jacket.

The group expanded with Jack Drysdale and Dai Davies arriving. Soon after, Ron Couper was appointed to work with Dai Davies. They were initially located in the Zoology Building in Park Road, next to St Georges College and they had a bold sign made to indicate who they were. They moved after a short time to laboratory and office space provided in the new building that was erected for the Chemistry Department of the University of Western Australia.

Work commenced on the study of potash in glauconite using samples obtained by the Western Australian Mines Department. Studies were made on the occurrence of vanadium in the titaniferous magnetites of Western Australia. The recovery of lithium from West Australian spodumene was another area of research that would be very topical today. Dai Davies and Ron Couper investigated new or improved methods for deep exploratory rock drilling.

Ric Vigers joined Jim Graham who had acquired X-ray equipment that needed Ric's special skills. Ric would sit cross-legged on the floor of the laboratory smoking a cigarette while he solved whatever problem he had with the equipment in front of him. Mike Bussell joined the group soon after he had completed his honours year supervised by Dave Koch while Dave was on sabbatical at UWA.

Geological and mineralogical skill of the group received a boost when Dr Ian D. Martin was appointed.

It is interesting to see that Jim, Wilf and Ian commenced work on nickel sulphides. The "nickel boom" was booming.

[26] Prepared by Mike Thornber with assistance from Wilf Ewers, Alan Fletcher and Dick Morris.

New names continued to appear: Russell Hudson arrived a few months before Terry Parks and Mike Thornber, and Brian Martin came about six months after that. Mike was appointed to work with Jim Graham as his Experimental Officer after Jim had helped to supervise his PhD. Terry Parks' appointment gives some insight to Arthur Gaskin as Chief; Terry had applied for the job that was given to Russell Hudson, and Arthur and Wilf decided that Terry or TC (short for "Top Cat" as he was to be known), was too good be passed up; TC was told he had a position as a Research Scientist. He was told not to worry that the name on the pay packet was not his but the money was most surely his. The name turned out to be that of an ex-gardener at Fishermen's Bend and that was all that was to be known about the fiddle that went on.

The year 1966-1967 saw the introduction of decimal currency, and here is a list of the salary scales for scientific staff at that time.

	From	To		From	To
Research Scientist	$5250	$6622	Experimental Officer (1)	$3194	$5047
Senior Research Scientist	$6892	$7974	Experimental Officer (2)	$5261	$5918
Principal Research Scientist	$8242	$9490	Experimental Officer (3)	$7184	$7692
Senior Principal Research Scientist	$9918	$10230			

We need at this point to be reminded of the "bigger picture" of those times of the early formation of the great achievements of the Western Australian group. The Nickel boom was rampant; the town of Kambalda had been built on top of one of the undiscovered ore bodies.

The town of Newman was being built near what was still Mount Whaleback and not what is now the biggest hole in Australia. Tom Price was constructed at the other side of the Hamersley Range in the Pilbara. Heavy-duty rail lines to Port Hedland and Dampier respectively were being rapidly laid.

ALCOA still stood for the Aluminium Company of America and it had the capacity to produce 300000 tons of alumina and 600000 tons of caustic red mud at its Kwinana refinery. They are now "Alcoa of Australia" which must mean "Aluminium Company of America of Australia? The mineral sands industry was producing synthetic rutile at Australind north of Bunbury, and pouring its acidic effluent into the sand dunes turning the ocean and white beaches a red ochre colour.

The Club of Rome was giving warnings about "Limits to Growth". Embryos of the modern computers were becoming essential and leading to debates as to whether analogue or digital was best. Electron microscopes were being used in CSIRO Divisions. The ideas and concepts of "Plate Tectonics and Sea Floor Spreading, etc." began to appear in the literature.

Alan Bond was dealing in land north of Perth and making his first millions with other peoples' money and Whitlam was saying "It's Time!"

Sharing the Floreat Site.

Dai Davies had moved to another division in the east at about this time. Mike Thornber was inspired by the brilliance of Jim Graham and his many abilities, especially how he could work through a problem and come up with an answer or a new approach to what needed to be done. The great intellect and eccentricities of his good friend TC was at hand and there was also the privilege of getting to know Russell Hudson. Russell always seemed to have the time to explain geological concepts and the mysteries of rocks in such a way that anyone should have understood. Mike soon learned that Russell was the very best at whatever he did.

It was exciting to come to work! This excitement dissipated quickly when you had to sign in with Tom McNab looking over your shoulder. Jack Brophy managed the admin affairs and he could always be relied on to fiddle things in your favour.

It is disappointing to find very little recorded about the technical staff at that time but there is no doubt that their contribution was essential. Recollections can't be trusted; but it is believed that Steve Baggott was with Jim and Ric Vigers, and at some stage Wendy Mather was appointed to assist Russell Hudson. Ian Martin departed to make his millions from the nickel boom, and it is believed that John Wildman came as a replacement for Ian Moyle. Ron Couper must have obtained the services of Bill Bouwer at this early stage.

Wendy Mather captured the working environment of those days with this cartoon of TC:

Mike Thornber recalls that the first thing that happened to him was that to be sent to Fishermen's Bend to meet others in CSIRO that he should get to know. He remembers meeting Arthur Gaskin, Peter Darragh, John Perdrix, Don Swift and Jean Swift. All of them were later to come to Perth. Mike believes that the main reason he was sent to Melbourne was to provide an excuse for everyone to go to lunch at "Jimmy Watson's Wine Bar" where he was introduced to the "Jimmy Watson" in person.

The Mineralogy workers were located all over the new Floreat Laboratory building interspersed with other Divisional scientists and laboratories. Mike had an office on the ground floor in Jim Graham's laboratory; and this work area was shared with Russell Hudson. Mike was given a large table and a sink with workbench that was to be called a chemical laboratory. The good news was that the Floreat Labs had a well-stocked store and

provided that you were willing to listen to the store-man's grumbles; most of what you needed could be obtained by signing something.

Alan Fletcher was located on the second floor. To grind his rock samples he would use a steel percussion mortar, fill it with rock fragments, place the steel pestle on top and then whack the top of the pestle many times with a large hammer. To do this whacking he would place the apparatus on the floor of a vacant room that was directly above Clive Boundy's office, do the whacking and then grab it all and run well out of the way. Every time Clive would appear in the corridors shouting and ranting to catch whoever it was that had disturbed him. With some cause Clive was well known for his grumpy disposition.

All Wisdom Comes from the East.

Ivan Newnham came to visit the group and Wilf Ewers decided that all were to squeeze into his office as Ivan had an announcement to make. A rough estimate is that Mike Bussell, Ric Vigers, Ted Davis, Wilf, Jim Graham, Jack Drysdale, Russell Hudson, Brian Martin, TC, Fletch, Ron Couper and Mike Thornber were crammed into the office and this is more or less what Ivan conveyed:

> *"At the end of 1970 the CSIRO Executive introduced extensive changes in the Organisation's administration of minerals research. A new Division of Mineralogy was formed by combining the Western Australian Laboratory and the Mineragraphic Section of the former Division of Applied Mineralogy with the Sydney-based Geochemistry Section of the Division of Mineral Chemistry. This new Division was grouped with the Division of Chemical Engineering and the residual Division of Mineral Chemistry to form the Minerals Research Laboratories (MRL). The Chief of the Division of Mineral Chemistry (Ivan Newnham) was appointed Director of MRL, the Chief of the Division of Applied Mineralogy (Arthur Gaskin) was appointed Chief of the Division of Mineralogy, and. David Koch was appointed Acting Chief of the Division of Mineral Chemistry."*

Ivan did not say it like that, but more along the lines that he was the new "Super Boss" and he had all the power now. He controlled promotions, what we did and where we did it. Mike Thornber recounts that he was quite startled to hear this from Ivan who was one of his heroes. Several years earlier Mike had attended a seminar that Ivan gave at the UWA Chemistry Department and was so impressed that it made him lust for a job at CSIRO. However, after this the group went back to working much the way as they had previously; Wilf was still the boss. Colin Bennett came from the east and he was a great addition to the group. Then Jack Halberg arrived and the geology side of the work became stronger.

The New Building.

On 24 September 1971 the Division of Mineralogy's new building was opened by the Honourable R. Victor Garland, MP, Minister of State for Supply; actually the mineralogy group had been established in the building for several months

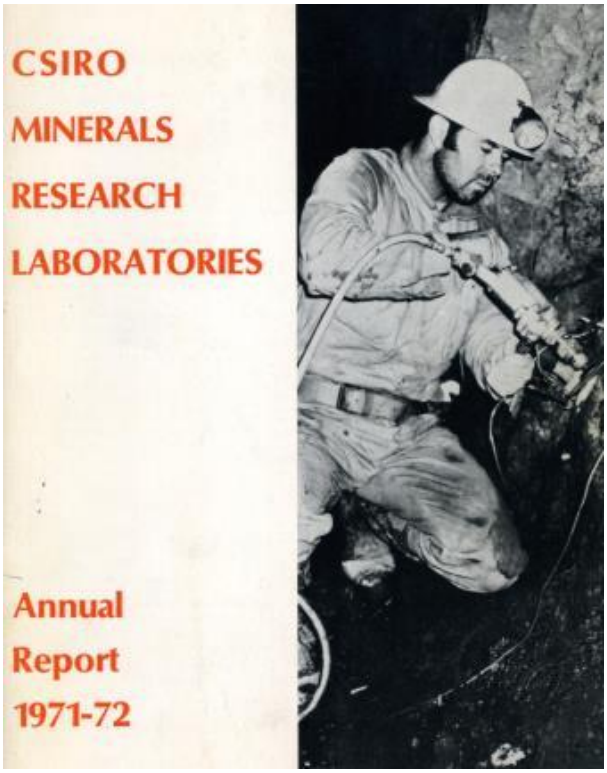
More on Nickel Research.

Some sort of collaboration was under way with Western Mining Corporation (WMC). Roy Woodall was their exploration/mining geology manager (or something like that). (Roy and his son had their picture in the paper the other day as big in their own uranium company.) A diamond drill core from the Lunnon shoot at Kambalda that traversed down through the hanging wall, on through the disseminated ore and massive ore into the footwall basalt, was sent down to Russell Hudson so that he could look at the nickel ore material. Jack Halberg got a look at it and made a quick and accurate assessment of the serpentinite with specks of sulphides in the upper part of the core.

A delegation of what was considered to be the nickel sulphide group led by Arthur Gaskin was sent to Kambalda to sort out what the CSIRO studies should be. There was Russell, Jack, Jim, Mike and others, possibly Wilf. Apart from Arthur's sailing as a lone one-armed land yachtsman on a salt lake (Lake Lefroy) in 40 knot winds, the highlight was the meeting to decide the CSIRO work program on the nickel sulphides. This was held at the hotel in the evening, helped by many bottles of red wine and lots of beer. It soon degenerated into a very heated argument between the WMC geologists and the CSIRO geologists. WMC wanted nobody but WMC to look at the hanging wall material. Jim, Arthur and Mike said nothing and the argy-bargy went on well past midnight. Jim was stunned, Mike was very sleepy, and Arthur sat there smiling with a wine glass in his hand that was continually being filled and emptied. The ultimate impasse was reached when Arthur asked if he could say something. The silence gave him an opening and Arthur calmly said directly to the WMC team, "I am the Chief of the CSIRO Division and these scientists answer to me not you." Silence followed and we went off to bed leaving Arthur to check if there was any wine left in any of the bottles.

The next day the research program was sorted quickly and amicably. Mike doesn't remember who was to do what but he does remember that he was to work with Jim to study the supergene alteration of the nickel sulphide ores; he came away thinking, "Wow"!

Col Bennett and Mike went to Kambalda to measure chemical potentials and collect samples from the supergene zones before they were mined out. They were met at Kambalda, not by Jim Ross of WMC but by Bruce Robinson of no attachment at all. Bruce had driven up just to join in. Mike was bewildered; Jim Ross was perplexed and he decided to treat Bruce as if he was one of the CSIRO group, giving him a room and fitting him out with hardhat, boots etc. Bruce tagged along carrying his camera. He was the unofficial photographer producing a set of excellent photos of Col and Mike having the time of their lives. One of these photos was cropped so that Mike was no longer in it before being enlarged, printed and used as a feature of a display in the foyer of the minerals building. It was also on the front cover of the Minerals Research Laboratories, Annual Report:



Colin has the enlarged photo from the foyer displayed in his office at home. Another of Bruce's photos made it into the MRL Annual Report.

Increasing Staff Numbers.

After the Kambalda trip, Mike was introduced to Ernie Nickel who had arrived while the group was away. Colin and Mike had samples of the supergene profile of the Lunnon, Durkin and Otter shoots and offered Ernie the opportunity to sample them hoping that he would become interested. Mike's office was remarkably tidy at the time and the samples were laid out on the office bench. Ernie dug into them with hammer, pick and spike. In a day or so the office was grit and dust. Ernie was away with high excitement. In the following weeks he had discovered many rare and unique minerals in those samples and Mike now had two Gurus: Jim, who was an absolute Christian, and Ernie the absolute atheist. Both of them loved to play bridge.

Bill Barker and John Taplin transferred over from the East, and Charles Butt was appointed from the UK. The group now included a genuine "geochemist" as well as the mixture of geologists, physicists and chemists. Brian Martin departed to take up another career and Jack Drysdale moved to Queensland University. The headquarters of the Division of Mineralogy was now in Perth. Des Baccini was administrative officer and Arthur Gaskin was in the process of moving to Perth.

The most useful person to be appointed was Colin Steel and his "Dr Martin's" colour slides gave the group a spectacular edge at all conferences that they attended.

Arzen Gedeon arrived to work with Charles; and Alan Mann was enticed back to WA after a period at Flinders University in South Australia. At some stage Arthur had said to Wilf "Who is this Robinson character who hangs around here all the time?" Wilf mumbled a reply, and then heard Arthur say "Well we had better find him some money for him." Bruce Robinson was on the payroll!

Riding on the Slow-Train.

Ivan Newnham got heavy and told all the Research Scientists and anybody more senior in the MRL that they were to travel to North Ryde in NSW to join in a talkfest. As a sweetener the group negotiated travel by rail. When the train stopped the football came out and it was kicking and brawling on whatever area of dirt was not too far from the railway. On the train the bridge was non-stop, except for meals.

The bridge group was Ernie, Des, Jack and Russell.

Alan Mann, Charles Butt and Bill as tourists at what could be Port Augusta?

Mike claims to remember nothing of the talkfest, but does recall a memorable Sydney Harbor evening cruise and a visit by the WA contingent to a Kings Cross strip club. Jack Halberg insisted that we all trained for rugby at a nearby field.

Jack, Charles, Alan Mann and the TCP legs at another station.

Tourists again: Russell Hudson, Des, Jack, Ernie, Bill and Alan Mann plus two unknowns lighting a fag.

Some of the More Important Activities.

Rob Hill joined the group late in 1973 and the workshop must have taken on Terry Harrison and Brian Alsworth around that time. Annual Reports recorded work on ore genesis, nickel mineralisation, sulphides, exploration geochemistry and mineral structures. What was actually done was sure to fit in there somewhere, such was the non-specific nature of these reports. Ray Smith arrived, but it was his wife, Kerry, who made the bigger impact at the CSIRO ball at that time. Mike recalls that the main project for Rob Hill, Alan Mann, Russell Hudson and Ron Couper was the floating sinker or "Flinker". Most of these were cast into the Indian Ocean, never to be seen again. Green ginger wine was blamed. Ross Andrew was another fisherman.

Bob Rummery, Alan Mann, Russ, Rob and Ernie formed a bush band that was appreciated by everybody that did not have a sensitive ear for music.

The installation of a turf cricket pitch was a major leap forward and this allowed the team to attract regular opposition keen to play on it. The team included Russell Hudson, keeping wickets, Alan Mann and his dickey knee, Charles Butt with his steady bowling, TC and his 'bean ball' bowling, Don Bell's spin bowling, Terry Harrison's unpredictable performances and Des Baccini with his all-round ability. Other Divisions also provided many legendary players. All this was held together by the superb scoring, recording and publishing of John Perdrix.

At about this time regular gatherings at the Floreat Hotel after work on Fridays were most memorable and exciting. TC would produce the latest publications on the implications of plate tectonics, seafloor spreading, etc. Mike says that he would listen in wonder, and drink as the consequences of these new ideas gradually sank in. He now takes part in passing on this information to children aged 9 to 11 at the local primary school.

Were We Doing any Work?

Alan Fletcher was synthesising single crystals of pyrrhotite and diffusing nickel into them. This was a remarkable achievement using methods that he and Mike Bussell developed. The electron microprobe gave a composition profile that allowed nickel diffusion coefficients to be calculated from this polished section through the best crystal that was several mm across.

*In punching this into the computer it has been difficult to remember everybody. In this regard the 1976-77 Minerals Research Laboratories, Annual report gives a staff-list showing a good indication of their research study interests. Here it is in alphabetical order; those names with a * appear for the first time as being part of the WA team:*

Eric Atkins* – Electronic equipment development.

Bill Barker – Crystal chemistry and phase equilibria in Ni-Fe-S system.

Col Bennett – Magnetic balance; rock permeability.

Mike Bussell – Alteration of nickel sulphide ores; hydrothermal synthesis of minerals, basketball and social club finance.

Charles Butt – Geochemical exploration; lateritization.

Peter Darragh* – Assessment and treatment of industrial minerals.

Ted Davis – Analytical procedures.

Rex Deutscher* – Electrochemical studies of metals in groundwaters.

Wilf Ewers – Officer-in-Charge; distribution of phosphorous in iron ores and banded iron formations, WA.

Alan Fletcher – Synthesis of sulphide minerals for experimental studies.

Arthur Gaskin – Chief; industrial minerals.

Arzen Gedeon – Analytical procedures.

Jim Graham – Crystal chemistry and magnetic properties of minerals.

Jack Hallberg – Rock geochemistry related to Archaen regional geology.

Rob Hill – Petrological and experimental studies on the occurrence of nickel ores.

Rudi Horwitz* – Paleogeography of Precambrian WA.

Russ Hudson - Geology, petrology and mineralogy of nickel sulphide deposits.

Al Mann – Behaviour of metals in groundwaters.

Dick Morris* - mineralogical, Petrological and microprobe studies of phosphorous in ironores.

Ernie Nickel – Mineralogy of sulpide ore weathering.

Terry Parks – Pore systems in rocks and their metasomatism.

Beta Bruce Robinson – X-ray diffraction, computer interfacing of electron microprobe and analytical facilities: information services and night shift operator.

Ray Smith – Geochemical exploration techniques – land-form zoning, pathfinder element dispersion and remote sensing.

John Taplin – Kinetic studies in rock-fluid interactions and election voting systems.

Mike Thornber – Experimental studies of the weathering of ores.

John Wildman – Preparation of iron oxides for weathering research and "Eyes and Ears" of the Building.

There was also a complete list of staff and for those not listed above are now listed with a suggestion based on unreliable memory as to their role in the events of the time.

John Atkinson – Boss of keeping the site running assisted by Tony Fitzgerald.

Bill Bouwer and Tony Bowyer* - Polishing rock samples for microscopic examination

Ron Couper, Brian Alsworth, Terry Harrison and Mark Dyson*– Produced impossible equipment that kept most of the researchers happy. (See Ron Couper's report.)

Mike Krencej* , John Crabb* and Charley Pope* – Crushing rocks, storing rock samples, maintaining field vehicles, two way radios, assisting with field trips. John Crabb was especially famous for designing a field toilet and Mike Krencej for telling the world over 2-way Radio how he helped to drive a vehicle in reverse for over 50 km.

Ann Gardner (Howe) and Margot Willing – Analytical chemistry and having fun with Ted Davis.

Mike Hart* – Worked with Charles Butt developing geochemical gas sniffing techniques.

John Perdrix – Worked on Ray Smith's projects, especially the multi element geochemistry.

Phil Shawcross* – Worked with Peter Darragh where he learnt to love gemstones.

Col Steel – Only drafting person until Angelo Vartessi came to give some assistance.

Ric Vigers – Worked on all Jim Graham's equipment to keep it operating with many new inovations.

Peter Wilson* – Worked with Bruce Robinson.

Alan Woodbridge* then Geoff Barnes* – Purchasing officers

Sue Downes* (Hooson) – Administration assistant dealing with Alan Fletcher hiding her trolley.

Doris Leadbetter*, Jenny Smith* and Anne Hepworth* – Library people. Doris dedicated herself to dominating the whole Floreat site. (See Bernadette Waugh's contribution.)

Pat Lawrence* – Arthur Gaskin's personal assistant.

Cheryl Harris (Damion) – Office staff but at some stage help must have arrived with Jenny Porter* then Irene Piercey* and Judy Forbes*.

Keith Symonds* – Known as Keith the carpenter with S.J. Ryan* as an apprentice and Ross Casey* came later.

Olive Drake-Brockman* – Canteen

Don Bell* – Gardner, cricket pitch maintenance, bowling green maintenance and participating in all sports.

Norm Jervis* – Caretaker, cat and dog owner.

Paul Richardson* – Appointed to work with Dick Morris, he was a quiet, obliging, fine looking lad of 19 years. He had worked with Dick for 9 months when there was tragedy 3rd March 1979 at his elder brother's 21st birthday party. A neighbor, an off-duty security guard,

objected to the noise and shot him dead in the front yard of his home. His mother rushed out and as she bent over her dying son he put another bullet into her, wounding her. The judge gave him 2 years! Here is a quote from Dick Morris: “He was a very quiet, well mannered guy who did some great preparatory and technical work effectively without supervision – all we had to do was to tell him what was needed and it was done quietly and efficiently. We were very lucky to have him as our first technician. What a hell of a waste of a young man’s life by a nutter.”

David Wright* - First worked with Dick Morris and later joined the Ted Davis team.

Pearl Phillips* - Came from the library to work with Dick Morris.

Major Equipment.

The electron microprobe was probably the group’s most successful major scientific tool but the Scanning Electron Microscope that was housed next door was undoubtedly the most useful. It was obtained as the free chuck-out of another division, (a verge pick-up by Beta Bruce Robinson) and modified to operate at low vacuum with an EDAX analyzer that allowed semi-quantitative assay of whatever the electron beam was guided to strike. Ernie Nickel loved it and would get in first thing and fire it up. The rule was that we could use it without supervision at any time but if it broke we were not to fix it.

The other item of equipment was Ray Smith’s giant baby and Arzen Gedeon’s torment. The giant size ICP chemical assay machine that was to assay 40 elements in a flash down to parts per million level. It was supposed to handle so many samples that a battalion of workers would be needed to prepare these samples. Only Valda Garcarkles was hired to do the work of sample preparation. Terry Harrison had a near full time job trying to switch it on. Arzen kept the workshop busy making modifications to the nebulizer system. The machine did its best work when John Wildman was co-opted by Arthur Gaskin to work on it. This machine was so large that it needed a new building to house it. These days ICP is the preferred method of chemical assay by a machine that sits on a laboratory bench with a single operator.

DIVISION OF MINERALOGY RESEARCH REVIEWS of 1983 and 1985.

The division produced two book form reviews of their research work that was current in 1983 and again in 1985. (CSIRO, Division of Mineralogy, RESEARCH REVIEW 1983 and CSIRO, Division of Mineralogy, RESEARCH REVIEW 1985). A very reliable library source says that these two documents provided material that was the most requested for copies by interlibrary loan of any of our publications. They were most popular with external users. Compare this to the glossy publicity reports of the later years that ended as expensive rubbish. Consulting these reviews will give a more accurate indication of who was doing what at this time. New names such as Martin Gole, Mel Lintern and Ari van Riessen appear in the contents pages.

The death of Arthur Gaskin in October 1983, and the retirement of Wilf Ewers marked the end of the “early days” of CSIRO minerals research in the west. The days, months, years and decades that followed were so chaotic and confusing that they defy further reporting. The only institution that has remained constant is the golf day for all minerals staff that was introduced by Wilf in the early 1970s.

In conclusion it can be said that those early times were most enjoyable and rewarding thanks to the skill and personalities of those who worked together as a great team. It is worth noting that at the time of writing this was 50 years since the minerals research in CSIRO commenced in WA.

BERNADETTE WAUGH[27] (1985 to 2007)

I was appointed as the fourth WA CSIRO Laboratories Librarian in May 1985 following in the footsteps of three well respected and noteworthy predecessors: Jean Kahn, Doris Leadbetter (nee Hudson) and Margaret Redman. Jean Kahn managed the library in the early days when it was located at the University of Western Australia. She was assisted by Sue Hicks and Kay Manning. Doris commenced at the UWA campus and was the first librarian at the Floreat laboratories after they were established in 1966. She made a lasting impression with her larger than life personality and wit. Many a scientist was wary of being on the receiving end of one of her famous Christmas awards. Linley Thornber who was at CSIRO when Doris was Librarian remembers going to Doris' wedding when she married an ex-Jesuit, Richard Leadbetter. Doris had made her own wedding dress out of green and white striped regency fabric. The reception was held at her home in Nedlands which was quite small with a lot of people shoulder to shoulder. There was no food but lots of sherry.

When Doris transferred to Canberra, Margaret Redman took over. These were difficult times as budgets were slashed and staff numbers reduced. Scientists bemoaned the fact that they no longer received personalised circulation services with young library assistants collecting overdue books from their desks. Staff numbers dwindled. Margaret resigned in 1984 when she married and moved east. She played a significant part in the establishment of the library at the School of Mines in Kalgoorlie, being the consultant librarian. Anthony (Tony) Evans, who started working in the Library in 1981, was acting Librarian following Margaret's resignation until my appointment in May 1985.

Tony Evans, Linley Thornber and Margaret Redman at the opening of the Library store (about 1983)

I still remember the day I went for my job interview. I arrived early and registered at the front desk then waited anxiously to be called by the interview panel. Time went on well past the scheduled interview time as I waited patiently, people coming and going through reception. Finally, nearly an hour after my arrival, the chair of the Library Committee, Ernie Nickel, came to the desk and asked where the hell the next interviewee was. Apparently there had been a mix up and they were unaware I had been waiting in reception. They were quite ready to record a black mark straight away for my tardiness. However, I got the job. The panel consisted of Ernie Nickel, Russell Hudson, Acting Chief of Exploration and Mining, Ben Rodgers, in charge of Administration for the Division and Peter Russell, standing in for

[27] Contributed by Bernadette Waugh

the Chief Librarian Peter Dawe. I had applied for the job because it had always seemed like the ideal position where I could use my science background and librarian training.

I had graduated as a Geologist from UWA and worked in the profession for four years before resigning to bring up a family, as was the custom in those days. The combined role of a mother and geologist was not possible then, so I did a post-graduate course in librarianship and worked part-time for architects, engineers and scientists until my children were sufficiently independent and I could seek full-time employment. I needed a push from family and friends to apply for the job as I was happy working where I was but, in retrospect, it was one of the best decisions of my life. CSIRO was a great place to work, the library was, what we call in the profession, a 'Special Library', with all the advantages of being closely aligned to the role of the organisation but at the same time having the advantages of a university library, serving researchers and with the resources to provide cutting edge information technology. It was a time of enormous change, structural within the organization and technological as we moved to greater use of computers and the Internet which made it a stimulating and challenging time to be Senior CSIRO Librarian in WA.

Peter Dawe (centre back) with members of the Library Committee (Norm Adams, Duncan Macpherson, Ernie Nickel and James Ridsdill-Smith) and Library staff (Tony Evans, Beryl Connors, Linley Thornber and Bernadette Waugh) in 1986 in the "temporary" Library located in a large transportable building currently used as the Library store known as "Brocky".

I was made to feel welcome from day one. Ernie Nickel as Library Committee Chair could not have been kinder in always taking me down to morning tea to meet the researchers. There was no better way to find out what people were doing. The two Chiefs on Site at the time, Russell Hudson and Ray Perry were also very supportive and made sure I was introduced to staff in their Divisions. Jack Brophy, Regional Administrative Officer, made sure I was included at Senior Management level at meetings; something that did not always happen after the Regional Administrative Office ceased to exist because the Library, while it served all the Divisions, did not officially belong to any of them being a Site service. For this reason it was easy to get overlooked when management meetings were held and changes planned for the Site. Peter Dawe, the Chief Librarian at the time invited me to Melbourne to introduce me to the CSIRO Central Library and the wider CSIRO library network and culture. I was rather surprised that he devoted a significant amount of time explaining the history of the CSIRO Library. I was more interested in current developments and the future. However, in retrospect this was an important part of my initiation as I learnt that the culture and history of an organization like CSIRO are important to understanding the structure and politics.

The Floreat Library is a Site Library serving several Divisions, primarily located at the Floreat site though this varied over time as Divisions restructured and moved to and from Floreat. Because the library served from 9 to 12 Divisions over the 21 years I was in charge, the collection was necessarily multi-disciplinary ranging from Entomology, Forestry, Agricultural and Environmental Sciences to Mineral Processing and Exploration. Only the Black

Mountain library had a larger more comprehensive collection. This diversity made it difficult to be an expert in all areas of the collection, something I regretted but fortunately I had the help of scientists and the Library Committee to help in suggesting additions and withdrawals from the collection.

All CSIRO libraries belong to the CSIRO Library Network and, in the early days this was controlled, financed and managed centrally. In 1988 Pappas, Carter Evans and Koop (PCEK) conducted a review of CSIRO's Corporate Services including the Bureau of Information Services which incorporated Library Services. As a result the role of Central Services was diminished and responsibility was devolved to Divisions.

At Floreat, all Divisions on site shared responsibility for Site Services which included the Library and were responsible for financing its staff, operation and resources. The budget was financed based primarily on per capita costs though the cost of serials was shared on an agreed-to basis resulting in a good deal of negotiation and bargaining each year. It meant that the Library had to closely relate to the needs of the users and prove its value to survive. When budgets were tight, tensions would rise over which Division paid what percentage of the cost for multi- disciplinary serials.

Chemical Abstracts was a particularly expensive serial (over $30,000 a year) and even a 1% share was begrudged by some groups who only had a marginal interest and limited budgets. Divisions that were left with the bulk of the cost threatened to have a sentry near the shelves to police who used the Abstracts! Negotiations took a lot of diplomacy and each service had to be clearly justified. There was a Library Committee, with representatives from each of the Divisions, who provided advice and support and were invaluable in these negotiations. By 2000 the situation had turned a full circle and a centralized model for library management was being proposed once again. Libraries had become affiliated with the Information Technology services where a centralized model was considered more effective to ensure standardization of services across CSIRO. By 2006 all library staff reported to corporate managers and library budgets were, once again, centrally managed and controlled.

Over the 21 years that I was Librarian at CSIRO in WA, change was constant. Structural change seemed to be a daily occurrence. Not only within the Library Network where we went from central to devolved and back to central but also at the Divisional level with splits and amalgamations and numerous changes in direction and name. This had direct impact on the library with collections having to adapt to reflect changing needs and even full scale transfer of collections as Divisions moved on and off site. In 1986 the entire library moved to temporary premises on the site while a new library was built at Floreat.

The Floreat Library vacated and the store is demolished in 1986. The library occupied a transportable building for 2 years until the new current library was opened in 1988. Work goes on for the Librarian, Bernadette Waugh. (As published in Coresearch)

New libraries were established at Kensington (Exploration and Mining and Petroleum) and Waterford (Mineral Processing) and branch libraries at Helena Valley (Wildlife and Ecology) and Marmion (Fisheries) moved to Floreat and were amalgamated with the collection there. We became experts at moving and relocating collections. These were exciting times and I enjoyed the planning and involvement in these changes. Management was always appreciative of library services and keen to ensure that a good level of service was maintained. To that end the library ran focus groups, surveys and workshops to find out what users wanted and needed.

I remember that in November 1988, following the PCEK review, we held a seminar at Floreat to help us plan library services to reflect user needs into the future. We called the seminar and workshop: Business, Books and Boffins (a name suggested by one of the then Library Committee, Duncan MacPherson) and involved the whole site, seeking people's views on four key areas of change at the time: devolution, technology, finances and the move to consulting and external funding. Many of the recommendations were not only adopted at Floreat but throughout the CSIRO Network as predicted outcomes came into effect.

Change was intense in the area of technology. In 1985, the Library had one “dumb” computer terminal that was connected to CSIRONet and was used to catalogue books to a central database as well as to search online databases on commercial networks like Dialog and STN. Personal computers were a new innovation and I recall getting somewhat impatient that it took several months to get one approved and operational in the library. I was accustomed to working in industry where things happened quicker without government bureaucracy - I had to learn patience.

Sir Charles and Lady Court visiting a display and demonstration of our Floreat Library and CSIRO’s online database Australis at an exhibition held at the State Library of WA in 1987. In the background are the nice graphics prepared by Anne McKenzie of CSIRO Division of Groundwater at the time.

By the time I retired in 2007, the library was fully automated with public online access terminals, user access to online catalogues and databases and electronic journals and books. Scientists no longer had to wait weeks for interlibrary loans but could expect copies of articles to be delivered to their desktops within 24 hours. Staff in the Library was always focused on user service and were keen to adopt new systems where they might improve services. Linley Thornber, as our Library Officer, quickly adopted new and faster methods of

delivering interlibrary loans and Tony Evans, as cataloguer, worked consistently to move all our catalogue records from cards to electronic format. The Internet was an amazing benefit to research libraries like ours.

Corporate Information Services in CSIRO were always keen to be at the forefront of new developments and technology that could benefit our researchers and I always found them very proactive in helping enable access to useful resources providing we had done our homework and could justify expenditure. I enjoyed being on Corporate teams set up to test and evaluate online resources. One particular achievement I feel proud of was the part I played in CSIRO being the first library network in Australia to provide access to the ISI Web of Science to our clients. In 1997 the ISI Citation Indexes had recently become available to scientists via the ISI Web of Science. The Library Committee put access to these databases high on their priority list for researchers. After testing the database, I wrote a submission with recommendations to the Corporate Centre. Negotiations with ISI were successful and CSIRO became the first Research Organisation in Australia, before the universities, to provide online access to the Web of Science.

Citations are a key measure of the quality and impact of research and the citation indexes are now one of the main tools used to measure research quality by academic institutions and by funding bodies. Purchasing resources was never easy. Unfortunately finances were always an issue as these were times of economic restraint and accountability. A lot of negotiation between Corporate and Divisions was needed to decide who would pay for what. Our own Library Budget was financed by all Divisions on site as mentioned before. The smaller Divisions in particular had very limited budgets and needed to know they were getting their money's worth before being prepared to contribute to any library resources. Fortunately they must have been relatively happy with the service as we usually managed to get our annual budget approved by the Site Committee though it was a harrowing time each year. I was always aware that once the budget was approved we had very little chance of getting additional resources during the year so we planned carefully and didn't over spend.

The Library was a team and I was lucky to have the support of good staff with a mixture of skills and personalities who all gave of their best. In 1993 I was presented with the "Special Librarian of the Year Award" by the Australian Library Association WA Branch but could not have achieved this without the support and backing of my staff.

WA Specials Award

Bernadette Waugh: 1993 WA Special Librarian of the Year

WA Specials held a successful dinner late last year to celebrate the presentation of the Award of WA Special Librarian of the Year. The 1993 recipient is Bernadette Waugh from CSIRO library.

The award is made to a Special Librarian who has made an outstanding contribution to the library profession. The criteria for the Award include a willingness to share professional expertise and participate in informal and informal networking activities; evidence of good management practices, and demonstration of successful promotion of the Library/Information Service within the parent organisation.

The award consists of a perpetual trophy, an individual trophy and a book voucher. It was presented by the sponsor, Roger Stanton (RAECO, WA Area Manager) and Irene Nutt (President, ALIA Special Libraries Section, WA). ■

(from left) Roger Stanton (RAECO), Bernadette Waugh & Irene Nutt

From Incite: the news magazine of the Library and Information Management Association 15(2), p.20, 1994)

There was never a large staff turnover. Tony Evans, the Assistant Librarian and Linley Thornber, the Library Officer/Technician, were with us nearly the whole 21 years I was there with Linley retiring just 2 years before me. Both had been there before I commenced, Linley having worked part-time in the Library since 1979. Tony was a laid back personality, chief cataloguer for most of the time. He didn't venture much out of the Library during working hours except to purchase lunch from the canteen. Linley, the dependable one, placid and reliable, was hard to ruffle. The only time I ever saw her off the planet was the day she first became a grandparent when her son's wife gave birth to twin girls. In 1995 we were very proud of the fact that Lin won the National Library Technician of the Year award for her "outstanding contribution to the advancement of library technicians and her personal contribution to the development of library services".

We also had 3 Library Assistants over the years. The first was Beryl Connors, a real lady, methodical and caring. When Beryl retired, Peta Beasley was appointed and the reputation of the library as a social gathering place flourished. Peta broadened her role by assisting researchers to compile bibliographies, in particular she assisted John Scott in Entomology in the compilation of a significant bibliography on Asparagus Weed. When Peta left to go to greener pastures, Jane Fletcher was appointed. Jane later became Jane Pollock when she married one of our young researchers in Land and Water. It must have seemed that we often had a lot of staff in the library but mostly the others were either temporary staff appointed for a short time to complete a specific task or library students on practicum experience of whom we had more than 50 over the years. Two temporary staff who stayed with us longer than most included Carol Newton-Smith and Kandace Horton. Carol worked with us for a year while Tony was on long service leave. Carol loved a new challenge and was one of the most organized people I have ever met. Kandace maintained our library website having shown an aptitude for this when on her practicum. When the library expanded to service the mining and exploration and other Divisions off site, new librarians were appointed including Evalyn Beaumont (Minerals), Julie McInerney (Geomechanics) Beth Allen (Wildlife & Ecology), Mari Sell and Sue Cook (ARRC) all of whom served the Divisions as local Librarians at various times.

A family affair: the Library team and relatives helping to stack the shelves in the new ARRC Library 2000?. Standing: Russell Waugh, Tony Evans, Jane Pollock and her parents, Mari Sell and seated: Bernadette Waugh, Linley Thornber and Mike Thornber.

It was quite a challenge to keep up with new developments and the changing role of librarians. I had always believed that the aim of the library was to provide our scientists with

the published information they needed, when they needed it, to do their research and the format of the information was not as important as the access, so the change to electronic media was never a problem, and in many ways, was a boon as it meant faster access and scientists could have the information delivered to desk tops no matter where they were, theoretically at least. A downside was that many scientists no longer had to physically come down to the library and they wondered what we did all day now that "everything was on the web". They never stopped to wonder how it got there. An enormous amount of time was spent evaluating resources and then negotiating with vendors for a good deal. Publishers were not inclined to lose out on profits and hence charged high costs and had very strict access and copyright regulations. Librarians had to become much more aware of their legal obligations and to implement measures so that we couldn't be sued for illegal use. The days of the printed book on the shelf were so much easier.

The world of information became a lot more complex as we helped our users navigate through a maze of information. Regular user training sessions had to be held not just at orientation but on an on-going basis. Scientist's expectations and needs changed over the years as they had to rely more on money from external sources. This meant shorter deadlines and more demands on library staff for quicker access to information.

The Library Committee was originally set up as an advisory committee to assist the librarian in assuring the library reflected the needs and requirements of Divisions and it played an invaluable role in keeping us aware of new research directions and changing needs. The Committee usually comprised 4 or 5 senior scientists who represented the interests of one or more Divisions. A chair was appointed and the committee met 4 or 5 times a year. The Chairman was always the representative from the Division to which Library staff were attached for administrative purposes. This was originally Exploration & Mining and Ernie Nickel was the first Chairman followed by Charles Butt and Steve Barnes. Library staff moved from Exploration and Mining to Land and Water when it was decided that the mining Divisions would relocate to Kensington. Geoff Syme then took over the role of Chairman. I personally found the Committee a great support; they were unstinting in providing advice and guidance so important in the planning and administration of services and were always available to assist when I would drop by with a question. They said they enjoyed the quarterly meetings we had but I secretly believe it was the chocolate cake we provided.

Zan Mazenac and Shirley Winstanley exchange views at an art display

Staff always endeavored to make the Library a good place to be, not just a repository for books but a place to meet and exchange information, a kind of social hub: a place where users could feel welcome and could interchange ideas with people from other Divisions. To this end we held a number of social gatherings like art displays where we served wine and

cheese. The art we displayed was created by our own scientists and support staff and I was always amazed at the breadth of artistic talent on site given that it was a scientific organisation. For example, artists like Zan Mazanec, Frank Hingston, Ray Smith and Shirley Winstanley all displayed paintings, then there was sculpture, photography, woodwork, bonsai and various other art forms.

Other outreach services the library provided included training sessions with morning tea held out in Divisions. Where possible and time permitted, library staff attended Divisional meetings and seminars and joined in Divisional activities so that the library could be seen as an integral part of all activities on site. One experience I will never forget was my participation in a team building workshop arranged by Bruce Hobbs when he was Chief of the Division of Exploration and Mining. We travelled to the North West and I was with a team of 6, comprising geologists and technicians who were let lose for 6 days in uncharted territory in the middle of the Kimberley. Among other challenges we had to cross a crocodile infested stream in a raft we built ourselves. Needless to say it was a traumatic experience for me as I wasn't used to carrying my worldly processions on my back and sleeping out in the wild but I survived and I learnt a lot about myself and working in a team.

The "Billion Years" Team: Andrew Bistow, Russell Mason. Peter Nicolay, David Robertson, Bernadette Waugh and Sheng Yu, in "the Black Pig", our raft, constructed from a trailer, traversing the crocodile invested river at Galeru Gorge.

Our library was part of the wider CCIRO Library Network which comprised all the Divisional and Site libraries in CSIRO. In particular we belonged to the Remote group which included most of the libraries that were not in Melbourne, Sydney and Brisbane.

The "Remote" librarians gathered at a Library Conference in 200?. Standing: Evalyn Beaumont. Rob Bickford, Tony Evans, Ilma Lo Iacono, Denis Abbott, Linley Thornber. Seated: Bernadette Waugh, Gillian McNaughton ??, Michelle Gacca?, Fiona Painting? and Leanne Griffiths

The CSIRO Library Network with John Stocker the CSIRO CEO in 199?

It was a tremendous advantage being part of this wider network as we could share knowledge and resources and it meant we had a lot more clout when negotiating with publishers to purchase electronic resources and serials. I enjoyed being part of National Committees, Working Groups and Library Reviews which provided me an opportunity to develop professional skills and where I made some lasting and valued friendships. In 2004 I was appointed by the Network to be their representative on the One Information Services Steering Committee which was a challenge but a great honour though I did feel in retrospect that a lot of the hard work and gathering comments and opinions and recommendations from the network went unheeded as the journey of the ship of change for Information Services was predetermined and all of our recommendations had little impact on the outcome. Our biggest concern had been that changes did not result in a drop in services. I fear that outcomes of the review made it a lot less possible to retain the close working relationship

that we always aimed for with our local scientists and library users as more services were centralized and library staff reported to managers who were often a long way away. Maybe I retired at the right time in 2007 as I would have missed the diminished local role.

I always considered that I was very lucky to be a Librarian at CSIRO, not only was it stimulating to be working for researchers at the cutting edge of science but also because the work was especially challenging and exciting at a time of enormous structural, technological, social and economic change. I was lucky to work with really nice people with many different characters and personalities, cultural backgrounds and areas of interest. It was always a thrill to have a researcher acknowledge the help we provided in writing that final report, wining that grant, submitting that patent or just fostering a new research idea.

As part of my job I was to travel East and to be involved at the Corporate level on various planning Committees and I even travelled overseas to the UK and Prague on a couple of occasions to attend International Conferences and bring back new ideas and technologies for assisting in assessing information. When I retired in 2007 I knew that while librarianship was not my career of first choice, it turned out to be the most rewarding.

PETER YENDLE[28] (1973 to 1985)

Peter Yendle applied for a position in the catchment salinity program only a few days after arriving in Perth from London where he had worked with British Telecom. His experience in electronics and outside work was what we were seeking, and within a few days of starting with CSIRO he was being escorted around the experimental catchments in areas of State Forest east and west of Collie in the southwest of WA.

Peter was equipped with a van, light motor bike (to minimize impacts of traffic on the catchment natural forest vegetation), a neutron moisture meter, and other items. His role in the field was to visit the catchments every month to measure water levels and quality in around 100 monitor bores, rainfall in 25 storage gauges (and bring back water samples for chemical analyses), and soil moisture in 75 access tubes. He also maintained local contact with staff of the Forests Department to ensure that instruments were protected from damage during control burns, logging operations etc, and that our access to the forest did not contribute to the spread of die-back disease.

In those days, Peter travelled alone, and he had no radio contact when in the bush 20 or 30 km from Collie. On one visit, he was bitten by a red-back spider that had camped under the seat of his motorbike, and he had to drive himself into Collie hospital. In his words, it had just about stopped hurting by the time he got to hospital! On another occasion, he described hearing a noise behind him as he operated the neutron moisture meter, and turned to find a small feral pig nosing about. He took some action to frighten the pig away, but then saw the very much larger mother pig, at which time Peter decided to retreat to the safety of his van!

Peter played a vital role in ensuring the accuracy of data collection throughout the period of CSIRO's 10-year experimental catchment program. Some of his recollections of his adventures follow:

"In those days we played very hard, so it was only fair that we worked hard. The *routines* as they were called, started very early on Monday morning. I used to leave home about 4am, idea being to get to Del Park by sunrise and I had many interesting trips in the dark. One trip I had turned onto the South West Highway only to see two horses running towards me on my side of the road. A blink of the eye and they were gone. Lucky there were not four, or I might have moved to the other side. The four horsemen of the Acropolis, when you see the fourth, your gone. I do not know to this day if it was my imagination, or they were real. Another trip the local baker got in way of the Toyota, I guess his bread was late that day.

On one very rainy morning in the dark someone had stolen a grader on Del Park road and parked it across the road in the dip. Only just missed it, not so lucky was the Water Authority ranger who came along as I was backing out of the bush. Anyway, I made it to the gauging station always, and set up. I think from memory, there were about ninety bores and a couple of rain gauges. The site was divided up into three in my brain, so I set off on the trail bike to read about twenty-five to thirty bores at a time before coming back to the Toyota to have something to eat and then do the next thirty or so. One of my passions of the day was Marron, and just down stream from the gauging station was a pool with lots of cover, ideal to hang drop nets off. I had done it many times and got a good feed of size marrons. Only problem, not supposed to fish in water catchment areas and they have rangers like the one who hit the grader. I came back to the Toyota one time to find my nets neatly hanging on the rear door and a note which we will not go into here. Anyhow, the day used to finish about four or five in the afternoon, then there were two options, stay in the community hotel in Dwellingup, or push onto Collie through the back way. Only ever stayed in that hotel the once. Used to get to Collie in a couple of hours, nip into the lab and get set up for the eastern catchments next day, then off to Workers club for a beer or two.

[28] As recalled by Adrian Peck and Peter Yendle

Not much ever happened on the eastern side, apart from getting bogged, and getting bogged, and getting bogged. I had a few problems with wild pigs and pig hunters, but normally solved with the shotgun. I used to work through the weekends in those days, and sometimes later in the time frame John Marshall and Dave Briegel would spend two weeks blowing trees away with their shotgun. Being of Scottish heritage, they camped out on Dons catchment, so on Sunday morning I would take them out Saturday's paper. As you most likely remember, Collie was a day behind the rest of WA, so Saturday's paper got to Collie about midday, Sundays or Monday. Anyway, used to take John and Dave a paper to read on Sunday, normally got their about seven am. On the track up to their camp I could smell something very very bad. As most people know Collie on a Saturday night is one long session at the bar or pool table and one can feel quiet seedy next morning. The smell was getting worse. As I got out of the Toyota to deliver the paper the urge to throw up became paramount, catchment or no catchment. John was cooking Kippers!.

Another, time I was packing up for the day on Dons and could hear the sounds of a guitar and some singing. We are some thirty Ks from anyone, have I finally gone over edge. No, it was just John and Dave singing to each other.

The western catchments brought more trouble for me than the eastern three. Wights was always wet and boggy, but when cleared was a nightmare in winter and later years as wet areas became bottomless pits of mud even in summer, I seemed to spend countless hours pulling sheep and horses out of the mire. In the early days we used a kombi van, with the motorbike on a rack on the back. Only VW could build such a heap. Already heavy on the rear, we had to put a motorcycle on the back to make it worse. Drove like a dog. One day the trail bike was giving trouble, clutch slipping. No problem, only had to finish reading the wells and the bike was not needed any more, could get back to Perth and get it fixed. With three wells to go the clutch gave up. No problem, walk the rest, go get the kombi, pick up the bike and go back to Collie. Picked up the bike, reversed up the track to a point where I could turn around. Bogged again, and no way of getting it out without a winch. The time is 6pm, the workers club shuts at 11.00pm, 18 km's should take about four hours or so, its a nice night for a walk. I got the workers club at 10.05, did not see one car on the road in that four hours.

One very funny time was on Ernies catchment. There were Colin Johnson, Jeff Turner, myself and another person whose name escapes me. We arrived at the site early in the morning because we had to pull the augers and set up again a few metres away. It was the middle of summer and very hot. We had borrowed Wally's fridge, it being bigger than mine [more room for beer], and being hot our scientist used his brain to pull the fridge out of vehicle and put it in the shade under the drilling rig, in fact, in front of the duel wheels. Remember, first job, pull augers and move rig. Goodbye fridge and cold drinks for the day.

Then there were the Christmas parties at Deakin St. Dennis Hurle is lucky to be alive. Fast asleep, or out cold, on the grass late at night, only to be woken buy the wheel of a Range Rover inches from his head. The nurses, won't go there. Wednesday nights playing in the snooker tournaments at the workers club, being driven home by my partner for the night, the local police sergeant, and picked up at six next morning and taken back to the Toyota. They were the days. I was not back in Perth too often, infact I think Collie was my home. But the odd Friday I was there was spent at the Pumphouse with Dennis and Maurice Height drinking cider, or over the Floreat, drinking again."

3. PROGRAMS

ENTOMOLOGY IN THE WEST [29]

The Division of Entomology

The Division of Entomology has a long history both in WA and in CSIRO. As the Division of Economic Entomology, it was one of the founding Divisions of the then CSIR in 1927. The headquarters of the Division and its recent successor, CSIRO Ecosystem Sciences remain in the original CSIR building at Black Mountain in Canberra. It became the Division of Entomology when CSIR became CSIRO in 1949, and is one of the very few Divisions to effectively not have a change of name or charter until its amalgamation with other Divisions to become CES in 2011, having maintained its discipline focus for close to 85 years.

Entomology has always been a substantial Division in CSIRO, with a broad national and global reach of laboratories and field stations - largely because of its long history in biological control. Although one of the smallest of Divisional regional groups based in WA, it has been continuously represented in WA almost since the beginning of CSIRO.

Pasture Entomology in WA

Dick Norris, who later went on to become Assistant Chief, joined the Division of Economic Entomology as a temporary Research Officer on 31 May 1937 to inaugurate the Division's presence in WA. This was after completing a project on red-legged earth mite population ecology with a Hackett Scholarship at the University of Western Australia, and by request of the WA Advisory Committee of CSIRO. He worked mostly at Katanning and his work described the seasonal occurrence and abundance of the mite, the summer aestivation and the damage it did to seed production of sub clovers in the spring. All this work has provided an excellent basis for later work.

In January 1942 he transferred to Canberra to work on wool pests, and in April 1946 Murray Wallace was appointed to the position of Assistant Research Officer in the CSIRO Division of Economic Entomology in Perth. His work was on red-legged earth mite (RLEM) at Katanning. Firstly he looked at the effectiveness of (then new) organochlorine chemicals (notably DDT, the 'miracle' insecticide to come out of WWII) to control RLEM and pasture pests in general. In 1949-1950 he went to Cambridge University to work with Vincent Wigglesworth, the eminent insect physiologist but he returned without completing a PhD. Stories indicate that too much enthusiasm for cricket and tennis contributed to this. On his return he carried out work on the biology, ecology and control of RLEM, including measuring their impact on pasture production, and work on egg laying and the factors breaking egg diapause, a critical dormancy mechanism for surviving the harsh summer.

Meanwhile, the lustre of the 'miracle' insecticides as cure-alls was beginning to fade amongst professional entomologists, as the limitations of excessive use of residual chemicals with residual action became apparent. This dramatically reached the public domain with the publication of Rachel Carson's 'Silent Spring' in 1962. Research focus in the Division of Entomology changed to become one of the world's foremost centres for the study of insect ecology and biology as a basis for more ecologically-based approaches, with pest 'management' being favoured terminology over 'control', which had overtones of an insecticide-only approach.

Murray Wallace was based for a year in Antibes, France, searching for natural enemies of RLEM and lucerne flea. Limited knowledge of these organisms led him into taxonomic

[29] Prepared by James Ridsdill-Smith and John Matthiessen

studies of mite predators. Murray's assistant for a long period during this ecological and taxonomic work was Alec Mahon who retired in 1977. Murray had further trips in 1967 to France and other countries, particularly in the Mediterranean basin, searching for beneficial species to use in biological control. Predators selected by Murray were successfully introduced to WA pastures but have proven frustratingly slow in spreading.

The 1960's represented the golden age of ecology in the Division of Entomology. Many new appointments were made, particularly from Britain because so few PhDs were awarded in entomology in Australia at that time. The period arguably contributed to recognition of the Division as a global centre of excellence. Murray Wallace was a key Divisional scientist of this period.

Forest Entomology

Zan Mazanec, a Czech-born forester had fled his native country by trekking through the forests with barely anything but the clothes he wore to escape communism. He transferred to WA in the mid 1960's when the Division's Albury forest pests field station closed. Zan studied the ecology of the jarrah leaf miner, a small moth the larvae of which pepper Jarrah leaves with small holes as they feed, and cut out protective cells that fall to the ground and in which the insects pupate. This insect caused major damage to Jarrah and its rapid spread was causing great concern. Zan's diligent studies showed that the thinning of the forest by logging was opening up a less shady habitat and this suppressed the action of a normally rich suite of natural enemies and 'released' jarrah leaf miner into outbreak modes.

Murray Wallace had initiated the Jarrah leaf miner work as a 'side' task from his pasture pests research, and he was pleased when Zan came to WA because it finally added to the professional staff of Entomology here, doubling it in the process. Murray and Zan were ably assisted by Erik Holm and Ken Wright during that period, while Mike Justin was Zan's technical assistant later in the leaf miner work. One of the interesting things about that work was the use of a small-bore 410 gauge shotgun to shoot leaves from the crown of Jarrah trees to obtain leaf samples. Murray was able to obtain such a gun in a pistol-style format, complete with wild-west style leather holster on a low-slung belt, which could be easily used one-handed. Zan's yearly order of thousands of rounds of 410 ammunition was passé at the time but can now be seen as the stuff of legend.

Horticultural Entomology

This period coincided with the opening of the Floreat laboratories and the move from the UWA campus. Soon after, in about 1968, Brian Springett a new PhD graduate from Durham University was appointed to Entomology in WA to work on orchard pest ecology and management. At that time, the Division in Canberra was engaged with the Departments of Agriculture in the eastern states in a large-scale cooperative program of research on pest management in pome fruit orchards (who said CRCs are new?). Codling moth was the main pest that effectively drove the overall control program for all pest insects in pome fruit orchards. Because codling moth does not occur in WA, the idea behind Brian's appointment was that it would allow investigations of pest population dynamics, management and natural enemy activity in a situation not so constrained by a 'key pest'. Brian appointed Lynne Glasson (later Lynne Hayles) as his technical assistant. That work was principally directed at San Jose scale and light brown apple moth ecology.

The 1960's was an era of detailed insect ecological studies on key pests. The 'spray and pray' methodology and heavy broad-spectrum pesticide use was resulting in development of resistance and upsurge in secondary pests because of natural enemy disruption. It was also an era characterised by attempts to use biological tools such as highly specific insect virus diseases as bio-pesticides. One of the first attempts by the Division to use a virus for pest insect control was against the potato moth. This insect was a severe pest that had

developed such high levels of resistance to DDT that chemical control was impossible. WA was chosen for a large-scale field test of the virus as a bio-pesticide and to determine whether self-sustaining epizootics could be induced. The choice of WA was largely because of its warm dry summer potato-growing season that favoured the insect and the regulated potato industry that gave stability for longer-term follow-up studies.

In collaboration with Eric Reed, an insect virologist from Canberra, Brian was responsible for the WA operations of the fieldwork in the Manjimup-Pemberton area. In the 1969/70 summer season of the field trial, John Matthiessen was appointed as a vacation student and was based at Manjimup to carry out the field work and sampling. Following the successful trial, John was appointed to a new full-time position in December 1970. This swelled the ranks of professional staff of Entomology in WA to four.

Continuing the Entomology firearms theme of the time, John found that one of the main mechanisms for spread of the virus across the Manjimup region was by feeding of flocks of silvereyes on virus-infected potato moth larvae. Much sampling of silvereyes using another 410 shotgun revealed dynamic relationships of the intensity of bird feeding with insect density and the capacity to excrete viable virus widely. Interestingly, this period coincided with the first plantings of grape vines in the Margaret River region and the occurrence of silvereyes as a major pest of the ripening grapes, particularly in years when the marri trees flowered poorly – hence the large areas of grapevines now netted during fruit ripening in the region.

For the virus field trial, insect larvae were painstakingly bred in a glasshouse, infected with virus, collected and macerated to make a relatively small amount of a spray-on suspension. We were faced with the need for very large quantities of the virus for efficacy and safety testing if it were ever to become a commercial bio-pesticide. In 1975, with the help of a cooperative grower planting a special crop at Manjimup, the potato moth population was induced early and boosted with glasshouse-reared insects. It was then sprayed with virus at an optimum time. Millions of virus-infected larvae were readily collected, solving the virus supply issue in one operation. This was not developed further, because high cost prevented the full safety and efficacy testing for registration of the virus being carried out, while changed cultural practices and new non-residual insecticides diminished the pest status of the insect.

Dung Beetles and Bush Fly

In 1976, Murray Wallace moved to Canberra to head the CSIRO dung beetle introduction program. In particular, given that Murray was an expert on mites, emphasis was also turned towards investigating whether predatory macrochelid mites, phoretic (riding on) on dung beetles, could be used to complement dung beetles in the biological control of dung-breeding flies. Soon after Murray's move, Brian Springett decided to move to New Zealand to take up an appointment at Massey University. These changes presented an opportunity for Doug Waterhouse, the long-serving (1961-1981) Chief of the Division, to set some new directions for the WA Entomology group.

The dung beetle program of the Division that had been initiated in the mid-1960s was gaining widespread fame around Australia and across the world, becoming one of the Division's largest and highest-profile research projects. James Ridsdill-Smith who had been working on pasture scarabs in the Division at Armidale NSW since arriving from Britain in 1964, and who had recently completed a PhD at the University of New England, moved to the WA labs to initiate dung beetle research in the west. This arguably began one of the most significant and high profile periods in the history of Entomology in WA. Again, some very significant WA-centred history preceded this change.

As an aside, when the push came to amalgamate all the agricultural-directed Divisional outposts that comprised the Floreat laboratories into the new Division of Land Resources Management, or to move the Entomology group to Helena Valley with CSIRO Wildlife in the 1970s, Doug Waterhouse held out to maintain Entomology as a discipline-based outpost of the Division. We always felt thankful for Doug's firmness in maintaining the Entomology status quo as we felt it would be difficult for a small and uniquely-focussed group to thrive within a much broader Division like LRM.

Early work demonstrating the lack of dung beetle activity in pastures of southern Australia was carried out from Perth by Geoff Snowball (1942) and George Bornemissza (1951), both at the University of Western Australia. Both later joined the Division of Entomology in eastern Australia and George subsequently became the father of the whole CSIRO dung beetle introduction program starting in 1967, first in Canberra and later involving the establishment of the Dung Beetle Research Unit at Pretoria in South Africa. Introduced dung beetles from this program were released in WA by Alec Mahon from the early 1970s, and by 1977 the first species were well-established.

The role of James Ridsdill-Smith was to evaluate the ecology and impact of beetles in the winter-rainfall Mediterranean climate region, particularly directed at reduction of bush fly abundance. James studied dung beetle ecology, John Matthiessen bush fly ecology, and they worked together to evaluate the impact of introduced beetles on bush fly populations. Graham Hall was appointed as a technical support for James, and Lynne Hayles worked in a technical support role with John. James and John showed that at Busselton in early January where high activity of the introduced beetles coincided with bush fly breeding, there was good fly control.

As Chief of the Division, Doug Waterhouse was an enthusiastic supporter of the whole program. When he was returning from South Africa through Perth airport late one night bringing some live dung beetles from the quarantine lab in Pretoria he was challenged by Customs. James was phoned by the airport Customs staff to vouch for the fact that Doug was entitled to bring in beetles, and they were no threat to Australia.

Meantime, John's work was showing that bush fly over-wintered further south and west than previously thought and he determined the timing and characteristics of the regular October south-westwards dispersal of the bush fly, following their extinction during the cool wet winter. It became apparent that the September upsurge in bush fly breeding in the overwintering zone, barely 150 km east and north of Perth, led to a highly regular re-colonisation event and that was the precursor of the legendary bush fly hell in the lower southwest such as at Busselton and Dunsborough around Christmas-New Year. Importantly, it revealed an important gap in activity of introduced dung beetles in the crucial spring build-up period of the bush fly.

Initially, the dung beetle program had focused on the immensely rich, but more tropically-adapted dung beetle fauna of southern Africa to source introductions. The search for suitable dung beetle species began to move into the more temperate regions of southern Europe and the Mediterranean basin. During various studies in southern Europe and especially Spain, where the fighting bulls grazed pasture all year, four further species with spring activity were identified to fill this gap. This work was carried out by James Ridsdill-Smith, Alan Kirk, who was based in Montpellier, and then by Keith Wardhaugh who worked from Cordoba during 1984-1987. Low numbers of two of these species were released and became established in the west. However, before the work was completed, there was declining support for the dung beetle program, which became mainly focused on northern Australia against what was proving to be the much more intractable buffalo fly. This brought an end to the whole project, prematurely dragging down the WA component.

By chance, at that time Peter Dowding, then Premier of WA, came to our rescue. When visiting CSIRO at Floreat in 1988 to open new laboratories he was greatly troubled by a persistent bush fly while delivering his speech. He uttered memorable words to the effect that "...CSIRO should do something about the flies..". This was James' cue to swoop on the Premier following the event and the rest, as the saying goes, is history as his Government provided further support to the program for five years to introduce the Mediterranean dung beetles. James and John had already moved on to other work but the quarantine issues in importing dung beetles meant that such work could not be done in WA; in any event, the introduction procedures were not James' or John's research specialty.

Keith Wardhaugh led the quarantine work in AAHL bringing the new species into the country in 1991-1992, while Ian Dadour headed the WADA program in Perth from 1989-1994 to mass-rear and release these beetles. The European species are difficult to rear because they had restricted life cycles which needed to be synchronised to the southern hemisphere, and unfortunately, very few beetles were released. A monitoring program was also carried out at this time with cropping and redistribution to accelerate the spread of existing dung beetle species.

In 2012-14, now that dung beetle distributions are likely to have equilibrated on a regional scale, the WA Department of Agriculture and Food is looking again to determine where there are gaps in dung beetle activity. This will help plan for possible release of the two missing European species from the suite originally selected. James and John are consultants for this work, revisiting farms and farmers where they released beetles 35 years ago. The beetles incidentally are doing very well, averaging 4-6 species at any given location in the south-west agricultural region.

Soil Pests and Diseases

At the time the dung beetle work was winding down in 1987-88, a crisis hit the meat industry in WA. Beef contaminated with the residual organochlorine insecticides dieldrin and heptachlor threatened to halt meat exports. A major use of these insecticides over many years was for control of soil-dwelling beetle pests (African black beetle and white-fringed weevil) in potato production in rotation with beef-grazing pastures. Facing bans on chemicals used for control of these intractable pests, industry funded a joint CSIRO Entomology/WA Department of Agriculture research project that John Matthiessen moved onto in collaboration with Stewart Learmonth, a WADA entomologist at Manjimup. John's part of the work was particularly directed at understanding the population biology of the insects. Soil-dwelling insects can be very damaging in low abundance and present a very difficult control problem for farmers because it is so hard to monitor what is going on in the soil. Mark Shackleton was appointed as technical support for John in this work.

Over the next 15 years, the soil insects work expanded in horticulture to include the associated issues of soil-borne diseases and further branched out from horticulture to include bluegum plantation forestry and amenity turf. Soil-borne pests and diseases are such a unified problem in horticulture that it cuts across entomology and pathology boundaries. Farmers began using broad-spectrum fumigant-like chemicals as a 'one stop' approach to both insect and pathogen control. These have the desirable property of not being residual but repeated use can lead to the phenomenon of enhanced microbial degradation that can severely limit their performance.

In 1999, Ben Warton was appointed as a post-doc chemist to investigate this problem and a particularly revealing period of work followed. We showed that the coarse sandy, high pH soils of the Swan Coastal Plain are particularly susceptible to the problem, harbouring very hardy bacteria that respond very quickly to 'feed' on applied fumigants. This degrades them so quickly that their intended action against pests and diseases is negated. Also during this

period, John developed a strong collaboration with John Kirkegaard an agronomist at CSIRO Division of Plant Industry in Canberra to develop the use of high isothiocyanate-producing brassicas as 'biofumigants' for integration into production systems as a bioactive rotation crop and green manure.

By around 2005, this work had matured and come to a logical conclusion, Mark Shackleton moved to CSIRO Land and Water at Floreat, and in 2006, after more than 36 years with Entomology, entirely in WA, John Matthiessen decided to retire. He retains (at 2013) an Honorary Fellow position with CSIRO Ecosystem Sciences, the Division of Entomology's successor, which facilitates his role as honorary Chief Editor of the Australian Journal of Entomology.

Red-legged Earth Mite

In collaboration with Dennis Gillespie, a plant breeder in the WA Department of Agriculture, James Ridsdill-Smith started a new project in 1990 on red-legged earth mite to develop plant resistance in clovers to RLEM. Subclover seedlings were bioassayed and mechanisms involved in resistance identified. The work was funded originally by the Australian Wool Industry with additional funding from the Cooperative Research Centre for Legumes in Mediterranean Agriculture. Over eight years, this supported a biological chemist, initially Yang Jiang and later Shao fang Wang. They worked with Emil Ghisalberti in the Chemistry Department at UWA to identify the chemical basis for mechanisms of resistance. Technical support was provided Tanya Picen and Jenny D'Arcy-Evans (later Jenny Reidy-Crofts). Induced volatiles were shown to be important and the compounds involved were described. This work has resulted eventually in the release by the plant breeders of one gland clover and three subclover varieties with enhanced resistance to RLEM.

The ongoing mite ecology work was supported by Experimental Scientists Amanda Annells and Kylie Gaull. The ecology provided an unexpected 'blue sky' outcome from studies of the causes of onset of summer diapause. The timing seemed to be very consistent from year to year at any site, but varied between sites, and could be predicted with a site-specific model for the whole of southern Australia. Celia Brown (later Celia Pavri) dissected thousands of 1 mm long female mites to provide the data to test this idea. A trademarked decision support system TIMERITE™ was developed by James Ridsdill-Smith and Celia with important inputs from colleagues in the WA Department of Agriculture, CSIRO and farmers, including Phil Michael, Mike Grimm, Jim Shovelton, Allan Clarke, Art Diggle and Darren Kriticos.

A single well-timed insecticide spray in spring killed the last generation of RLEM before they entered the diapause eggs that were immune to any control treatments. In this way, effective control was exerted in spring over the following autumn's mite emergence, eight months later. The system has been widely adopted by farmers across southern Australia. Independent economic evaluations of this project show benefits ranging from $15 million a year (AWI) to $37 million a year (Council of Rural Research and Development Corporations) against a total cost to all parties of $2.3 million. We demonstrated the potential for high benefits to pasture productivity from well-focused projects, and we found the need during development to involve all key players, and the value of on-farm demonstration sites across Australia that were run by Celia Pavri.

The Economic Benefits from Scientific Research

Scientific research can provide significant contributions to the nation and many projects have successful economic outcomes. James Ridsdill-Smith was a member of several teams that assessed the economic benefits of these programs.. The information developed, and its use by various science leaders, helped the Prime Minister Bob Hawke to support the idea of Australia as the smart country and research being an investment.

On several occasions as OIC of the Perth group James was asked to justify the value of having an entomology group in the west, rather than closing it down. The most memorable of these was just after the agricultural Divisions had moved to their new Rural Research Laboratories, and Entomology featured widely on TV news and current affairs talking about the valuable work we did. CSIRO scientists demonstrated to express their concern for falling support for science, and on one of these events Perth scientists decided to stage an all-night work-in at Floreat. At this James gave a sex-themed talk on mating behaviour of thynnid wasps that pollinate orchids (using a Japanese TV film produced in SWA 'The New World Travelogue: the Love Life of Wild Creatures') at 2 am in the auditorium at the Floreat lab. It was a popular interlude.

One of the great pleasures for members of CSIRO Entomology in Western Australia has been the high level of public support for our work from colleagues in the State Department of Agriculture as well as the universities and the general public at these times.

Members of CSIRO Entomology have been happy to get involved in supporting both the communities in which they work and their discipline. Mark Shackelton, Rick Horbury and Celia Pavri for example helped with social club events, John Matthiessen is currently editor of the Australian Journal of Entomology, and James Ridsdill-Smith has served as Vice President and President of the Australian Entomological Society, and Secretary General of the Council of the International Congresses of Entomology. We have on numerous occasions been involved in publicity for our work with stories on TV, newspapers and in other media.

Recent History

John Scott returned to Perth in 2002 from Montpellier, studying the biological control of invasive weeds using introduced insects and pathogens with Paul Yeoh, and impacts of climate change. He and Kathryn Batchelor had considerable success in the biological control of bridal creeper in areas of natural vegetation, where the use of herbicides is not permitted. Owain Edwards joined CSIRO in 1998 to work on aphid/host plant interactions at the whole organism and the molecular levels. He has studied the molecular basis for host resistance of Russian wheat aphid, a biosecurity threat to the cereal industry, working in China and France. James and Owain have looked for pest resistance in crop plants. We identified mechanisms of resistance in yellow lupins to aphids working with the WADA plant breeders. In addition James looked at wild relatives of chickpeas as a novel source of resistance to budworm. This work was in conjunction with Hari Sharma from ICRISAT and involved joint work in India. In 2009 two new scientists joined the CSIRO Entomology group. Raphael Didham is a joint appointee with the University of Western Australia working on insect biodiversity, and Bruce Webber is working on climate change. In 2011 the Division became part of a larger Division of Ecosystem Sciences.

The future of entomology as a discipline within CSIRO in WA is in good hands, even if CSIRO no longer has a dedicated Division of Entomology.

Graham Hall, John Matthiessen, Lynn Glasson (Hayles), James Ridsdill-Smith, Zan Mazanec

Christmas lunch: back row; Rick Horbury, Paul Yeoh, James Ridsdill-Smith, John Matthiessen, Celia Pavri, David Henry (Animal Production), John Scott, Zan Mazanec, front row Yang Jiang, Lifang Gu, Jenny Wilson (Forward), Jenny Reidy Crofts (D'Arcy Evans), Tanya Picen

FISHERIES AND OCEANOGRAPHY[30]

Crayfishing was a very small canning industry in WA until American servicemen, stationed here during the war, developed a taste for these plentiful "live, at threepence-each at the pub" delicacies. After graduating in 1951, Ray George joined Keith Sheard in 1952 to get a better understanding of the complex biological lifecycle and unique niche that has become Australia's richest fishery. Crayfish are now known as the Western Rock Lobster for marketing reasons. Ray was to determine that it was a taxonomically independent species, (named by him, *Panulirus cygnus* in 1962) and was awarded his PhD for setting the scene for research that continues today. It is "Australia's best managed fishery" that exports live lobsters throughout the world. Howard Gray's book "The Western Rock Lobster" provides a rich record of the early trials and tribulations of the pioneering work of these two scientists. Ray's first 'research vessel' was the Betty Robin, a 12-foot dinghy with an 8 HP Chapman Pup motor, which was contracted by CSIRO from two young fishermen to carry out a 5-month crayfishing test on the shallows at the Southern Group of the Abrolhos islands. They also carried 'Spot', their dog. Ray reported by letter each week – no radio or Health and Safety Requirements in those days – and he had only one break to Geraldton. Life was simple and most enjoyable!

Bruce Malcolm was appointed to study the salmon and herring migrations associated with breeding, concluding that the Bass Strait region generally separates an Eastern and Western subspecies (stock) of salmon, and that separate management regulations were required. His field work in WA was centred on the isolated wintry fishermen's beach camps that were scattered along the south coast, where he waded into the shallows to wrestle, weigh, tag and release the reluctant fish. His summer operations in the eastern states were much more pleasant.

Graham Chittleborough was the whaling man with previous experience in the Antarctic. His species were the Humpback and Sperm whales and their migrations and biology were studied through tagging with dart guns from the commercial whalers and biologically sampling them on the flensing decks at Point Cloates, Carnarvon and Albany. He was small in stature with research species of a giant size.

In the late 1980s, commercial whaling was beginning to be closed down and the crayfish program was put on temporary hold too. Ray George moved into the newly rejuvenated WA Museum. When the CSIRO crayfish program was renewed, Graham Chittleborough transferred to it, recruiting Bruce Phillips, and they further expanded research of its oceanic and life cycle characterisation and designed a unique prediction system for future commercial catch production based on monthly numbers of the puerulus stage that settled on the special collectors placed at selected positions along the coast.

George Cresswell and Terry Golding built on the early work of Dom Serventy whilst Dave Rochford (dropping drift cards from ships and aircraft to see where they ended up) provided early understanding of the oceanic circulation patterns that appeared to determine the paths of the lobster larval stages in their one year long circuit before swimming to the coastal settlement areas along the WA coast. The hydrographers had made bold prediction of a strong south-flowing counter-current hugging the WA Coast. It was later named by them as the Leeuwin Current.

[30] Prepared by Peter Hick from notes provided by Ray George

MINERALS RESEARCH IN WA [31]

Minerals research in CSIRO Western Australia commenced in 1963; the time of compiling this history is 2012 so that the following year will be 50 years since the start.

The person punching this into his computer is the opposite of a perfectionist and thus even though it is bad form, I commence with an apology for all the mistakes that it contains. Any offence is entirely unintentional even though there are many of my former workmates that I enjoyed offending at times. Anything that can be regarded as libelous has been omitted and the many scandalous happenings will also be avoided. What troubles me most are the "Sins of Omission" and I do apologise to those I have missed.

The First Twenty Years (1963 to 1983).

The CSIRO mineral scientific work commenced in WA when Wilf Ewers moved from Victoria; the 1962-63 Annual Report of CSIRO revealed these good intentions as follows:

> *"A section of the Division to be known as the Secondary Industries Laboratory is being established in Perth, and is housed temporarily in the University of West Australia. Its activities will be mainly concerned with the development of products from indigenous minerals and related products. In addition to pursuing their own research objectives, many officers of the Division have provided specialized advice and assistance to outside firms and to other Divisions and Sections."*

They were actually located in the Zoology Building in Park Road, next to St Georges College and Wilf assures me that he had a bold sign made to prove who they were.

The Annual Report of the CSIRO Chemical Research Laboratories 1963-64 showed that plenty was happening at the Secondary Industries Laboratory:

> *"The laboratory will shortly move to laboratory and office space provided in the new building which is being erected for the Chemistry Department of the University of Western Australia. Three main projects have been selected for study. Work has commenced on the study of glauconite. Using samples obtained by the Western Australian Mines Department by boring six exploratory holes in the Dandaragan area and another six close to Gingin, the potash content of the glauconitic green sands is being surveyed. Particularly in some localities, the green-sands have been weathered to considerable depths and in this process the greater part of its potash content has been leached out. Methods of releasing potash from glauconite, including the natural process of weathering, will be studied.*
>
> *Preliminary studies have commenced on the occurrence of vanadium in the titaniferous magnetites of Western Australia. With the aim of developing a process for the economic recovery of vanadium from these materials, attention is being concentrated on the geochemical factors controlling the distribution of vanadium in iron minerals and its redistribution during weathering.*
>
> *The recovery of lithium chemicals from spodumene by an improved method is the long term aim of the third project. Again the basic approach will be geochemical, studying*

[31] Prepared by Mike Thornber with assistance from Wilf Ewers, Alan Fletcher and Dick Morris. This contribution covers principally the period of major development of the minerals research endeavors in WA that followed the 1960s resources boom and coincided with the establishment of the Floreat Park Laboratories. The growth of mineral targets was matched by the expansion of research staff, the range of projects and discoveries, and the use of summaries in annual reports to ensure that scientific issues of the day are captured and set the scene for the turbulent times that followed.

experimentally the genesis of spodumene in pegmatites and attempting to elucidate the nature of the solvent system by which the lithium was introduced."

The following Annual Report (1964-65) is itemised so that particular researchers at the Secondary Industries Laboratories are identified with the work:

"Some progress has been made in initiating research in this new Laboratory, most of it based on the thesis that an understanding of the chemical nature of some geological processes could well give a new insight into means of utilizing minerals.

Major equipment for the selected projects has been ordered and some of it, notably the X-ray unit including the diffractometer and fluorescence spectrometer has been set up. The X-ray equipment will be used for structural studies, mineral identification and analytical work connected with the geochemical program of the laboratory. The Kratky low angle X-ray camera from the Melbourne laboratories has also been set up in Perth so that the interlayer spacing's in swollen lithium and butyl ammonium vermiculite can be measured as a function of the pressure applied normal to the layers, thus giving information about interlayer forces. A structure analysis on a recently synthesised nonstoichiometric oxide K_2SMo0_3 (a potassium molybdenum "bronze" was undertaken in collaboration with A.D. Wadsley of the Division of Mineral Chemistry, and resulted in the description of an unusual structure type. (Jim Graham)

Hydrothermal equipment capable of temperatures up to 1100 C and pressures up to 4000 atmospheres is expected to be delivered shortly. This will be used initially in studies of pegmatite systems and particularly on the genesis of spodumene. Some preliminary ion exchange studies on spodumene have been done at relatively low pressures. (D. J. Drysdale)

One of the occurrences in Western Australia of vanadium-containing titaniferous magnetite is in a large body of gabbro at Coates Siding. This deposit is of particular interest in that it is overlain by a deep weathered zone in which the vanadium content of the original gabbro has been retained, presumably in a more highly oxidized condition. The process of weathering has been accompanied by the loss of most of the sodium and calcium and about half of the silica, potassium and magnesium, whereas the iron, titanium, aluminium and vanadium contents have been only slightly reduced, if at all. A study of the weathering process has been commenced with the object of elucidating the chemical changes involved, of assessing the possibility of accelerating the process at ambient temperatures, and of determining what modifications of the process are necessary to render the vanadium leachable. An electron micro-probe analysis conducted by the Australian Mineral Development Laboratories has established that the vanadium in the gabbro is mainly concentrated in the magnetite rather than in the ilmenite inclusions. Within the magnetite it is uniformly distributed at a concentration that corresponds to one vanadium ion to each two unit cells of magnetite, that is to each 64 oxygen ions. (Ted Davis, Wilf Ewers)

Test bores which the West Australian Geological Survey sank into the glauconite beds at Gingin, Dandaragan and Bullsbrook yielded samples of greensand which are being used for mineralogical work in connection with the transitions that accompany the weathering of glauconite and the loss of potash from it. Some tests on the extraction of potash from the glauconite appear to indicate at this stage that these samples behave somewhat differently from the New Jersey glauconite marl which was the subject of earlier work in the United States of America. (Ted Davis, Wilf Ewers and Alan Fletcher)

One of the most serious brakes on mineral exploration is the cost of drilling holes to test geological theories concerning the extension of known ore bodies and to determine the

real significance of geophysical and geochemical anomalies. Consideration is being given in the Laboratory to initiating research on novel methods of producing exploratory holes. A decision to proceed will depend on whether a preliminary survey indicates sufficiently promising lines of research that can be pursued with advantage in Perth (D. A. Davies).

Some analytical services have been rendered to other sections of the Division. In collaboration with A. F. Trendall of the Western Australian Geological Survey the possible origin of puzzling slag-like materials found over a wide area surrounding Kalgoorlie is being studied. So far this work has been limited to the analysis of samples of slag and soil. (Ted Davis)

The Laboratory has received several enquiries from local industrial companies. The majority of these have been of a metallurgical nature and have been referred to CSIRO Laboratories in Melbourne. Several mineral deposits of interest to this Laboratory and to its parent Division, have been examined and samples collected for test work."

The following year's Annual Report (1965-66) acknowledged the Western Australian Laboratories for the first time:

"The Western Australian Laboratory in Perth continues to occupy space provided by the School of Chemistry of the University of Western Australia. Early in 1966-67 it will move into a new building which is being erected at Floreat Park.

The laboratory's programs include research in geochemistry of certain economic minerals and also investigations into new or improved methods for deep exploratory rock drilling. The Laboratory also provides a link between industry in Western Australia and those chemical, physical and metallurgical Divisions of CSIRO that are able to assist with its problems.

The build-up of equipment for the Laboratory has continued during the year. Major acquisitions included hydrothermal equipment capable of operating at pressures up to 4000 atmospheres and temperatures up to 1100°C. A start was made also in acquiring machine tools for a future workshop to serve the research programs.

Approximately 100 runs under hydrothermal conditions were made in attempts to synthesize and to determine the stability relations of spodumene. This mineral, which is the major economic source of lithium, occurs in large quantity in Western Australia and new routes to the extraction of lithium from it are being sought. Pressure, temperature, and composition conditions were chosen in the light of the extensive literature concerned with individual pegmatite bodies and their mineral compositions, and with the laboratory studies of the physical chemistry of pegmatites and synthesis of their minerals. A variety of starting materials were used, both glasses and mixes of oxides, carbonates etc., with composition corresponding either to natural spodumene or to the bulk composition of spodumene-rich zones of well explored pegmatites. These have been recrystallised at various temperatures and pressures in the presence of varying amounts and concentrations of NaF, HF and borax solutions. In nearly all cases the system has been moderately alkaline. A large proportion of the runs have been at 460°C, 15,000 psi as alpha spodumene almost certainly can crystallize in nature under these conditions. No spodumene was produced, although it would seem from the stability trials that the form is not decomposed under these conditions. Assemblages consisting variously of petalite, eucryptite, quartz and beta spodumene have been obtained. (D. J. Drysdale)

Changes - presumably metasomatic - in two pegmatite minerals, spodumene and beryl, suggest that there are relatively mild conditions under which these minerals can yield at

least a portion of the metal ions they contain, lithium and beryllium respectively. Preliminary work both by chemical analytical and X-ray mineralogical methods has been done on the nature of these changes. (Ted Davis, Wilf Ewers and Jim Graham)

Further work has been done on the 95 ft. thick weathered zone which overlies the large body of gabbro, rich in vanadiferous magnetite, at Coates. The overall changes in chemical and mineral composition revealed in samples from various levels from the surface down to the relatively unaltered rock at 100 ft. have been summarised as a first step in defining the sequence of chemical changes during weathering. (Ted Davis, Wilf Ewers and Jim Graham)

The oxidation of magnetite, a process which occurs early in the weathering sequence, is being studied by an electrochemical technique which is expected to yield information on the rate of the process under various conditions of oxidation potential and pH (Mike Bussell and Wilf Ewers).

A study of the swelling of vermiculite single crystals using a low angle X-ray camera has resulted in qualitative conclusions concerning the mechanism and kinetics of the process. The lack of reproducibility has prevented the quantitative evaluation of interlayer forces, but it is at presently felt that the existing theory (based on diffuse double layer distribution of the cations between the silicate sheets) is reasonably adequate to describe the swelling behavior, when certain structural irregularities and inhomogeneity of the natural mineral are allowed for. A gentler approach to the saturation procedures used as a first step in the swelling process will be tried in an effort to achieve quantitative results, but the physics group will in future concentrate more attention on structural studies of minerals and transformations of interest to the general program of the laboratory. (Jim Graham and Ric Vigers)

As part of the survey on methods of drilling rock a high-pressure water bomb has been constructed for the purpose of evaluating the potential of water jets as a drilling method. Jets of short duration can be produced and pressures up to 2000 atmospheres may be used. Preliminary tests have shown that jets are capable of producing appreciable penetration even in hard rock and systematic tests are being designed. Equipment is also being assembled to gain an insight into the mechanism of rock surface fracture under a diamond point on the premise that an understanding of this process is essential to improvements in conventional methods of diamond drilling. (D.A. Davies)

Apart from providing an analytical service within the Laboratory and in the remainder of the Division, the analytical group has continued an investigation of methods for the rapid analysis of Portland cement and other siliceous materials. Atomic absorption was shown to be particularly suitable for determining magnesium which is not easy to determine quickly and accurately by other methods. Further analyses have been made of the puzzling slag-like materials which have been collected over a wide area by members of the W.A. Geological Survey. (Ted Davis and Alan. Fletcher)

The physics group has collaborated informally with members of the Department of Physical Chemistry on crystallographic problems and has provided a post-graduate student in petrology with facilities for an extensive program of analysis by X-ray fluorescence spectrometry. A growing number of enquiries from local industry are being handled, some of them by direct assistance and others by passing the enquiry to the CSIRO Division or other Laboratory best able to advise."

Western Australian Laboratory

"The Division was transferred during the year into the CSIRO Western Australian Laboratories in their new building at Floreat Park. The Laboratory's programs are

directed to problems of the mineral and mining industries. They included geochemical investigations on economic minerals and investigations of new or improved methods for deep exploratory drilling. Recently it had been decided also to work on a study of dispersion haloes as an aid to geochemical exploration. The Laboratory continued to act as a link between industry in Western Australia and those chemical, physical and metallurgical Divisions of CSIRO that are able to assist with its problems.

"An extensive survey has been made of the literature relating to complex pegmatite bodies and their minerals and to experimental studies of pegmatite systems and pegmatite mineral syntheses. Although opinion has oscillated between believing that spodumene crystallizes from a melt on the one hand, and from a super or sub-critical low temperature aqueous phase on the other, the large body of information now available gives clear instances of both origins - sometimes both occurring in the same pegmatite. It was decided not to embark upon an investigation of melting relations in spodumene pegmatite melts at this stage, as this would seem to be already under way in America, but rather to continue to attempt to synthesize spodumene hydrothermally at geologically probable temperatures, pressures and compositions in a gel or in a predominantly aqueous fluid phase.

The first runs, using highly reactive (and, where possible, soluble) forms of the components, showed these starting materials to be completely useless, as it was clear that the components did not react together well. Methods of preparing gels having very intimately mixed Si, Al and Li were then developed. These also proved to be less than satisfactory, as they would seem to be inherently disposed to form minerals having Al in four-fold co-ordination.

The literature survey revealed also that commonly the closing act of pegmatite formation has been the decomposition of previously formed spodumene. An example of an alteration of this type occurs in the Ravensthorpe spodumene and X-ray studies on this material are referred to below. A preliminary experimental study of this process of alteration was also undertaken. It has been possible completely to destroy the structure of finely milled spodumene with alkali carbonate dilute solutions at 350°C. and 400 bars pressure, and an apparatus for looking more closely at this process has been designed. (D. J. Drysdale)

The crystal structure of spodumene from Mt. Marion has been refined using a single crystal diffractometer, the crystallographic computations being performed on the University's PDP6 computer. This involved the writing and modification of a number of Fortran programs to build up a general purpose crystallographic library, a task which is still continuing. The spodumene refinement gave good parameter values which can be compared with those of other recently determined pyroxenes.

Many of the spodumene single crystals from Ravensthorpe samples show mica alteration products which are in definite orientation relationship to the parent pyroxene. This suggests that the removal of Li from the structure does not necessarily involve an entirely reconstructive mechanism. A sample of white spodumene from this area which is depleted in lithium and other alkalis has remarkably similar lattice parameters to those of the typical Mt. Marion specimen, suggesting that the structure can accommodate a certain proportion of hydrogen ion before becoming unstable.

The X-ray spectrometer has been used for quantitative analysis of rock by outside users; its usefulness could be considerably extended if it could be used for rapid qualitative scanning. With this in mind a method for automatically keeping the pulse-height constant throughout a scan is being developed. Service work on mineral identification and

structure has been carried out for members of the Section, for the Government Chemical Laboratories and for Industry.

An interesting suite of samples from a borehole at Marchagee suggested that montmorillonite was forming in situ from kaolinite, quartz and dolomite. This is the first field of confirmation of some low temperature experimental results of American workers.

In collaboration with members of the University Chemistry Department staff, a structure analysis program has been initiated using powder methods (Guinier camera) to elucidate the structures of fluorite-related phases. The structure of $Zr_{10}Sc_4O_{26}$ has been solved and the program will be carried on solely by the members of the Chemistry Department. (Jim Graham)

In connection with studies on the mechanism of weathering of gabbro containing vanadiferous magnetite an apparatus has been constructed for studying the electro-chemical oxidation of magnetite in suspension using as a measure of the oxidation reaction, the magnitude of the current flowing from a counter electrode to a platinum working electrode in order to maintain the working electrode at a given potential. Compared with blank' runs in an inert electrolyte (0.5 M Na_2SO_4) the presence of magnetite causes definite currents which vary with pH and potential. Systematic studies are now under way to seek a detailed interpretation of the measured effects. (Mike Bussell and Wilf Ewers)

A semi-quantitative study of the driving forces that could cause post-depositional recrystallization of stratiform sulphide deposits was presented to a seminar of the Baas-Becking Geobiological Laboratory. The study aimed to assess the relative importance of particle size per se, of temperature gradients, formation of new phases and of pressure (Wilf Ewers).

The exploration for commercial ore bodies depends ultimately on drilling into rock which appears promising from geological, geophysical and/or geochemical indications. This final and very expensive exploratory step could be made very much more effective if it were possible to recognize an intersection not only with actual ore, but also with a zone of alteration around the ore body. In this way the effective target for drilling could be made considerably larger, and it might be possible also to determine in which direction from the hole the actual ore body occurs. The nature of the alteration zone and the means of recognizing it will vary, but the elements that are most likely to be useful as indicators are those which can diffuse to some distance from an ore body by reason of their volatility (as element or compound) or of their high solubility in hydrothermal solution.

The Western Mining Corporation have demonstrated dispersion haloes of mercury and arsenic around gold mineralization, and at the instigation of this company an attempt is being made in this Laboratory to develop a very sensitive method for tellurium analysis, for similar studies. The method comprises two parts, the concentration of tellurium by volatilization from rock, collecting it on a water-cooled cold finger from which it is dissolved, and then the determination of tellurium by atomic absorption. High sensitivity (0.02 ppm) has been achieved using a long tube burner with air-hydrogen flame in the atomic absorption step, but further work has yet to be done on the recovery stage. (Ted Davis and Alan Fletcher)

A more general program on dispersion haloes is now being planned. One section of this work will be concerned with alteration zones around hydrothermal ore bodies. A second line of work will deal with the persistence of certain elements in alluvial soils and weathered rock, in an attempt to provide geochemical exploration techniques applicable

to the vast arid areas in Australia where outcrops are few and the underlying geology is obscured by soil cover. (I. D. Martin)

Exploratory tests have been made to evaluate the potential of high-pressure water jet as a cutting tool for rock. Pressures up to 2000 atmospheres have been used with a jet 1 mm in diameter. With a stationary granite sample the jet makes a wide trumpet-shaped hole. By translating the sample at right angles to the jet direction it has been shown that for granite the damage sustained is due not only to the initial impact of the jet but is a process continuing with time. Finer grained rocks appear to be more resistant and presumably higher pressures would be required.

Equipment is being constructed to measure the forces operating on a single diamond point when cutting rock and it is also intended to set up equipment to measure the temperature of the rock-diamond interface whilst the diamond is cutting. It is hoped that this work may give some insight into the efficiency of coolants and lubricants. (D. A. Davies)"

The following year was when Wilf Ewers, the Officer in Charge of the group at Perth, visited research laboratories concerned with geochemistry and research on rock drilling in the USA, Britain, Europe and South Africa. This must have helped the planning for the Perth group which took another step forward as reflected in the new title Economic Mineralogy and Geochemistry

The work now centered on geochemical problems and the shift towards objectives foreshadowed in the 1966-67 Annual Report, developed further as some of the research on drilling had been discontinued. The main geochemical emphasis was on studies designed to provide an improved basis for, and possibly new techniques for, mineral exploration. This would involve an expansion of work on haloes of alteration around ore bodies, associated studies' on ore genesis and studies on the geochemical consequences of weathering processes. All of these studies were directed at 'specific problems relevant to the special conditions prevailing on the Pre-Cambrian shield of Western Australia'.

"Large deposits of lithium ores, particularly the mineral spodumene, occur in the pegmatites of Western Australia. A better understanding of the conditions of formation and decomposition of spodumene could assist in establishing local treatment of the ores.

Work on spodumene has been concerned largely with elucidation of the phase relationships among the lithium aluminosilicates at 300^0 to 500^oC and 2000 bars $P(H_2O)$, using various synthesis fields and reactions between natural minerals. No evidence has been found in this work that alpha-spodumene is part of any' equilibrium assemblage formed at this pressure. A hydrothermal synthesis of the mineral bikitaite was achieved in the course of the work.

The decomposition of spodumene to micaceous material, with removal of Li in solution, has been achieved experimentally at 200^oC to 300^oC under 400 bars pressure using dilute potassium carbonate solution. Further study of the factors influencing the rate of this reaction is in progress. (D.J. Drysdale)

Certain Western Australian gabbro bodies contain important amounts of vanadium, but the element is too evenly dispersed in magnetite to be economically extracted at present. Vanadium is liberated during the natural weathering of the magnetite and the mechanism of this process is being studied.

In connection with these studies electrochemical work on the oxidation of magnetite suspended in aqueous electrolyte has produced some interesting experimental results.

Potential-current plots show a definite current; plateau constituting sensitive evidence of a very slow oxidation reaction. At pH 7 the platinum electrode turned a gold colour due to the plating of ferric oxides, a phenomenon which other workers have ascribed to the oxidation of ferrous ions in solution. At higher pH values current plateaus were again observed but without the electrode becoming plated.

A sustained oxidation at a fixed potential showed that the amount of ferric iron in the plated film accounted for only about one sixth of the amount of reaction calculated from the current passed. This allowed several alternative explanations, one being that oxidation of magnetite in the solid is occurring concurrently.

In order to determine whether magnetite is being oxidized to a hematite inside the solid, as appears to occur in nature, a long term experiment is being performed, in oxygen-free conditions, to oxidize electrolytically an appreciable amount of the suspended magnetite. Microscopy will then be used to determine whether solid state oxidation has occurred (Wilf Ewers and Mike Bussell).

A suite of niobium-tantalum minerals is being studied using the Guinier camera, supplemented by single crystal (Weissenberg) methods. The Western Australian tantalites are unusual in that most are poorly ordered; both partially ordered and disordered tantalite become fully ordered on annealing to 450^{o}C. Other phase changes (probably involving oxidation) do not become apparent until temperatures of the order of 700^{o}C are reached. An attempt is being made to interpret the state of order in terms of the conditions of formation of the ore bodies. The provision of samples by the Western Australian Government Chemical Laboratories is acknowledged. (Jim Graham)

Because of the importance of sulphide systems to the mining industry, a program is being commenced to try to relate the crystal chemistry of such systems with their conditions of formation and subsequent history. A survey is being made of the previous work in the system Ni-Fe-S-As, which reveals a number of interesting problems associated with almost every phase of the system. It is expected that work will need to be done on both synthetic and natural materials, and it may be necessary to include other transition metals such as Co and Cu to explain some of the anomalies. Particular attention is being given to the examination of nickel-iron sulphide species from Kambalda. (Jim Graham)

When an ore body is formed by the penetration of hot fluids into a rock mass, certain mobile elements may move out beyond the limits of the ore itself, forming a primary dispersion halo that can be a useful indication of the nearby presence of ore.

The possibility of dispersion haloes of rubidium, cesium, thallium and barium around hydrothermal ore bodies at Kalgoorlie has been investigated. Negative results are reported for cesium and thallium. Rubidium shows a minor dispersion but this is not significant. Analytical methods for barium have had insufficient sensitivity; Selenium dispersion is also under investigation. An analytical method of adequate sensitivity (0.01 ppm) is available. It is thought that selenium may penetrate further into the country rocks than sulphur. Selenium anomalies may suggest sulphide mineralization with no restriction on the metallic species involved,

From purely chemical considerations, Selenium is likely to concentrate in near-surface alteration products, gossans and derived soils. Analytical verification of this hypothesis is not yet forthcoming but selenide minerals are present in near surface alteration products from Kambalda. Anomalous high selenium concentrations in soils and gossan-like material should suggest sulphide deposits with, again, no restriction on the metallic species involved. Concentrations of this type are classed as secondary haloes. (I. D. Martin)

Many gold ore bodies in the West Australian goldfields contain the rare and moderately volatile element tellurium. It is possible, therefore, that if one encounters rocks containing abnormally high amounts of tellurium in a drill hole, these may be primary dispersion haloes indicating the proximity of gold mineralization.

Because of the low crustal abundance of tellurium (about 0.001 ppm), a sensitive method for its determination is required to detect such haloes. A simple method has now been developed where the rock is mixed with pyrite and heated The tellurium is volatilized, collected, dissolved and determined by atomic, absorption in a long tube, after interfering substances have been separated.

This method, applied to typical Goldfields rocks, has been shown to be capable of detecting tellurium in amounts of about 0.02 ppm of rock. This detection limit is imposed mainly by the blank arising from the tellurium content of the natural pyrite that has been used as a reagent. Pyrite is sometimes consumed in side reactions, so that up to 10 per cent of pyrite has to be added to many Goldfields rocks to ensure that all the tellurium volatilizes. As nearly all samples of natural pyrite contained at least 0.3 ppm Te, it may be necessary to prepare pyrite synthetically, to obtain lower tellurium contents and lower blanks. (Ted Davis)

A study of the processes of weathering and the development of laterites and lateritic soils is in the early stages of investigation. An area containing basic igneous rocks ranging from troctolite to anorthosite, all rock types showing progressive weathering, has been selected. Potentially economic vanadiferous and titaniferous horizons are included in the weathered areas.

This study is of the weathering of the minerals in the rocks, changes of mode of weathering with change in mineral composition and the disposition of the economically more interesting elements in the weathering process. A parallel study of the partition coefficients of these same elements between oxide, sulphide and silicate minerals in the fresh rocks is under investigation. (I.D. Martin)

Programs being planned for work on alteration haloes and ore genesis need to be supported by studies of processes occurring in mineral systems as a result of imposed chemical activity gradients. In particular, studies of the transport and alteration of sulphide minerals are being attempted using compositional variations and temperature gradients to impose the activity gradients. A gradient furnace has been constructed in which the temperature can be systematically varied over a length of about 15 cm inside a pressure vessel. (Wilf Ewers)

The further study techniques of rock drilling using water jets at pressures up to 30,000 psi confirmed that this pressure although sufficient to produce spectacular damage in coarse grained granodiorite, coarse sulphide ore, and in materials comprising cemented grains such as sand-cement mortar, is inadequate with a fine grained dolerite, or with fine-grained sulphide ore. To achieve a practical drilling method a pressure higher by a factor of perhaps two would be required. This requirement emphasizes the second major difficulty is delivering water at this sort of pressure down a drill hole. Considerations of pressure loss and pipe strength suggest that a minimum pressure of 10^4 psi would be required assuming that an intensifier could be designed to increase this pressure to say 7 x 10^4 psi at the bottom of the hole. Even at this initial pressure drill stem couplings as pressure joints would constitute a considerable safety hazard and these problems would be compounded if the alternative of pumping at full pressure from the surface were adopted. These considerations have led to a decision to abandon this approach to drilling for the time being. (D.A. Davies)

In diamond drilling there is still a considerable uncertainty concerning the mode of action of the individual diamonds in a drill crown in fracturing the rock surface and concerning the influence of additives (e.g. soluble oils) on this mode of action. An experiment has been set up to extend the work of Schlossin in South Africa in observing the cutting behavior of a single diamond point on a plane surface of glass or crystalline material. The effect of such variables as load, speed, radius of curvature of the diamond, and various lubricants is being evaluated from the crack patterns observed after etching. It is hoped that the results may be useful in the design of drilling crowns and in the selection of optimum operating conditions in diamond drilling. (Jim Graham and I.D. Martin)"

The 1968-69 Annual Report showed that there had been a great increase in the annual expenditure in Australia on geochemical exploration for base metals. In Western Australia particularly, many companies were actively searching mainly for nickel and copper. The methods being used primarily were those developed for African and Canadian conditions and did not necessarily apply to Australian regions such as the 250,000 square miles of flat, arid, ancient landscape that constitutes the Achaean shield of Western Australia.

"Research studies have therefore been undertaken to define the patterns of behavior of elements under local conditions of weathering, topography and rock occurrence in order to provide a basis for the modification of imported techniques or the development of new methods. Since data on the movement of elements can have general application to quite different types of rock alteration, these studies have been as much concerned with the mechanisms and effects of metasomatic changes in rocks at depth as with weathering processes near the ground surface.

Three main lines of work are being followed. In the first the aim is to obtain an understanding of the processes of change which convert various types of hard, ore-bearing rock to soils, laterites and other weathering products having characteristics related to specific regional conditions. There are a wide variety of combinations and only a few situations have been examined to date but even in these, it has already become evident that current geochemical prospecting methods have serious shortcomings.

In a second, more fundamental study, the objective is to trace the progress of changes at the surfaces of minerals and along cracks through grains when a rock is being altered. The basic data from this detailed work on the mechanism of mineral alteration relate both to the weathering process and to the formation of dispersion haloes around ores during emplacement in host rocks at depth. Studies on such haloes form the third group of projects concerned with exploration geochemistry.

The main value of haloes in prospecting could be to provide larger drilling targets. A drill may miss an ore body but intersect a halo of more mobile elements genetically related to the ore. Since the cost of obtaining drill core is high, there is ample justification for devoting effort to the recognition of haloes in core samples. Rapid analytical methods are important in this work and a variety of facilities have been set up, including X-ray fluorescence, atomic absorption and fluorimetric-equipment. An electron microprobe is being acquired.

Surface Prospecting to determine element distributions in soils and laterites have been investigated on non-transported soils and weathered materials at three localities in the Murchison and Yalgoo goldfields, selected to determine the extent to which the migration of nickel and copper out of underlying rocks could be affected by local weathering factors. Each situation proved to be complex and it was evident that ordinary geochemical prospecting techniques would not give useful results at all or would require considerable background information to become intelligible.

In the first locality, samples were taken at 10 cm intervals down to bedrock across a troctolite-anorthosite contact where the rocks showed different contents of, nickel and copper sulphides. Rapid XRF analyses for Ni, Cu, Zn, Mo, Sr, Rb and Mn showed that the soils were so leached that no indications of the bedrock variations could be obtained. The only Ni and Cu concentrations found were in areas of high soil pH and these were unrelated to the bedrock.

At a second locality, gossans containing appreciable Ni and Cu were examined along a serpentinized peridotite contact. Soil samples from within a few feet of the gossan showed no increases over background for these elements in the -80 mesh fractions. Slight anomalies, proved to be due to fragments of the gossan were detected in the +20 mesh fraction up to 400 feet down-slope from the gossan. It would appear that the common practice of examining the finer fractions of soil samples in geochemical prospecting may not be suitable for locating lightly-covered gossanous material under the weathering conditions prevailing in the region.

In a third area of serpentinite where the lateral drainage was very poor, auger cores of soil and weathered rock were taken to a depth of 16 feet and the underlying fresh rock was sampled. The results indicated that Cu, Zn and Mo had been thoroughly leached out of the profile, though the Cu content increased slightly where the pH increased from 6.5 at the surface, to 8.4 at a depth of 4 feet. Nickel showed a typical pattern for a lateritic situation, with leaching in the top 12 feet then a sharp increase to values around 13,000 ppm just above fresh rock.

From the three localities examined it was evident that little significance could be attached to negative results from geochemical surveys based on acid extraction of the 80-mesh fraction of samples from the surface or shallow sub-soil. An attempt is being made to correlate element distributions with features of soils in areas which have been intensively studied, in collaboration with officers of the Division of Soils, and this may permit some general principles to be defined. Geobotanical work has been started, both in regard to the selective occurrence of certain species of Eremophila and Cassia on particular rock types and in connection with the distribution of distinctive trace elements in parts of plants. (I.D. Martin)

A study of the process of weathering of minerals has been initiated. An immediate objective is to clarify the role of grain boundaries and cleavage planes in facilitating weathering and replacement, particularly of feldspars. It is possible that certain types of oxygen bridges between the aluminium and silicon atoms in these structures are more susceptible to hydrolysis than others and this could result in the release of characteristic pieces of the alumino-silicate framework suitable for rapid reconstitution as weathering products. In attempts to detect superstructures which might result from this type of preferential hydrolysis, glancing-angle electron diffraction studies of feldspar surfaces have been carried out with the cooperation of the Electron Microscopy Centre of the University of Western Australia. To date no superstructures have been revealed, but replicas from feldspar surfaces have contained fragments showing interesting structures which are being studied further. Fresh surfaces of cleaved feldspars have commonly shown enough evidence of weathering to imply that the cleavage had already parted and allowed entry of weathering agents. (Terry. Parks)

In Western Australia, particularly in the northern portion of the State, most of the significant gold and base metal discoveries have been made in NNW-trending belts of Achaean meta-igneous and meta-sedimentary rocks known as "greenstones". Ore bodies contained in the greenstone belts may be surrounded by envelopes in which alteration has occurred by migration of material from the ore zones into the wall rocks. Despite the potential significance of such alteration haloes in geochemical prospecting, in

the interpretation of diamond drilling data and in ore genesis, as yet they are poorly documented and the mechanisms of formation poorly understood.

In an initial investigation, selected diamond drill cores from Western Mining Corporation's nickel mine at Kambalda are being examined. These cores pass from the Ni-Fe-S ore of the Lunnon Shoot into a footwall sequence of basaltic rocks. The extent and nature of any halo around the ore body is being assessed in terms of textural and mineralogical variation, as well as chemical variation, in the footwall rocks. Seventeen minor elements (Ti, V, Cr, Mn, Co, Ni, Cu, Zn, Ga, As, Rb, Sr, Y, Zn, Nb, Mo and Pb) have been selected for semi-quantitative chemical study by a rapid X-ray fluorescence technique.

The XRF analytical procedure is designed to give rapid quantitative to semi-quantitative data down to a detection limit of 10 ppm. Using a single scattered background radiation measurement to determine element background and allow for matrix variation, the entire analysis of a sample for the above elements can be completed in about 20 minutes with an accuracy of better than 20%.

This work is part of a broader investigation of ore-greenstone interaction throughout the mineralised Achaean belts, in which it is proposed to examine the effect on wall rocks of ores differing in both composition and genesis. The electron microprobe should facilitate study of the migration of materials from the ore zone, especially by permitting the recognition of indicator elements in grain boundaries and cracks, whereas their concentrations in analyses of bulk rock would not be significant. (Russell Hudson)

The analytical determination of tellurium as an indicator element in dispersion haloes around gold lodes has been improved. Natural pyrite, used to sweep out the tellurium from a heated rock sample and yield a concentrate suitable for analysis, gave high blank values for Te. It has been replaced by a pure synthetic pyrite, made by reacting dried ferrous sulphate with elemental sulphur in a stream of nitrogen. When using 10% of this pyrite to remove Te from 15 g rock samples, blanks of less than 0.01 ppm were obtained compared with 0·05 ppm or more when using natural pyrite. As a result it has been possible to estimate down to 0·01 ppm Te in rocks although it must be pointed out that the recovery of Te from very dilute synthetic mixtures was sometimes as low as only 50%.

From the limited number of analyses on core on either side of gold lodes, supplied from underground drilling by Gold Mines of Kalgoorlie Ltd., it appeared that the value of tellurium as an indicator for gold may be somewhat limited, as its occurrence in anomalous concentrations appeared to be restricted to zones on either side of a lode only of the same order of thickness as the lode itself. The Western Mining Corporation, which supported the work on the development of this method, is currently using it to explore more thoroughly its potential usefulness. (Ted Davis and Alan Fletcher)

The use of compositions of detrital tourmalines as indications of the occurrence of hydrothermal ores in the rocks from which they were derived has been investigated, following studies made by A.M. Taylor and B.C. Terrell (Melbourne Laboratory) in which they synthesized tourmalines containing elements of the first transition series. The basic assumption that is being tested is that tourmalines which are genetically related to ore bodies containing V, Cr, Mn, Co, Ni, Cu or Zn should carry anomalous concentrations of these elements. The study is made attractive because of the high chemical and mechanical stability of tourmaline, causing it to be preserved in deeply leached soils, laterite profiles and stream sediments. Twenty-five tourmalines have been collected and analysed and it is hoped to obtain as many specimens as possible, particularly from sources where there is a clear association with known ore. (Russell Hudson)

A characteristic of the important sulphide ores which has made them amenable to beneficiation and commercial development is that their grain size is coarse enough to permit a more or less complete physical separation of one metal sulphide from others. They owe this property to some process of segregation that has occurred during the crystallization of the ore whatever its ultimate origin may have been. Stratiform ores that have formed as a result of chemical or biologically-aided precipitation remain very fine grained unless subjected to a subsequent recrystallization; an ore of magmatic origin will in general have been derived from a single homogeneous molten sulphide phase which differentiated during cooling; and in hydrothermal ores, where the components of the ore may be introduced in a homogeneous aqueous solution, nucleation and crystallization of the individual sulphides could permit coarse grain size to develop as a primary feature.

These processes of producing ores of significant grain size involve transport of the components of the sulphide minerals over distances of a few millimeters of less (recrystallization of stratiform deposits) or over large distances (emplacement of hydrothermal deposits), perhaps through an aqueous phase. Transport by diffusion in solids, may be important in some magmatic sulphides. Vapour phase transport in non-aqueous systems has also been proposed. In all of these situations, whether flow or diffusion or both is involved, a driving force in terms of chemical potential gradients must exist to make it possible.

The mechanisms whereby the components of metal sulphides move are thus a basic part of any study on ore genesis and it is for this reason that studies of the transport of sulphides in aqueous phases have been undertaken. Although the experiments may appear to apply most directly to hydrothermal ore genesis, the results should shed some light on post-depositional changes in stratiform ores and may possibly suggest an alternative mode of formation of ores considered to be magmatic.

In broad terms it has been suggested that aqueous phases capable of transporting sulphides are either alkaline and rich in sulphide and polysulphide species, or acid and chloride-rich. Without ruling out the possible importance of the former, attention has been confined initially to chloride-rich media. This choice has been encouraged by the abundance of natural brines, some of them with significant contents of heavy metals, by the common occurrence of chlorides in inclusions, and by measurements of metal sulphide solubilities in chloride solutions.

The year under review has been used mainly in building equipment and developing methods for assessing the capacity of selected systems of transport sulphide minerals under imposed temperature gradients. Preliminary work has been concerned with sphalerite and pyrite.

The sphalerite system was suggested by the known fact that the solubility of this mineral in potassium chloride solutions could be enhanced considerably by buffering the solutions on the acid side with an equilibrium mixture of quartz, muscovite and potassium feldspar, and that the solubility increases with increasing temperature over the range 300°C. to 500°C. After demonstrating that in the absence of convection sphalerite could be transported along a temperature gradient of about 10°C. (500 to 490°C) in 2·5M KCl at 10,000 psi in the presence of the silicate buffer, the ability of the same system to transport pyrite was investigated.

It was demonstrated that pyrite can be transported in measurable amounts in periods of the order of 1 week and over distances of the order 1 to 2 cm. The chemical and physical conditions were as given above for sphalerite with the exception that sulphate ion, presumably by virtue of its ability to raise the oxygen fugacity, appeared to be necessary to the transport. When a weighed seed crystal of pyrite was placed at the cooler end of

the reaction capsule virtually all of the transported pyrite formed on the seed. By this means it should be possible to investigate quantitatively the factors that control the transport. A program of such studies has commenced and will cover such variables as salt concentration, pH, $f0_2$, temperature and temperature gradient and the length of path between source material and seed. (Mike Bussell and Wilf Ewers)

The Division is collaborating with the Western Mining Corporation on a study of the Kambalda nickel ores. The long term aim is an improved understanding of the chemical and physical basis of the associations of the ore as a guide to exploration. Current activities fall into two main categories, firstly experimental work aimed at testing the feasibility of various genetic models and secondly, investigations in crystal chemistry aimed at relating the characteristics of sulphide minerals to conditions of formation.

An initial task has been the preparation of a comprehensive bibliography of pentlandite and its occurrences, and of the published descriptions of experimental investigations of relevant sulphide systems, including phase equilibria determinations in dry systems, experiments in hydrothermal conditions, and the reactions of nickel-containing silicates with sulphur in both dry and water-containing systems.

It is clear that, in spite of some field evidence of hydrothermal origins for pentlandite, the hydrothermal status of this mineral has not been demonstrated experimentally. Indeed there appear to be no experimental studies of the role of water or of electrolyte solutions in systems involving nickel sulphides.

Water is certainly involved in the formation of the serpentinites which are the common association of most of the nickel ores discovered so far in Western Australia and experiments are being conducted to test whether the release of nickel from the silicate phase could have been associated with the hydration of olivine rocks. Another proposed mechanism for the release of nickel from silicates, by sulphurization, has also been considered. Here the nickel-containing silicates react with sulphur or H_2S to form nickel sulphides. Such a process, commencing with a rock containing <0.3% Ni would yield sulphides in a widely disseminated form. The collection of these to form a massive ore body would require a transport process, possibly involving water.

To test these ideas exploratory experiments have been designed and some of the materials required, for example olivines containing various concentrations of Ni, have been synthesized. Attempts are being made to produce from these materials, nickel-iron sulphides at low temperatures (200 - 300°C.). At the same time, the characteristics of mineral assemblages in the ores are being examined and considered against the published phase equilibrium data. From this, some limits may be set upon the temperatures of differentiation into the various parts of the ore body and of segregation of the component minerals. (D. J. Drysdale, B. Martin and Wilf Ewers)

The crystal chemistry of sulphide minerals, the common ore sulphides, the most likely to develop structural variations as a function of composition and conditions of formation is pyrrhotite, Fe 1-xS. Variations can include magnetic order, as well as ordering of vacancies, on a lattice which is basically that of NiAs. In order to study the mineral in detail a pure sample is required. Several methods have been tried to separate pyrrhotite from natural ore samples, and the most satisfactory has been a small free-fall magnetic separator designed for the purpose. Individual grains of pyrrhotite of size <120 mesh from the Kambalda nickel deposit invariably showed a range of orientations extending over a few degrees but orientation relationships have not yet been established, and it has not yet been possible to study a good single crystal from this source, even when the crystals are further reduced in size by acid etching.

Guinier X-ray diffraction patterns showed a very constant monoclinic unit cell for pyrrhotites in all the magnetic fractions. Though there is perhaps some evidence of different ordered states, optical evidence that two pyrrhotites are present has not yet been confirmed. Even the reactive pyrrhotites from the oxidized zone of the ore have the same monoclinic cell. Specimens are being examined by Mossbauer techniques in collaboration with the Physics Department of the University of Western Australia.

There is at present some doubt whether single crystal diffraction photographs of the copper and iron sulphides indicate a fine scale twinning or an unusual structural modification. Before the matter can be resolved, good single crystals are required.

In addition to the search for suitable natural crystals already mentioned, a program has been initiated to synthesize pyrrhotites which are likely to be free from growth or transformation twins. Twinning is likely to occur when crystals grown at high temperatures are cooled, so the main effort has been directed at room temperature synthesis. Crystallization has been attempted from an aqueous phase in silica gel and in solution, with control of acidity and oxidation potential, so far without success. It should also be possible to grow a variety of sulphides from hydrazine solutions but preliminary studies suggest much lower solubilities than those reported in the the literature. (Jim Graham, Mike Thornber and I.D. Martin)"

The electron microprobe was probably the group's most successful major scientific tool but the Scanning Electron Microscope that was housed next door was undoubtedly the most useful. It was obtained as the free chuck-out of another Division, (a verge pick-up by Beta Bruce Robinson) and modified to operate at low vacuum with an EDAX analyzer that allowed semi-quantitative assay of whatever the electron beam was guided to strike. Ernie Nickel loved it and would get in first thing and fire it up. The rule was that we could use it without supervision at any time but if it broke we were not to fix it.

The other item of equipment was Ray Smith's giant baby and Arzen Gedeon's torment: the giant size ICP chemical assay machine that was to assay 40 elements in a flash down to parts-per-million level. It was supposed to handle so many samples that a battalion of workers would be needed to prepare these samples. Only Valda Garcarkles was hired to do the work of sample preparation. Terry Harrison had a near full time job trying to switch it on. Arzen kept the workshop busy making modifications to the nebulizer system. The machine did its best work when John Wildman was co-opted by Arthur Gaskin to work on it. This machine was so large that it needed a new building to house it. These days ICP is the preferred method of chemical assay by a machine that sits on a laboratory bench with a single operator.

The death of Arthur Gaskin in October 1983, and the retirement of Wilf Ewers marked the end of the "early days" of CSIRO minerals research in the west.

PLANT INDUSTRY[32]

CSIRO Division of Plant Industry was first represented in WA with the appointment of Reg Rossiter in 1940 at the University of Western Australia. The Division was well recognised for its introduction and evaluation of a wide range of pasture species through the 1960s and 1970s, but this is for others to record. In 1983, the WA State Committee successfully petitioned CSIRO to re-establish a group of plant and soil scientists in Perth to work with scientists at the WA Department of Agriculture (WADA) and the University of Western Australia (UWA). Appointed by the Chief of Plant Industry, Jim Peacock, and the Chief of Soils, David Smiles, Neil Turner moved from Canberra to Perth as Research Leader of the Dryland Crops and Soils Unit in January 1984 and began the task of finding accommodation at the Floreat site, appointing five other research scientists and six technicians and establishing a research program. By this time Reg Rossiter was retired, but was still at Floreat daily (except when there was a test match at the WACA) and was pleased to see the re-emergence of Plant Industry in Western Australia. Reg would frequently stop Neil Turner in the corridor to comment on a recent research paper that he had read.

Some staff of the Division of Plant Industry in Perth in 1985 (above: Christian Jensen, a visiting scientist from Copenhagen University, and Ian Henson; below: Ann Hamblin, Marc Nicolas and Neil Turner)

Accommodation at Floreat was at a premium in 1984 so a small laboratory and office building was built for the new group. In the first 18 months, Ian Fillery. Ann Hamblin, Ian Henson, Brian Attwell and Kevin McInnes were appointed and by 1986 a field site adjacent to the WADA Merredin Research Station was established. With the opening of the new Laboratory for Rural Research in 1988, the Dryland Crops and Soils Unit moved into the new building. Through access to industry funds, the group began to grow. Marc Nicolas, Miss Kerry Regan and Shaun Bellairs were appointed to study early-vigour genotypes in wheat in association with breeders at WADA, while Terry Bolger, Campbell Thomson and Ross Chapman were appointed to work on pastures production and survival. As a research

[32] Contributed by Neil Turner and Gerald Watson

partner in the Cooperative Research Centre for Legumes in Mediterranean Agriculture (CLIMA), a number of CLIMA scientists worked closely with Plant Industry staff from 1992 onwards, particularly Laurent Leport, Jens Berger and Qifu Ma.

One of the features of Plant Industry in the 1980s and 1990s was the diversity of countries of origin and training of the research team. Ian Fillery, a New Zealander, came to Australia after working on flooded puddle soils at the International Rice Research Institute in the Philippines and could not believe that farmers grew anything in the sandy soils of WA, a view shared by Kevin McInnes who came from the USA. Ann Hamblin, who had worked at WADA for several years and Brian Attwell, who had a PhD from UWA and whose family farmed near Williams in WA assured the new arrivals that farming in the south-west of Australia could be profitable if the soils were managed correctly. Jairo Palta who replaced Ian Henson grew up in Columbia, but studied for his PhD at the University of Melbourne and had experience working in the UK and USA.

The first Visiting Scientist, Christian Jensen from The Royal Veterinary and Agricultural University in Copenhagen, Denmark, joined the team in 1986 by which time the scientists had established a routine of driving to Merredin after dinner, sleeping in a motel in Merredin for an early start the following morning. When approaching Merredin on his first trip, Christian commented that in Denmark he couldn't drive as far as Merredin without crossing into another country. On the way back we stopped at a farm about 19 km out of town. Ian Henson, who came to Australia from the UK, commented that it was a long way for the postman to walk to deliver a letter! Other Visiting Scientists included Professor Alvin Smucker from Michigan State University, East Lansing, USA, Peter Gregory from Reading University in the UK (who later joined the staff for three years), Professor Detlef Schulze, Bayreuth University, Bayreuth, Germany, Maria Gallardo, Cordoba University, Cordoba, Spain, Professor Ken Shackel from the University of California, Davis, USA, Professor Shahal Abbo from the Hebrew University of Jerusalem, Rehovot, Israel, Professor Pravat Mohapatra from Sambalpur University, Sambalpur in India, Tohru Kobata from Matsue University in Matsue, Japan, Xi-ping Deng from the Chinese Academy of Sciences Soil and Water Conservation Institute in Yangling, China, Hossein Behboudian from Massey University, Palmerston North, New Zealand, Ali Gangeali, Ferdowsi University, Mashad, Iran, Wolfram Hartung, Julius-Maximilians-Universität, Würzburg, Germany, Sunita Kumari, Indian Agricultural Research Institute, New Delhi, India, David Mungai, University of Nairobi, Nairobi, Kenya, Magdi Abdelhamid, National Research Centre, Cairo, Egypt, and Ajit Nandwal, Ashok Kumar and Raj Pannu, Haryana Agricultural University, Hisar, India. By the time that Professor Detlef Schulze arrived, the major research was being conducted at a site near Beverley. Detlef preferred to stay in the caravan on site when taking measurements in the field, rather than retiring to the local hotel, and when his brother-in-law visited he insisted on taking him to the site (the only place visited in WA) because he said that there was no place in Europe where you could stay without seeing or hearing the activities of other people!

The initial focus of the Unit was the adaptation of wheat and lupin crops to the semiarid Mediterranean-type environment of southwest Australia and the improvement of yields of these two key crops. Soon after the Unit was established a farmer from Mukinbudin visited the team and asked whether he should give his wheat crop more nitrogen as he had had 76 mm of rain shortly after seeding and wondered whether additional nitrogen would increase yields. Immediately an experiment at Merredin was modified to add an additional treatment and showed that yields could be doubled by strategic additional fertiliser. While not claiming to be primarily responsible, in the 15 years after the group was established yields of wheat in WA doubled as a result of the introduction of increased fertiliser inputs, minimum tillage, earlier planting, and better-adapted cultivars. With the recognition that farmers in the dry eastern wheat belt were making optimum use of rainfall in many years, the group began to shift emphasis to research crop and pasture performance in the medium rainfall areas of

Wongan Hills and Beverley where a new site was established with the assistance of WADA. Transient waterlogging was identified as an issue on the duplex soils of the region. Measuring the degree and impact of waterlogging and its alleviation by perennial shrubs and trees became a major theme of the research at sites on farmers' properties at Narrogin, Katanning and Kojonup, and led to two conferences and publication of the proceedings in special issues of journals.

On-farm research was complemented by detailed research under controlled environments, particularly with input from a number of graduate students and visiting students from overseas. In addition, crop modelling skills were introduced with the appointment of Senthold Asseng (from Germany), skills that became particularly important when climate-change impacts and adaptation strategies needed to be evaluated for WA. In 1999, Karam Singh (from India, Germany and the USA) was appointed to expand the research of the Plant Industry group into the area of molecular biology and quickly established a team of about six scientists to work on the molecular basis of insect and disease resistance in wheat and legumes. The establishment of the team made it necessary to convert the former Dryland Crops and Soils building and some controlled-environment facilities to PC2 level laboratories and growth cabinets.

The Division of Plant Industry group was very active on the Floreat site, playing in the annual cricket match against WADA, and for several years organising a fun run for staff and their families in memory of a Plant Industry technician who was electrocuted while working for CSIRO.

Yalanbee Research Station was a key element of Plant Industry's research and Gerald Watson spent over half of his 50years+ on the station, his story is added here.

Gerald Watson, Yalanbee "30 years" 1962 – 1992

The decision to move Plant Industry's research farm from "Glen Lossie" (Kojonup, 250km South of Perth) to Yalanbee (Bakers Hill, about 80km East of Perth) was made after careful thought and priority setting so that senior research staff could have their morning bowl of cereal and read the daily newspaper and then take a leisurely drive up to the research station to work or supervise their experiments and maybe pick a few mushrooms or figs, as Yalanbee had plenty of both, before returning to Perth. No PPE in those days.

After the property was purchased the first priority was to settle a staff member on site, so a couple of buildings ex Perth Airport were purchased and shifted to Yalanbee. One was made suitable for accommodation and thus I was the first Staff member to settle on the Commonwealth-owned Yalanbee Research Station. One of the major factors for shifting to Yalanbee was that only small plot work would be carried out. Glen Lossie had outgrown this demand. The first experiments at Yalanbee were plant introduction and seed production plots consisting of soft and hard brome grasses, medic clovers and rye grasses.

Harvesting and cleaning of these were a major start to developing non-clover dominated pastures. As with new ideas and innovations, we were soon to get a new OIC in the West. This was a wise man from the East who hit like a bolt of lightning, resulting in top-priority research such as animal behaviour studies. To avoid confusion to administrative staff, and since any new project needed an approved pre-schedule, it was decided that project P1160 being originally approved would continue by becoming P1160 +A+B+C+D+E. Simple!

Until now, there was no clearing done on Yalanbee, but as there was no way you could run 2 sheep to the acre, as well as trees, you guessed it, major clearing was the order. With animal behaviour research underway on sheep, such as on plots P1160, it was decided to

add horses; of which one staff member just happened to run a horse breeding property. These were shifted to Yalanbee with free board and lodgings. Cattle were also purchased.

Then, with the advent of the "closed flock" animal behaviour studies, ewes and rams and lambs all lived together as families. I think in some places they resemble communes, and male lambs were not doctored, resulting in confusion at shearing time and shearing contractors demanding full ram penalty rates for these youngsters of 6 months. This hurt the budget, but as it was controlled by the OIC in Perth it was alright to continue. Specially adapted milking machines were also used on the ewes to establish their milking potential.

In the mid-1970s political pressure was on to cut agricultural research in CSIRO with a leaning towards ecology and environmental research. So our ever vigilant OIC decided there was work to be carried out on the kangaroo population behaviour. This type of work was eventually transferred to the Division of Wildlife and Ecology. Salinity research then took a rise in popularity and some of the wisest men in the game were called in to investigate and, if possible, make recommendations and give solutions to its control. But alas, they too, turned tail and walked away, and decided to shelve it in the too hard basket. Then, agro-forestry started and trees were planted, fences put up, as was the then "in thing". This was also started off on a site at Mundaring, under the same watchful eyes. One of the problems at Yalanbee was the security problem regarding stock, as they found out on the Mundaring site was that a certain element in a nearby township was feasting royally on CSIRO grown and fed lamb. This was a challenge to the local constables and one "Sherlock" Anderson to track down and deal out a strong reprimand.

Just one of the more amusing situations was during a re-clearing project. Some old stumps were being pushed out of the ground, and much to the sheer horror of one researcher, out came the stump that he had been using as an experimental database. One can still see this researcher seething with rage, smoke coming off his boots, heading towards the office of the station supervisor. He got strips torn off him and told in no uncertain terms what he could do with his research station and if he could not be guaranteed security for his research projects then he would take his research elsewhere. Evidently he was not assured of this and he packed up his stump and went elsewhere.

Another interesting experiment was in the 70s when certain species of clovers were being grown and used for feeding in the animal house. The clover was cut in the field and loaded into utilities and carted down to Greenmount to be dried out in a huge fruit drying oven and then carted back to Yalanbee. Some 25 years later, it is noticed that some of the same species are being grown in the glasshouses at Floreat Park and fed to the sheep in the animal house. It seems to me that this research is either very thorough or nobody believed what came out of the first lot of trials.

One of the more interesting experiments was the researcher who required his clover plots to be top dressed at the rate of 250 lbs/acre of double super. This was in the times when Yalanbee's super order was 180 tons per year, all carted and spread by farm staff, (no contractors). Farm staff numbers were around 7 plus technical staff for stock work.

During the 20years I spent on Yalanbee, I saw the place develop from virgin bushland to highly productive research plots on which a lot of high class research was achieved. Still, with changing political priorities, agricultural research by CSIRO took a hiding, and so a lot of us were shifted away to work on other research projects elsewhere. Yalanbee, although threatened with closure many times has survived and as with inflation, so too has the salinity problem risen. This article was written with no intention of insulting or offending any person whatsoever. It was never intended to be Yalanbee's history, only a small part of it of which I am proud to have been involved. Since this was written Yalanbee was sold in 2011.

LAND AND STREAM SALINITY[33]

Background

David Bennett and Duncan Macpherson have written a history of events relating to land and stream salinity in WA and this piece of our History simply expands on the role of CSIRO in many of those events. David moved to CSIRO in WA with a background in agriculture, but an interest in many other things. Duncan has an unusual disciplinary mix including history and engineering. He was one of a few recruits with greater interest in the social sciences appointed (controversially at the time) soon after Ray Perry settled in as Chief of the first CSIRO Division headquartered in WA (Division of Land Resources Management).

David and Duncan have noted that early farmers, engineers and scientists correctly interpreted the primary cause of land and stream salinity as land clearing, but for many years there was a reluctance to accept this by WA Governments whose policy was to encourage the extension of areas of farming, particularly to settle ex-servicemen following the World Wars. Soon after WW2, the Government stance was supported by advice from one of their senior public servants that the link between clearing and salinity was not proven.

It has been argued that the major role of science applied to salinity in WA has been to provide details of the processes of accumulation and movement of solutes in soils of this particular environment, and that the empirical observations of our pioneering farmers and engineers have been at best overlooked.

Before CSIRO Began Work on Salinity in WA

There are good reasons to believe that saline soil and water existed in Australia, particularly in WA, for a very long time before they were observed and recorded by European explorers. It is likely that Australia's Aboriginal population, our first environmental managers, had their stories to explain the presence of salinas (salt lakes), salt-tolerant vegetation on saline soils, and springs that yielded saline water, but we have yet to hear these stories.

Soon after European settlement in WA, Ensign Dale recorded areas of salt-affected land, and in 1907 the Government Analyst of the time discussed the relationship between clearing and salinity in the WA Journal of Agriculture. A railways engineer (Bleazby) reported problems of salinity of water supplies for locomotives in 1917, and in 1923 another railways engineer (Wood) presented a classic paper documenting increasing salinity of water supplies at several sites in the southwest of WA.

In 1938 Teakle (later Vice Chancellor of the University of Queensland) and George Burvill (later Deputy Director of the Department) of the WA Department of Agriculture published results of analyses of a great number of soil samples (all done during a long field trip) showing lower salinity in near-surface soils of farmed land after clearing native bush. These results appear to contradict many other observations of increasing soil and water salinity following removal of the foliage of perennial trees and shrubs for development of dryland agriculture.

The emphasis of work by the WA Department of Agriculture in the 1930s to 1950s was on surveys of the salinity of land that was being considered for agricultural development, and surveys of the extent of soil salinity. There was little official concern about the loss of formerly productive farmland, the argument being that there was an abundance of land available so that nothing to prevent salinity or rectify saline land was worthwhile. However, the increasing salinity of water sources attracted the attention of engineers responsible for water supplies for steam locomotives.

[33] This article includes sections that were drafted by many of those who contributed to the CSIRO research: Eric Bettenay; David Bennett; Frank Hingston; Denis Hurle; Adrian Peck; David Williamson.

Responding to a request for advice, in 1965, Samuel (then Director of the WA Government Chemical Laboratory) wrote to Government advising that there was no evidence of increasing salinity resulting from land clearing in WA. Whilst this conclusion is consistent with the results of the soil analyses by Teakle and Burvill, it appears to be contrary to the conclusions of many other scientists and engineers over more than 50 years. It can be argued that Samuel was taking a very cautious approach as there had been no carefully designed and conducted experiments at the catchment scale to gather evidence of changes of land and stream salinity following clearing native vegetation.

Advice to CSIR

Following WW2, in 1945 Teakle and Burvill suggested to a meeting of the CSIR State Committee that there should be studies of soil physics in relation to salinity in WA, but there is no evidence of any immediate response.

CSIRO Division of Soils had established a WA Regional Centre in the early 1950s. On a visit to WA in 1950, RR Pennefather (Officer-in-Charge of the Agricultural Research Liaison Section in Melbourne) consulted extensively with local CSIRO staff and UWA, toured many sites in the wheatbelt with Burvill (then WA Commissioner for Soil Conservation) and Lewis (a Public Works Department Engineer), and met with the Minister for Agriculture. Previously Pennefather had worked on problems of salinity and soil fertility at Griffith, NSW. He produced an insightful report (printed in The Western Mail of 12 July 1951) and he is said to have put a case to the CSIRO Executive for appointment in WA of a person with experience in 'watershed hydrology'. Whilst no specific response from the Executive is known, soon after (1953) Tjeerd Poutsma of CSIRO Division of Soils in WA presented a report on salinity in relation to proposed agricultural development in the North Stirling area of WA. This report was not well received by the then Director of the WA Department of Agriculture.

Belka Valley Study

Eric Bettenay joined CSIRO in 1952, soon after graduation from UWA. During his course work, he had had taken part in surveys of soils and potential land use in the Great Southern and Swan Coastal Plain. JK Taylor (then Chief of Soils Division) suggested that Eric should investigate some soils of the inland agricultural areas.

Eric mapped salt lake systems in the Merredin area, and decided to take a natural boundary (surface water catchment) approach to study the link between salinity and hydrology in the Belka Valley (an area of about 1.8×10^3 km^2). Frank Hingston and Bill Blackmore provided inputs of chemistry and hydrology for this project. Determination of the nature of the deeper soils and groundwater levels and salinity was possible as their equipment included a small drilling rig and coring equipment capable of recovering soil samples to about 20 m depth. After removing the drilling augers, plastic casing was placed in the borehole to enable monitoring of groundwater levels and salinity. This marked the first step of CSIRO's investigations of the nature of the deeper strata and groundwater in relation to salinity in WA.

An interesting observation was that when a train passed by, the water level in a bore in the rail reserve would rise temporarily. This is typical response of swelling clay soils subjected to 'overburden load'.

Meckering Sandplain Study

Surveys by Eric Bettenay, Max Churchward and Bill McArthur had identified a significant area of sandplain soils in the wheatbelt of WA. These are usually associated with salinity in the lower parts of the landscape, with fresh and saline lakes forming at various elevations. The sands usually contain a shallow aquifer perched on deep subsoils rich in kaolin that is the end-product of weathering feldspar of the granitic basement rocks.

David Williamson began his working life with CSIRO in 1964 when he began the study of a sandplain catchment north of Meckering. Under the broad direction of John Holmes (Division of Soils HQ in Adelaide) all components of the water balance were measured over a 4 year period, including the hydrology of the shallow groundwater that had accumulated in the sands since clearing. It was concluded that about 15% of the annual rainfall was moving vertically into the deep subsoil clays and contributing to the discharge of deeper saline groundwater in the valleys. Small lakes that had developed in depressions in the sandplain were linked to the shallow groundwater system, some being terminal and saline.

The shallow groundwater in the sands could provide a valuable resource for stock and rural household water supply. Some landholders showed interest in using this resource for irrigation purposes, but the scale was too small to support economically viable production. The use of open ditch drains to prevent shallow groundwater seeping onto the valley floor soils was considered but not developed. By extrapolation, using the maps of sandplain soil in the wheatbelt, it was estimated that these plains held about 10-times the volume of fresh water that was supplied to Perth in the 1960's. However, the geographical spread of this resource did not support it as a potential source of potable water for urban use.

Bakers Hill (Yalanbee) Studies

CSIRO established a research station ('Yalanbee') near Bakers Hill in about 1967. To assist land use planning, a detailed map of soils and geomorphology was prepared by Geoff Dimmock, Eric Bettenay and Frank Hingston. This study included determination of the salt content of soil profiles.

Tom Bromilow measuring electrical conductivity of soil near a drain at Yalanbee

The Belka Valley and Meckering studies had emphasised the need to quantify the hydrology of salinity development as a consequence of land clearing. John Holmes had suggested a water balance study to estimate the change of water use due to a change of land use. Uncleared areas on Yalanbee provided the opportunity to instrument a pair of small catchments (each about 10 ha) in 1968. Rainfall, streamflow and soil moisture was monitored at several sites in each catchment before clearing, and after correlations were obtained one catchment was cleared and put into standard agricultural practice. These catchments were found to be too small and lacked sufficient geomorphological and hydrogeological variety to allow greater analysis of the impact of land use change. However the study was significant for the development and refinement of methodology eventually applied to larger catchments in the Collie River Basin.

A third catchment at Yalanbee that had been cleared prior to acquisition of the property showed signs of salinity development. This 'Subdued Catchment' was instrumented to observe groundwater, streamflow and stream salinity providing conclusive evidence that when the hydraulic head of the rising saline groundwater reached the soil surface, there was an immediate and dramatic increase in the salinity of the streamflow. This was later reproduced by data collected at Lemon Catchment in the Collie Catchment Study.

It was in the early 1970s that the non-irrigated salinity problem was being increasingly recognised as a water problem with soluble salts a secondary factor dependent on the water for transportation to sites where damage to much of the vegetation would result from both water logging of the root zone and the salt content (possible a secondary factor).

Liaison with Public Works Department

The Public Works Department of WA (PWD) was concerned about the quality of water in Wellington Dam, which provided water supplies to farms and towns over a large area of the Great Southern, and to irrigated land on the Swan Coastal Plain in the Roelands – Brunswick Junction area. PWD had proposed a ban on further clearing in the Collie River catchment above Wellington Dam in 1951, and in 1960 the WA Purity of Water Committee recommended a ban on further alienation of Crown Land in that catchment. Liaison between PWD and Maurice Mulcahy (OIC of Soils Division in WA) began behind the scenes culminating in a proposal for catchment studies, which was submitted to the Australian Water Resources Council (AWRC – a group within the Commonwealth Government's Department of National Development) for financial support.

One of the initial tasks which Adrian Peck undertook on his move to Perth from Canberra in 1970 was to review the historical work on salinity and strengthen the planned scientific objectives in the project proposal. This project demonstrated the value of combining the engineering skills of the PWD and CSIRO science to broaden the outcomes and likely applications expected from the project. Each organisation had specific skills which they brought to the project and enhanced the effectiveness of the results obtained.

The Collie Catchment Study (AWRC Project 71/31)

The proposal for joint CSIRO-PWD paired catchment studies in the Wellington Dam catchment area received financial support as AWRC Project 71/31. A condition was that a committee should be established to facilitate liaison, detailed planning and regular communication of progress to AWRC. This Committee was established in 1972. It included representatives of key organisations with well-defined responsibilities or interests in relation to the project:

- CSIRO for surveys of soil, landforms and vegetation, selection of proposed paired catchments; drilling within the paired catchments and analysis of soil cores, installation of neutron probe access tubes and monitoring of soil moisture, monitoring of monthly rainfall and analysis of rainfall chemistry, monthly monitoring of groundwater level and quality, data collation and reporting;
- PWD for design, installation and monitoring of streamflow from the experimental catchments, collection and analysis of daily samples of streamflow; streamflow and salinity reporting, and installation and operation of climate stations;
- Forests Department of WA for forest management (including controlled burns), maintenance of access tracks, catchment clearing and leasing of cleared catchment areas for conventional agricultural development;
- Department of Agriculture for advice on agricultural development of cleared catchment areas;
- Mines Department (Geological Survey) for geological and hydrogeological advice

- Bob Hebbert of the water research group within the Department of Civil Engineering at UWA was included in the Committee to maintain liaison with that group.

Eric Bettenay and Max Churchward began the project with a broad-scale survey of soils and landforms of the Collie River catchment area above Wellington Dam. A preliminary survey of the catchment had been reported by Keith Barrett of PWD in 1965.

After approval of the original project proposal and the whole-catchment surveys, a revised plan for the AWRC project was developed based on a paired catchment approach. The plan was for instrumentation of three catchments (later called Ernies, Dons and Lemon) in a group within forested Crown Land about 25 km east of the town of Collie, and two catchments (Wights and Salmon) in forested Crown Land close to Wellington Dam west of Collie. With good average rainfall, the eastern areas would be attractive for agricultural development, but the western catchments were in areas of productive hardwood and softwood (pines) forestry and some distance from any agricultural land. Choice of the latter catchment areas was proposed by Adrian Peck because responses of surface and groundwater to clearing were expected to be more rapid in the higher rainfall area, so that within a 10-year period of experimentation (including about 7-years post-clearing), some evidence of an approach towards a new equilibrium of salt input and output was expected to be detectable.

The experimental catchments were chosen of such an area to include soils and landforms representative of the areas east and west of Collie. Within each representative landform unit, one or two sites (each of a nominal 0.1 ha) were chosen for the instrumentation by CSIRO to monitor rainfall beneath the forest canopy, and soil water content to 6 metres depth, and to determine the nature and salinity of the deeply weathered soils above bed-rock (or the limit of the capacity of the drilling rig).

Soil cores were recovered using a trailer-mounted Gemco rig powered by a VW engine and driving hollow augers. Monitor bores were constructed by running PVC casing down the hollow augers after removal of the coring equipment. The casing was slotted over a short interval, and the annulus was back-filled to produce a piezometer.

At many sites, a second fully-slotted tube was installed above the clay layer to measure any perched groundwater in the surface gravels and loams.

Eric Bettenay, Wally Russell, Peter Hick and Norm Campbell checking quailty of water samples.

Eric Bettenay, Wally Russell, Peter Hick or David Williamson recorded a description of the lithology of each soil core. Samples of each core were taken at regular intervals for determination of bulk density and the chemistry of extracts in CSIRO's lab. Some sections of soil core were selected for determination of mineralogy by staff of the Division of Mineralogy. Many of the cores are still available for inspection or further sampling.

CSIRO drilled more holes to monitor groundwater on a nominally 200 m grid in areas that were to be cleared, and in areas that were subjected to special clearing patterns on Dons catchment.

PWD installed a stream gauging station and automatic stream sampling equipment at the outlet of each catchment. Where the cut-off wall did not reach bedrock, CSIRO drilled additional boreholes to allow estimation of groundwater outflow from the catchment.

At one site within each group of catchments, PWD established a climate station for continuously recording wind, rainfall, temperature and humidity. An unsuccessful attempt was made to monitor pan evaporation.

The program of drilling and installation of equipment took many months, and those who were frequently at Collie over this extended period rented a Housing Commission house in Collie. As funds diminished and staff changes occurred, assistance was provided by the WA Geological Survey drilling section to install piezometers.

CSIRO employed an experienced driller (Jim Moynihan) and several other people for instrumentation and monitoring of the catchments. Peter Yendle made monthly visits to the catchments to monitor soil moisture and groundwater (level and quality), to measure rainfall and collect rainwater samples, and to liaise with the Collie office of Forests Department. From 1976, access to the catchments was subject to all vehicles being washed down before entry to remove soil which was a source for spreading Jarrah dieback disease (*Phytophthera cinamomi*). Over time, Peter conducted a small scale test of every borehole to determine the hydraulic properties of the aquifer within the deeply weathered regolith. Peter was a key person who with great persistence and skill over the duration of the project provided the accurate and reliable field data that was essential to the success of this study.

In those days, Peter Yendle worked alone in the bush up to 25 km from Collie and he was only able to communicate by phone from town. We were unable to get funding for a 2-way radio, but fortunately there were no serious accidents. Peter did suffer a red-back spider bite whilst alone in the bush, and on another occasion he made a strategic retreat from a wild pig with piglets.

In Perth, Peter Yendle was the front-line person for entry of data into a database that had been put together by David Williamson and Denis Hurle. Tom Bromilow and Peter looked after the electronics and construction of various pieces of equipment to facilitate the field work. Many other CSIRO staff were also involved in data analysis and other projects that arose from the catchment study. Barry Carbon and Greg Bartle studied leaf-water potentials to estimate water use and tree water stress across the range of seasonal conditions. Munna Sharma and Mark Fernie measured infiltration properties of soils in Wights Catchment and analysed the infiltration and soil moisture data. John Marshall studied the edge effects of clearing native vegetation by taking long-term time-lapse photographs of the native forest showing striking variations of leaf area from year-to-year reflecting rainfall variability. Peter Hick and Wally Russell found evidence in stereo air-photos of past land-slips, which was surprising given the relatively low slopes. A short-term visitor (Bob Luxmoore) from the Environmental Sciences Division of Oak Ridge National Laboratory in the US ran a soil-plant-atmosphere water budget model that he had helped to develop (PROSPER) to simulate the water balance of natural forest, crop or pasture, and part-cleared land (parkland

clearing). The model was too large for CSIRO's computer in Perth, so it was run at night on a machine at the State Electricity Commission.

Salmon catchment was the site for post graduate studies by Colin Johnston (who later joined the salinity research team) and Bob Stokes (WA Water Authority). Colin investigated the movement of water down preferred flow paths to the deeper aquifer following the observation that groundwater levels responded within the first year after clearing in the western region of the Collie Catchment. He developed techniques to install piezometers at different depths in the clay profile and watch the response in the hours after rainfall. He noted that short time variation of the hydraulic head was not recorded when longer periods (e.g. monthly) between monitoring were used. He complemented the Collie work with a study using Rhodamine WT dye, to trace the flow paths of water movement to the deeper aquifer at the Del Park Catchment near Dwellingup (see below).

The catchment work began without any commitment to the costs of clearing, but PWD managed to get this into the State Government's budget, and with considerable inputs from Forests Department and the Department of Agriculture, areas were cleared in the summer of 1976-77, leases arranged, and farming (cropping or grazing) began in the following winter.

Following Government acceptance of the cause of salinity, parts of one of the eastern trio of catchments (Dons) were subjected to several different clearing strategies that, it was hypothesised, may at least minimise the change of water balance.

In 1981, the WA Government funded visits by the Director of the US Salinity Laboratory and a number of other eminent scientists for a workshop and seminar in Perth 'Land and Stream Salinity' that was published in *Agricultural Water Management (1981)*. Collection of data in the experimental catchments proceeded for a total 12 years, and the work was reported in a special edition of the *Journal of Hydrology* (1987). Subsequently, UWA staff and students have used the catchment data, which are considered to be of the highest quality and of great interest in relation to impacts of climate trends and changes of land use.

It was considered at the time that continuation of the Collie catchment study, which involved much data collection and analysis, was not an appropriate role for CSIRO although somewhat similar catchment studies that began in the US at about the same time (specially Hubbard Brook Experimental Forest, New Hampshire) have continued. PWD (and their descendants in the WA Government) monitored streamflow and quality from the Collie catchments irregularly since the CSIRO program ceased. Examination of the available data strongly suggest that at least 25 years after clearing, the discharge of salts had not reached a new equilibrium, even in the higher rainfall region west of Collie. This is contrary to the original hypothesis that significant recovery of the salt balance of the western catchment would occur within a decade after clearing.

There have been suggestions that the Lemon Catchment (50% cleared in 1976-77) could be the site for studies of reforestation and its impact on groundwater levels and stream salinity. But this has been resisted as the catchment has a greater benefit for its long data record in studying the approach towards a new hydrological equilibrium.

The role of experimental catchments in planning water resource management was reviewed by David Williamson and Adrian Peck for the Water and Rivers Commission of WA and published in June 2002. This provides a summary of the key findings of the studies in the Collie Catchments and their use by other agencies to manage the salinity problem. An evaluation of the future role of these experimental catchment areas is discussed. The bibliography shows that relevant data from the experimental catchments have been included in many studies of dryland salinity by a range of scientists and engineers in Australia.

It is sometimes forgotten that the Collie catchment studies were designed to provide evidence of changes of soil and water salinity following typical agricultural development within the Collie River Basin. However, during the period of these studies, the WA Government accepted the relationship between clearing and salinity, and in 1976 legislation was introduced to control clearing in the catchment of Wellington Dam. Perhaps the vast difference between chloride balances of farmed and forested catchments that Adrian Peck and Denis Hurle had reported in 1973 influenced the decision makers (see below).

Hydrological Impacts of Bauxite Mining

In the early 1970s, Sir Laurence Brodie-Hall was both a Director of Alcoa and Chair of the WA State Committee of CSIRO. There was widespread concern that Alcoa's bauxite mining operations in the Darling Range may affect the quality of water captured in dams that had been constructed for public water supply.

A visit to some areas east of Jarrahdale was arranged. Brodie turned up in his Rolls and invited Maurice Mulcahy and Bruce Beggs (then Conservator of Forests in WA) to join him whilst 'other ranks' followed in a CSIRO vehicle. The more lowly scientists were allowed to listen to the hi-fi music emanating from the Rolls, but not to get too close to that vehicle! The tour proceeded along forest tracks that got narrower and narrower whilst the Conservator of Forests insisted that he knew the way to get through to Albany Highway. Of course the convoy finally got though, but it was quite an event to see a Rolls on such tracks.

On the basis of concern about bauxite mining in Perth's water supply catchments, and the evident progress of the Collie study, the State Committee proposed CSIRO studies of stream salinity in catchments that were targeted for bauxite mining. Brodie wanted Alcoa to fund CSIRO to instrument and operate several experimental catchments in forested areas over a range of rainfall. At that time Alcoa was the only bauxite mining company operating in WA, and CSIRO refused to take this offer as it came from a single company rather than a consortium of bauxite miners!

As often happened in those days, whilst there were debates about funding at a higher level, CSIRO and PWD began work on a small catchment near Dwellingup (Del Park) where a stream gauging station was established by PWD and cored holes were drilled by CSIRO to install monitoring bores on a nominally 200 m grid. After some time, this catchment was mined and very relevant data were accumulated for comparison with predictions of a simple model that Adrian Peck had developed.

Although there was no exchange of funds, Alcoa arranged for the excavation of a pit to a depth of about 7 m within the Del Park catchment. During the preceding winter, the excavation site had been irrigated (at the same rate as rainfall) with water to which tracers (Rhodamine WT and NaCl) had been added. By good fortune, the excavation straddled the intersection of weathered granite and dolerite rocks. The pattern of staining (by Rhodamine) on the pit face showed very irregular wetting due to the presence of weathered root channels. These allow rapid flow of water downwards beneath a perched water table that often develops in the shallow surface soil following heavy winter rainfall. The results of this tracer experiment contributed greatly to understanding of the mechanisms of accumulation of soluble salts in the deeply weathered soils, the rapid response of the deeper water table following rain, and the leaching of these salts after the groundwater level rises following a change of land use.

Alcoa also contributed to the installation of a ventilated chamber enclosing a living Jarrah tree in the Del Park catchment for Eric Greenwood and his colleagues to measure evapotranspiration.

An inter-agency committee was established by the WA Government to oversee selection and instrumentation of several small catchments in areas that could be mined for bauxite. CSIRO was represented on the Bauxite Committee which was very similar in membership to that established for the Collie study, but Chaired by Harold Hunt, Chief Engineer of the Metropolitan Water Supply and Drainage Board. By this means, CSIRO was able to contribute to the design of experiments and to get early access to results.

Hydrological Impacts of Logging for Woodchips

CSIRO staff also contributed to the planning of small catchment studies in the Manjimup Woodchip Licence Area. Again a Committee was established along the lines of the Collie study committee, but in this case it was chaired by Ken Kelsall a PWD engineer. Again CSIRO was able to contribute to the design of experiments and to get early access to results.

Catchment Salt Balances

The concept of salt balance of areas of land had been developed in relation to management of irrigated areas, and in 1972 Adrian Peck realised that existing data could be used to compute the chloride balance of certain catchments in WA. Inputs could be calculated from Frank Hingston's work on the salinity of rainfall and rainfall isohyets published by the Bureau of Meteorology. Outputs from several catchments could be computed from stream gauging by the Public Works Department of WA and their monthly sampling of streamflow to determine salinity (inferred from chloride concentration). It was found later that Tom Smith of the WA Department of Agriculture had discussed salt balances for WA catchments in his MSc thesis in 1962.

To determine salt balances, Adrian Peck and Denis Hurle selected several catchment areas that were uncleared and others that included substantial areas of farmed land. Denis used his computational skills in this project which showed close to chloride balance for the forested catchments, but outputs exceeding inputs by up to a factor 21 when there was significant farmland in the catchment. This project provided quantitative evidence of impacts of clearing for agriculture in the Darling Range, on stream salinity. The chloride balance results came before the Collie experimental catchments had been cleared, although the catchment results would subsequently provide details of the hydrology of forested catchments and the dynamic response of the hydrologic systems to the impact of clearing for conventional forms of agriculture. In 1976, legislation to control clearing for agriculture in the Wellington Dam catchment (the Collie River Basin) was introduced to the WA Parliament.

Soil Salinity Profiles

Many profiles of salinity in the deeply weathered regolith of the Darling Range had been recorded from CSIRO drilling at Collie, Del Park and Bakers Hill (Yalanbee) and State Government agencies made available results of their work near Manjimup for CSIRO analyses. This provided a tremendous body of information about the quantity of soluble salts stored in the landscape, which provides the storehouse resulting in discharge of salt to surface soils and streams following disturbance of natural hydrology. Colin Johnston and Bill McArthur collated and published much of this information together with the ionic composition of soil-water extracts and groundwater.

A distinctive bulge above the permanent water table is evident in many profiles of chloride concentration in soil water. Adrian Peck, Colin Johnston and David Williamson interpreted these profiles as resulting from very small rates of upward flow in the soil matrix between the water table and the bulge, whilst during a short part of the year water moves rapidly downwards not through the soil matrix but in remnant root channels. This is the essential mechanism that has resulted in the accumulation of great quantities of soluble salts in the deeply weathered soils that are common in WA. During these studies, Jim Watson (a

visiting scientist from Utah State University), carried out detailed mathematical analyses to assist in the modelling of the flow of water and salt within the soil profile above a water table.

Barry Carbon studied soil core material and concluded that roots of native eucalypts in the Darling Range extend to depths of 10 to 20 m. The analysis of maximum soil solute concentrations in forested catchments allowed David Williamson to estimate effective water uptake depths with median values of 5.6 m in the higher rainfall catchments and 6.8 m in the lower rainfall eastern catchments.

The Murray River Land Use Study

Maurice Mulcahy was a great one for posing challenging questions. One knew what to expect when he would whistle as he walked along the corridor seeking out his target person. After the catchment chloride balance study he asked Adrian Peck what area of the (WA) Murray River catchment would need to be reforested to reduce the salinity of this major river to values acceptable for water supply.

Soon afterwards, the Division of Land Resources Management was established in Perth, and the new Chief (Ray Perry) appointed scientists with a range of skills appropriate to the wider objectives of the new Division, but differing from those of the plant and soil sciences that formed the background of the majority of the existing staff.

With the background of interactions between land use and land and stream salinity in the southwest of WA, David Bennett, Duncan Macpherson, Jon Thomas and several others undertook a case study of application of methods of systems analysis to develop a plan for management of land uses within the Murray catchment. A very wide range of potential land uses, their economic costs and benefits, and their impacts on water and salt yield were included in a linear programming model. The objective was to maximise economic benefits from land uses in the catchment subject to various constraints, including stream salinity. This project included active participation by many CSIRO staff as well as scientists from the WA Forests Department and the WA Department of Agriculture.

Salinity Management by Drainage

A common method for management of soil salinity is to lower the water table by installation of a system of drainage, or by pumping from a suitable aquifer. These methods are used in irrigation areas in Australia and overseas, but often they are not acceptable because costs exceed benefits, or there is no acceptable site for disposal of drainage water, which is commonly saline and may contain unacceptable levels of other chemicals.

The possibility of applying drainage for management of dryland salinity was discussed by Eric Bettenay in the 1950s and 60s during the Belka Valley and Meckering studies. There was strong resistance from State Government agencies to conduct drainage research. However, the development of salinity on the CSIRO field station ‘Yalanbee’, at Bakers Hill in the 1970’s provided locations for Eric to conduct some tests. He installed slotted plastic drainage pipe beneath saline seepages, but blockages developed due to the precipitation of iron oxide compounds.

In another drainage trial at Yalanbee, a channel was blasted through a shallow rock bar that appeared to impede drainage from an extensive saline seepage (‘Crocodile Creek’) but there were only very local effects on the hydraulic head of the groundwater. This was attributed to the lack of a suitable aquifer within a few metres of the soil surface, and the limited cross-sectional area of the breach in the rock bar relative to the width and depth of the flow zone across the valley.

Salinity Management by Pumping

Wallatin Creek north of Kellerberrin was the site for an experiment by Ramsis Salama to lower the hydraulic head in an aquifer by pumping from within the relatively coarse grits immediately above basement rock. A windmill-driven pump was installed in the bore and water discharged into the nearby creek. The hydraulic head was lowered by at least 2 m. However, after pumping for about 15 months, the downstream neighbour complained of rising salinity upslope of the creek and it was agreed, after discussion, that the pumping would cease. The lowering of the hydraulic head was adequate for a Murdoch PhD student (Phil Bourgault) to use the saline area to study the process of leaching of salt by natural rainfall for a soil profile to 2 m depth. The conditions required to achieve successful leaching were identified.

The Salt River near Quairading was the site for a study of the capacity to recover salt from saline aquifers for transport to a proposed petro-chemical plant at Kwinana. Palaeo-aquifers were identified in the valley and high capacity pumps were installed to test the volume of saline water which could be removed on a sustainable basis. Flow models were used to estimate the yield and lateral extent of the decline in hydraulic head to aid the design of a production bore field. Hydraulic head was found to be lowered by up to 1 m at a distance of 1 km from the production bore, and the yield of salt was estimated to meet the client's requirements. The project did not proceed due to the collapse of the Petro-Chemical Plant proposal.

Risat Ali investigated ditch drains that have been installed by some farmers to lower saline groundwater levels in the wheatbelt. Many of these installations have been found to lower the water table in only a narrow strip along the drain. The benefits of major open-ditch drains (such as one that passes through Narembeen) have been studied using groundwater monitoring lateral to sections of the drain. These studies show that unless there are subsurface layers of permeable material to convey water into the drain the lateral effectiveness is very limited. Studies of the decrease in salinity of soils adjacent to the open-ditch drains were included in the investigations. Issues of proper drainage design, the acidity of the drain outflow and the safe disposal of effluent water were identified as key factors which can limit the usefulness of drainage methods.

Salinity Management by Reforestation

An option for salinity management is partial reforestation to increase the interception of rainfall by plant canopies and increase evapotranspiration, thereby reducing groundwater recharge. In the early 1900s, the Helena River catchment above Mundaring Weir was partly cleared with the objective of increasing runoff, but in less than 10 years increasing salinity was detected. It was decided to permit natural regrowth and to undertake a program of partial reforestation of the areas that had been cleared.

In areas of Australia where salinity is a problem, the concept of partial reforestation has been used by government agencies to encourage a reduction of groundwater recharge. Eric Greenwood, Ernie Biddiscombe and other colleagues established reforestation trials in catchments of the Hotham and Helena Rivers and at North Bannister. These included various species, block sizes and locations. Of particular interest was the idea of agroforestry operations, with cultivated agriculture in alleys between strips of trees. Geoff Anderson carried out experiments with agroforestry in higher rainfall areas. In the USA, strips of trees have been used to reduce wind erosion from cultivated land after the 1930s 'Dust Bowl' experience.

There are two key factors in the use of vegetation to reduce recharge to groundwater:

- The 3-dimensional zone in which the vegetation is able to capture soil moisture and use it in plant production; and
- The volume of water captured per unit area of land relative to the volume of infiltration over that area.

There is abundant evidence that some types of vegetation ('phreatophytes') can withdraw water from the capillary fringe above a water table. Eric Greenwood's early studies in WA aimed to use evergreen trees to intercept groundwater flow close to areas of seepage, but results showed that seepage continued. It was recognised that a more effective approach could be to place trees in areas of major aquifer recharge, which may be quite high in the catchment and distant from seepage areas. However, it is now considered that the major way in which vegetation operates to reduce groundwater recharge in areas of WA where salinity is a common problem is by interception of rainfall by plant canopies, and capture of water stored in the unsaturated zone well above any water table.

Reflections

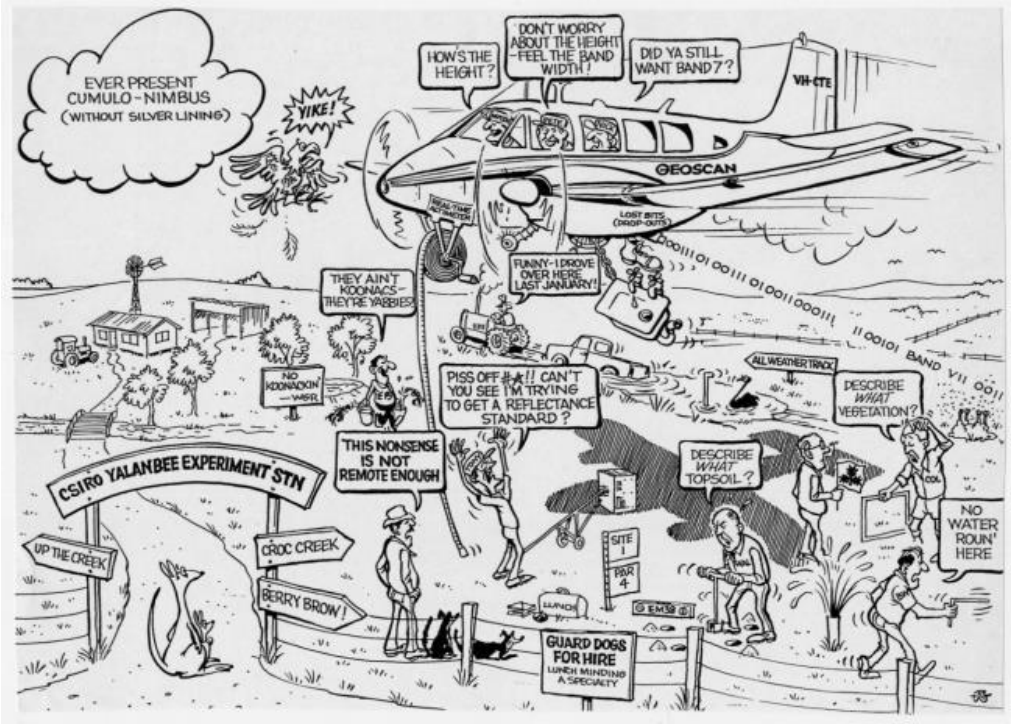
Previously productive soils that become affected by dryland salinity, and associated increases of stream salinity are not restricted to WA, or to other states of Australia, although the geology, climate, land use and ionic composition of the salts differ in other areas where these problems have been investigated (USA; Canada; Thailand; South Africa).

Our peers in other agencies have sometimes criticised CSIRO's salinity work in WA as having been too focussed on areas of intermediate rainfall; that is, neglecting the broad valleys with relatively low slope and lower rainfall of the wheat-belt. These comments overlook CSIRO's pioneering work in the Belka Valley and Meckering areas. Moreover, they overlook the fact that the intensive work in the Collie River Basin was strongly supported by the PWD and AWRC specifically because of the importance of Wellington Dam as a source of water for irrigation and public water supplies.

Comparing CSIRO's salinity work in WA with somewhat similar programs in the USA and Canada, we can claim to have achieved a detailed understanding of the amounts of soluble salts stored in our soils, the effect of vegetation on groundwater recharge in our environment, and the role of shallow and deeper aquifers in the development of dryland salinity in our environment. But we have not developed a capacity to provide economic solutions for the prediction of salinity risk, the diagnosis of specific causes of salinity at particular locations, or the successful management of farms and catchments in which salinity has developed. The management of land and stream salinity remain environmental problems that affect many members of our society.

This complex of 'projects' within the CSIRO salinity 'program' survived several organisational changes, and provided an early example of very close liaison with several agencies of the WA Government (some of them being actively involved in the work). The Commonwealth Government (AWRC) provided seed money for the Collie Catchment study, but this contribution was minor in comparison with direct costs incurred by CSIRO and various agencies of the WA Government.

REMOTE SENSING[34]



This Rod Waller cartoon (1985) depicts the Yalanbee Remote Sensing for salinity studies and its conspirators. It includes with apologies (from L-R) representations of Eric Bettenay (Koonacking), Ian Southey (with his dogs) Tony Rea (with Radiometer) Gerald Watson (on tractor), Mitch Blakers, Peter Hick and Nic Andronis (in Aircraft) Wally Russell (with hand auger), Peter Crown (Canadian post doc,) Baden Williams and Colin Lendon.

The term “Remote Sensing” was not widely used until the late 1960s although the use of air photos to measure and describe the landscape and vegetation had always been a major part of the activities of the Division of Soils in Western Australia. The term was adopted by the photogrammetry and air photo interpretation industry as the technology of “obtaining information from an object without actually coming into contact with it”. This coincided with the data acquisition moving from not only aircraft but also to spacecraft. Most recognised achievements that are now used in our daily lives come from satellite-derived data. However, aircraft-based systems, especially for high resolution hyperspectral passive and active sensing systems and in traditional geophysics, have always played a significant role in our understanding of the Earth and in the challenges and directions that CSIRO’s remote sensing research has taken over the past 30-40 years.

When I joined the Division of Soils in 1967 we were definitely in the air photo interpretation era and I remember well Eric Bettenay, who after watching the weather news on TV visited Channel 7 where he obtained a Weather Satellite image extending from the Nullarbor in the East to The Indian Ocean. The image covered the whole of the South West Agricultural region showing all the major natural features. A slide made from this became a valuable adjunct to talks and seminars where it frequently evoked comments such as -"Where did you get that?!" We spent hours looking at this first ever view of the whole of WA. We could see the salt lake chains becoming rivers, the extent of agricultural clearing and salinisation, the Darling Fault reaching the south coast, the swirls and patterns in the ocean that we later knew to be the Leeuwin Current

[34] Compiled by Peter Hick with help from Ian Tapley and Frank Honey

Change was afoot; the new order was upon us. The turbulent Whitlam years led to an agreement being hammered out with the State Premier (Sir Charles Court) that "two CSIRO Divisions must have their headquarters in WA". The reorganisation following the Underwood review was the creation of a "Western Australian Division" to be called the Division of Land Resources Management. The appointment of a locally-based Chief (Ray Perry) was an organisational tsunami that rocked the foundation of all that we knew and very comfortably understood in CSIRO at Floreat. Ray was a Rangelands Ecologist and brought with him groups from Alice Springs and Deniliquin. The demise of the strong and influential Soils Pedology group was regretted in many quarters, especially in the State Government departments who in some cases picked up the slack. However, WA did get its two Divisions and experienced significant growth in the Land Management and Minerals streams as well as Fisheries, Oceanography and Wildlife all of which had an entrenched requirement for quantitative spatial data as provided by remote sensing.

The success of local company Kevron Photographics, the availability of flexible modified aircraft and other technologically aware and inquisitive companies such as Peter Byrnes AAM were to have a strong influence on CSIRO's Remote Sensing direction in WA. The willingness for industry to adopt colour and false-colour infrared (IR) films, shadowless acquisition and precision geolocation meant that the academic institutions had a strong demand for Photogrammetry graduates. But the most significant driver was the fact that we lived in a huge resource-rich state that for much of the time was cloud free and there was an insatiable appetite for spatial knowledge for exploration, planning and monitoring.

The end of the Vietnam War was also significant as the space-borne surveillance technology was becoming unclassified and one such platform was the ERTS-1 satellite, later to become known as Landsat. This was the first of a series of sophisticated polar-orbiting environmental satellites that provided repeat local coverage (every couple of weeks) at spatial resolution (about an acre) that could tell you much about "paddock and forest-sized targets" and it had mystical spectral resolution in bands even beyond the visible. However, the technology differed significantly from the set of skills built up by a generation of computer-shy photogrammetrists in that the data came on magnetic tapes that needed computers to read them, and even more complex systems to display the pictures.

It is to the credit of Ray Perry that he recognised the potential of this evolving technology and, while in the US in 1976, took the time to visit Stanford University where a young expat West Australian post-doc, Frank Honey was working with another ex-pat professor, Ron Lyon. Ray met with Frank and Ron in rather informal circumstances and invited Frank back to Perth to start a "remote sensing" group. Frank's name has become synonymous with remote sensing, especially in WA.

The software and hardware that Frank developed enabled us to create pictures from Landsat data that could be used to predict crop type and yield trends in the wheat belt; detect algae blooms and water quality in the Peel Inlet; water depths in the Monte Bellos; cyclone damage to mangroves; dieback and fire severity in the Jarrah forest; overgrazing of rangelands, and degradation of wetlands. There seemed no limit to the potential uses and measurements that could be made from these data. Most enthusiasm came from a flood of company geologists who were able to see a whole range of immense tectonic structures down to subtle spectral and vegetation anomalies that may predict great mineral wealth. We were not without our critics, and our enthusiasm may have led to some unrealistic expectations!

However, it was about this time that Ian Tapley and I discovered the full meaning of the magic term "ground-truthing". All this stuff that was being rolled out in prodigious quantities had to be checked on the ground, or the air, or from a boat – bloody heaven! Ian, who had returned to CSIRO in Alice Springs from service in Vietnam, had a wide experience before

coming to Perth in aircraft deployment and acquisition for studies in the rangeland conditions in the NT.

Frank was not satisfied just getting satellite data that someone else had acquired; he wanted to get his own! Together with Bill Carroll, of WAIT (Curtin) they contrived to build a satellite receiving dish to acquire daily data from the NOAA series of satellites, fundamentally a high-resolution weather satellite. A war-surplus Bofors Gun mount was craned onto the top of the Physics building and a surplus receiving dish from Carnarvon tracking station was attached. Some of Curtin's brightest students and lecturers were harnessed into developing hardware and software for the system. The brilliant young engineer Nic Andronis (who built the acquisition electronics from scratch) a farm boy and software guru Steve Boak and Mike Carlton were students who joined us. Later, fine contributions were also made from Merv Lynch's and Doug Myers' groups including Fred Prata and John Wells all who came to work with our group from this association. But the turning point from where this all started came in November 1979, when after many technical setbacks, the first actual moments of acquired NOAA-6 AVHRR data streamed onto the computer. Frank was so excited he never thought to record the details of the overpass and to this day the only record is the label on the tape "Bloody Ripper".

Since the start of the group, we had also developed strong collaboration with the State Government departments especially with responsibility for the rangelands, and Ian made significant contributions to the management of our over-grazed pastoral country in the Pilbara region. The forward-thinking WA Surveyor-General (John Morgan) appointed and resourced two of his best people, Henry Houghton and Bill Holman, to build up a group in the Department of Lands to concentrate on the development of satellite products. Similarly, Curtin was being led by visionaries such as John de Laeter and the Bureau of Meteorology's Len Broadbridge's team who understood the value of collaborative activities. Our groups had strong synergies and a complex interdependence that culminated in the joint hosting of the 1987 Remote Sensing Conference in Perth. Still recognised as one of the most important and pivotal remote sensing meetings ever held in Australia!

During the growth of the Floreat-based remote sensing group, various Divisional changes came and went. The departure of Frank, Nic and Mike to set up Geoscan came a couple of years before Ray Perry retired, and it was decided at a fairly high level meeting (at a BBQ) that the Sydney-based Remote Sensing Group in the Division of Mineral Physics should assume responsibility (read take over) the Perth Group. The options were not great as my salt money was drying up, so Ian and I decided that we should agree to the move (not that we had much say in it) as it would give us access to their superior software development capacity. We did have a very good and close working relationship, especially with Andy Green and Jon Huntington, who lead the remote sensing group for CSIRO in Sydney. However, there had always been a spirit of competition between the two groups.

Despite some early problems, the appointment of Brian Embleton as Chief, the influx of some new and very talented people (Andy Gable, Maurice Craig, Tim Munday, Tom Cudahy) gave new impetus to the group. The close collaboration with the Division of Mathematics and Statistics and eventual merging of such quantitative groups was developed at this time. The co-location of Norm Campbell's group brought the rigor and analytical power to the massive data streams now threatening to swamp our ability to apply the data. The simplification and calibration procedures made the use of remotely sensed data reliable tools for management. Mark Palmer, Jeremy Wallace, Harri Kiverii and Sue Furby made great inroads into demystifying spectral, spatial and temporal confusion and unlocked the potential to produce and reproduce quantitative maps of fire risk, crop type, and vegetation trend from the mountains of data.

Our very strong working relationship with the Lands Department's Remote Sensing Applications Centre (RSAC) and data discipline provided by Norm Campbell's Maths and Stats group meant the numbers were being constantly swelled by staff from State Government agencies: Graeme Behn from CALM, Buddy Wheaton from Agriculture, Bob Gozzard from Geological Survey, and others from industry. We had long discussed the pipe-dream of some form of co-location of our groups as we were now involved in the routine acquisition of satellite data at Curtin, Lands were occupying expensive facilities in the centre of the city and we were spread throughout the Floreat Site. The first seeds of a combined research, applications, education and industry remote sensing centre were sown, and Brian Embleton warmed to the idea.

When the political will is present it is amazing what can be achieved. The co-location of State and Commonwealth agencies with education and industry is a very sexy opportunity for the politicians of the day. Henry Houghton, now acting as Surveyor General, was a very convincing advocate as was our Chief Brian Embleton. Curtin University, TAFE and the trump card, World Geoscience (originally Aerodata that later was sold to Fugro) who operated Australia's largest airborne geophysics company, wanted the co-location to happen. CSIRO had the land adjoining the Floreat Labs and the State Government came up with $25 million to build us a new "Remote Sensing Centre" overlooking McGillivray Oval on the CSIRO endowment land at Floreat Park.

More shuffling of Divisions and repositioning of CSIRO's priorities saw the formation of a new group of mining and exploration Divisions and the appointment of Bruce Hobbs as the Chief in 1992. I had been doing mainly environmental work with a strong marine remote sensing emphasis. Bruce turned up in my office with an offer to join the National Minesite Rehabilitation Program with assurances that they needed a remote sensing team. We developed our "remote sensing for the mining environment" business model which was well planned, effective, and well accepted by Industry. But more importantly, we were back hanging things out of aeroplanes, helicopters and boats, going to fantastic locations throughout the country and taking our findings to the world.

From then until my retirement 10 years later, the group grew and flourished. We produced significant work in all aspects of quantitative remote sensing as it applied to measuring environmental consequences of the mining and resources industries. We used hyper-spectral airborne systems to measure the dust from iron ore production (that has effects on health), hydrological changes and contamination from evaporative salt ponds, leakage from uranium extraction and mineral sand mining, rehabilitation and ecosystem functioning of revegetation after bauxite mining, and the pervasive effects of acid drainage leaching and dewatering from mining. We used spectrometers to measure light disorientation of turtle hatchlings near oil rigs, and optical fibre attachments to measure the colour of pearls inside their living hosts. We tracked oil spills and assisted the development of satellite imagery that is now being distributed daily to land managers, telling of the effects of weather and climate. But most importantly for CSIRO, we made money! Ian Tapley, who had made an international name for himself based on imaging radar applications, took responsibility for the group when I retired, but soon realised that I was having even more fun, and soon he followed!

Spatial information processing such as that captured in the earliest aerial photographs from which contour maps were laboriously produced to help military and civilian planning is still in great demand. The difference today is that the digital computer can process data infinitely faster than ever before, digital elevation models are generated from active systems such as lidar and radar that can provide millimetre accuracy, and these data can be combined with geophysical data and high resolution space and airborne acquisition systems with incredible repeat coverage capacity. The industry has matured!

Remote sensing has come of age, the practitioners have now specialised skills in all manner of quantitative engineering, geology, physics, biology, oceanography and agriculture. The statistical and mathematical rigour that is being applied makes products that can be routinely produced with a level of certainty that gives them real-time applications that affect people's daily lives. Western Australia had several clear advantages that made the wide application of remotely-sensed data so successful. These influences, as mentioned earlier, were topographic, demographic and probably economically driven but the most significant factor was the unique and visionary level of collaboration within and between CSIRO, the State Government agencies, academia and industry that has made it all work.

SOIL CHEMISTRY[35]

Trace Elements and Pastures

On arrival in WA, I started some lab and glasshouse work on potassium but also put in some field plots near Pinjarra because it was the dairy industry which provided the money for my position. At that time, it was accepted that, once you had applied copper and zinc, the only nutrient that mattered was phosphate. Sulphur could not be deficient because it was part of superphosphate. No-one realised that the sulphur got washed out of the soils by the winter rains and that, by spring, sulphur was very deficient. The main problems with pastures were: sulphur deficiency in spring, potassium deficiency caused by removal of hay, and acidity caused, ultimately by nitrogen fixation. Once you had fixed up these problems you got terrific pastures. However, this work went over like the famous lead balloon and farmers continued to apply superphosphate. This message is still not fully accepted. Farmers still use, and are advised to continue to use, phosphate fertilisers even on land that has been fertilised for 80 or more years. We see the consequences in poor pastures and in excess phosphate finding its way into rivers including the Murray and the Swan.

In about 1970, I decided to switch my emphasis to phosphate. There were two reasons for this. One was that on land that had been fertilised for many years, such as those I had been working on in the dairy regions, no one really knew what the current value of previously applied phosphate was and hence no one knew what policies to adopt when reapplying phosphate. The other was that Peter Ozanne and Tom Shaw had just about completed a project in which they showed that on virgin soils the phosphate required increased as the capacity of the soil to sorb phosphate increased. That enabled the first years application of phosphate to be rationally chosen, but what should the farmers do next year, and the years after that?

The essence of the question is: what is its residual value? If you applied some last year, what is it worth this year? That question had been little asked and the first job was to worry about what we meant by residual value and how to measure it. The tendency was to speak of residual value in terms of years; that is, to say that this application had a residual value of say five years or perhaps seven years. However, this is not very informative because if you define it this way the answer will surely depend on the level of application. After much thought, I decided that the only way to define it was in terms of relative effectiveness. That means that you compare the response curve of freshly applied phosphate to that of phosphate applied some time earlier.

In order to investigate the rate at which residual value declined, I set up a pot trial involving several different periods of contact between phosphate and soil to make this comparison. The results were a mess. There did not seem to be any smooth relationship between the time of contact and the relative effectiveness. And then it hit me. Those treatments that were started first had gone through several months of hot summer weather. Surely we were dealing with some kind of physicochemical process and the rate of such processes is affected by temperature. So I repeated the experiment, this time using a range of controlled temperatures. It worked beautifully – the higher the temperature the faster the process. Although we didn't understand it at the time, this told us a great deal about the mechanism of the process. It also gave us a very good means of investigating the effects of long time contact: just use high temperatures and you can produce the effects of several years and reaction within a week or so.

This experiment also told us some interesting things about the rate. Many rate processes are "first order". That means that if the time to halve the residual value was say three months then it would halve again in the next three months. This was not the case; the

[35] Contributed by Jim Barrow

period required for each halving increased. This was a very important result because it showed how phosphate can build up after many years of application.

While the pot experiment was very informative it was quite time-consuming. I thought it would be nice if we could measure the rate using less tedious means. You can measure the rate of any process either by measuring the disappearance of the reactants or the accumulation of the product. Because we did not know what the product was (when phosphate became less effective) the only option was to measure the disappearance of the reactant. Previously, these kinds of measurements had been made by shaking a fairly large volume of phosphate solution with a few grams of soil. Under these conditions, the amount of product is not constant but increases as more and more phosphate is transferred from the solution to the soil. This makes it difficult to interpret the results. I realised that if you measured the rate when the soil was just moist, say at about field capacity, the *amount* of phosphate on the soil would scarcely increase. I therefore devised a simple way of measuring the concentration (the reactant) in the soil solution. The change in this concentration indicates the rate of the reaction. Again the rate did not follow any of the simple rate laws for chemical reactions, but was proportional to a fractional power of time. We also found that there was nothing special about P – the same sort of behaviour occurred for molybdate, for fluoride and even for sulphur if you looked very hard. However, we still didn't know why the rate was so unusual. At first we worked with the Western Australian soils. The results were surprisingly uniform. The soils differed, of course, in the amount of reaction, but the subsequent time trends were very similar. In an endeavour to find a variation from this pattern, I organised collection of some soils from the eastern states and also from overseas including New Zealand, and USA. Again, most of the results followed a similar pattern, but there were some exceptions. The continuing reaction was less marked in some sub-soils from Western Australia, and in some soils from New Zealand. In both these cases, it is likely that the main reactant was not iron oxides, but kaolin in the case of the subsoil and allophane in the case of the New Zealand soil. I did not understand that at the time because we had no idea of the mechanism involved.

A Model for Describing Reactions of Ions with Iron Oxides

About the middle of the 1970s, I went to a seminar by Bill Bowden, who was then a PhD student at UWA. Bill had developed a model for describing reaction of ions with iron oxides as models for soil particles. I certainly didn't understand it, but I knew he was on to something. When the model was published, I studied it for weeks. (You could do that sort of thing in those days.) To simplify, the argument was that if you wished to understand the reaction of charged particles (ions) with a charged surface, you had to take into account the electrical potential of the surface. The problem is that there is a feedback effect. Reaction with ions changes the potential of the surface. That means you have a "chicken-and-egg" problem; you need to know the potential in order to calculate the amount of reaction, and you need to know the amount of reaction in order to calculate the potential. I realised that I had encountered a similar problem as an undergraduate studying hydraulics. To calculate the flow in a pipe you need to know the pressure, but that there is a similar feedback because the greater the flow the greater the pressure drop. These kinds of problems can be tackled by taking an initial guess, see how it pans out and then taking a series of better guesses. Such cycling calculations are ideal for computers. It didn't take long to work out a way to spiral down to the correct guess. I used the PDPs, which were by then equipped with disks (about 30 cm diameter) to get the logic right using BASIC. I then combined the program that solved the equations with a program that chose the best values of the parameters and so fitted Bill's equations to sets of data using FORTRAN and the batch computer in Canberra. It was pretty tedious.

Other activities were in train.

- A major problem with many of the Swan Coastal Plain soils is that they are very sandy. They do not retain either moisture or phosphate very well. The coastal plain is also the site for bauxite refineries; bauxite ore is mined in the Darling Range and about two thirds of the material mined is residue. This means there is a large supply of material that should be capable of holding both water and phosphate. The problem is that it also retained appreciable caustic material left over from the mining process. Much of that was sodium carbonate formed by reaction of sodium hydroxide with carbon dioxide from the air. I realised that if the caustic residue was mixed with gypsum (calcium sulphate) a simple interchange will give you calcium carbonate (lime) and winter rains would leach out the excess sodium sulphate, thus giving you a product in which plants could grow very well and which served the further function of neutralising some of the acid soils. This is currently used to ameliorate some of the soil problems of the coastal plain. (I have a feeling that this material could also provide an excellent cricket wicket. Someday someone is going to try it!)
- I also undertook an experiment to measure the fertiliser requirements of native plants. At that time, we knew that many plants could grow quite well on soils too deficient in phosphate for agricultural plants, but we knew little about the range of behaviour within native plants. I showed that some native plants, for example the small-seeded, quick-growing Karri, responded to phosphate at pretty similar levels to subterranean clover. In contrast, a Banksia with a large seed, packed with phosphate, was inherently slow growing and did not respond at all to added phosphate within the period of the experiment.
- I was also involved with work on mycorrhyzas (cooperation between fungi and roots). I found that the presence of mycorrhyzas helped plants to take up phosphate but that did not give them any special access to residual phosphate. On the other hand, we found that mycorrhyzas did give plants access to phosphate that was held at very low concentrations in the soil solution.

Bill Bowden's model was fine for nice clean pure compounds. However it was not much good for soils. I kept teasing at it and about 1982 we eventually got a PC. It was an eight-bit Cromemco, pretty primitive by today's standards, but you didn't have to share it. You could spend as long as you liked. And you could store your programs and data on 5 1/4 inch floppies. Even better, when you were programming, you instantly found you'd made a mistake instead of having to wait a couple of hours for the job to come back from Canberra only to find it had thrown you off because you had left out a comma.

So I thought I would try to incorporate Bill's model into a soil model. It seemed axiomatic that soils were not uniform, and we knew by this time that positive and negative surfaces could coexist in the same soil. It therefore seemed logical to assume a distribution of electrical potentials and since the distribution had to have a positive and a negative end, it also seemed logical to assume a normal distribution. Within a computer program, that distribution could be cut into a series of slices. Within each slice, I assumed that a form of Bill Bowden's equation applied with a simplified feedback so that the potential decreased with increasing reaction. This worked very well, explaining a whole series of previously puzzling observations such as the effects of changing the electrolyte concentration on sorption and the differing effects of pH for different anions. However, how could we explain the effects of time and temperature?

The idea that the adsorbed ions diffuse into the reacting soil particle had been around for many years but was generally discounted. I decided to test it by modifying the model so that there was an initial adsorption reaction by which ions were transferred from the solution to the surface of the soil particles. This was followed by a diffusion reaction into the particles and the driving concentration for this reaction was the surface concentration of the adsorbed ions. I assumed that the depth of penetration was small compared to the size of the

particles and that I could use the mathematics of planar diffusion. It worked very well indeed. In solid-state diffusion, the moving molecules have to jump over an energy barrier and so there must be a rather large effect of temperature. This is why the fertilisers become less effective with time. They are not locked up or "fixed" but merely more deeply buried. If the surface concentration is depleted, they can return to the surface, but ever more slowly.

I finally put it together in June 1982. I detail this because of the supposition that scientists do their best work when they are in their twenties. It's not true.

I then had all the data we had obtained in earlier years and now a model to compare it with. So that led to a rash of papers. In 1987, these won me a prize of $10000 from the International Phosphate Institute (our only trip to Paris) and a gold medal from the Australian Soil Science Society. I also published it in a book.

I added to these with some work on boron, on mercury, and also on selenium. As computers became more powerful, I was able to upgrade the model to fit more complicated data, eventually describing competition between two ions and also reaction with radioactive P.

Selenium is required in truly minute amounts by animals. Despite the minute amounts required, many Western Australian soils do not have enough for healthy growth of grazing animals. Selenium is unusual in that two oxidation states seem to be stable under soil conditions. These give rise to the selenite and selenate ions. The soil chemistry of selenite is analogous to that of phosphate; soils hold it fairly tenaciously and it continues to react. It is therefore a fairly inefficient fertiliser. On the other hand selenate is analogous to sulphate; it is only loosely held and scarcely continues to react. We found that selenate could be used as a source of selenium to sheep. Because it is not required for plants, it need not be spread uniformly across a grazing area. However sampling the minute concentrations involved provides an analytical and sampling challenge. We circumvented that by using sheep to sample the pastures and we monitored their selenium levels. We found that an application of as little as 10 g of the selenium per hectare provided an adequate supply of selenium for up to 3 years.

As a result of the work described above, we could describe and understand the reaction of anions and cations with iron oxides and we could similarly describe and understand the reaction and the continuing reaction of anions and cations with soils. But was there a continuing reaction with oxides? It was almost universally accepted that there was not. There were literally hundreds of papers published in which it was assumed that reaction reached equilibrium fairly quickly. There was one exception. Gerd Brümmer working initially in Kiel in North Germany and subsequently in Bonn showed that both anions and cations continued to react with goethite. I was able to cooperate with him, and with his students, initially to show that the model that involved the diffusion of the adsorbed ions into the goethite particle was able to closely describe reaction of cations, including the effects of temperature. Subsequently, we were able to apply the model to reaction of phosphate with goethite. Goethite crystals are normally grown by the experimenter prior to use, but they are never quite perfect: they have ragged ends and gaps between sub-crystals. They can be "healed" by heating them in a pressure cooker for many hours. Goethite that was so treated then ceased to continue to react with phosphate. We interpret that as indicating that phosphate penetrates into gaps between sub crystals. In a subsequent set of experiments, the effects of "healing" goethite were measured using cations. The results were quite different. These and other results convinced us that some metallic cations actually enter the crystal lattice of iron oxides. This is especially so for nickel cobalt and chromium but not, to our surprise, for manganese. That is, ions differ in the pathways they follow.

4. ORGANISATION, REORGANISATION AND DISORGANISATION

NEAR-DEATH OF MINERALS RESEARCH IN CSIRO[36]

Mike Thornber recalls marching with Terry Parks Ted Davis and Margaret Davis in the 'Moratorium Marches" hoping to end Australia's involvement in the Vietnam War. Several years later the main beneficiaries, Gough Whitlam and Rex Connor decided to move Divisions working in the area of minerals research from CSIRO to the Bureau of Mineral Resources. This would have been a form of slow and painful death for Australian Government minerals research. It is a great example of the type of rubbish that is still flowing out of Canberra today. It turned out that we were reprieved by the efforts of Jerry Price (later Sir Jerry Price) and the CSIRO Executive. Here is an extract from a Jerry Price biography by Tom Spurling and Dave Solomon:

Jerry Price

"The election of the Whitlam Government on 2 December 1972 was the start of the most turbulent time in Jerry's career. An insight into just how much he was affected by some of the decisions of that Government's Ministers can be found in a speech that he gave to Melbourne staff on 3 July 1975, three and a half weeks after the Government announced that the Mineral Research activities of CSIRO were to be transferred to the Department of Minerals and Energy.

He started by saying:

'This has been a period of considerable difficulty for all of us, and it is imperative that we now pause and look closely at the situation'. After congratulating the staff on their patience and restraint he continued:

It is necessary to go back about two years; CSIRO fully recognises its responsibility to do research to meet national needs and therefore to be responsive to Government

[36] Contributed by Mike Thornber

policies. After the new Government came into office we immediately started thinking about our role in relation to the new Ministries that had been established. As part of this communication exercise we drafted a letter to Mr Connor that Mr Morrison signed on 5 April 1973, advising him of our research program on solar energy and suggesting that discussions take place at officer level. Then on the 3 July that same year, a review of our Minerals Research Program went from Mr Morrison to Mr Connor. Mr Morrison invited Mr Connor to establish direct contact with CSIRO if he had any questions about the review, or if he wanted further information.

Unfortunately, no reply was received from Mr Connor to either of these letters. Then in December 1973, Mr Connor made a statement in Parliament about the Government's intention to undertake a crash program on coal hydrogenation. Mr Morrison again wrote to Mr Connor telling him CSIRO was prepared to help in this program and he asked Mr Connor to let him know details of the proposed crash program. Again, Mr Connor did not reply. Jerry reminded his audience of a press statement dated 11 September 1974 in which the two Ministers had agreed that CSIRO would pursue research in many areas that would bear on the utilisation of solar energy and that the Department of Minerals and Energy would take over the development phase of those CSIRO results that were approaching practical realisation. Many other attempts were made to work with the Department of Minerals and Energy but, according to Jerry, they were all ignored until 13 May 1975 when Mr Connor replied that at least the responsibility for liquid fuels from coal had been assumed by the recently formed Coal Conversion Sub-committee of the Coal Research Advisory Committee.

Jerry then gave a detailed account of developments after Thursday 5 June 1975:

"Now to more recent developments. You probably all remember that on Thursday 5 June the Prime Minister issued a press statement outlining new Ministerial responsibilities. One sentence of his statement said, and I quote: 'The Department of Minerals and Energy will take over responsibility for the Minerals Research Laboratories and the Solar Energy Studies Unit.', but let me reiterate my attitude, the attitude of the Executive and, I believe, the attitude of the Organization as a whole. This is that we object most strongly to the manner in which this decision was made and announced — without prior consultation with the former Minister for Science, Mr Morrison, his successor Mr Cameron, with the Organization, with the recently established ASTEC — the Australian Science and Technology Council — or with industry. We also object to the disregard of the practical requirements for conducting effective Government-based scientific research in this country. We do not question the Government's right to so order the affairs of CSIRO — that is its right — but such ordering should be brought about with the full understanding of all the factors involved and I believe we have preserved our credibility as responsible scientists and administrators by using every proper means to express our point of view to the Government. We have explained in very clear terms that the ad hoc dismemberment of CSIRO in this way could be disastrous to Australia's scientific output for years to come."

Lady Price recalls that before Jerry went to give that speech he told her to expect that he would lose his job over his stand.

History records that the Government, already under pressure from adverse reactions to many of its decisions, and with the urging of the Acting Minister of Science and Consumer Affairs, Moss Cass, finally rescinded the 5 July administrative orders. Jerry had thus very effectively preserved the integrity of CSIRO and enhanced his reputation both inside and outside the organization.

Jerry retired on his 65th birthday, 24 March 1977. The Prime Minister, Malcolm Fraser, wrote:

"I thought I should write to you on the occasion of your retirement as Chairman of the Executive of CSIRO.

My two periods as Minister of Education and Science enable me to write to you with first-hand knowledge. I am well aware of the contribution you have made, successively, as an individual scientist, Chief of Division, member of the Executive and finally as Chairman of the Executive. Your appointment as Chairman designate was of course made while I was Minister responsible for CSIRO.

May I, as Prime Minister and personally, express my gratitude and appreciation for the service which you have rendered the Government and the nation, in your various capacities — but more particularly as Chairman of the Executive. The very high world-wide standing of CSIRO (and CSIR before it) is due in no small part to the quality of the leadership over the years of its existence.

However, I believe it is fair to say that your period as Chairman has occurred at a time when contemporary circumstances have never been more challenging. Throughout your service, your sense of dedication and loyalty, and your integrity, have been manifest for all to witness.

In conclusion, may I once again both thank and congratulate you for a job well done. I would like to express my very best wishes for a long and happy retirement.

Yours sincerely (Malcolm Fraser)

Jerry was awarded KBE in 1976 in recognition of his services to science and government. He was made an honorary member of the Royal Society of New South Wales in 1977. It can be seen from this that Jerry risked everything to achieve the outcome that saved us. I don't think the Bureau of Minerals and Energy exists any more.

Soon after the threat was known, Ivan Newnham came to the Floreat laboratories to put his spin on the bad news by addressing all minerals staff. We prepared ourselves by borrowing the CSIRO footy jumpers and basketball T-shirts which were worn to the meeting. It was obvious that Ivan immediately understood where we stood on the matter.

Some years later Ivan was gradually overpowered by Motor Neuron Disease. He was Director of the CSIRO Institute of Earth Resources from 1979 until his retirement due to ill health in 1983. He was previously Chief of CSIRO's Division of Mineral Chemistry (1961-1970) and Director of the Mineral Research Laboratories (1971-1978). During his thirty-seven year tenure with CSIRO he made numerous significant contributions, including the introduction of research planning for commercialisation.

REORGANISATION OF LAND RESOURCES MANAGEMENT[37]

Background to the role of the Officer's Association

In the June 1982 edition of the CSIROOA Bulletin, articles were written about changes to the Divisions of Mechanical Engineering, Chemical Technology and Building Research. In that case the CSIRO Executive acted with only a hint of impending action. Later the break-up of the Division of Land Resources Management (LRM) was reported, a process that was becoming apparent to the staff of LRM early in 1981 as a result of excessive delay in the release of the report of LRM's review committee. In both cases morale had been severely affected, not only through anxiety and disruption inevitable in change processes, but also through bewilderment at the lack of essentially any discussion of, or public justification for, these moves. This report commences with a description of the events leading up to June 1982. It concludes with recommendations to the CSIROOA which might make the process of Divisional destruction more tolerable and less traumatic, and have less effect on the morale and therefore productivity of the staff.

The Division of Land Resources Management (LRM) was formed in March 1973 by the amalgamation of units in WA of the Division of Soils and the Division of Plant Industry in response to a demand for expansion of CSIRO's environmental research. With the appointment of Ray Perry to the position of Chief in October 1973, the Rangelands Research Group of the Division of Land Use Research (LUR) was added to the Division. LRM staff were called upon to develop new areas of expertise appropriate to the Division's role. Some groups, such as those concerned with agricultural production decayed or were transferred to the Division of Animal Production, while other groups such as those concerned with the study of the influence of vegetation changes on land and stream salinity expanded. The "honeymoon" positions provided to the new Chief were used to develop a new group in Landsat imagery and to appoint social scientists, since they were needed to study certain aspects of land use and resource conflicts. One component of LRM's history is worthy of particular note: the Division was reviewed many times, including four Executive reviews, in its short life, and all reports, including the last, were complimentary. All the indications were that a useful, productive Division had been formed. The last review of LRM took place in August 1980 at the same time as reviews of LUR and Soils, coinciding with the end of terms of appointment of all three Chiefs concerned. The review committee for LRM and LUR was chaired by Keith Boardman of the Executive. This committee recommended that the two Divisions continue as separate units and commented that the resources available were "minimal considering the growing importance of land use issues to the Australian community". (Subsequent events suggest that these are not the opinions shared by the Director of the Institute of Biological Resources (IBR) Michael Tracey, or the Executive.)The review report is dated December 1980 and was reviewed by the Executive in June 1981. It remained secret until September 1981. At that time Ray Perry, faced with the heaviest cuts in IBR recommended to the Executive the closure of LRM's Deniliquin Laboratory, which had been suggested by the Review Committee. Shortly afterwards, the Chief reorganised LRM's Perth structure to comply with the Review Committee's recommendations. It was assumed that this structure would endure for some years.

In October 1981 it was rumoured that the Executive was investigating ways to respond to a Parliamentary proposal ("The Jacobi Bill") which sought to expand water research in a separate federal institute in South Australia. The rumour suggested that the response could involve a certain amount of restructuring of LRM to emphasise the water research being performed in WA. Subsequently other forms of change and break-up were rumoured.

[37] Contributed by David Bennett with material from records of the CSIROOA.

The W.A. Branch of the CSIROOA called a meeting in November 1981 to discuss these rumours. It was decided to forward to the Executive a case in support of the continuation of the Division as an entity. The case pointed out that LRM could respond to the need for more water research and to demands for more agricultural research in WA without major alteration in structure. It suggested that this might avoid some of the administrative problems that were experienced in Perth before the Division was formed, and it explicitly requested consultation before major changes were promulgated. After deliberation by Federal Council, this case was forwarded to the Executive in January 1982. No response to this submission has been received.

When in Perth on other business, Michael Tracey was invited to address the staff. He gave assurances that, if only because of shortages of buildings, it could be stated that there would be no mass staff relocation. This was not the major concern of those scientists interested in the pursuit of excellence. Subsequent attempts made by individuals to discuss the issues involved failed. A feeling of increasing helplessness developed. Consultation was minimal and in the final drawn-out stages it was stated that consultation was impossible due to the risks of leaks (see "The Australian" 7/6/82, p3) pre-empting the Minister's statement on 15/6/82 (17/6/81 was the date that the demise of the Divisions of Mechanical Engineering and Chemical Technology was announced). This statement announced that LRM was to be dissolved. A Division of Groundwater Research (DGR), containing initially thirty-one scientists, of whom only eight have groundwater expertise, had been formed. A substantial majority of the remaining twenty-three, while possessing skills that can be brought to bear on certain groundwater problems, doubt whether the new arrangements will make optimal use of their expertise. These include the "honeymoon" appointees to LRM already mentioned, for whom the objectives of the Groundwater Division are unnecessarily restrictive. These restrictions also affect several scientists whose previous focus has been land and vegetation studies that are peripheral to "the physical and chemical processes affecting the quality and quantity of groundwater" – the primary objectives of DGR. Thus there is a feeling that a large number of square pegs are being put into boreholes, a situation which could have been improved through adequate consultation.

Some scientists who have been allocated to other Divisions feel that they could continue to make a substantial contribution within the Groundwater Division. It is difficult for individuals to publicize their disappointment, but at least two senior scientists with relevant international reputations have been transferred to other Divisions. Another scientist who, since arriving in Perth from the closure of the CSIRO Tobacco Research Station at Mareeba, has been working successfully on groundwater pollution from septic tanks, was transferred without consultation to the Division of Animal Production (DAP).

The continuum between land and water research that was being harmoniously administered by LRM now has discontinuities. The major field trials in agroforestry, a land use to control salinity, are in DAP; while DGR has a program on phosphorus pollution of the Peel Inlet from agricultural fertilizers, but no experts in soil phosphorus. An "Officer-in-Charge, CSIRO Laboratories for Rural Research (Perth)" is to be appointed, with powers over some Divisional Units in Perth. He will be answerable to the Director of IBR while most of the staff within the laboratory will be in the Institute of Animal and Field Sciences! These organisational complexities raise serious concerns for members, both as individuals who will be directly affected by the changes, and as officers with a concern for the overall effectiveness of CSIRO.

Organizational Change

On the demise of the Divisions of Mechanical Engineering and Chemical Technology the Executive produced a policy statement which read in part: "where industry's needs have become more tactical, support measures other than through CSIRO direct performance of

research should be employed." (CSIROOA Bulletin No. 181 p.16). No evidence can be found that the Executive investigated the degree to which this criterion was met for LRM. The statement by Michael Tracey at the time simply said that the Executive "had decided" that the changes were necessary if an "effective" program of water research was to be carried out. The discontinuities mentioned above, however, seem to point in the opposite direction. It was already known, of course, that water research was to become a high priority. But many alternative structures were possible which would not have caused such dislocations.

REORGANIZATION IN CSIRO – AN OLD PROBLEM

"For some time Council of the Association has been concerned about aspects of the management procedures used by CSIRO when undertaking Divisional reorganizations... Officers have been asking:

(i) Why has there been excessive secrecy surrounding each decision and an apparent lack of confidence shown in the staff, whose opinions have rarely been sought beforehand by the Executive?

(ii) Why have the announcements been made without warning in a number of cases?

(iii) Why have some announcements been followed by administrative muddles, indicating that plans for implementing the changes were not fully thought out?"

J.G. Collins

OA President
Bulletin No. 148, September 1973

Complex structures are becoming more frequent in CSIRO. Recent new examples are the structure for water research in Canberra and the administrative structures for Perth and Griffith. There is ample evidence from earlier CSIRO experience, including Perth pre 1973, from Universities and from industry that such structures seldom work. Exceptions occur where rare combinations of compatible personalities and clear objectives coincide and group harmony prevails. They are always stressful for senior staff, yet the Executive is creating more and more such structures. There is a need for the Association to become concerned and oppose these moves.

Since both the Association and the Organisation are bureaucracies that work on standard operating procedures (SOPs) and we already have an SOP (the Consultative Council) to develop SOPs then:

> *It is recommended that the association request that a consultative council committee be formed on procedures for organizational change.*

Within this Committee we should press for adequate discussion, justification and debate of the need for, and speed of, change and for arrangements to protect the interests of members.

Consultation

Effective consultation over organizational change requires that those affected see that their viewpoints are understood, and that those directing the change give a justification that is in proportion to the concern aroused. These principles apply in this case to groups both inside

and outside the affected Divisions. In this connection we have to reconcile the Executive's behaviour with a statement by the Chairman (Paul Wild) in CoResearch (September 1981) that "No changes are made without proper examination, exhaustive discussions and wide consultation." In the present case, both staff and outside bodies seemed to have received the same level of justification (or lack of it) for the changes, as indicated above. Little evidence is available to show that the viewpoints of the community, government and industry have been heard. It must be presumed that most members of LRM's last Review Committee,[38] the one group known to have been consulted, are surprised by an outcome so different from their recommendations. It seems also that the WA State Committee[39] knew little about the impending decisions. State Committees are supposed to give valuable advice to CSIRO but will rapidly lose interest if ignored. And the WA State Government apparently feels some pique. The press release of 15 June entitled "New CSIRO focus for rural research in WA" gave an impression of greater resources for agricultural research by the use of such phrases as " a stronger focus ". However by June 23, the Minister for Agriculture, for one, had found that the only definite effect was the loss of one agricultural scientist. The headline in "The West Australian" read "WA duped in CSIRO Move". It may be worth making the point that, at this level, consultation foregone is political support set at risk.

Among the research workers themselves morale has been lowered by lack of consultation. The membership realises that the Executive has to make decisions about research priorities and the framework of Institutes and Divisions within which they can be carried out. Thus personal inconveniences to members are to be expected. But some of the researches redirected in this case feel that their inconveniences are not appreciated, and the Organisation wishes they were closer to retirement. If changes were necessary for an "effective" program of water research, then it is understandable that some scientists feel they are being implicitly judged "ineffective". It is into the gap left by a lack of reassuring communication and of more extended justifications that speculation about the "real" reasons for the changes floods. Cynical analysts at the Floreat laboratories explain events in terms of hidden motives of Directors and Executives. This is inevitable where communication from above is generalised, belated and brief.

There was little discussion with Chiefs, and virtually none with even senior staff. General assurances that buildings would remain full and staff movements would be minimal were less than sufficient. If greater information flow is impossible in such cases it would be better if this were stated clearly, rather that information should be always too little and too late, until after decisions have been made. The level of consultation that did occur is shown by the fact that staff were called on to decide "in ten minutes or less" to which Division they wished to be assigned. All choices were restricted, but for most the choice was *Hobson's.* Members of the WA Branch wish to ensure that problems caused by lack of consultation are minimized in future.

[38] Apart from Keith Boardman, members were R.G. Downes (formerly Permanent Head, Ministry for Conservation, Victoria); R.B.M. Dun (Deputy Director of Agriculture, NSW); Noel Fitzpatrick (Director of Agriculture, WA); Ken McCracken (Chief, CSIRO Division of Mineral Physics); Jim Quirk (Director, Waite Agricultural Research Institute, SA), and George Seddon (Director, School of Environmental Studies, University of Melbourne, Vic.).

[39] Members are: Dennis Horgan (Prindiville Holdings); Mr J.B. Kirkwood (Commissioner, WA State Energy Commission); Professor R. Street (Vice Chancellor University of Western Australia); Bob Hillman (Director Engineering, WA Public Works Department); Noel Fitzpatrick (Director, WA Department of Agriculture); Eddie Gorham (Coordinator, WA Department of Resources Development); John deLaeter (Chairman Division of Engineering and Science WAIT); Mr J. Shepherd (Farmer, Shackleton WA); Mr S.G. Morgan (Group General Manager, Westralian Forest Industry); Mr W.J. Hughes (Chairman, Westwool Holdings).

It is recommended that the association press for a review of consultation procedures for staff involved in divisional reorganizations including rights of appeal and that the association consider whether it should be represented at these times to ensure the rights of members.

Promotion Guidelines

We must sympathize with the problems of members of the present Executive whose task is far more difficult than those of their predecessors. At least Paul Wild is trying to develop a consistent policy and communicate this to government, the nation and staff. But objectives often conflict. In this case the first objective of the Executive's current policy "Whatever we do we must do well" is conflicting with its desire to restructure to give importance to water and soils and the other area singled out for expansion. It is difficult for square pegs to fit properly into round holes, and once they have been rounded, they again will not fit if they are put back into square ones. But there has been for some time suspicion that the Executive is trying to create square/peg round hole situation from which members can be evicted using Clauses 15 (unsuitability, incapacity, inefficiency or incompetency), 16 (excess) or 18 (catch-all) of "Terms and Conditions". This is the antithesis of "doing it well" both in professional time wasted and in poor personnel management.

Redirection, restructuring and relocation are happening more and more frequently as the Executive desperately attempts to meet expanding demands for research with decreasing resources. Any one of these interventions and certainly a combination of the three will seriously impair a scientist's ability to meet promotion guidelines. For EOs these require experience, expertise and skills. For RSs these require " contribution in his field of activity research in a direction consistent with the objectives of the Division "(!) " other scientists seek his consultation " and for high levels – national, international and world status. The higher the scientist is on the EO or RS scale the more these interruptions affect his/her promotion prospects.

It is recommended that the association negotiate alterations to classification/promotion guidelines such that staff involved in redirection, restructuring, relocation or combinations of these do not suffer vis-a-vis staff not so affected, and that promotion cases include a record of severe career dislocations.

Epilogue

The height of absurdity in the 18-month run of this dark grey comedy occurred in the last scene. Head Office did not send news of the changes to Perth, so Ray Perry had to announce changes to LRM on June 15 from a tape recording of Michael Tracey's announcement of changes to LUR in Canberra, relayed by telephone, re-recorded in Perth and then typed. (This was the way an applicant for a senior position discovered that he had been unsuccessful.) Staff in Perth were left guessing as to the final outcome for them as individuals, as *Letters of Appointment* did not arrive until June 17. The letters arrived in two bundles. One, addressed to the Chief, CSIRO Division of Groundwater Research included letters to staff located at Rockhampton, and the other was addressed to the "Officer-in-Charge, CSIRO Laboratory for Rural Research (Perth)", a position that had only officially been created two days earlier, and whose occupant was, at the time of writing, still unknown. Even on Monday June 21 the Chief of the Division of Forest Research was not aware of who in Perth had been reassigned to his Division. At that time, the LRM staff in Deniliquin and Alice Springs had not been informed of their Divisional affiliations.

5. SPORT AND SOCIAL ACTIVITIES

SPORT IN CSIRO[40]

I arrived at CSIRO on the 7th of November 1966 at the age of 19. I had been playing sport from about age 8 and was still actively playing when I joined CSIRO. Anything that was going at CSIRO in the way of sport, I would be in it!

Softball team on the Nedlands foreshore in the early 1950s. Back row: Peter Ozanne David Dor, Blair Hunt, Graham McCutcheon, Alf Humphries, Neil Gayfer, Maurice Mulcahy, Frank Hingston, Ron Pack, Murray Wallace, Lin Rodgers, Dave Kirton, Glyde Turton, Tim Earley, Jack Brophy (holding hat), Jeff Priest (holding dog). Middle row: Lexie Nicholls, Yvonne Holland, Zig Titmanis, Alec Mahon, Mary Roskams Front row: Rita Williamson, Sue Dubberlin, Jill Crockett, Pam Meckle??????, Jean Ladomirska, Janet Cornwall, Julie Katai,(with bat and ball) Alison Young, Honor Thompson, Judy Bell

Football.

My earliest recollection was of some locally organised social football matches. We were able to use the University-owned grounds at McGillivray Oval, adjoining the CSIRO Floreat offices. We were well connected with UWA through research and indeed had just moved from UWA's Nedlands site to the new Floreat labs in 1966.

While we had matches against other sides socially, I believe we had the odd "scientific verses Technical" staff matches. This could of course be seen to be a great opportunity to bring things on to a more equal footing or "chance to get even", but while such banter occurred, the matches were played in good spirit. The most serious injury I remember was of a ball dribbling along the ground between John Beresford and Eric Bettenay and neither wanting to take possession resulted in a flurry of soccer attempts resulting eventually with one player nursing a very sore shin and the other apologising profusely, much to the mirth of those not involved.

As time moved on a CSIRO team was formed to play in a small local competition. I am not sure who the driving force was, but think it may have been Russell Hudson who was very actively involved with the social club at that time.

We had our own football jumpers which were maroon with yellow CSIRO motif and yellow numbers. Mine succumbed to moth holes and cupboard shrinkage some time ago, (correction I found it, but not allowed to model it – still fits like a glove!!!!!!).

[40] Contributed by Greg Bartle

The biggest problem that occurred with our footy side was that after a short competition season, we tried to start again next year but there were very few CSIRO people available or who wanted to play. The majority of the side were outsiders and interest dwindled rapidly. I do not recall well all the people who played. Most memorable was Russell Hudson, the original Austin "Occa" Robertson who regularly played at full forward.

Norm Campbell was a very demanding centre half forward. If he offered a lead and you ignored it, or did not forward the ball in an appropriate manner, he had a knack of letting you know. He was a good player, very tall, and a good bloke. John Smith who was husband to one of our CSIRO colleagues was very keen and played right to the end, was also quite a tall player.

Barry Carbon who was umpiring league football at that time played at times around his league umpiring commitments. He was very quick but had to nurse a dodgy cruciate ligament repair, done with old technology. This would have been bread and butter these days. Rumour has it that Barry was approaching national record running times at high school and so a promising athletics career was thwarted. He umpired for us at times as did his father Arthur who was also a former umpire.

Basketball.

Mike Bussell was a very keen supporter of basketball and I think behind our CSIRO basketball side. We played for quite a few years in the local Perry Lakes competition. Our official shirts were the same as football with maroon shirt with yellow motif. There was Mike Bussell, myself, Peter Farrington, Norm Campbell, Eric Holme, Peter Petrusevic and others. We had a couple of games between LRM and Mineralogy. Most notable for Mineralogy and for the CSIRO side, if we could get him, was Jack Halberg. Jack was of American heritage and not very tall but had uncanny shooting ability particularly from what would now be the three point line and rarely missed. He could beat you on his own if he was on song.

Eric Holme was not only a former state level volley-baller but had played very high level basketball. He was very tall and very strong and knew his way around the court better than most of us. It was frustrating for him at times with us not being able to read his plays. Our basketball was played at a fairly low grade and was made very frustrating at times as the

umpires were volunteers and it was a very umpire dependent sport. We were often scragged at the basket and I was sent off a few times as my football background kicked in.

Hockey.

Graham Arnold was a keen hockey player as was John Hill. We formed a hockey team and had several games both within and outside the organisation. I can remember playing mixed gender games and there were some good hockey players among the women. John Hill was our goalie; Paul Downes was very skilful and our main goal shooter.

I played fullback probably being too immobile to play up-field, I could hit the ball hard and had a good eye but that's about all. Again I had trouble with the footy background (used to play hockey in my footy boots) and not a big background in the rules of hockey. In a game against the Department of Agriculture at the hockey stadium at Bentley, I had my nose split open by a hockey stick by one of their very good hockey players (I think they had some Bells, former top level players there). As awful as it might seem to say, to this day I always felt he knew what he was doing, so perhaps it was payback.

We all need our characters in sport and Malcolm Howes was one and also a fellow I liked a lot. I cannot forget Malcolm's habit of giving chase at full pace presumably for the ball with the hockey stick raised vertically above his head. You were never sure what would happen.

Golf

We had a once-a-year golf competition between LRM and Mineralogy. There were many people playing regular golf and so this competition was very popular. However, for me it was a real problem. I liked to play any sport but I was a terrible golfer. The problem was my boss and good friend Barry Carbon was a good golfer and insisted on having me as his partner. The stronger golfers from Mineralogy liked to play against Barry which left me well out of my depth and certainly out of my comfort zone.

It seemed it was out of Wilf Ewers and Colin Steel or Wilf Ewers and Russell Hudson who would beat us. The only thing I could offer Barry was that I carried the maximum handicap. He was convinced I would have a good round one day but it never happened. I still got round in the same number of good shots as the others it was the ones in between that spoiled it. I could be as sore after 18 holes of golf as after a footy match, it was that physical for me. I did make runner-up while playing with Vit Gailitis after Barry had left CSIRO. It was a great social day and good companionship.

Soccer

Russell Hudson, Alan Mann, Rob Hill and Alan Woodbridge formed up a soccer side. They played socially and I think a few internal games. I can recall Drew Morphet of the ABC playing against and for CSIRO. I did have one official game for CSIRO so can claim to have taken part. I did not have the right build or temperament. I thought it was non-contact so I would keep my hands to myself only to find I was being pulled and shoved so in would go the old hip and shoulder and a free would result.

Tennis

We had two grass tennis courts built and maintained by the social club and members. It is a lovely setting in amongst the native trees. The courts would be marked out and the lawn mown by staff sometimes on a roster. There were competitions and many social events. Divisions sometimes used the courts to have social days and get-togethers.

Table Tennis

Table tennis went through a very popular phase in the early seventies as a lunchtime outlet. There was no organised system to get a game, and so it was often a mad scramble to get on the table. It's a wonder there weren't more injuries, it was almost in the same league as the rush down the stairs by the bridge players so as not to miss out on getting a hand. I don't recall any competitions internally, but Margot Willing (Adams), Terry Power, Louis Cline and I did represent CSIRO in a competition played up at the Mullaloo surf lifesaving club.

The Lunchtime Sports.

Over the years we had many softball, lawn bowls and volleyball competitions during the lunchbreak with a wide selection of the staff participating. It was a great way to mingle and meet with staff from all areas of the site and provided a lot of comic relief. The sporting activities waxed and waned as the demographic of the place changed. Sport played a special role in my history with CSIRO and I think the organisation and the people who drove the sporting agenda's should feel they did it very well.

CRICKET – MATCHES AND PLAYERS

McGillivray Oval had several turf cricket pitches which we were allowed to use when not in regular use for cricket competitions. The social club bought a kit of cricket gear. As I recall we started by playing internal matches and I think there were several "tech staff versus professional staff" matches. Eventually we formed a combined CSIRO team and played matches against other social sides. It took us some time to educate other sides that while playing social cricket, we were very serious and competitive during the match, and the libations came after. We were always in whites. Some sides would attempt to drink on-field and were usually given a belting by us and not welcomed back.

The wickets at McGillivray Oval were usually quite firm allowing good pace. Big Norm Campbell could get good bounce. I can remember many of the older staff members playing there, including Neil Catt with his slow swinging off-breaks that took many wickets and Wally Russell as an opening batsman. Murray Wallace from entomology, Barry Carbon, Malcolm Howes, Graham Arnold and many others made memorable contributions. How well I remember Malcolm, who was fairly short of stature and serious in demeanour, taking about eight foot strides with steam coming out his ears, storming back to the pavilion when he considered he'd been given out (invariably) unjustly.

Some years later a push came to put in our own turf wicket in one of the animal house paddocks, as well as two tennis courts and a bowling green. Again I think the push for this came from Russell Hudson who certainly held great interest in the science of wicket preparation and with Don Bell was often seen pulling the roller over it. All the sporting facilities were built by volunteers and were a credit, providing a great deal of enjoyment for staff and families for many years. We were also lucky to have staff members who knew where to source the heavy clay-loams used by the WACA that were necessary for the wicket.

A turf practice wicket was installed in the nets, but by mutual decision it was abandoned. Terry Parks used to bowl a good full length, flat and usually very driveable ball. When these started to come up around ones chin and the ball bounced unpredictably, we opted for safety. There was some very subtle abnormality that we couldn't get out of that strip.

Our cricket ground was small, the wicket generally tended to be softer than normal because we couldn't put full time work into it and it had to be watered to recover for our games that sometimes happened after only a one week break. Our ground was very popular, our games were popular and we were often inundated with sides wanting to play. Both teams

would have to get over the fence into the animal house paddocks or onto the roof of the university book bindery if someone “got onto one”. However, many a person got out trying.

We had a very successful time on our new ground. A new series started where we played between Divisions, with a great competition between the Division of Mineralogy and the Division of Land Resources Management. I was in the LRM side. These games were played very competitively with the bragging rights going to the victors. All was forgiven afterwards as we often socialised well into the evening. John Perdrix would score with great detail and he was an integral part of those matches. The few remaining copies of his reports are produced later in this chapter.

We had our work cut out dealing with Alan Mann who was a competent graceful right hand batsman and more often than not a thorn in our side. Alan also was a handy bowler and very tall. On occasions when we had had unseasonal rain and the wicket was tacky, myself and the other opening batsman had some very uncomfortable times against Alan’s fiercely cutting and rising off-cutters. With Ross Casey’s swing and Charles Butt in-swinging from a great height they had a great attack.

Two incidents come to my mind with Alan Mann in the intra games. We had to play one game away from our ground, maybe we had had rain. I think we played at a ground in Wembley on a malthoid wicket. Mineralogy was batting and Terry Parks was umpiring at square leg. Alan Mann had made a few runs when he hit the ball to leg whence it was pounced upon by Malcolm Howes who threw down the wickets from side on which was a good effort if not unexpected. There was a raucous appeal led by a feisty Malcolm and Terry Parks turned calmly around and said Not Out to which Malcolm replied at the top of his voice “It f……well was!! Everyone saw the great humour in this (except Malcolm) and it was a very important wicket and might I say very, very close and he might have been lucky to get away with it.

The second incident showed Alan’s competitive nature, as was my own. I got lucky on one occasion and bowled Alan middle stump with an inswinger which wasn’t my stock ball and not always on line. It was a very rare occasion that Alan got bowled (the only time I ever did it). When my turn came to bat I thought I would try to get stuck into Alan’s bowling to try to force home some one-upmanship. The pitch was dry and he was bowling off-cutters a little short and I was getting stuck in with several boundaries. I could see Alan not enjoying this and he wasn’t accepting it. He worked away at changing his whole style, started bowling fuller length away swingers and shortly he bowled me. Such was the competitive nature and I thought fair enough.

Russell Hudson could cause us problems. Apart form being a competent wicket keeper, as a batsman, like many left-handers he was deadly on anything on or outside the stumps and would pull through midwicket. On our wicket if you dropped short with your bowling (a common occurrence as we aged) the ball really stood up and begged to be hit. Russell was a very social fellow and had a good way with words. In one of his reports of an “intra” game he said of one of his players, “narrowly missed being hit by a very takeable catch”.

Don Bell was a more than handy leg spin bowler and claimed many scalps including mine. He wasn’t an overly skilled batsman but had a magic eye and would cut anything, even from outside leg stump to the offside boundary.

I must mention Terry “TC” Parks: he was a zany scientist who loved playing cricket. Most players would warm up with a few hits or throwing catching practice before going into the field. On one occasion I went over for the customary pre-batting nervous pee behind the gardeners shed and there was TC sitting on an old bed-frame pondering over a large paper. I asked what he was doing and he replied I am analysing the circuit diagram of a stereo

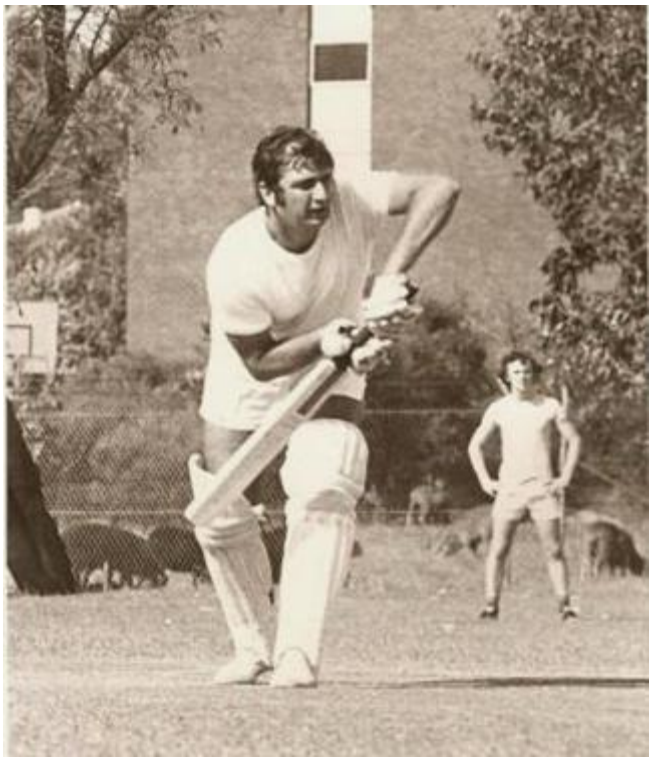
system to see if I'll buy the Kenwood or the other. You've got to admire that. A most memorable thing about TC's fielding was his iron shins. Where most would bend to field the ball, TC would simply drop the legs together in front of a hard hit ball with the resultant thud and much wincing by his fellow players.

He did it all the time and didn't complain. There were many players for the Mineralogy side but to try to list them all would do injustices to some so I won't try.

On our LRM side we had Norm Campbell, Barry Carbon, Jon Thomas, Ian Cullen, John Rainer and Bob Hunter who bowled with pace and played at different times. Myself with a bit of swing, Bob Rummery with off-cutters and Nick Malajczuk could fling them down but was "the Carl Rackeman" type where you were never sure about where they were going. We had a very dedicated wicketkeeper in John Marshall. John had a soccer "goalie " style and would lunge violently at any chance without fear of the body and resulting in a great "thud" followed by much vigorous scuffling to get to his feet to return the ball. One could never accuse John of not giving it his best.

Nick Malajczuk was fairly "agricultural" with the bat but had a good eye and a very hefty swing. If he got on song there was some massive hitting. I believe he has the record for the biggest "six" hit on our ground. Again there were many dedicated players for us.

Well that's our "intra" divisional games. They were very enjoyable, strongly supported by the staff. Arthur Gaskin and Ray Perry, our chiefs, would always wander down for a while and often join us afterwards for a barbie and libations.



Myself being deffensive…..

...and on the offensive, Russell Hudson with the bat and Justin Murphy in the field. (Photographs property of G Bartle taken by Bill van Aken most likely.)

We enjoyed a lot of competitive games as a CSIRO side for many seasons and we were regularly challenged by a side from Graylands Mental Hospital, City of Perth, Department of Agriculture, Murdoch University to name a few and many one-off social games.

Every year we were challenged at least twice by Graylands Hospital. I shall never forget our first game at Graylands on their malthoid wicket. There was not as much security in those days and when we were in the field, the patients seemed challenged by the idea of wandering onto the field and sneaking up on our players. It was humorous watching our fielders trying to concentrate on the game with one nervous eye watching the approaching patient, until one of the Graylands batsmen yelled some instruction and the patient would move on much to the relief of our fielder. There was no harm liable from the patients, rather it was our non-familiarity with that situation and in fact our association with this group of players led to us having a much better understanding of the treatment and management of mental illness. There were some patients who regularly came over to our games at CSIRO.

It was either this game or another where we were enlightened further. The Graylands lads were supplying the beer, which they had stored for after the game in one of the fridges near the wards. You guessed it, (patients 1, players 0) all gone, and so we had to adjourn back to our venue.

Most of the games were played on our ground, but I recall one other game we played over there when they had opened access to another area of the hospital and a turf wicket. This was very memorable for the fact that a feature of this wicket was a fair wack of crab grass plants through the surface with the resultant unpredictability of where the hell the ball was going to go. They had a bowler called Wayne Endersby who was pretty quick and life at the crease was pretty uncomfortable. In the interest of self-preservation, I remember making the conscious decision to try to get to the bounce of the ball and hit it as hard as possible. Think I got a few but it was nerve-racking. Maybe we won because we had a good social session with them there if I remember rightly. TC headed for home on a wobbly path on his bike that

night, but returned several times and merrily sought information on how to get out of the place.

Other players I can remember for Graylands were, Bill Mutch, Clive Speck, Bernie Arthurson, Peter Cummings, Tony Bell and Brad Scott. We often had the wood on Graylands but on one forgettable game at home, they thrashed us due to some skilful bowling by a fellow I can only recall being called “coalminer”. He came on to bowl what looked like very juicy off breaks but was deceptive in flight and I think took almost all our wickets. We enjoyed many after match barbecues with them at our wonderful barbecue setup under the trees at Floreat. One of their many characters was “kid Neuron” (their name not ours) who seemed to find a few left over vegetables from the kitchen.

We had another very memorable game organised for us by Graylands against a team of visiting nursing home staff from the Eastern States. It may have been Morriset hospital I believe. I am not sure about the outcome of that game but a feature was their former “A” grade opening bowler. He was the only bowler I ever saw who could lift a ball on our wicket. He was many steps faster than anyone we had faced and knew how to move the ball around. As an opener I had to face him and he was very hard work. He bowled with such force that when I snicked the ball outside off stump it flew probably 10 metres to a young fellow who got hands to it but it went straight through with a sickening thud into his chest and unfortunately for me back into his hands. I think he was pretty sore. A few of us watched this fellow bowl over at Graylands a week later and from side on to the wicket he looked menacing.

I think for those who played cricket and came along in support, it would be remiss not to mention a very special game we had against a Qantas crew. There were several features of this game, not the least of which was the “hosties” who used to serve up some of the food to us. That might have been the only highlight of this day. Qantas used to roster an international jumbo, a crew of sporting enthusiasts who would play cricket matches at world venues. They had played at Lords; I think South Africa and recently Bombay. These guys had played a bit of cricket before. They really knew what to do with the ball and while some were not young they knew how to exploit our wicket. They carried a certain amount of confidence if not arrogance and several could really bat. I think they got us all out for around for 50 or 70 which they got quickly.

I well remember the ball that got me out. It pitched about a foot outside off stump at fairly full length so I raised my bat and offered the pads out to let it pass through to the keeper. To my absolute amazement it hit the pitch and nipped back onto the stumps. I never saw anything like it. That had never happened to me before. It was no fluke as he did it several more times in the innings. Perhaps they had a bit more pace than us.

Having belted us up at cricket and since it was too early to start our barbie several of the players headed down to our wonderful tennis courts and the Qantas side proceeded to belt everyone at tennis as well. But worse was yet to come!

There was considerable drinking done after the match and when most of our stayers were spent and ready to head home, we couldn’t get them out of the place. I think we had to bribe them with drink to take away to get them out. So there you are, a complete “pants job” we were comprehensively whipped, we lost the cricket, tennis and drinking!

There was a very memorable incident with this match and one that is a little hard to put into words here. It was probably most memorable to those of our players who were forced to be involved. It involved one of the Qantas entourage who had been recently in Bombay and had obviously picked up a severe dose of “Bombay belly”. He disgraced himself in a rather

athletic way in one of our amenities. I never felt quite the same going in there and I'm sure Alan Mann and Russell Hudson felt the same way.

Another incident that comes into my head (literally) was during one match I was fielding in the outfield and the batsman hit one rather forcefully into the outfield and most (including myself) would have expected me to take it. I rose like a trout to the fly as Russell Hudson would say and felt the very hard smack to one of my hands followed by a very hard smack to my head. Looking around the ball had gone over the boundary for four. Completely embarrassed, I bent over to pick up the ball, as great flow of blood covered the whites and someone offered me a towel. The players kindly took me off to RPH for a couple of stitches and we returned. During post match discussions some of us more senior cricketers wondered whether the writing was on the wall and retirement approaching.

CRICKET – MATCH REPORTS[41]

1976-77

CSIRO enjoyed a most successful cricket season in the summer of 1976-77 by winning six of the thirteen matches played. It was successful because all the players enjoyed the matches, with nearly all players having a throw and a hit. The social atmosphere of the games with most players pushing their skills at the opposing batsmen may have cost a couple of games. However, it certainly produced a feeling of full participation for all concerned.

Two down for 190 is a remarkable start for any innings by any team. This was the score after 20 overs when Alan Mann retired; Greg Bartle having retired after 15 overs with the score at 122. The match against University Administration was the best yet when we finished all out for 259 at the end of the 27th over - that is, at a rate of just over nine and a half runs per over. It is also interesting to note that the run rate did not drop off with the tail, for the first 190 came up in 83 minutes and the total of 259 was there in 115 minutes - a rate of just over two and a quarter runs a minute. A memorable day was Sunday, January 16.

The change of venue to Graylands with gaping cracks in the pitch, grass 10 cm high and the absence of a couple of regular players produced the figures of all out for 81. Although

[41] [41] With thanks to John Perdrix

beaten in the match, Sunday, February 20 was not a complete disaster as the opposition could score only 89.

The season could not have been so successful without the tireless and unceasing efforts of Russell Hudson who prepared the wicket to just that right degree of firmness for interesting matches.

The highlight of the year though was when Mineralogy continued its sequence of successful encounters with LRM, when they won by 40 runs on a rain-affected wicket at Floreat on Wednesday December 22. Some of the previous results of matches between the Divisions are:-1974/5 - Mineralogy 123 vs LRM 114; 1975/6 -165 vs 161 and 125 vs 96.

Alan Mann won the toss and elected to bat on a wicket that had the consistency of a Christmas pudding. However, in comparison with its almost hopeless appearance at 10 am, the well-drained pitch had responded well to repeated rolling and five hours of sunshine. Barry Carbon and Greg Bartle soon demonstrated to the batsmen that stroke play would be difficult, with the ball coming on slowly to the bat, and rising awkwardly from divot holes if pitched at all short. It was not long before Terry Parks skyed a ball to mid-on, where Taylor accepted a well-judged catch. Alan Mann was joined by Des Baccini, and the pair played soundly for a second wicket partnership of 38, before Mann was dismissed for 22. Baccini, who played his most determined and attractive innings of the season, went on to make top score for the match with 34. With the loss of Baccini, Mineralogy slumped to a score of 5 for 72, and LRM appeared to have a good grip on the game. However, a valuable stand by Russell Hudson and Don Bell saw the score move on to 124 before Bell was well caught by Adrian Peck off a hard hit shot.

Wickets were evenly divided amongst the LRM bowlers, and only Ken Wright (immaculate figures of 2 wickets for 0 runs off 5 balls) captured more than one. Nick Malajczuk sent down some hostile balls, Jon Thomas bowled economically and John Marshall kept wicket efficiently, taking two catches.

Wally Russell and Greg Bartle opened against an attack that had been instructed to keep the ball well up to the batsmen. Whilst both played soundly the bowling was tight, and run-scoring was difficult. Both openers gave chances before Russell was out to a brilliant gully catch to Bell. Justin Murphy joined Bartle, but runs still proved difficult to score, and when his dismissal was followed in quick succession by the loss of Peck (playing across the line to a full toss), Bartle (well caught at first slip by Hudson when he did not get to the pitch of a spinning delivery from Bell), Malajczuk, Carbon, Taylor and Thomas, LRM were in trouble at 8 for 51. A staunch rear-guard action by John Marshall (22) and Denis Hurle (19) saw the batting on top for the first time in the innings, and they together gave respectability to the LRM total.

The different tactics employed by the bowlers from the two sides were reflected in the number of boundaries (19 to Mineralogy, 7 to LRM) scored by the batsmen. Almost all were the result of hooking the shorter-pitched delivery.

Don Bell was the most successful bowler with 4 for 10 off 3.3 overs of quality leg spin, while Terry Parks took 3 for 13 and Alan Mann 2 for 16. Des Baccini kept well and Bell showed that he had lost no agility in the field. Wilson narrowly avoided being hit by a catch at deep square leg.

Best on the field were: Don Bell - 21 runs, 4 wickets for 10, a brilliant catch and excellent fielding; Ken Wright - 2 wickets for 0 runs off five balls, not out 1 and all-round good play; and, Russell Hudson - 33 runs (retired) and an excellent slips catch.

1977-78

CSIRO won nine of the thirteen matches played this summer to make it perhaps the most successful season to date. All of the matches were played at home and, aided by a good turf wicket, improving outfield and the excellent CSIRO BBQ facilities the contests were enjoyed as both sporting and social functions.

A total of thirty six players 'pulled on a glove' for CSIRO or for their Division during the year and numerous spectators were entertained during the Sunday and Wednesday afternoon matches. Ten different club teams visited us, three of them on two occasions.

A remarkable 2,243 runs for the loss of 107 wickets were scored this season at an average of 173 per match or 21 per wicket (last year 1,802 from the same number of matches). Totals in excess of 200 were scored in three games with a best of 8 for 250 against the Government Chemical Laboratories. There were nine half-centuries including 96 by Alan Mann. Five of the best batting partnerships were 50 or over, with a 114 stand between Alan Mann and Russell Hudson for the second wicket being the highest. The "eclectic score", based on best partnerships, is 529.

Despite these fine batting performances most credit for our success must go to the bowlers. Twenty eight rolled the arm over during the season, twenty two of these were used against outside teams. Bowling highlights included Charles Butt and Greg Bartle finding outswingers and inswingers respectively and Bob Hunter's hat-trick and Bob Rummery's noteworthy 17 wickets. Despite a steady length, Terry Parks did not bowl a maiden over in 30.7 attempts. Several fielding performances deserve mention. None did better, both before and after breaking his finger, than Mark Rummery at cover, lan Tapley caught surely all year, Graham Hall was courageous at short forward leg, Terry Harrison reliable at fine leg, and who can forget the spectacular dust-raising diving attempt by Des Baccini to impress a blonde spectator.

New faces this year included the Queensland opener Ken Turner, Duncan Peter, Graham Hall, Colin Hingston and Mark Wheeler. Old faces that deserve special thanks include the meticulous keeper of the score, John Perdrix, the enthusiastic and competent team of ground waterers, gear maintainers and pitch preparers. Bob Rummery's organization of fixtures, Alan Mann and Russell Hudson who took turns in captaincy throughout the season, and all of the players who not only tolerated the decisions not to bat or bowl them, but actually seemed to enjoy the long hours in the sun, accepting a cool beer as more than sufficient reward.

Results of trophy matches played this year were -

- "How ya Bin" trophy lost to Swanbourne - Graylands Hospital
- "Emu Lager" trophy won from Geology Department of UWA. (+ 4 dozen bottles).
- "Bearded Clam" trophy won from Western Mining Corporation.

1978-79

CSIRO played twelve interclub matches, one inter-Divisional test match, a 'six-a-side' and a 'double-wicket' game, to complete yet another most enjoyable and successful season. This year, the team played two of its games away from home - against Swanbourne-Graylands for a win and Murdoch University for a narrow loss. However, most games were played on the CSIRO turf wicket and the true batting surface, fast and well-grassed outfield, barbecue facilities and well-stocked cool room, combined to make the cricket matches enjoyable for visiting teams, spectators and CSIRO players alike.

We won seven of our twelve games, and in doing so regained the "How ya bin" trophy from Swanbourne-Graylands Hospital and then successfully defended it, won our 'customary' two-

dozen bottles and the 'albino-emu' trophy from the UWA Geology Department, and retained the WMC "bearded-clam" trophy for the fourth year.

In achieving these excellent results, CSIRO compiled 2125 runs at a cost of 108 wickets for an average of 20 runs per wicket, against opposition figures of 1428 for 118 at 12 runs per wicket. Last season special mention was made of the role of our consistent bowlers. This year they continued in the same form, but the batsmen deserve credit as well (who said what about the opposition bowlers?)

Five scores in excess of 200 were made by CSIRO this season and all resulted in wins except for the 208 to 226 loss against Cockburn. The greatest winning margin was 183 runs in our 8 for 241 vs 58 victory against Broadway Tavern; we gave the evening rematch a fair nudge too!

High scoring partnerships were a feature of the season, with five partnerships greater than 50 runs; Alan Mann and Don Bell did best with 87 runs. The "eclectic score", based on best partnerships was 532, compared with 529 in the 1977-78 season. Memorable batting displays included Greg Bartle's 103, Don Bell's fast scoring rate, Bob Rummery's three consecutive ducks to start the season, and Bob Hunter's red blooded display in the inter-Divisional match. A number of bowlers tried for the hat-trick, but none with more distinction than TCP, who gave up the new ball for his family and then returned to take two wickets off his first two balls against SGH. Charles Butt bowled 10 maidens over, Bob Hunter took 21 wickets at 7.71 and Bob Rummery and Don Bell each took 16 wickets.

David Williamson's match-winning catch to dismiss Don Bell in the inter-Divisional game was only one of many memorable fielding performances. Who can forget John Marshall's diving saves, TCP's resilient shins, Bob Gowland's outfield catching, Ian Tapley's cover fielding, and Alan Mann's inability to bowl to his slips field?

New captains in Bob Rummery, Don Bell and Bob Hunter were blooded with success, but whether Bob Hunter or Malcolm Howes captained their 2-wicket side is still unresolved. The Qantas game must rank as a highlight of the season. Despite a difficult wicket, a lost toss and a lost game those involved have lasting memories of quality cricket and hospitality previously not seen in the CSIRO tea-rooms. Qantas hostesses and stewards did us proud with steaks, salads, champagne, trophies and ties, and then cleared up the debris. (The unfortunate in the Gents' john obviously got a bad Bombay snagger).

LRM wrested the ashes from Mineralogy in the annual test match, and in doing so have revitalised inter-Divisional cricket - congratulations Perry's Players.

Innovations this year included the 2-wicket match, won by Alan Mann and Don Buscall, and a 6-a-side match, won by Bob Hunter's team. These attracted new players in Pat Keogh and Don Buscall. Other players who pulled on the gloves for CSIRO for the first time this year included Brian McIntyre, Lance Mitchell, Colin Weir, Clyde Speck and the CSIRO sons Derek Parks and Michael Hudson. In all, thirty seven different players had a run this season, demonstrating yet again that Social Club funds are well spent in supporting CSIRO cricket.

Thanks are due to our scorer and statistician John Perdrix, match organiser Bob Rummery, captains Alan Mann, Russell Hudson, Bob Rummery, Bob Hunter and Don Bell, ground staff led by Russell Hudson, Alan Mann and Don Bell, equipment organisers and fund raisers Alan Mann, Charles Butt, Greg Bartle and Terry Harrison, and the wives, spectators, casual drink stewards and cleaner-uppers that all contributed to a great 1978-79 season.

RESULTS OF 1978-79 MATCHES

29.10.78	CSIRO	104	U.W.A. Soccer	111
12.11.78	CSIRO	8/241	Broadway Tavern	58
22.11.78	CSIRO	114	Murdoch	166
26.11. 78	CSIRO	197	G.C.L.	75
29.11.78	CSIRO	239	U.W.A. Geology	105
2.12.78	CSIRO	143	Qantas	8/169
10.12.78	CS IRO	175	C.R.C.	148
14. 1. 79	CSIRO	208	Cockburn C.C.	226
4. 2.79	CSIRO	6/221	G-S Hospitals	84
12. 3.79	CSIRO	6/144	G-S Hospitals	34
25. 3.79	CSIRO	9/235	W.M.C.	145
28. 3.79	CSIRO	9/104	Murdoch	107

HIGHEST PARTNERSHIPS

First	75	Bartle-Harrison	4. 2.79
Second	79	Bartle-Mann	26.11.78
Third	68	Hudson-Mann	12.11.78
Fourth	48	Bell-Hall	14. 1. 79
Fifth	87	Bell-Mann	25. 3.79
Sixth	47	Hunter-Tapley	12.11.78
Seventh	54	McIntyre-Rummery	4. 2.79
Eighth	18	Bell-Harrison	14. 1.79
Ninth	33	Hunter-Williamson	20.12.78
Tenth	23	Butt-Gowland	2.12.78

1979-80

This summer saw CSIRO play ten interclub matches, one interdivisional test match and a 'seven-a-side' intra-club match in yet another enjoyable cricket season. As in 1978/79 two games were played away from home – against Murdoch for a loss and against' Swanbourne-Graylands for a win. All other games were played on the CSIRO turf wicket, that remained in excellent condition throughout the slightly shorter than normal season.

Playing conditions at CSIRO continue to improve in response to the hard work of the ground-staff, ably led by Don Bell. Removal of a few trees, installation of the cricket shed, and the lawn bowls, tennis, barbecue and cool room facilities guaranteed enjoyable, social and sporting afternoons for staff, visitors and families. Thirty CSIRO -cricketers' took to the field at some stage during the season.

We won five matches, drew one match and lost three games to the University Soccer Club, Western Mining Corporation and Murdoch University. Qantas gave us another thrashing, but proved once again that you don't necessarily have to win to have a good game.

Home-and-away victories against Swanbourne-Graylands retained the "How ya bin" trophy and the CSIRO side went on to win the drinking as well. The latter feat had only once before been within our grasp, but slipped with victory in sight, in what has become known as the Parks' bicycle debacle.

Western Mining deserved victory in a game that saw the "Bearded Clam" leave Floreat Park for the first time in five years. The other traditional trophy, the "Albino Emu" was not

contested this year. The Geology Department, presumably still smarting from their three consecutive losses of the trophy, not to mention the two dozen bottles each time, failed to issue a challenge.

The total score compiled by CSIRO for the season was 1424 for a loss of 81 wickets at an average of 17.6, against opposition figures of 1310 for 89 at 14.7. Unlike 1978/79, when we scored in excess of 200 in five matches, our top score for this season was only 190, against WMC. Our lowest score of 29 was registered against Qantas. Alan Mann was once again the backbone of the CSIRO batting with a total of 401 runs at an average of 40.1, with a highest score of 100. Others to do well were the "oldies", Greg Bartle, Don Bell and Russell Hudson and rising star Bob Hunter.

Four partnerships in excess of 50 were scored with Alan Mann and Russell Hudson doing best with 101, closely pressed by Bob Hunter and Alan Mann with 96. The "eclectic score" for best partner-ships was 474, well below the 532 for 1978/79 and 529 for 1977/78. The all-time (1976-1980) eclectic score of 697 suggests that if we all came-good together we could take on the Pakistanis.

Bowling honours were shared. Don Bell took most wickets with 14 from 40.1 overs for 201 at an average of 14.36. Both Bob Hunter and Alan Mann took more than ten wickets and Bob Rummery had the excellent figures of 5 for 56 off 24 overs at an average of 11.20. Both Bell and Hunter took 4 wickets in a match. Norm Campbell could not adjust to the length of Australian wickets and took only 1 wicket at a cost of 63 runs.

The ashes returned to Mineralogy in the test against LRM. High-lights of the game were the welcome return of Peter Farrington to cricket (with David Williamson he compiled the highest seventh wicket partnership for the season), a century by Mann, Jack Halberg facing 5 balls (but still not opening his account) and strong batting displays by Bob Gowland, Nick Malajczuk and David Williamson. Justin Murphy took 3 for 24 in a sustained bowling display.

Other highlights of the season included - Nick Malajczuk showing signs of northern hemisphere disorientation by going in to bat with a pad upside down, Malcolm Howes' electrifying fielding, the return of Terry Parks after injury, Duncan Peter, Nick Malajczuk and lan Tapley catching brilliantly and Graeme Hall facing 29 balls without scoring.

1980-81

During this season CSIRO won seven of the twelve interclub matches played during a full and enjoyable program. The annual LRM - Mineralogy Test Match was contested in the week before Xmas, and resulted in a win to Perry's Players. Ground-staff, ably led by Don Bell, maintained the turf wicket and outfield in superb condition throughout the season, and despite the eleven games and numerous centre-wicket practices the wicket showed little wear even when stumps were drawn for the last time at the end of March. It was sad to note the pruning of a *Grevillea menzeii* and a stunted *Eucalypt*, of unknown parentage, that had withstood abuse and threats for many years.

Traditional rivals Swanbourne-Graylands were thrashed by CSIRO in the opening game of the season, with 10 of their batsmen making 5 runs or less. Bob Hunter, playing in his testimonial match, took 4 wickets off 5 overs and conceded only 2 runs. The "How ya Bin" trophy was retained following an away win against Swanbourne-Graylands in January. Alan Mann was so confident of victory that he didn't even bother to bring the trophy along. lan Tapley, celebrating the birth of his first child, was appropriately caught out by Youngson for 4.

Overwhelming victories against ElecSales, Seltrust and UWA Geology, in which CSIRO scored 9/248, 237 and 7/221 respectively, did much to boost the averages of batsmen and

bowlers, but did little to further the cause of competitive cricket. The games against ElecSales and Seltrust, however, were played in excellent spirit, and the game against UWA Geology resulted in us drinking excellent free beer. Home and away games against Murdoch University were, once again, competitive and enjoyable, resulting in one win for each side. Our win, on Murdoch's home ground, was most gratifying after having threatened, but failed, on several previous occasions. Congratulations to Alan Mann who kept the side from "running about" in the home straight. A DYSR side, strengthened by the inclusion of a couple of young and competent bowlers and batsmen, put up their best ever display to beat CSIRO. Browns Dairy also gave us an enjoyable match, and later demonstrated that very few were content to "milk it instead",

An exciting game saw CSIRO narrowly beaten by Cockburn, but we were unable to match it with G.J. Coles, who had no trouble in beating us in a warm-up for their interstate competition. For the second successive year Western Mining beat us to retain the "Bearded Clam". John Perdrix, our excellent scorer and statistician, once again compiled the details that some would like remembered and many would like forgotten. Highlights this year included the aggressive striking of Nick Malajczuk, the early promise of Dave Colwell as a bowler, the way Bob Gowland shouldered the bowling responsibility in the absence of Bob Hunter, and the enthusiastic approach to the game of John Bright.

The total score for the year was 1676 for the loss of 102 wickets, at an average of 16.4, slightly lower than last year's figures of 1424 for 81 at 17.6. Three scores in excess of 200 were counterbalanced by a 44 against Murdoch and an 88 against WMC. Main contributors to the scores were Don Bell with 236 from 9 innings, Russell Hudson 230 from 10 innings and Greg Bartle 198 from 10 innings. Terry Harrison gets the "stone-wallers" award for facing 17 consecutive balls without scoring (he fell far short of Graeme Hall's record 29), Russell Hudson "hogged" the batting to the tune of 409 minutes, and Don Bell "slogged" 22 off 9 consecutive deliveries.

In addition to Bob Hunter's good bowling figures, Bob Gowland took 4 for 13 off 4 overs against ElecSales, and 4 for 21 off 4.5 overs against Seltrust. Three wickets in a match were taken by Bob Rummery (twice), Alan Mann and Terry Parks. Nick Malajczuk took 2 for none off 3 overs against ElecSales.

A highlight of this year's statistics is the compilation of "all time" averages. These show that, for the period 1978-1981, Alan Mann has scored 819 runs, Greg Bartle 668, Don Bell 648 and Russell Hudson 617. Bob Rummery has taken 63 wickets, Bob Hunter and Alan Mann 53, Don Bell 50. Greg Bartle and Terry Parks 49. Perhaps the most important statistic, however, is that which shows that over 60 players have taken to the field to play cricket for CSIRO.

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