Hydrological Histories: Mike Stewart

I joined the Institute of Nuclear Sciences, a division of the Department of Scientific and Industrial Research (DSIR), in 1965 with a newly minted Master of Science in Physics from the University of Canterbury.

My first job was in the new field of environmental (isotopic) geochemistry, with Athol Rafter and John Hulston, initiating measurements of deuterium/hydrogen ($^{2}H/^{1}H$) ratios in water using a home-built mass spectrometer and vacuum system. I happily analysed water from various sources around New Zealand: rainfall, rivers, lakes, groundwater, hot springs, geothermal wells, and volcanoes (White Island). The $^{2}H/^{1}H$ measurements were soon joined by oxygen isotope ratio measurements ($^{18}O/^{16}O$). Geothermal systems (springs and wells) were my main focus at this time.

In 1970, I had the opportunity to undertake a PhD with Irving Friedman at the United States Geological Survey in Denver, through the University of Pennsylvania. I studied isotopic effects in atmospheric vapour and various types of precipitation with the National Hail Research Experiment run by the National Center for Atmospheric Research in Boulder, Colorado. This was exciting research. We flew into thunder clouds and sampled vapour, cloud droplets and precipitation within the cloud, being alternately buffeted by powerful updraughts and downdraughts. The PhD was completed in 1974.

On my return to DSIR, I began work on Canterbury groundwater with Claude Taylor and Len Brown. In 1976, I decided to sample four deep Christchurch wells for carbon-14 (^{14}C) measurements along with tritium measurements by Claude. At the time, four samples for ^{14}C were a truckload, because each sample required 600 litres of water to provide enough carbon for the measurement. Measurements of ^{14}C have been made every 10 years since, with far smaller amounts of water because of method improvements, and have provided valuable information on flows within the system.

I also worked with Tasman District Council (mainly with Joseph Thomas) on groundwater in the Tasman District, notably Waimea Plains, Motueka Plains and Te Waikoropupū Springs/Takaka Valley. Waimea Plains groundwater had the first observed and strongest nitrate plume of any seen in New Zealand groundwater. Motueka Plains, in contrast, has a deep aquifer bearing pristine ice-age waters, shown by ^{14}C measurements. Te Waikoropupū Springs are the outflow of a karst system draining a wide area in Golden Bay. Stable isotope measurements established the source areas of the water. The springs discharge extremely clear water with a low but slowly rising nitrate concentration.

My introduction to catchment hydrology came with a letter from Andy Pearce of the Forest Research Institute, Christchurch, in 1983. He asked me to work with him and Mike Sklash on runoff mechanisms at Maimai Catchment, following pioneering work by Paul Mosley in the late 1970s. Mike and Karen Sklash arrived from Canada and settled down at the DOC hut at Maimai for a six-week period (15 August to 27 September 1983), gathering a comprehensive set of samples and hydrometric data with help from Forest Research Institute personnel. The samples were analysed for oxygen-18 (^{18}O) at the Institute of Nuclear Sciences, DSIR, leading to two highly cited papers (Pearce et al. 1986; Sklash et al. 1986).

The second major phase of Maimai work for me came in 1988, when Ian Owens and I were thesis advisors to Jeff McDonnell for his PhD at the University of Canterbury. Drawn by the divergent conclusions of Mosley and Pearce/Sklash/Stewart, Jeff set about reconciling the two, leading to an impressive collection of papers from his thesis (e.g. McDonnell et al., 1991) and a continuing series of papers on Maimai in collaboration with many students and colleagues.

In the 1990s, I held the role of editor of the Journal of Hydrology NZ for six years, with a couple more as a committee member of the New Zealand Hydrological Society. These were both satisfying commitments.

Figure 1 (left). The DOC hut at Maimai.

Figure 2 (right). Karen Sklash and automatic stream sampler at the M6 (natural beech forest) gauge in 1983.

Figure 3. Rainfall samplers and corner of DOC hut at Maimai.

Other valuable collaborations in the catchment field were with Uwe Morgenstern (GNS Science), Barry Fahey, Lindsay Rowe, Tim Davie (Landcare), and Roland Stenger, Greg Barkle (Lincoln Ventures/Lincoln University) at Pukemanga, Toenepi, Glendhu and other catchments.

Interpretation of tritium with Uwe Morgenstern became important for stream water dating around the world, not least because of the different background levels of tritium in the Northern and Southern Hemispheres (e.g. Stewart et al. 2010). In particular, the roles of surface water and groundwater in streamflow were of particular interest to studies in Oregon, Luxembourg, Spain, Japan and Maimai, as well as uncertainty assessment (Spain) and effects of areal aggregation on tritium ages.

Following these 60 years of science, there are two remaining hydrological questions I would like pursued. First, to increase understanding of the Te Waikoropupū Springs system, especially in terms of nitrate sources and biology, to help management of the system. And second, to continue regular decadal ^{14}C

measurements on the Christchurch Artesian System (CAS) to monitor flows and how they are changing because of exploitation of the system.

Mike Stewart's recollections are part of a New Zealand Hydrological Society series that documents the times and memories of New Zealand's senior hydrologists.

References

McDonnell, J.J.; Stewart, M.K.; Owens, I.F. 1991: Effect of catchment scale subsurface mixing on stream isotopic response. Water Resources Research 27(12), 3065 3073. https://doi.org/10.1029/91WR02025

Mosley, M.P. 1979: Streamflow generation in a forested watershed, New Zealand. Water Resources Research 15, 795-806, 1979. https://ui.adsabs.harvard.edu/link_gateway/1979WRR....15..795M/doi:10.1029/WR015i004p00795

Pearce, A.J.; Stewart, M.K.; Sklash, M.G. 1986: Storm runoff generation in humid headwater catchments. I: Where does the water come from?. Water Resources Research 22(8), 1263 1272. https://doi.org/10.1029/WR022i008p01263

Sklash, M.G.; Stewart, M.K.; Pearce, A.J. 1986: Storm runoff generation in humid headwater catchments. II: A case study of hillslope and low order stream response. Water Resources Research 22(8), 1273 1282. https://doi.org/10.1029/WR022i008p01273

Stewart, M.K., Morgenstern, U., McDonnell, J.J. 2010: Truncation of stream residence time: How the use of stable isotopes has skewed our concept of streamwater age and origin. *Hydrological Processes 24*(12), 1646-1659. https://doi.org/10.1002/hyp.7576