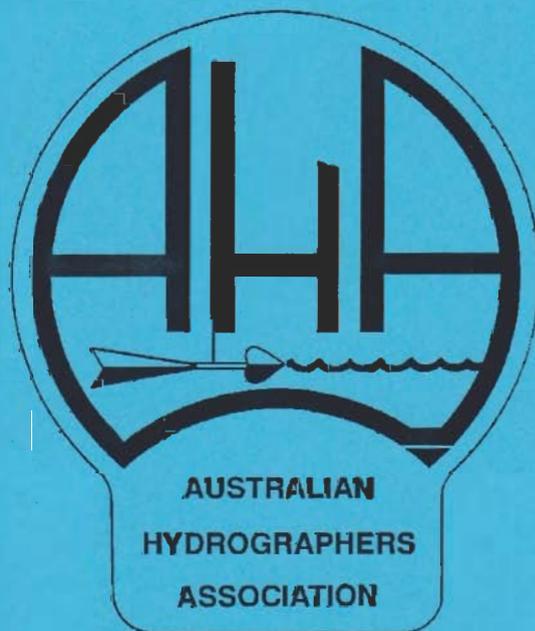


# *Australasian Hydrographer*

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**May 2002**

**Volume 6 Number 5**

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### Quote:

*It's clear to me that I will return here, as well as to other wilderness frontiers within me -- whether next year or some time later -- because I know that what the river says is what I need to hear: to know myself, to feel wild again, to confront my own limits and move beyond them into the untamed country on the other side. I will return here in spite of the river's name; but I will never return the same again, and that, after all, is most clearly what the river says.*

Jeff Wallach, *What the River Says*

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The **Australasian Hydrographer** is the Journal of the **Australasian Hydrographers' Association**. The Journal is distributed monthly, free of charge to Members.

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Please visit our web site at:

<http://www.austhydro.tascom.net>

to download a Membership Application and to find Contact Details for your State Representative.

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Editorial and Advertising enquiries should be directed to the Association's Publicity Officer, Les Marshall.

e-mail [hydrographer1@optusnet.com.au](mailto:hydrographer1@optusnet.com.au)  
or PO Box 200, SNUG, Tasmania, 7054

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## Editorial

Hello once again, and welcome to our May Newsletter. Once again we're late, and once again I've had to go searching far and wide to find something interesting for you. The sum total of the contributions for this from Members is zero. Not to worry though, like the intrepid Hydrographer your editor is we'll go on, conquering mountains and wild rivers in the never ending quest for the next Newsletter.

One of the reasons we're late is that I've also been busily engaged trying to learn all the road rules to get my Coxswain's Certificate. Please forgive my indulgence in giving the Academy a plug in this issue. And, no, I haven't got it yet. I'm caught up in some bureaucracy, but that's another story.

As I write this, the Hydrographic Conference is drawing ever closer. We should all acknowledge the enormous contributions from our sub-Committee. They have worked tirelessly, and all for free by the way, to set this up. There has been great interest in the event, and I'm sure it will be the best yet.

In this issue, I have included a Conference update, including the Agenda. Please note that the Agenda includes the AHA Annual General Meeting on Wednesday 3<sup>rd</sup> July, from 1730hrs. As you would all know, all positions are to be declared vacant, so here's your chance! I know I keep saying it, but if we are to grow then we need to inject some new blood into the Committee. The fact is that us old broken down droggies won't be around forever, and when we eventually do either leave, retire or fall off the perch then it's sink or swim for the Association.

Speaking of old timers, Max Hayes has had the books audited, and I was going to include the Report in this Newsletter. However, since Max will be at the Conference, I thought it would be appropriate for him to present it at the AGM.

Les Marshall

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**WEATHER FORECASTS WARNINGS and OBSERVATIONS**  
National  
Victoria  
New South Wales  
Aus. Capital Territory  
Queensland  
South Australia  
Western Australia  
Northern Territory  
Tasmania/Antarctica  
International  
High Seas  
WARNINGS SUMMARY

**OTHER WEATHER SERVICES**  
Weather Charts  
Radar Images  
Satellite Images  
Marine Weather

**CLIMATE SERVICES**  
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Seasonal Outlooks  
Climate Averages  
How to get Climate Data

**HYDROLOGY SERVICES**  
Flood Warning Service  
Hydromet Advisory Service  
Water Resources

**REGISTERED USERS**  
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Marine Users  
Defence Users  
General Users

**THIS MONTH'S FEATURE**  
Visit the 2002 weather calendar for sales information and to preview the photos.

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**CURRENT NEWS SUMMARY AND LATEST MEDIA RELEASE**  
Read the most recent Media Release.  
2002 weather calendar available from early to mid November.

**SILO SERVICES FOR AGRICULTURE**  
**SSU** SPECIAL SERVICES UNIT (SSU)

ACCESS THE BUREAU WEB SITE AT: [www.bom.gov.au](http://www.bom.gov.au)

A wide range of climate related data, information and products are available. Of particular interest to people in the water industry are:

- Real time rainfall and river height data
- Climate averages in map and graph form
- National catalogue of river stations [www.bom.gov.au/hydro/wr/sgc](http://www.bom.gov.au/hydro/wr/sgc)
- Drainage divisions and river basin boundaries
- National catalogue of rainfall stations [www.bom.gov.au/hydro/wr/rgc](http://www.bom.gov.au/hydro/wr/rgc)
- National evapo-transpiration maps

The Bureau of Meteorology's Hydrology Program would like to thank the hydrographic and data management groups in all State and Territory water agencies for their support over the years. Data and information have been provided for many projects, including:

- Global Runoff Data Centre sponsored by WMO
- UNESCO Asian Pacific Friend Project
- Stream Gauging Information, Australia
- Flood warning system development and operation
- Rainman Streamflow Project
- Specialised rainfall analyses

# 11<sup>th</sup> AUSTRALASIAN HYDROGRAPHIC CONFERENCE



## SYDNEY (Olympic Park)

July 3<sup>rd</sup> to 6th 2002

Hosted By: Australian Water Technologies Pty Ltd, Hydro Tasmania  
Hydrological Services Pty Ltd; The University of NSW (Civil & Environmental Engineering School)

Postal Address: P.O Box 112 Regents Park. 2143

## Australasian Hydrographic Conference Update and Agenda

The 11<sup>th</sup> Australasian Conference is drawing near and commences on the 3<sup>rd</sup> of July. To-date the convenors have accepted registrations from over 80 participants from the major water agencies in Australia, New Zealand, Papua New Guinea, USA, and South Africa. In conjunction with the conference approximately 16 companies will take part in the Trade Show.

The conference theme of “Innovative Environmental Data Collection” has also drawn a wide array of topical papers ranging from the effect of September 11 on the USA data collection agencies, applications and accuracy of acoustic gauging technology, impact of 2001/2002 Sydney bushfires on stream gauging networks, through to a comparison of turbidity sensors for continuous field deployment. There many more papers being presented to address the wide array of issues faced by today’s agencies.

To facilitate the interaction of ideas each presenter has been allocated time to address questions and issues raised during their technical presentation.

Registrations for participants are still being accepted.

The following pages outline the agenda for the three-day conference [plus a field visit on the fourth day].

If you have any questions or wish to register please contact one of the convenors.

### Convenors:

Jim Tilley (UNSW)  
Paul Langshaw (AWTPL)  
Bill Steen (Hydstra)  
Michael Lysaght (AWTPL)

J.Tilley@unsw.edu.au  
Paul.langshaw@sydneywater.com.au  
Steenw@hydstra.com  
michael.lysaght@sydneywater.com.au

## Official Agenda (Subject to Change)

### Venue

Bentley Forum, Novotel Homebush Bay

### Tuesday 2<sup>nd</sup> July 2002 [Trade Only]

12:00 - 17:00

Trade representative will be allowed access to set-up their display booths.

### Wednesday 3<sup>rd</sup> July 2002 Commencement of the Conference

08:00 - 09:00

#### Registration

09:00 - 09:30

#### Opening Address

Rt. Hon. John Aquilina

Minister for Water Resources

New South Wales State Government

09:30 - 10:00

#### Keynote Address

Mr. Alex Walker

Managing Director

Sydney Water

1000 - 1030

#### General Address

Prof James Ball

University of NSW

10:30 - 11:00

#### Morning Tea

1100 - 1130

#### Technical Paper

Patrick Hayes

Hydstra Pty Ltd

**Topic:** Effects of September 11 on US water agencies

1130 - 1200

#### Technical Paper

Christoff Le Grange

Dept of Water Affairs and Forestry, South Africa

**Topic:** Surface Water Monitoring in South Africa

1200 - 1230

#### Technical Presentation

Bill Barratt

Hydrological Services

1230 - 1330

#### Lunch

1330 - 1400

#### Technical Paper

Nathan Rugless

Sydney Water

**Topic:** Impact of 2001/2002 Sydney Bushfires of Stream Gauging Networks

1400 - 1430

#### Technical Presentation

Tony Jarvis

Focus Systems

1430 - 1500

#### Technical Paper

Prof. John Fenton

Uni. Of Melbourne

**Topic:** The Application of Numerical Methods and Mathematics to

Hydrography

1500 - 1530

#### Technical Paper

John Fenwick

National Institute Water & Air Research New Zealand

**Topic:**

1530 - 1545

#### Afternoon Tea

- 
- 1545 - 1615      **Technical Paper**  
 Mark Harvey  
 DWR South Australia  
**Topic:** Fish Passages in Hydrometric Weirs
- 1615 - 1645      **Technical Presentation**  
 Tony Ladson  
 Uni. Of Melbourne
- 1645 - 1715      **Technical Paper**  
 Neil Harper  
 New South Wales TAFE (OTEN)  
**Topic:** Tertiary Training for Hydrographers
- 1730 - 1900      **Australian Hydrographers Association    Annual General Meeting**

**Thursday 4<sup>th</sup> 2002**

- 0830 - 0845      **Registration**
- 0845 - 0915      **Technical Paper**  
 David Griffin,  
 Manly Hydraulics Lab  
**Topic:** Innovative Data Collection
- 0915 - 0945      **Technical Paper**  
 Jon Hought  
 VEGA  
**Topic:** Radar Level Measurement in Hydrological Observation and Flood Prediction
- 0945 - 1015      **Technical Paper**  
 Les Marshall  
 Department of Water Resources South Australia  
**Topic:** Financial Benefits of Hydrometric Innovation
- 1015 - 1045      **Technical Paper**  
 Phil Downes  
 Environment Canterbury New Zealand  
**Topic:** Evaluation and Improvement of the Flood Rainfall Network
- 1045 - 1100,  
 1100 - 1130      **Morning Tea**  
**Technical Paper**  
 Michael Clayton  
 Dept. Primary Industry Water Environment Tasmania  
**Topic:** A Comparison of Turbidity Sensors for Continuous Field Deployment
- 1130 - 1200      **Technical Paper**  
 Glenn McDermott  
 Sydney Water  
**Topic:** Measurement Uncertainty - Ramifications and Issues
- 1200 - 1230      **Technical Paper**  
 David Williams,  
 Dept. of Infrastructure-structure Northern Territory  
**Topic:** TBA
- 1230 - 1330      **Lunch**
- 1330 - 1400      **Technical Paper**  
 GD Carlin  
 CSIRO Queensland  
**Topic:** The Effectiveness of Sampling Multiple Points using a sensing chamber
- 1400 - 1430      **Technical Paper**  
 Andrew Maughan  
 Water & Rivers Commission Western Australia
-

1430 – 1500	<b>Topic:</b> Establishment of Performance Monitoring of a Rural Constructed Wetland on the South Coast of Western Australia <b>Technical Paper</b> Dave Johnstone National Institute Water & Air Research New Zealand
1500 – 1530	<b>Topic:</b> Optimising Data Quality from Environmental Monitoring Stations <b>Technical Presentation</b> Scott Walker Sydney Water
1530 – 1600	<b>Afternoon Tea</b>
1600 – 1630	<b>Technical Presentation</b> Graham Armstrong Ecowise
1630 – 1700	<b>Technical Paper</b> Andrew Skinner MEA <b>Topic:</b> Innovative Environmental Data Collection <b>Conference Dinner</b>
1830 - 1900	Pre-Dinner Drinks [Master of Ceremonies – Bill Steen]
1900 – 2030	Entrée & Main Meal
2030 – 2045	Presentation of Alex Miller Award by Mrs Gloria Miller
2045 – 2115	Entertainment, Mr Brian Doyle, Comedian
2115 – 2230	Dessert
<b>Friday 5<sup>th</sup> July 2002      Hydstra Users Group</b>	
0800 – 0900	<b>Registration</b>
0900 – 1030	<b>Hydstra Users Group</b> Welcome address by Ian Donoghue General Manager Hydstra The year in review
1030 – 1100	<b>Morning Tea</b>
1100 – 1230	<b>HUG Users Group</b> Update on the merger of TimeStudio & HYDSYS Integration of TimeStudio & HYDSYS Practical demonstrations of integration
1230 – 1330	<b>Lunch</b>
1330 – 1500	<b>HUG Users Group</b> Computer industry trends New features
1500 – 1530	<b>Afternoon Tea</b>
1530 – 1700	<b>HUG Users Group</b> Future developments Changes and Ideas Question time Summary and Conclusion
1830	<b>Hydrographers Reunion</b>

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**Saturday 6th July 2002 Field Day**

0800	<b>Depart Novotel</b>
0945 – 1030	<b>Warragamba Dam Auxiliary Spillway</b>
1115 - 1145	<b>Werriberri Ck at Jooriland Road</b>
1300 – 1500	<b>Hydrological Services P/L Lunch</b>
1545 - 1550	<b>Sydney Airport - Domestic Terminal</b>
1550 - 1600	<b>Sydney Airport - International Terminal (if necessary)</b>
1700	<b>Novotel Homebush Bay</b>



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**AUSTRALIAN HYDROGRAPHERS' ASSOCIATION  
ANNUAL GENERAL MEETING**

**WEDNESDAY 3<sup>RD</sup> JULY 2002 AT  
BENTLEY FORUM, NOVOTEL HOMEBUSH BAY, SYDNEY**

**The Ordinary Business of the AGM is to:**

- Confirm the Minutes of the last Annual General meeting
- Receive from the Committee, Auditor, and workers of the Association reports upon the activities of the Association during the last preceding financial year.
- Elect the Office bearers of the Association and other Committee Members.
- Special Business of which notice is given.

**Nominations are required for the following positions (three year terms):**

- Chairperson
- Treasurer
- Secretary
- Publicity Officer
- Two Committee Members

**According to our Constitution (Part 16 a, i-iv) this is how to nominate:**

- In writing
- Signed by a nominator and seconder, each of whom shall be a financial member
- Accompanied by the written consent of the candidate
- Clearly state the office or offices for which the candidate has been nominated

A nomination form is included with this notice.

**In addition to the above positions, we also require:**

- One Representative for each State, Territory and New Zealand
- Sub Committees for Next Hydrographic Conference and Training Committee.

**AUSTRALIAN HYDROGRAPHERS' ASSOCIATION**

**NOMINATION FORM**

**We, the undersigned Financial Members of the Australian Hydrographers'**

**Association hereby nominate .....**

**For the position of (choose one or several)**

- Chairperson
- Treasurer
- Secretary
- Publicity Officer
- Committee Member
- State, Territory or New Zealand Representative
- Sub Committees for Next Hydrographic Conference and Training Committee.

**Nominated By .....**

(Please Print Name) .....

**Seconded By .....**

(Please Print Name) .....

***Consent By Candidate:***

**I consent to my Nomination for the above Position(s)**

.....

Please send this form to:

The Secretary  
Australian Hydrographer's Association  
5 Wilbung Road  
ILLAWONG  
N.S.W. 2234

**According to our Constitution (Part 16 a, i-iv) this is how to nominate:**

- In writing
- Signed by a nominator and seconder, each of whom shall be a financial member
- Accompanied by the written consent of the candidate
- Clearly state the office or offices for which the candidate has been nominated.



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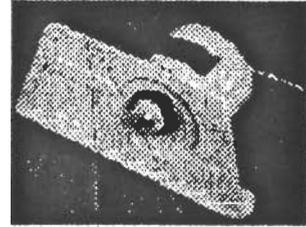
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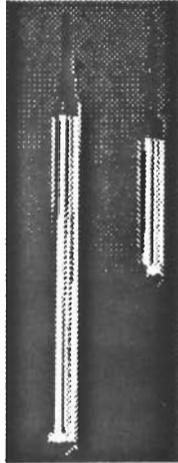
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- Parameters are user selectable via push buttons on the shaft encoder housing.
- Unit can function for extended periods even with the loss of the current-loop driving voltage. Unit has lithium or alkaline batteries.



**Figure 1 AD375-AN-LCD**

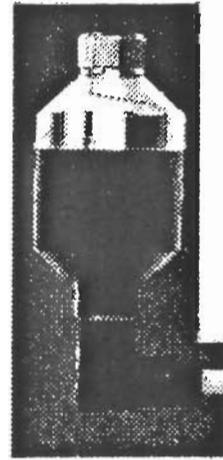
**Submersible Pressure Transducer  
Model WL1000W**



**Figure 2 WL1000W**

- Water Level Monitoring and Recording
- High Accuracy = 0.05 % F.S.
- Pre-Calibrated Sensor
- Temperature Compensated
- Thermally Preconditioned
- Output Signals :
  - 4 TO 20 mA, 2 Wire system
  - 0 TO 5V
  - 0 TO 250 mV Differential
- Standard Model,
  - Mass- 400g
  - Dimensions:  
Diameter-21 mm, Length-200 mm
- Borehole Model,
  - Mass-700g
  - Dimensions:  
Diameter-21 mm, Length-380 mm

**Dry Pressure Transducer  
Model WL1000D**



**Figure 3 WL1000D**

- Water Level Monitoring with Gas Purge System
- High Accuracy = 0.05 % F.S.
- Zero & Span Adjustment
- Pre-Calibrated Sensor
- Temperature Compensated
- Thermally Preconditioned
- Output Signals :
  - 4 TO 20 mA, 2 Wire system
  - 0 TO 5V
  - 0 TO 250 mV Differential
- Dimensions:
  - Diameter-41 mm
  - Length-131 mm
- Mass-300g

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# Australia State of the Environment Report 2001

*This article is taken from the Conclusions of "Australia State of the Environment Report 2001 – Inland Waters Theme Report." The whole report is available at <http://www.ea.gov.au/soe/2001/inland/index.html>*

## WATER RESOURCES

### Key Findings

The key findings in relation to water resources are as follows.

#### *Availability of surface water*

Surface water use has traditionally been high and continues to increase. At the same time, scientific knowledge about sustainable yields has improved, placing limits on the availability of surface water for consumptive use. The current estimates of water use relative to sustainable yield indicate that approximately one-quarter of Australia's river basins are either close to sustainable yields or are being over-used. These river basins account for around 70% of total surface water use. It is clear from this assessment that any growth in water use in these basins must be serviced either from other river basins or from other sources of water such as groundwater, improvements in water-use efficiency, or re-use of wastewater. In river basins where sustainable yields have already been exceeded, other regulatory and/or economic mechanisms may need to be triggered. These include embargoes on further extraction and structural readjustment.

#### *Water reforms*

In response to pressures on the availability of surface water resources, a number of reforms have progressively been introduced as part of the National Water Reform Framework. These reforms include changes to legislation, water industry structure, water policy, water trading, water pricing and the increasing incorporation of environmental flow provisions into water resources planning. States and territories have progressed well in implementing these reforms, with the exception of environmental flows. Environmental flow provisions have been

developed or are being developed in many river basins, but as yet have largely not been implemented. Only 13% of Australia's river basins had a formal environmental flow allocation in place as of June 2000 (NLWRA 2001). Caps on water diversion have been put in place in a number of river basins in the interim until adequate environmental flows are established. Groundwater reforms are lagging behind surface water reforms.

#### *Availability of Groundwater*

Groundwater available for allocation has reduced substantially in the last decade, and is now over-used and over-allocated in many Groundwater Management Units (GMUs). Use has increased not only because of increasing demand on groundwater, but also because of caps placed on the extraction of surface water resources. Unsustainable use of groundwater has significant impacts on both users and the environment, including:

- reduced water levels which can leave bores dry and impact on dependent ecosystems
- inducing seawater intrusion which results in reduction in beneficial use of groundwater
- land subsidence due to compaction of aquitards that have dried up due to pumping
- reduced access to water, not only for current users but also future users, due to substantially reduced groundwater levels.

#### **Comparison with the keys findings of *Australia: State of the Environment 1996***

##### *Surface water resources*

The primary difference in accounting for water resources in the current SoE Report is the inclusion of updated figures on water use

and water availability for the year 1996/97, which were extracted from data compiled as part of the National Land and Water Resources Audit.

Importantly, these latest data include consideration of sustainable yields. Prior to this, the most recent figures on water use and water availability at the river basin scale were for the year 1983/84, which formed the basis of the assessment of surface water availability in *Australia: State of the Environment 1996* (State of the Environment Advisory Council 1996). Yields from this report were only available as divertible yields and did not take into account any environmental considerations. Mean annual water use in Australia has increased by 65% from 14 600 GL to 24 100 GL.

Most of this change was attributable to a 70% increase over the same period in average annual irrigation water use from 10 200 GL to 17 400 GL. Mean annual surface water use was estimated to have increased by 59% from 12 000 GL in 1983/84 to 19 100 GL in 1996/97.

The current estimated volume of nationwide mean run-off (392 000 GL/yr) is essentially the same as the 1983/84 estimate. However, where available, estimates of sustainable yield are considerably lower than 1983/84 estimates of divertible yield. For instance, in the Timor Sea Drainage Division, the current annual sustainable yield is approximately 10 000 GL compared with a divertible yield in 1983/84 of 22 000 GL.

### **Groundwater Resources**

Groundwater extraction has increased considerably over the last two decades. *Australia: State of the Environment 1996* (State of the Environment Advisory Council 1996) did not discuss groundwater in detail and hence no comparison can be made. However, a comparison of the status of groundwater from the AWRC review (1987) and recent NLWRA assessments (NLWRA 2001b) has been made. Nationally groundwater extraction has increased by 90%

from 2634 GL in 1983/84 to 5000 GL in 1996/97. This increase in use has occurred predominantly in discrete areas, which are now encapsulated within GMUs.

From a state and territory perspective the changes in groundwater use are as follows:

- Western Australia, New South Wales and Victoria increased their use of groundwater by over 200% between 1983/84 and 1996/97.
- In Western Australia, groundwater use increased by nearly 800 GL/year, and in New South Wales by 690 GL/year between 1983/84 and 1996/97.

Groundwater issues in 1996 were similar to 2000. The difference is that groundwater is now beginning to be managed at more discrete spatial scales through the GMUs, and that many policy and management initiatives are being developed or implemented at national and state levels.

### **Emerging Issues**

#### ***Surface Water Resources***

Emerging issues in relation to surface water quantity include:

- Current estimates of sustainable yield are based on methods adopted by each state or territory. These methods vary widely, and the absence of a consistent method for estimating sustainable yield for surface waters makes it difficult to directly compare yield estimates across state borders. It also brings into question the validity of sustainable yield estimates when alternative assessment methods potentially produce different results.
- Surface water use is close to or exceeds estimates of sustainable yields in 26% of river basins across Australia. If surface water extraction is to be sustainable into the future, then it will need to be reduced, alternative sources found, or efficiencies in usage implemented in order to meet demands.
- There is evidence of a climatic shift that has reduced inflows in south-west Western Australia. Sustainable yields in this catchment have been adjusted accordingly. The enhanced greenhouse

effect may result in lower average rainfalls across much of Australia and produce a corresponding decrease in river flows. In general, and in the context of climate change, the adjustment of sustainable yields may require a similar adjustment in allocation if environmental flows are to remain unchanged. This will be particularly important in river basins with water use close to or exceeding current estimates of sustainable yield.

- Water use and losses from farm dams have not been incorporated into current water-use estimates. A number of studies are emerging which more accurately quantify the hydrologic effects of farm dams and will form the technical basis for water resources planning on this issue.
- The hydrologic effects of farm forestry and tree clearing on sustainable yields are an emerging issue, but are unlikely to be resolved before the next SoE reporting cycle in anything other than isolated case studies.
- Similarly, the effects of groundwater use on surface water baseflows are currently being investigated. Increased groundwater use has the potential to reduce sustainable surface water yields.

### ***Groundwater Resources***

Although our understanding of groundwater has not changed significantly in recent years, the management of the resource is currently undergoing much change, and will continue to evolve as the use of groundwater management units increases and data are collated at local scales.

Water scarcity means that the pressures on groundwater will continue to increase over time. To ensure sustainable practices, water resources will have to be used more efficiently in the future. An important issue that needs urgent attention is how to reduce allocations and use to sustainable levels.

- New policy and management initiatives are required to manage the resource.

Several policies have recently been developed on the issue of over-allocated and over-used systems. The solutions have considerable socioeconomic impacts. Each GMU will need to identify the most appropriate way to either 'buy back' or redistribute water resources within its area to ensure sustainability and fairness. Trading of water licences will play a part in ensuring that this occurs, although most states are still grappling with the issues and solutions are yet to emerge.

- Environmental water requirements of groundwater-dependent ecosystems need to be determined. Currently there is considerable information available, but it has not been included in the management and resource allocation processes currently in place. In the future, groundwater-dependent ecosystems will play a significant role in resource development, and if allocations are not determined soon, these ecosystems will be affected by over-development of resources that are the lifeline of these ecosystems.
- Reliable information on groundwater use is required. Without accurate data it will not be possible to determine areas which are over-developed or nearing full development. A way of determining impacts on the environment will be through monitoring. Groundwater information is scarce in many GMUs, and the cost of groundwater investigations and data collation is high. Minimum groundwater monitoring standards are required for GMUs to ensure that consistency in reporting and assessment occurs nationally, and within each state.
- Funding for bore capping and maintenance programs is not sufficient and the implications of not undertaking these works include loss of resources, pollution due to corrosion and cross-contamination of aquifers

### **Threats to Sustainability** ***Surface Water Resources***

The main threats to sustainability are:

- the continuing over-extraction of water from many river systems, especially in the Murray–Darling Basin
- the absence of sound estimates of sustainable surface water yields and total water use in areas of rapidly increasing demand for water
- the ability to reduce water use or find alternative sources of water in the context of:
  - climate change
  - increasing farm dam development
  - changes in land use cover.

#### **Groundwater resources**

The sustainability of groundwater resources relate to four main issues:

- groundwater use in excess of sustainable yields
- aquifer salinisation from rising water tables, aquifer leakage and recycling of salts (irrigation and groundwater pumping)
- rising water tables causing dryland salinisation
- seawater intrusion.

#### **Water Quality and Pollutant Sources**

##### **Key findings**

Quality of groundwater is impacted by many land uses and there are differing mechanisms for pollution of groundwater to occur. Apart from nitrate pollution, most groundwater pollution is localised in its impact. Groundwater quality degradation can occur via the following pathways:

- pollution from industries and agricultural use of land
- salinisation of groundwater because of groundwater pumping, recycling of salts through the unsaturated zone, and mobilisation of naturally occurring salts in the soils and rocks as water tables rise
- seawater intrusion, which is caused by groundwater pumping and can draw seawater into the aquifer reducing its quality.

The key findings in relation to surface water quality and pollutant sources are as follows.

##### **Salinity**

Rivers, streams and wetlands in south-west Western Australia and western Victoria are already salinised. With the area of land affected by dryland salinity predicted to at least double over the next 50 years, higher salinities will be experienced in many other river systems in Western Australia and the Murray–Darling Basin. Higher salinities will adversely affect irrigation and drinking water supplies and damage aquatic ecosystems.

##### **Eutrophication and algal blooms**

Diffuse-source pollution and especially soil loss from catchments continues to contribute to the widespread nutrient enrichment and turbidity of inland waters. Soil washed into rivers and reservoirs will remain a source of nutrients for decades into the future. In some catchments, wastewater from sewage treatment plants and intensive agriculture also contribute significantly to nutrient enrichment. Nutrient enrichment and reduced streamflow due to over-extraction of water have increased the frequency and extent of toxic blue-green algal blooms, with some reservoirs being unsuitable for recreation or drinking-water supply over 25% of the time.

##### **Pollutants**

Contamination of inland waters by heavy metals, chemicals and pathogens is thought to be localised; however, there is no reliable information to support this assumption. There is evidence of pesticide contamination of rivers and streams draining cotton and rice-growing areas in New South Wales. It is likely that other waterways in Australia are affected, but no recent information exists on the extent or impact of pesticide contamination of other areas.

##### **Acidification**

This is an emerging issue in some catchments where increasing trends in water acidity and the area of land affected by soil acidity have been found. Higher water acidity may lead to increased availability and movement of pollutants as well as fundamental changes in the chemistry of rivers and streams.

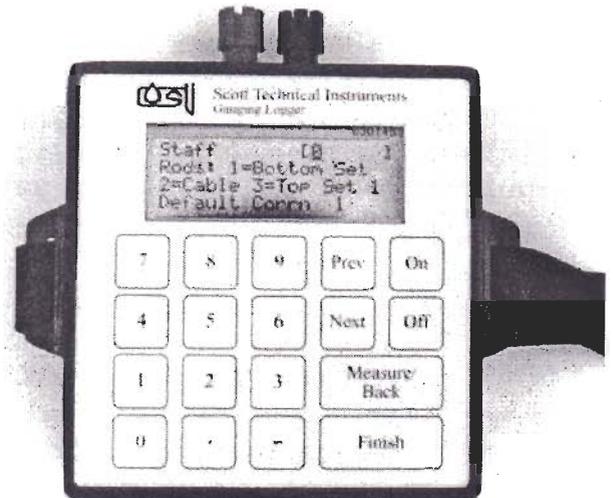
##### **Integrated catchment management**

The threats of salinisation, eutrophication, acidification and over-extraction to human

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Grant Best, Hydrologist

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water uses and aquatic ecosystems require an integrated response that considers the land, surface waters and groundwater. There have been some improvements in our knowledge that will enable better management of land and water resources, however, the implementation of better management practices is patchy.

### **Comparison with the keys findings of *Australia: State of the Environment 1996***

The key findings for surface water quality and pollutant sources are similar to those of *Australia: State of the Environment 1996* (State of the Environment Advisory Council 1996).

The water quality of rivers, streams and wetlands is significantly affected by reduced flow and catchment pollutant sources such as land salinisation, sewage discharge, erosion, diffuse source pollution and pesticide use in agricultural areas. The potential impact of dryland salinity on the salinity of inland waters is clearer since 1996, with many rivers risking increased salinity over the next 100 years if no measures to manage and prevent dryland salinity are implemented.

Since 1996, there have been some increases in the knowledge of the processes, causes and extent of the degradation in water quality of inland waters. There have also been some advances and initiatives to improve water quality such as:

- the preparation of land and water management plans
- the development of state and national strategies to tackle significant issues such as salinity
- improved management of some polluting activities such as pesticide use and pointsource pollution
- the increased recognition of the importance in protecting aquatic ecosystems.

Despite these improvements, there are still fundamental issues that have yet to be addressed such as the sustainability of land and water management practices, and the societal change required to implement

sustainable management frameworks. The current management frameworks and funding arrangements do not appear adequate to address these issues.

### **Emerging Issues**

The emerging issues for surface water quality and catchment sources of pollutants are:

- The extent of impacts from dryland salinity are much more significant than previously thought and this will require major changes in the management of land and water resources in some areas.
- Management actions to reduce soil acidity (such as large-scale liming) will be required, otherwise water acidity will become a significant problem in many river systems.
- Pesticide contamination of rivers and streams draining agricultural areas has been measured; however, it is unclear what the effects of new pesticides and genetically modified crops will have on pesticide use and impact.

### **Threats to Sustainability**

The threats to sustainability in terms of water quality are:

- increasing salinity of rivers and streams due to dryland salinity and irrigation-induced salinity
- nutrient enrichment and frequent blue-green algal blooms
- pesticides in rivers, streams and sediments.

## **AQUATIC ECOSYSTEMS**

### **Key Findings**

#### ***Modification of Natural Flow Regimes***

The natural flow regimes of many regulated river systems have been modified because of water extractions and the use of rivers as irrigation and water supply channels. Many of Australia's native flora, fauna and habitats are dependent on natural flow regimes so changes in flow patterns have a significant effect. Aquatic ecosystems in the highly regulated river systems of the Murray–Darling Basin and a number of smaller eastern coastal river systems are likely to be under pressure from



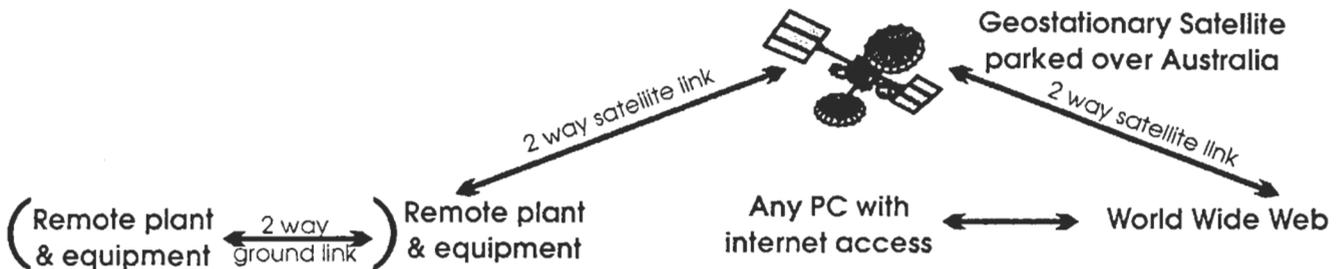
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modification to natural flow regimes. Environmental water allocations are currently being determined for many regulated river systems.

### ***Salinity Impacts on Aquatic Ecosystems***

Increasing salinity of inland waters is a major threat to many aquatic ecosystems. Already aquatic ecosystems in western Victoria and south-west Western Australia are affected by salinity and it is predicted that many wetlands and river systems in the Murray–Darling Basin will be severely affected by increased salinity by 2050. Eighty important wetlands are already affected by salinity and this will rise to 130 by 2050 (NLWRA 2001b).

### ***Other Water Quality Impacts on Aquatic Ecosystems***

Cold-water thermal pollution is estimated to affect up to 3000 km of rivers in New South Wales alone and is likely to be occurring in many regulated river systems throughout the nation. Pesticide contamination of groundwater, surface water and sediments has been detected in agricultural areas, although their impact on aquatic ecosystems is not fully understood. Algal blooms are common in many waterways and can have impacts such as reducing dissolved oxygen levels and decreasing light penetration.

### ***Loss of Habitat***

Riparian zone habitats (including wetlands) are in poor condition in many areas and are decreasing in others due to the effects of grazing, land clearing, modified flow regimes, salinity, floodplain isolation and the spread of exotic species.

### ***Aquatic Fauna***

Native fish populations in some river systems are under severe stress from barriers to fish movements, poor water quality, reduction in habitat and competition from exotic species. Six per cent of native fish species are considered threatened. Over 10% of native frog species are considered threatened due to loss of habitat, poor water quality and pesticides. The chytrid fungus has been implicated as a significant cause in the

decrease of some frog populations in Australia. Fifty per cent of Australia's inland waterbirds are listed as extinct, vulnerable or near threatened primarily due to wetland and riparian habitat loss. Platypus and some species of freshwater crayfish are considered to be at risk, primarily from loss of habitat. However, there is only limited information on the distribution and condition of these animals.

### ***River Health***

A national assessment of river 'health' was undertaken using the AusRivAS protocol. At 31% of sites macroinvertebrate communities were significantly impaired, at 8% of sites they were severely impaired and at 1% of sites they were found to be extremely impaired. Generally the degree of impairment was related to land use in the catchment and disturbance of the river system.

### ***Groundwater-Dependent Ecosystems***

The main issues for groundwater-dependent ecosystems include:

- groundwater-dependent ecosystems are poorly understood
- arguably the most significant groundwater-dependent ecosystem is baseflow to rivers. As such, the management of groundwater is fundamental to surface water quality and availability
- the geographic extent and dependence of vegetation on groundwater is not well understood
- environmental water allocation have generally not been determined and so protection mechanisms for groundwater-dependent ecosystems are not in place.

### ***Protection and Management of Aquatic Ecosystems***

Some of the major management responses to protect and maintain aquatic ecosystems include:

- action plans for the conservation of native frogs and waterbirds

*(Continued Page 20)*

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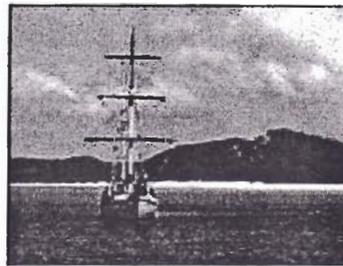
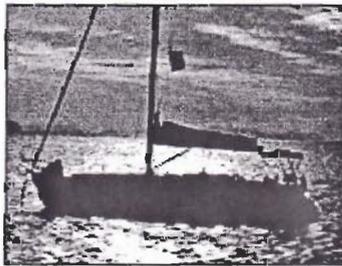
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- restocking of native fish and construction of fishways
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- additional wetlands listed under the Ramsar Convention and the development of wetland protection policies
- environmental water allocations for surface aquatic ecosystems
- state legislative mechanisms for the protection of riparian zones and threatened aquatic species, and the provision of environmental flows
- the new Commonwealth environmental legislation *Environment Protection and Biodiversity Conservation Act 1999* which provides additional protection for threatened aquatic species and Ramsar-listed wetlands from activities on public and private land
- pest management programs.

In many instances there is a lack of conclusive data on the effectiveness of improved environmental management practices on overall aquatic ecosystem health or on individual species or habitats. Increased funding for monitoring the effectiveness of management intervention is urgently needed.

### **Comparison with the keys findings of *Australia: State of the Environment 1996***

The current pressures on inland aquatic ecosystems are the same as those reported in *Australia: State of the Environment 1996* (State of the Environment Advisory Council 1996). Modified river flows, water quality and exotic pests are still the most influential elements of inland aquatic ecosystem health.

As in the 1996 report, there is still a lack of national datasets on the condition of most inland aquatic habitats, flora and fauna. The only national dataset available for this assessment was macroinvertebrate communities measured using the AusRivAS protocol. The AusRivAS protocol is specifically designed to provide an indication of river 'health' and is a useful tool.

The AusRivAS assessment and other indicators of condition continue to show that Australia's inland aquatic ecosystems in highly developed agricultural and urban areas are in poor health, with reductions in habitat and biodiversity. Programs to collect these data are being implemented (e.g. National Wetland Inventory) and there should be considerably more data on the condition of aquatic ecosystems for the next SoE reporting cycle.

Since 1996, management responses to maintain and protect aquatic ecosystems have improved. These have included legislation to protect remnant riparian vegetation, threatened species and wetlands; strategies and policies for conservation of aquatic habitat, flora and fauna; and funding for research, community-based restoration projects and national conservation programs.

### **Emerging Issues**

The emerging issues for aquatic ecosystems are as follows.

- Recent studies have shown that clear macrophyte-dominated ecosystems can switch to degraded turbid algal-dominated systems due to the effects of vegetation loss, poor water quality and reduced river flows. Once these ecosystems have 'switched' it is very difficult to return them to their former state.
- The future predicted extent of the salinisation of inland waters and their catchments is far greater than previous estimates. Based on impacts measured in currently affected ecosystems, many important aquatic ecosystems risk significant degradation from effects of salinity.
- Baseflows in rivers, streams and wetlands are essential for many aquatic ecosystems and are under threat from over extraction of linked groundwater resources.

### **Threats to Sustainability**

The threats to the sustainability of inland aquatic ecosystems and riverine and

floodplain wetlands can be summarised as follows:

- the extraction of water (including groundwater) in excess of sustainable yields for the maintenance of dependent aquatic flora and fauna
- the modification of surface water flow regimes and water storages
- poor water quality—primarily from catchment activities such as the removal of riparian vegetation, habitat modification, the discharge of pollutants, soil erosion, salinisation and pesticide use
- land clearing and modification—land clearing and modification impacts include direct loss of riparian habitat, increased soil erosion and a higher risk of dryland salinity
- introduction and spread of introduced exotic species—they can compete with native species for resources, may have no natural predators in Australia and can affect other environmental characteristics (e.g. water quality)
- lack of data on the condition and extent of most aquatic fauna, flora and habitats.

## ASSESSMENT OF INFORMATION GAPS

### *Surface Water Resources*

Water use and availability data sourced from the National Land and Water Resources Audit (NLWRA) is a major improvement on previous information, but a number of gaps remain.

Most notably, estimates of water use and sustainable yield have not been made for unregulated streams in New South Wales and estimates of sustainable yield have not been made for Queensland. Most states and territories made simplifying assumptions or needed to extrapolate data when providing water use and yield estimates. In highly developed basins, with 70–100% of sustainable yield being used, approximately 75% of water use and yield estimates were

based on reliable data or approximate hydrologic analysis (NLWRA 2001).

However, in the overdeveloped basins, 82% of water use and yield estimates were based on poor data or were estimated without data (NLWRA 2001).

As stated previously, there is no nation-wide estimate of water use from farm dams. Projects are under way to estimate farm dam storage volumes, water use and impacts of catchment yield in a number of highly developed catchments.

### *Surface Water Quality*

The percentage of drainage regions where there was sufficient water quality data to undertake exceedance and trend assessments for six key indicators is presented in Table 44. It is likely that the coverage is slightly higher than presented below as there were other known sources of water quality data that were not made available for the assessment. Also, it must be recognised that surface water quality information for many inland arid regions may not be as important as in other areas, as these regions are largely undeveloped and do not have permanent waterways. As well, the waterways that are typical to these areas are often unique (i.e. salt lakes such as Lake Eyre) and have highly variable water quality, and there is little information on what is typical or 'good' water quality.

Overall, water quality data coverages are low. Of major concern are the low percentages for the trend assessments, and especially nitrogen and phosphorus. There were no nutrient data of sufficient quality to undertake trend assessments in Queensland waters. In Tasmania and the Northern Territory, there were insufficient data to undertake either exceedance or trend assessments for all key variables.

Other water quality indicators that have insufficient data include:

- pesticide contamination of waters and sediments

- endocrine disrupters and their impact
- other forms of nitrogen and phosphorus (e.g. nitrate and phosphate) that are important in triggering algal blooms
- the extent and impact of wastewater discharges from intensive agriculture
- algal blooms in some areas.

### **Groundwater**

There are many groundwater information gaps, most of which relate to the actual physical data that are required to characterise groundwater resources. Water quality data, recharge sources, groundwater-use information and the temporal variability of the resource all require extensive investigations to obtain relevant information. The information is not easily collated, and is costly to collect. As such, much of this information is scarce, and usually available only in areas of significant development or high environmental value.

For the NLWRA, most of the groundwater use information in GMUs was collated on the basis of little or no investigation data. This is the case not only for those GMUs of low development, but also for many areas that are considered to be highly over-developed.

Considering the poor reliability given to these estimates, extensive work is required to increase consistency in the groundwater-use estimates.

There is an increasing knowledge base on groundwater-dependent ecosystems in Australia; however, there still is a large gap between relating this knowledge to the management of the resource. Groundwater-dependent ecosystems are rarely included in the allocation process, and hence resources used for development could be endangering dependent flora and fauna. There is a need for assessments of groundwater-dependent ecosystems within highly and over-developed GMUs in the first instance, moving down to those GMUs of lesser development status. Most importantly, groundwater should not be thought of as exclusive to surface water

resources, but rather as one component of the hydrologic cycle.

### ***Aquatic Ecosystems***

Knowledge on the extent, distribution and condition of inland aquatic ecosystems is fundamental to their effective management and the conservation of biodiversity. There are many information gaps on the condition of inland aquatic ecosystems and these include:

- no national datasets on diatoms, the condition and distribution of native fish, frogs, waterbirds, platypus and freshwater crayfish
- no national datasets on geomorphic or physico-chemical condition, in-stream ecological processes such as community metabolism, and the condition and extent of important aquatic habitats such as riparian vegetation and wetlands
- general lack of information about aquatic ecosystems in remote rivers and the less developed states and territories such as Tasmania and Northern Territory (sic)
- very little data on fundamental ecological processes.

Certainly, there are data for these indicators on a local or catchment level; however, these do not provide a national picture of condition. Some of these data gaps are currently being addressed through Commonwealth and state government programs.

The other major data gap is the linkage between management actions and the condition of aquatic ecosystems. Although there have been many small projects to demonstrate the effectiveness of management actions on the health of aquatic ecosystems, these results may not be able to be scaled up to larger ecosystems without further research. The impact of environmental water allocations on the health of aquatic ecosystems in large river systems is one area where additional research is required.

## APPENDIX

### The Antarctic Territories and Their Lakes

#### *Macquarie Island*

Numerous freshwater lakes, ponds and pools are found on Macquarie Island, where the almost constant rain ensures a plentiful water supply. The water bodies range in size from small ponds in waterlogged peat areas to moderately large and deep lakes in fault-controlled valleys. Short, steep streams connect the lakes to the ocean. The surfaces of most of the lakes freeze for short periods during winter, with water temperature ranging from 0°C at these times to 8°C in summer. Many of the lakes have abundant emergent vegetation, and are home to collections of microscopic animals that have more similarities to

other Subantarctic islands, including Heard Island and South Georgia, than the Australian mainland.

#### *Heard Island*

The glaciated cone of Big Ben, an active volcano 2745 m high, makes up the greater percentage of Heard Island. Numerous lakes and bogs are located in the ice-free areas around the coast of the island. These can be divided into two main types: pool complexes in peat, which have many similarities to string bogs in alpine Tasmania and boreal forests of the Northern Hemisphere; and large, deep freshwater lakes which occupy depressions left by retreating glaciers. These glacial lakes are often separated from the ocean by narrow sandbars, some of which have been breached in recent years resulting in intrusion of saltwater into the originally freshwater lakes.

*(Continued Page 24)*



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### ***Australian Antarctic Territory***

Even though Antarctica is largely a continent of ice, there are a surprising number of Antarctic lakes. Most of the lakes are located in coastal ice-free areas such as the Vestfold, Larsemann and Bunger Hills, where they are dominant features of the landscape. These lakes, which can be up to 10 km<sup>2</sup> in area and over 150 m deep, are of two main types: fresh and saline. Summer meltwater run-off from the Antarctic ice sheet into the ice-free areas has resulted in the formation, in some cases, of large freshwater lakes which form part of short drainage systems to the ocean. The water in some of these lakes is amongst the purest naturally occurring water in the world, and has particularly low levels of nutrients and therefore productivity. The saline lakes were formed when seawater was trapped in basins during uplift of the land at the end of the glacial period approximately 10 000 years ago.

Since isolation from the ocean, these lakes have evolved as a result of the balance between dilution by meltwater and evaporation. The most saline of these lakes, Deep Lake in the Vestfold Hills, contains over 250 g salt per litre, and rivals the Dead Sea as one of the saltiest lakes in the world. Remarkably, some of these saline lakes are only a few kilometres from the meltwater-fed freshwater lakes.

Many of the saline lakes are meromictic or stratified, which means that the water in the lakes does not mix completely during each year. This behaviour is due to an increase in salinity, and therefore density, with depth, and leads to the depletion of oxygen in the deeper, unmixed waters, and production of hydrogen sulfide gas. These conditions are particularly favourable for the preservation of sediments that reveal the history of the lake and climate change over its lifetime. There are very few meromictic lakes in Australia. All the lakes except for the most saline freeze to a depth of up to two metres during winter, but this ice insulates the lakes from freezing completely. Water temperatures under the ice in meromictic lakes can be surprisingly warm due to solar heating, reaching 20°C in some cases.

Perhaps the most fascinating of all the lakes in Antarctica are located under thousands of metres of ice in the continent's interior. These subglacial lakes were discovered during radioecho sounding traverses to map the thickness of the Antarctic ice sheet. The largest, Lake Vostok, which is located

beneath Vostok Station under nearly 4000 m of ice, has an area of 14 000 km<sup>2</sup>, and a maximum depth of over 500 m. No drilling program has yet been undertaken to confirm the existence of these lakes, but this could occur soon.

The biology of Antarctic lakes is often quite simple, but is of considerable interest. The lakes are dominated by microbial processes (i.e. involving single-celled organisms), and the largest animals in the lakes are small crustacea, including cladocera (water fleas) and copepods. Fish are absent. A major scientific question is the source of the biota of the freshwater lakes, as at the height of the previous ice age it is thought that there were no areas of exposed land on Antarctic, and therefore no land-based lakes. The biota either survived in lakes on the ice itself, or has been transported from continents and islands to the north by winds, migratory animals or ocean currents. The source of the biota in the saline lakes is clearer – organisms that were present in the seawater trapped to form the lake. Subsequent changes in salinity and water temperature have placed pressure on the organisms, and only those that can adapt to change survive.

The biology of the subglacial lakes is as yet unknown, but they are thought to contain life (probably limited to bacteria) that has been isolated from the atmosphere for perhaps 400, 000 years.

### **Environmental Pressures and Responses**

The main environmental pressures on most of the lakes come from scientists studying them. Protocols for sampling the lakes have improved dramatically over the last 20 years, and are now aimed at reducing the possibility of chemical contamination by, for example, fuel spills, or biological contamination by the introduction of organisms from one lake into another. Other threats are more subtle, and involve deposition of pollutants, such as lead and persistent organic chemicals, either from nearby scientific stations or from temperate areas. For a small number of lakes in the immediate vicinity of scientific research bases, pressure can also come from the use of the lakes as a potable water supply, pollution, and disturbance to the drainage basin by vehicles, construction and pedestrian traffic.

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