Dr David Nash (DipEd, BAgrSc (Hons.), MAgrSc, PhD, CPSS, CPAg, CAg)

Dr David Nash is a soil chemist and physicist who specialises in the processes responsible for generating the contaminants from agricultural production and processing that adversely affect downstream water resources. David completed an Agricultural Science Degree (La Trobe University, Hons.) in 1975 under the Victorian Government Teaching Studentship program. He completed a Diploma of Education (Monash University) in 1976 and his 3-year bond at Morwell in the Latrobe Valley in south-eastern Australia.

In early 1980 David commenced a Master of Agricultural Science at La Trobe University under scholarship. Before completing that degree, he was recruited by the Conservation Commission of the Northern Territory as the Officer in Charge of the Darwin region for the Soil Conservation Unit. In the Northern Territory David established a soil research program at the Douglas Daly Research Farm aimed at improving the hydrological and erosion performance of cropping conservation structures.

In mid-1984 David submitted his master's thesis: Discharges from land application systems in Victoria. The thesis was one of the first publications to identify that the accumulation of sodium on the exchange complex of clays may be contributing to the impaired soil physical properties attributable to wastewater irrigation. Moreover, possible reasons for this occurring were presented. These concepts have been more fully explored in some of David's more recent papers (Halliwell *et al.* 2001; Nash and Butler 2011).

In 1985 David and his family returned to Victoria where he recommenced working for the Victorian Education Department. In 1986 David established Soil and Allied Services Pty Ltd. Through his company David undertook compliance and development work for companies such as Protech Car Care Centre and Mobil Oil Ltd, and was a founding partner of Sportscover Australia Pty. Ltd. For example, as part of Mobil's Quality Assurance Program, David analysed and optimised oil packaging lines, undertook blending analyses and introduced Statistical Quality Control to some laboratory systems. The skills learnt through exposure to commercial industries were extremely useful later in his career.

In 1992 David and his family moved to a small farm in the Strzelecki Ranges in West Gippsland. While still a teacher, in 1993 the opportunity arose for David to re-engage with research at the Ellinbank Dairy Research Centre a few kilometres down the road from his farm. David was appointed to study the environmental impacts of dairy production as part of the Phosphorus for Dairy Farms program.

In 1993 it was believed that phosphorus (P) exports from grazed pastures were the result of erosion processes in which P that had been adsorbed to soil minerals was physically transported to streams. Stream monitoring seemed to support that contention. But drawing on his experience from the Northern Territory, David was unconvinced and consulted with Dr John Williams from the CSIRO who visited Gippsland. They concluded that there seemed insufficient kinetic energy for P to be mobilised by erosion processes alone.

Funding was subsequently received to measure and sample runoff water from farms in Gippsland. David designed a remotely controlled water monitoring/sampling system with an independent, low-cost backup system. Darnum was the first of a number of sites where the equipment was installed on commercial farms. The scale of monitoring was crucial. For the research to be successful, the scale needed to be sufficient to reflect field-scale processes but not big enough to enable in-stream reprocessing. From an extension standpoint scale was also important. Farmers needed to believe that the water being monitored was what was otherwise leaving their paddocks and that their management unit (i.e. paddocks) was relevant for remedial measures.

Data from the initial monitoring site at Darnum confirmed the suspicion that dissolved P (DP; <0.45μm), a more potent form of P than particulate P (PP; >0.45μm), comprised >90% of total P exports from the paddocks (Nash and Murdoch 1997). Unfortunately, the concentrations of P compared unfavourably with those for treated sewage that the Victorian EPA would normally licence for discharge to water. Nitrogen (N) was also measured but considered less immediately relevant in terms of its environmental impact (i.e., toxic algal blooms) in the internationally renowned Gippsland Lakes system.

Based on the field data, the Action on Nutrients for Sustainable Agriculture Program was instigated. The program had both research and outreach components. David was asked to lead the project. Given the animosity between the regulators and the farming community at the time it is a credit to the project team and their success that they were subsequently awarded the Victorian BHP Landcare Award for Research (1999), the Australian National Committee on Irrigation and Drainage (ANCID) – Improved practices in drainage management award (2002) and the Agriculture Victoria Executive Award for Innovation (2002).

The early 2000's was the start of the millennium drought and the emphasis shifted from water quality to water scarcity. In addition the role of State governments in addressing public and private good activities was in question. While the need to address deteriorating water quality remained, David's team started to focus more on the applied research aspects of the problem.

David and his team:

- Used conventional statistical techniques to model between storm variation and the likely effects of various management activities (Nash *et al.* 2000);

- Studied the environmental properties of commercial P and N fertilisers (Nash *et al.* 2003; Nash *et al.* 2004b);

- Laid the foundation for using biological marker compounds to trace water borne pollutants (Nash and Halliwell 2000; Nash *et al.* 2004a; Nash *et al.* 2005b); and

- Measured P and N exports at a range of scales (Barlow *et al.* 2005; Barlow *et al.* 2006; Barlow *et al.* 2007).

It was clear from the studies that the misuse of fertilisers could overwhelm all other sources of P (Nash and Halliwell 1999) and to a lesser extent N. However, the modelling effort was providing some perverse outcomes. For example, the original multiplicative statistical model (Nash *et al.* 2000) implied that the effects of fertiliser were related to how long it was since a pasture had been grazed. The monitoring data were revisited using a base (i.e., a "systematic" component due to the prevailing soil/site properties) and increments due to critical incidents (i.e., "incidental" components). The subsequent model was of similar strength to previous analyses (Nash *et al.* 2005a). On that basis it was possible to extract the “systematic” component for the year. As a result of this and related work David was a Finalist in the 2007 Land and Water Australia Eureka Prize for Water Research and Innovation.

Two things were apparent from subsequent P modelling:

- Soil test P was very poorly related to field scale dissolved P concentrations in runoff; and

- It was the legacy of previous fertiliser applications rather than that freshly applied that was responsible for most P exports from these systems.

For example, David and his team used an innovative modelling platform (i.e., Bayesian Networks) and fertiliser distribution data from specific regions of Gippsland to conclude that “…improved fertiliser management is unlikely to have a major impact on Total P (TP) exports (i.e., <10%)” (Nash and Hannah 2011). In a more recent paper David has provided further explanation for such findings (Nash *et al.* 2019).

Nutrient exports are a challenge not only for pastoral industries. In 2004 David was asked to bring the learnings from his work in pastoral industries to high rainfall cropping where the emphasis was on N exports. Once again it became apparent that nutrient exports were conditionally dependant on a range of interrelated factors that were difficult to represent in conventional modelling. So a Bayesian network was developed to describe N exports following fertiliser application (Nash *et al.* 2010). In a subsequent paper that was the European Society of Agronomy featured paper of the month (Nash *et al.* 2013a), the cropping N network was used along with APSIM and economic modelling to suggest that for flexible cropping systems of the type analysed in the paper “… where farmers increase their gross margins they are improving their environmental performance.”

David has also made notable contributions relating to:

- Field scale hydrology in relation to pollutant mobilisation (Nash *et al.* 2002);

- Global water quality perspectives (Nash and Haygarth 2005);

- Mitigating N exports from vegetable production in China (Nash *et al.* 2013b);

- Simple methodologies to help address dissolved P exports (Nash *et al.* 2007; Nash *et al.* 2015);

- The potential use of organic P for sustaining grazed pastures (Nash *et al.* 2014); and

- The limits of soil tests and small scale rainfall simulators for predicting legacy P exports (Nash *et al.* 2021).

David retired from the Victorian Government in 2014 and is currently a Senior Research Fellow at the University of Melbourne. Using his unique set of skills, David undertakes a range of academic and commercial activities through his company Soil and Allied Services Pty Ltd.

References

Barlow, K, Fenton, J, Nash, D, Grayson, R (2006) Modelling phosphorus transport in a surface irrigation drain. *Advances in Water Resources* **29** 1383 - 1398.

Barlow, K, Nash, D, Grayson, RB (2005) Phosphorus export at the paddock, farm-section, and whole farm scale on an irrigated dairy farm in south-eastern Australia. *Australian Journal of Agricultural Research* **56** (1), 1-9.

Barlow, K, Nash, D, Hannah, M, Robertson, F (2007) The effect of fertiliser and grazing on nitrogen export in surface runoff from rain-fed and irrigated pastures in south-eastern Australia. *Nutrient Cycling in Agroecosystems* **77** (1), 69-82.

Halliwell, DJ, Barlow, KM, Nash, DM (2001) A review of the effects of wastewater sodium on soil physical properties and their implications for irrigation systems. *Australian Journal of Soil Research* **39** 1259-1267.

Nash, D, Clemow, L, Hannah, M, Barlow, K, Gangaiya, P (2005a) Modelling phosphorus exports from rain-fed and irrigated pastures in southern Australia. *Australian Journal of Soil Research* **43** 745-755.

Nash, D, Clemow, L, Leeming, R, Hannah, M, Halliwell, D, Allen, D (2004a) Sterols and other alcohols in overland flow from grazing land and possible source materials. In 'Supersoil 2004, International Soil Conference'. 5-9 December, Sydney, Australia Available

Nash, D, Hannah, M (2011) Using Monte-Carlo simulations and Bayesian Networks to quantify and demonstrate the impact of fertiliser best management practices. *Environmental Modelling and Software* **26** 1079-1088.

Nash, D, Hannah, M, Halliwell, D, Murdoch, C (2000) Factors affecting phosphorus export from a pasture-based grazing system. *Journal of Environmental Quality* **29** (4), 1160-1166.

Nash, D, Haygarth, P (2005) Grassland productivity and water quality: a 21st century issue. In 'Grassland a global resource'. (Ed. D McGilloway.) pp. 239-250. (Wageningen Academic Publishers: Wageningen, The Netherlands)

Nash, D, Murdoch, C (1997) Phosphorus in runoff from a fertile dairy pasture. *Australian Journal of Soil Research* **35** (2), 419-429.

Nash, D, Riffkin, P, Harris, R, Blackburn, A, Nicholson, C, McDonald, M (2013a) Modelling gross margins and potential N exports from cropland in south-eastern Australia. *European Journal of Agronomy* **47** 23-32.

Nash, D, Waters, D, Bulda, A, Lin, Y, Yang, W, Song, Y, Shu, J, Qin, W, Hannah, M (2013b) Using a conceptual Bayesian network to investigate environmental management of vegetable production in the Lake Taihu region of China. *Environmental Modelling and Software* **46** 170-181.

Nash, D, Webb, B, Hannah, M, Adeloju, S, Toifl, M, Barlow, K, Robertson, F, Roddick, F, Porter, N (2007) Changes in nitrogen and phosphorus concentrations in soil, soil water and surface run-off following grading of irrigation bays used for intensive grazing. *Soil Use and Management* **23** (4), 374-383.

Nash, DM, Butler, C (2011) A review of factors affecting phosphorus exports from sites irrigated with abattoir wastewater. *International Journal of Environmental Engineering* **3** 18-47.

Nash, DM, Halliwell, D (1999) Fertilisers and phosphorus loss from productive grazing systems. *Australian Journal of Soil Research* **37** (3), 403-429.

Nash, DM, Halliwell, D, Cox, J (2002) Hydrological mobilisation of pollutants at the slope/field scale. In 'Agriculture, Hydrology and Water Quality'. Eds PM Haygarth, SC Jarvis.) pp. 225-242. (CABI Publishing: Oxon, UK.)

Nash, DM, Halliwell, DJ (2000) Tracing phosphorous transferred from grazing land to water. *Water Research* **34** (7), 1975-1985.

Nash, DM, Hannah, M, Clemow, L, Halliwell, D, Webb, BJ, Chapman, D (2003) A laboratory study of phosphorus mobilisation from commercial fertilisers. *Australian Journal of Soil Research* **41** (6), 1201-1212.

Nash, DM, Hannah, M, Clemow, L, Halliwell, D, Webb, BJ, Chapman, D (2004b) A field study of phosphorus mobilisation from commercial fertilisers. *Australian Journal of Soil Research* **42** (3), 313-320.

Nash, DM, Hannah, M, Robertson, F, Riffkin, P (2010) A Bayesian Network for comparing dissolved nitrogen exports from high rainfall cropping in south-eastern Australia. *Journal of Environmental Quality* **39** 1699-1710.

Nash, DM, Haygarth, PM, Turner, BL, Condron, LM, McDowell, RW, Richardson, AE, Watkins, M, Heaven, MW (2014) Using organic phosphorus to sustain pasture productivity: a perspective. *Geoderma* **221-222** 11-19.

Nash, DM, Leeming, R, Clemow, L, Hannah, M, Halliwell, D, Allen, D (2005b) Quantitative determination of sterols and other alcohols in overland flow from grazing land and possible source materials. *Water Research* **39** (13), 2964-2978.

Nash, DM, McDowell, RW, Condron, LM, McLaughlin, MJ (2019) Direct exports of phosphorus from fertilizers applied to grazed pastures. *Journal of Environmental Quality* **48** (5), 1380-1396. 10.2134/jeq2019.02.0085

Nash, DM, Watkins, M, Heaven, MW, Hannah, M, Robertson, F, McDowell, R (2015) Effects of cultivation on soil and soil water under different fertiliser regimes. *Soil and Tillage Research* **145** 37-46. https://doi.org/10.1016/j.still.2014.08.006

Nash, DM, Weatherley, AJ, Kleinman, PJA, Sharpley, AN (2021) Estimating dissolved phosphorus losses from legacy sources in pastures: The limits of soil tests and small-scale rainfall simulators. *Journal of Environmental Quality* **50** (5), 1042-1062. https://doi.org/10.1002/jeq2.20265