ICI's Chemical Engineers and their Colleagues

Early Leaders in Process Safety in Australia - 1976 to 1996

A chapter in the History of Chemical Engineering in Australia

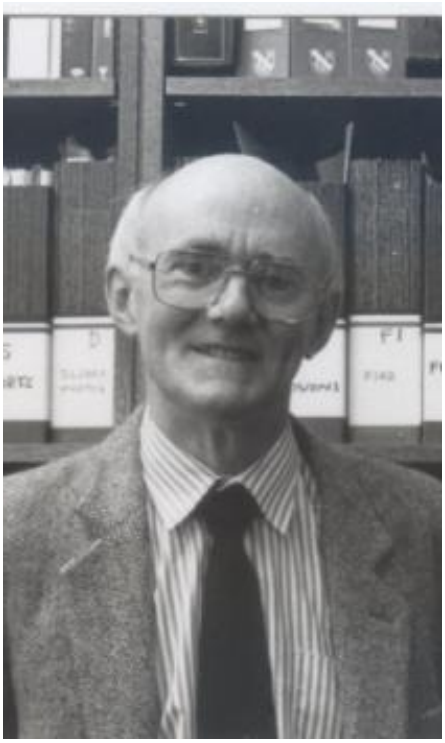
Imperial Chemical Industries (ICI) was a British chemical company formed in 1926 from the merger of Nobel Explosives, Brunner Mond, United Alkali and British Dyestuffs. Soon afterwards, in 1928, the interests of the antecedent companies in Australia and New Zealand were merged to form a regional subsidiary known as Imperial Chemical Industries of Australia and New Zealand (ICIANZ). When ICI and ICIANZ were formed, the companies inherited formidable capabilities formed over a period stretching back into the nineteenth century, including Nobel Explosives' expertise in the safe manufacture of black powder and expertise in achieving the purposes of the Explosives Act (1875) such as the standardised use of safety distances around inventories of explosives.

By the mid 1970s, ICIANZ was known as ICI Australia (now Orica) and was still controlled by Imperial Chemical Industries PLC. The global company was still active in explosives, chemicals, alkalis and colours but had also diversified further into petrochemicals, plastics, fertilisers, agrochemicals, pharmaceuticals, animal health, paints and synthetic fibres. The practice of process safety had continued to advance and the ammonia project commissioned at Kooragang Island, NSW in 1969 included quantitative modelling of potential ammonia releases from its 12,000 tonne anhydrous ammonia storage tank (applying the best practices of ICI Agricultural Division) to develop emergency plans for the Newcastle locality (Blamey, 1). But in 1975 the global company was actively responding to the lessons learned from a major incident at Flixborough, UK on 1 June 1974 in which 28 people died as result of an explosion and fire in a caprolactam plant owned by Nypro UK. Through ICI's response, Trevor Kletz (then Technical Safety Adviser in ICI Petrochemicals Division) emerged as a global leader in process safety and the ICI Group earned a corporate reputation for its organisational capabilities in the field. Kletz' significant contributions to process safety - including to the development of the Hazard and Operability [HAZOP] study technique and to Inherent Safety - have become particularly well known across a broad range of process industries. His work is still celebrated by the Institution of Chemical Engineers through delivery of the annual Trevor Kletz Oration. At the same time, the other divisions of the global company were innovating in process safety. David Lowe was Kletz's counterpart in ICI Mond Division. The Mond Division team developed ICI's six stage framework for integrating process safety into capital projects at project specification, flow sheet review, HAZOP, physical checking, pre-commissioning safety inspection and post-start-up review. The Mond Division team also included David Gill whom James Hawksley (2) (who was later ICI Group Process Safety Adviser) remembers presenting his work on development of the Bow Tie technique when Hawksley attended the two week Mond Division Hazard Analysis course in 1975. Gill's internal paper on the Bow Tie formed part of the ICI Hazard Analysis Course Notes (1979 version of the two week course) that were later released (in 2007) to staff at the University of Queensland (Griffiths, 3). At the same time, ICI Pharmaceuticals was adapting HAZOP to their batch processes (Cornford, 4) and ICI Explosives was expanding its application of developments in quantitative risk assessment (QRA) to explosives that were coming from the subsidiary Canadian Industries Limited (CIL) and ICI Australia was part of that initiative (Cowper, 5).

The first HAZOP studies in Australia were conducted in 1976 at ICI Villawood near Sydney, NSW. In the mid-1970's, ICI Australia's Rural Division was an established manufacturer of L Tetramisole (marketed as Levamisole), the active ingredient in a range of anthelmintic preparations used to control parasitic infestations in livestock. The production process was a 26 step chemical synthesis based on a key raw material called ethylene imine, a human carcinogen. To reduce the hazard inherent in production, the company developed an alternative synthesis process based on monoethanolamine to produce the early intermediate 2-imino-3-(2-hydroxy-2-phenylethyl) thiazolidine ("IHPT") in a safer three step synthesis. Capital investment was approved in 1975 to the great relief of Villawood Factory Manager Mick Salmon who was anxious to create a safer work environment for his people.

Salmon engaged ICI Australia Engineering (ICIAE) to undertake the design and construction of the new "IHPT Plant" with mechanical engineer Laurie Hill appointed project engineer and chemical engineer Bill Mant (6) as process engineer in collaboration with process development chemist Dr Volker Maier (7). At the time, Volker was Research Plant Manager for ICI at Deer Park, Victoria where the process was developed at pilot scale to support design of the Villawood plant. The Villawood project was the first in Australia to apply the HAZOP approach developed by Kletz. Bill Mant guided the project team in application of the HAZOP methodology, using written guidance that Trevor Kletz had prepared and circulated for reference around the global ICI. Volker recalls "when the first Tetramisole Plant was built, start up took over three months and lots of changes were required to get the desired production rate and product purity. As I recall, this (new) part of the plant never required any significant changes - it worked well from day one. The HAZOP certainly paid for the time invested." Plant Superintendent Felix Nieuwenhuizen (8) recalls that the HAZOP ran over 9 months at 2 days per week. Bill Mant remembers the HAZOP team as including project director Ken Sponberg (another chemical engineer) as well as Hill, Mant and Maier with support from Salmon.

Around the same time, ICI Australia explosives safety specialist Roger Shackleton was bringing the risk analysis techniques developed by CIL into the Australian operations and in 1978 Roger handed over this role to Trevor Cowper (5) who continued to develop the application of process safety techniques to explosives until the next handover (to Paul Harrison) on Trevor's retirement in 1998.



In 1977, the new position of Project Safety Manager was created in the ICI Australia corporate safety unit under Personnel General Manager Ted Pahlow FIChemE and Safety & Environment Manager Wilf Webster. Electrical engineer Mark Tweeddale (pictured in 1993) was hand-picked for the role to take advantage of his strong background in equipment manufacture, chemical plant maintenance, work study and business administration (8). Peter Hunt (9), who was a colleague and friend from the 1960s, recalls Mark's firm commitment to technical excellence and his care to communicate clearly and unambiguously, especially when communicating on safety matters. To accelerate the cascade of ICI's work into Australia, Trevor Kletz travelled to Australia in 1977 to provide Tweeddale with personalised training and to meet other ICI Australia people whose contributions would influence the growing process safety effort. The project focus of the new role reflected then-current intentions of ICI Australia to invest significantly in new plastics manufacturing facilities at its established Botany, NSW site (polypropylene), at a new site at Laverton North, Victoria (polyvinyl chloride) and to develop a new petrochemicals complex at Point Wilson, Victoria (the last of which never eventuated).

During 1977-1978, Tweeddale adopted a strong focus on facilitating application of the HAZOP technique to the design of the Laverton PVC plant that was being managed by ICIAE (later known as ICI Engineering). This project was at least an order of magnitude greater in scale and cost ($36M in 1977) than the IHPT Plant Project mentioned previously and required the study of more than 100 piping and instrumentation diagrams. The program of HAZOP studies provided an excellent opportunity to train significant numbers of engineering and operations personnel associated with the project. Chemical engineers involved included project manager Colin Fairweather, project engineer Hal Hopkins, Bill Mant, Peter Wetherell and Mark Latham, alongside operations personnel Les Rewell, Bruce Gotting, Ross McCann and Heinz Guilhaus (a process chemist) and mechanical, electrical and instrument engineers of the multidisciplinary project team (including Bryce Gordon,

Ralph Dutneall, Bryan Perry, Leo Waterfall and Jeff Lowinger). A number of these learned the skill of leading HAZOP studies and contributed to the cascade of competence within the company over the ensuing years.

Concurrently in 1977, ICI Australia purchased a design package for a new Polypropylene Process plant and C F Braun of Murray Hill, New Jersey, USA was contracted to do the detail design. The project manager from ICIAE was Gunars Priede initially and later followed by Bill Palmer. As part of the project plan it was determined that a HAZOP would be carried out. This was done over approximately 12 months by a team led and facilitated by Lex Simpson (Plant Manager)(based on guidance notes by Kletz), Ross Howie (Operations Manager), Greg Payne (Development Manager) and Derek Griffiths (3) (Engineering Manager) plus Ric Coles who was involved in the computer system design plus other specialist ICIAE staff (including Colin Symonds and Lyn MacDonald) and C F Braun design staff. The consequence was that the start up went without any process problems and the first product was on specification. An unrelated American company bought the same package as ICI Australia at the same time but decided not to subject the design to the HAZOP process. It was later discovered that they started up 18 months late and had great difficulty making on-spec product. Following the successful start up a detailed risk assessment was done of the Polypropylene plant to determine the off-site risk of the new facility.

In 1978 Tweeddale (9) started what was to become a regular pattern of overseas travel to keep ICI Australia's practices aligned with the growing body of know-how of the global ICI. In 1978 he attended the two week Hazard Analysis course in the UK and returned via the South African sister company, African Explosives & Chemical Industries. Such trips were an annual occurrence (with destinations in the UK, Germany, Holland, USA, Canada, Norway and New Zealand) until he relocated to London for a global role in 1984. Using his 1978 course experience as a resource, Tweeddale worked with Botany Plastics Factory Development Manager Colin Putt to develop a shorter 3 day course that was presented to 30 colleagues in Melbourne and Sydney in 1979.

Between 1978 and 1981, Tweeddale was engaged in the company's plans to reinvest in Olefines production at Botany. He won support from the Organic Chemicals business and Corporate Planning to apply process safety criteria to the specification and selection of process technology for the new plant to supply ethylene and propylene for the production of the company's plastics and petrochemical products. Trevor Kletz visited Australia in 1978 to help Tweeddale and Olefines Development Manager Trevor Whalley produce a tender specification of the major hazards safety and environmental performance required for the new investment in terms of the fatality risk criteria used by ICI at that time. To enable application of ICI Hazard Analysis (HAZAN) techniques during the tender evaluation, Tweeddale worked with Dr Ric Coles to develop the ISORIS suite of software that could be used for the timely comparison of process contractors' tenders. When Linde was contracted in 1980 to design and build the new Olefines plant, the conduct of HAZOP studies was required under the project contract. The ICI Australia team working with Linde in Munich included chemical engineers Colin Simpson (11), Rob Kitching and Graham Canning who were involved with Linde's engineers in the HAZOP studies. Tweeddale visited Linde's Munich office in 1980 to help set up the HAZOP program for the project. Another major component of the Olefines expansion involved the construction of a LPG Import Terminal at Port Botany. In 1981 Tweeddale (9) visited the offices of Chicago Bridge & Iron (CB&I) in the USA (Pittsburg) to support the process safety studies required by ICI Australia and the NSW government.

In 1981 Tweeddale started writing on process safety for publication with an editorial for Chemical Engineering in Australia (12). He had been on the committee of the Risk Engineering Branch of Engineers Australia's Victorian Division since 1979 and took the chair in 1982. He became MIChemE in 1988. Later he was to be foundation chair of the National Risk Engineering Society 1993-4.

Engagement with the NSW Department of Urban Affairs and Planning over planning permission for the "Botany Stage 2 Expansion" required Tweeddale (9) to represent ICI at public hearings (1979-1981). This resulted in establishment of an enduring professional relationship between Tweeddale and DUAP's Deputy Director, Sam Haddad and also an effective working relationship between the organisations. In 1982

Tweeddale succeeded Lance Kirkwood as Botany Site Development and Environs Manager to continue that government relationship whilst also maintaining oversight of the ICI Australia standards in process safety.

By 1982, Tweeddale (9) had further developed the 3 day HAZAN course to make training more accessible to large numbers of personnel in ICI Australia. He also developed a 1 day course to give senior managers an appreciation of HAZAN and their role as leaders. The courses were presented around twenty times in Australia and New Zealand between 1982 and 1983, including invited deliveries to the New Zealand Accident Compensation Commission.

By 1983, with Mark Tweeddale undertaking the Botany site role, the need for new arrangements to expand and sustain ICI Australia's process safety competence was recognised. Under ICIAE Development Manager, chemical engineer Peter Millikin, Bill Mant was appointed as process safety consultant. As mentioned above, Bill had already been involved in the HAZOP studies for ICI Villawood in 1976 and had played a key role as Lead Process Engineer for the Laverton North PVC Plant Project 1977-1978. In 1984, Millikin and Mant continued the delivery of the three day HAZAN course in process safety that was developed by Tweeddale. The HAZAN course was structured around a six stage process for the integration of process safety to new capital projects and modifications to existing process plant.

Between 1984 and 1985 Tweeddale worked as Technical Adviser with IC Insurance in London, contributing advice on the management of process safety risks in ICI, particularly Europe and South America. During this period in London he was active in IChemE's Process Safety and Loss Prevention Interest Group. Soon after his return to Australia, in 1986 Tweeddale hosted Prof Trevor Kletz on a visit to Australia with seminars run for both ICI and public audiences. Kletz (on the right) is pictured with Alan Barlee and Josef Marek at the ICI Melbourne seminar "People and Technology - The Engineering Approach".

Millikin set out to build a still stronger process safety team around Mant by appointing Dr Derek Griffiths as Principal Engineer (Process Safety) and Mark Latham in 1984 and Dr Geoff Stephens (13) in 1985. With a growing team and increasing recognition of ICI's capability, Millikin started developing opportunities for consulting business with clients external to ICI, including customers buying ICI's hazardous products. Through the initial work of Millikin and then John O'Shea (14), the Process Safety Group engaged in work on QRA, Hazard Studies, Safety Auditing and incident investigation throughout Australia, New Zealand, Malaysia and Taiwan. One major project was a QRA for the entire ICI Botany Site to provide the regulator with detailed information on the risks to the public and a nearby shopping centre. This study was completed in 1987 to satisfy concerns raised by the local community on the risks to residential areas.

The Bhopal disaster in 1984 was a critical event for the global chemical industry and the process safety discipline with more than 2000 fatalities in the vicinity of Union Carbide India's plant manufacturing methyl isocyanate (MIC). As ICI Australia was itself a user of MIC and holding 10,000 litres at the time, the company decided to suspend processing until a review of operations was conducted to assure itself, relevant government authorities and the community that the safest practicable course of action was agreed. Millikin and Latham worked with Research Plant chemical engineer Kevin Linehan and process chemists Errol McGarry and Richard Conway to undertake a full HAZOP and quantitative risk assessment and then engaged with the Victorian Department of Labour and other agencies until the MIC inventory was safely converted to commercial product in 1986. Review of Operations became a new feature of the company's process safety program as the benefits were recognised of applying HAZAN and HAZOP techniques to facilities with major hazards that had been built before their introduction. The ICIA SHE Council conducted a Review of Operations

1986 to 1988 under the simultaneous direction of two senior chemical engineers Trevor Sweeny (15) and Dick Blamey (1) and ICIA Engineering Manager George Rogers to handle the required workload across the diverse business portfolio

Mant recalls that Canadian-trained chemical engineer Chris Hampson (appointed managing director of ICI Australia in 1984) was a vigorous supporter of efforts to further strengthen the company's process safety capability and was later appointed SHE director of ICI PLC. Chemical engineer Trevor Sweeny (15) (who was corporate manager of safety and environment at that time recalls that Hampson brought a fresh approach to the management of safety in the organisation. He made an immediate impact when his first address to the assembled Head Office staff was devoted solely to safety and his determination to make it a priority. This had an immediate impact on his fellow directors and the executive team and provided the basis for renewed effort to improve safety. He was subsequently appointed to the Board of ICI PLC in London where he continued to provide strong safety leadership. In this regard he promoted the development of a set of ICI SHE standards for the global organisation. These standards were the basis for the preparation of annual SHE Letters of Assurance that all CEOs in the ICI organisation were required to submit to the ICI PLC Board. Those standards incorporated a clear set of requirements for process safety management, dictating the framework for the ICI Australia Safety Health and Environment Management System that won the Australian Chemical Industry Council's T G Crane Safety Award in 1992.

In 1986 Griffiths moved to become Site Engineering Manager at ICI Botany and Peter Millikin moved to CSIRO. Under Process Engineering Manager Jim Probert, the expanding roles of Dr Geoff Stephens and Bill Mant were recognised through their appointments as Senior Consultants Process Safety. Chemical engineer Ian Lake was appointed as Process Safety Consultant based at ICI Botany along with others including Dr Raghu Raman, Charles King, Paul Cornford, Karin Nilsson, Basil Ellis, Mats Lindgren, Jenny Polich and Dean Shewring joining over a period. Debbie Gayen and Myrna Hepburn joined in Melbourne.

ICI was actively involved in the Warren Centre Project on Major Industrial Hazards 1986-1987, Dr Griffiths was on the Warren Centre Steering Committee team and Dr Stephens was the conduit through which ICI input its global experience to the project. John O'Shea took over Millikin's role in developing opportunities for ICI Australia Engineering to provide consulting services to Australian industry.

A major outcome of the Warren Centre Project was creation of the ANSTO/University of Sydney Chair of Risk Engineering in the Department of Chemical Engineering to continue the work of the project. After his return from London, Mark Tweeddale ultimately saw the opportunity to expand his contribution to process safety in Australia by taking up this role in 1989 and continued at the university until 1995 in the dual role of ANSTO Professor and as Executive Director of the Australian Centre for Advanced Risk and Reliability Engineering (ACARRE). Before taking up his university role, Tweeddale worked briefly as Botany Chemical Factory Technical Manager and then as an independently as a consultant (1987-1988) and during that period supported Barry Hooper (16) on the process safety aspects of ICI's Ephedrine project.

The 3 day HAZAN course was reviewed in 1987 by Griffiths' team with support from Tweeddale whilst Technical Manager at ICI Botany's Chemical Factory. This course was offered until around 1995 and deliveries were made in diverse locations including overseas in Holland, New Zealand, Borneo and Pakistan). Griffiths (3) recalls collaborating with David Gill to present the HAZAN course to Shell in Holland in 1991, this being the first time the Shell participants had been exposed to Gill's Bow Tie concept. This may have been the beginning of Shell's interest and further development of the Bow Tie as reported by Burgess-Limerick et al (17).

Around 1990, ICIAE developed two further courses, the first being A HAZOP participants training and then a HAZOP leaders course. These courses were run both internally for ICIA and for other companies. A series of five of each were run in Singapore again for ICI and external customers. These courses are still run in 2017 by former employees Karin Nilsson, Myrna Hepburn and Dean Shewring under agreements with Orica. As part of

the HAZAN and HAZOP course there was an introduction to CHAZOP or the application of HAZOP principles to computer-managed/controlled systems. This became a specialist area and involved electrical engineer Ken Walters and chemical engineers Dr John Lear and Dr Brian Dale. Lear and Dale continue to run CHAZOP courses in 2017 under agreements with Orica.

Because of the multiple chemical, oil and gas operations developing in WA, an office was established in Perth in the early 1990s. Charles King relocated from Sydney and became involved in training, risk assessment, emergency planning, auditing and QRA with support from staff from the east coast when needed.

When the National Occupational Health and Safety Commission initiated a project to develop Model National Regulations for the control of Major Hazard Facilities (18) , Dr Derek Griffiths was a member of the expert working group representing the Australian Chemical Industry Council (predecessor of PACIA) along with Professor Mark Tweeddale. Those model regulations were reviewed most recently in 2016.

Between 1984-1996, ICI Australia's risk engineers presented some 45 papers on QRA, risk criteria, emergency planning, designing for safety and Integrated Risk Management for Projects at a wide range of events and locations including Chemeca, UN Inter-Agency Program Tel Aviv, The Australian Counter Disaster College and other public conferences.

In 1995, Ted Pahlow received the ICI Australia Award for Excellence in recognition of his contribution to the development of process safety competence in the chemical engineering profession in Australia (19). Apart from sponsoring the appointment and work of Mark Tweeddale within ICI Australia, Ted was a key figure in developing IChemE's provision of process safety training in Australia after he retired from ICI Australia in 1984.

In 1996, Dr Derek Griffiths left ICI to join CRA (later Rio Tinto) as global General Manager, Health and Safety. He was then succeeded first by Charles King (until Charles also moved to CRA) and then by Ian Lake who continued to provide company leadership in risk engineering and process safety through the 1997-8 transition from ICI Australia to Orica and then for more than a decade into the new millenium.

Although originally qualified as an electrical engineer, Mark Tweeddale became a Fellow of the Institution of Chemical Engineers in 1992 (Slane, 30). He published his first book (21) with Brian Lloyd and Peter Miller in 1994. Mrs Helen Tweeddale (22) recalls that Prof Rolf Prince had become a mentor for Mark after he joined the University of Sydney and encouraged him to nominate successfully for election in 1995 as a Fellow of the Australian Academy of Technological Sciences and Engineering (23). In 1996 he decided to compile fifty of his best publications as a doctoral dissertation to the University of Melbourne (24). One of the examiners was Professor Trevor Kletz of Loughborough University in the UK and Mark Tweeddale (pictured on his graduation day) was admitted to the degree of Doctor of Engineering in April 1999 (25). In 2004 Mark published a second book (26) consolidating the teaching materials he had originally compiled at the University of Sydney and later evolved whilst continuing to lecture as Adjunct Professor at the University of Western Australia until 2004.

Mark Latham FIChemE
3 July 2017

References:

1. Dick Blamey, Personal Communication 2017
2. James Hawksley, Personal Communication 2017
3. Dr Derek Griffiths, Personal Communication 2017
4. Paul Cornford, Personal Communication 2017
5. Trevor Cowper, Personal Communication 2017
6. Bill Mant, Personal Communication 2017
7. Dr Volker Maier, Personal Communication 2017
8. Felix Nieuwenhuizen, Personal Communication 2017
9. Dr Mark Tweeddale, Detailed Resume 2004 (courtesy of Mrs Helen Tweeddale)
10. W V Peter Hunt, Personal Communication 2017
11. Colin Simpson, Personal Communication 2017
12. Mark Tweeddale, Chemical Engineering in Australia June 1981
13. Dr Geoff Stephens, Personal Communication 2017
14. John O'Shea, Personal Communication 2017
15. Trevor Sweeny, Personal Communication 2017
16. Barry Hooper, Personal Communication 2017
17. Burgess-Limerick et al. "Bow-tie analysis of a fatal underground coal mine collision". Ergonomics Australia. 2014, 10:2.
18. https://www.safeworkaustralia.gov.au/mhf#overview viewed 26 June 2017
19. http://www.anzfche.org/images/update-to-register-of-chemical-awards-of-excellence_28111.pdf viewed 26 June 2017
20. Peter Slane, Personal Communication 2017
21. Lloyd, B E; Miller, P and Tweeddale, H M "Professionalism, Liability and Risk in Engineering Practice" The Institution of Engineers Australia 1994
22. Helen Tweeddale, Personal Communication 2017
23. http://www.atse.org.au/content/publications/focus/issue/157-infrastructure.aspx viewed 26 June 2017
24. Tweeddale, H M Selected papers and articles submitted (1996) for examination as Thesis (D.Eng.)--University of Melbourne, Faculty of Engineering, 1999.
25. Challenge "Mark Tweeddale: Outstanding Honour" University of Sydney Chemical Engineering Foundation, 1999
26. Tweeddale, H M "Managing Risk and Reliability of Process Plants" ISBN 0-7506-7734-1 Gulf Professional Publishing, 2003

Photos of Mark Tweeddale supplied by Mrs Helen Tweeddale

Photo of Prof Trevor Kletz with Alan Barlee and Josef Marek originally published in ICI Australia magazine "The Circle" in 1986.

About **Mark Latham**

I am an independent consultant in process safety, health & environmental management with special interests in the environmental impacts of losses of process containment and in social responsibility. Along with DuPont Sustainable Solutions, I work with clients who aspire to organisational excellence in process safety management through leadership, systems and technology. I lecture in environmental management at the University of Melbourne, and have served on the Program Advisory Committee for Chemical Engineering at RMIT University since 1995 - as chair since 2000. Between 2010 and 2012 I worked closely with RMIT to integrate risk-based project decision making into the undergraduate chemical engineering program using project-specific social responsibility criteria.

I represented ICI Australia on the ICI Group Soil and Groundwater Pollution Panel and the ICI Land Protection Group between 1989 and 1997, contributing to the development of ICI's global capability to manage the risks associated with losses of process containment to the subsurface environment. Consequently I was closely involved in the environmental liability aspects of many mergers, acquisitions and divestments as ICI Australia restructured its business portfolio in the 1990s, including becoming Orica in 1997-1998 and acquiring the international explosives business of ICI PLC.

I have project experience in China, India, Mongolia, Pakistan, Saudi Arabia, United Arab Emirates, New Caledonia, Papua New Guinea, Ghana, Peru, Singapore, Malaysia, England, Germany, USA, New Zealand and Australia - including assignments as a lead auditor and production technical expert for the International Cyanide Management Institute.

I dedicate this contribution to the memory of Mark Tweeddale, who died on 15 August 2009. I am writing around the time of the 40th anniversary of my joining ICI Australia as a graduate chemical engineer and welcome the opportunity to acknowledge many esteemed colleagues who contributed to my professional formation.