Part two

Our performance

Part two: Our performance

Our roles and strategy

CSIRO undertakes scientific research into practically all aspects of human activity and its interaction with natural and built environments. This includes our air and water; our diverse landscapes; oceans and climate; agriculture; energy; health; space technologies and exploration; manufacturing; materials science; minerals exploration and processing; information and communication technologies and more.

We seek to make a difference with our research and generate impact for Australia. We apply our knowledge to create jobs, national wealth, a healthy environment and improved living standards for all Australians.

Our place in Australia's National Innovation System (NIS) is unique due to our size, our breadth and depth of capability, our active research portfolio management and our ability to conduct large-scale, multidisciplinary research focused on tackling major challenges that matter to Australia's future. In 2009–10, over 90 per cent of our research addressed the Australian Government's National Research Priorities.

The conduct of excellent science on issues of national priority is fundamental to CSIRO's mission, but generating impact for the nation also depends on developing strong relationships with potential users and beneficiaries – in both the public and private sectors. We work with and on behalf of others, to turn results into social, economic and environmental benefits. CSIRO's Service Charter (see page 179) sets the standards of service we deliver to our customers.

Examples of how we are also addressing the Government's National Innovation Priorities are reflected throughout the annual report. Details on collaboration and partnering are provided on pages 102–105.

Five strategic elements form the core of CSIRO's 2007–2011 strategy.

Delivering on national challenges

We form partnerships to address national challenges and opportunities through our Flagships.

Exploring new horizons

We continuously extend and develop our science capabilities, promoting excellence in science delivery and shaping future research directions.

Conducting science with impact

We deliver impact for Australia through transformational science, better business practices, accelerated adoption of our solutions and enhanced communication.

Harnessing One-CSIRO

We work together in an innovative, collaborative, values and performance-based environment. Our systems, structures and processes support the enterprise and ensure that our people remain healthy, safe and productive.

Building our people and science excellence

We ensure a balance between developing our capability and delivering outcomes from science. We manage facilities and collections for national benefit.

Our outcome and program structure

The Australian Government appropriates revenue to departments and agencies such as CSIRO to deliver agreed 'Outcomes' set out in the relevant Portfolio Budget Statements. CSIRO's Outcome Statement is shown in Figure 2.1. To achieve the outcome, CSIRO allocates funds across four Programs, also shown in Figure 2.1. These programs reflect the Organisation's focus on delivering scientific solutions to Australian industry and communities, while simultaneously helping to build Australia's science base to meet ongoing challenges and opportunities.

The performance section of the Annual Report presents information on each of these four Programs including reporting against specific performance indicators set out in the Portfolio Budget Statements and the CSIRO Operational Plan.

The research and engagement activities that deliver on CSIRO's outcome and program objectives are managed through five Research Groups supported by Corporate Groups that provide critical enterprise functions. Each Research Group comprises a number of research portfolios and a number of Divisions.

- Research Portfolios (including Flagships) contain one or more research Themes with clear and specific goals.
- Divisions are the creators, builders and custodians of scientific capabilities. They develop and deploy capabilities to meet the objectives of Portfolios.

The five research groups for the reporting period 2009–10 are:

Agribusiness Group[3]

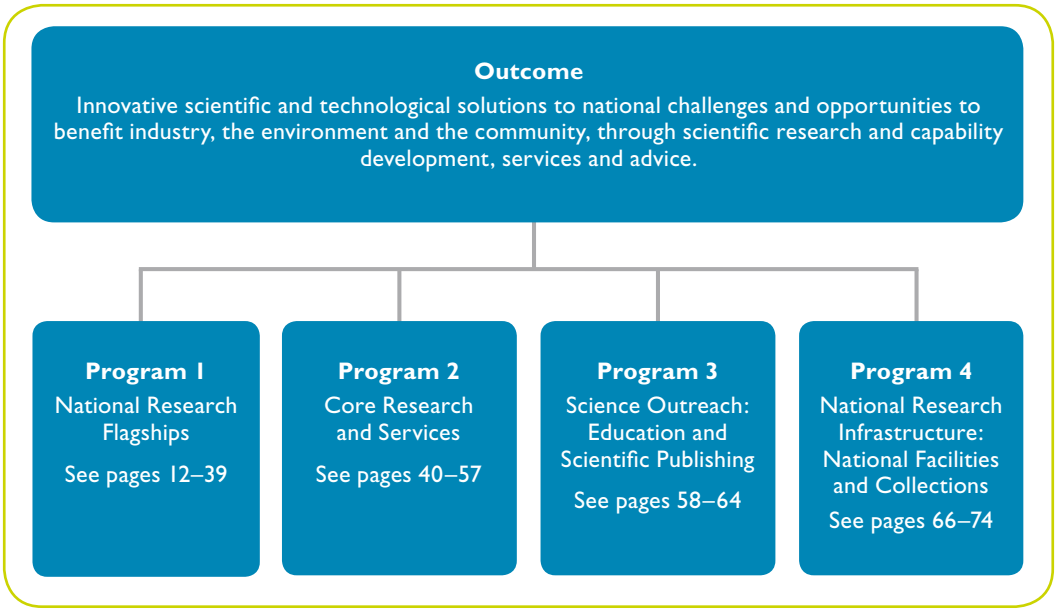
Portfolios: Food Futures Flagship; Preventative Health Flagship; Sustainable Agriculture Flagship; Entomology; Food and Nutritional Sciences; Livestock Industries; Plant Industry.

Divisions: Entomology; Food and Nutritional Sciences; Livestock Industries; Plant Industry.

The Agribusiness Group serves large and vital sectors of the Australian economy including the agrifood and fibre industries and the human health sector. In particular, the Group is responding to a strong demand for science-based solutions to global problems for humanity (food security, response to climate change, human health) that have a significant dependence on advances in biology. The Group's objective is to improve human wellbeing and community health by performing world-class and strategic research.

[3] *From July 2010 Agribusiness Group was renamed Food, Health and Life Science Industries; and Entomology merged with Sustainable Ecosystems to become Ecosystem Sciences within the Environment Group.*

Figure 2.1: CSIRO's Outcome and Programs



The Group also carries responsibility for policy oversight of biotechnology/bioeconomy, including regulation of gene technology research.

Energy Group

Portfolios: Energy Transformed Flagship; Wealth from Oceans Flagship; Coal Technology; Petroleum and Geothermal.

Divisions: Earth Science and Resource Engineering; Energy Technology.

The Energy Group is developing and applying leading-edge research to meet the triple goals of clean energy, energy security and wealth creation from energy in Australia and the region. Their priority is to help accelerate large-scale greenhouse gas emissions cuts, while achieving a smooth transition to a new energy future.

The Group also focuses on understanding Australia's oceans and their biodiversity, resources and relationships with the climate system.

Environment Group[4]

Portfolios: Climate Adaptation Flagship; Water for a Healthy Country Flagship; Biodiversity; Marine and Atmospheric Research.

Divisions: Land and Water; Marine and Atmospheric Research; Sustainable Ecosystems.

Australians have stewardship of a beautiful, diverse and unique environment. However, the cumulative effects of the past 200 years of natural resources development has left a legacy of environmental challenges juxtaposed with opportunities for new economies.

The Environment Group is responding to these challenges and opportunities by providing systems understanding, developing and applying new technologies and supporting our clients, partners and stakeholders in balancing economic development with ecological conservation.

Information Sciences Group

Portfolios: Astronomy; Australian Square Kilometre Array Pathfinder (ASKAP); Digital Technologies and Services.

Divisions: Astronomy and Space Science; Information and Communication Technologies (ICT) Centre; Mathematics, Informatics and Statistics; Information Management and Technology (IM&T).

The Information Sciences Group contains the core of CSIRO's research in the space sciences, information communication technology and mathematical sciences sectors. Each Business Unit within the Group has a unique focus:

- CSIRO Astronomy and Space Science: understand the universe and its origins.
- ICT Centre: develop globally applicable technologies to drive productivity gains in all sectors of the economy.
- CSIRO Mathematics, Informatics and Statistics: to develop innovative technologies and services through mathematical and information sciences research.
- IM&T: business support, data management and implementation of eResearch.

Manufacturing, Materials and Minerals Group[5]

Portfolios: Future Manufacturing Flagship; Light Metals Flagship; Minerals Down Under Flagship; Materials, Science and Engineering; Molecular and Health Technologies.

Divisions: Materials Science and Engineering; Molecular and Health Technologies; Process Science and Engineering.

[4] *Entomology merged with Sustainable Ecosystems to become Ecosystem Sciences within the Environment Group.*

[5] *From July 2010, Molecular and Health Technologies merged into Materials Science and Engineering.*

The Manufacturing, Materials and Minerals Group contains the core of CSIRO's research in the materials, manufacturing, minerals, mining, chemicals, health and infrastructure sectors. The focus of the operational units in the Group is to:

- stimulate and support the creation of sustainable value from Australia's minerals resources over the whole value chain
- maximise value to the manufacturing sector by developing and transferring innovative transformational technologies
- develop new materials and products for application in the health and chemical industries.

Corporate Groups

Enterprise functions provide critical support to both the development of research capability and the delivery of Theme outputs. These include the science outreach and education activities and the provision of support services, such as laboratory management, finance and accounting, property management, strategic and operational human resources capability (including leadership development), communications, procurement, legal and contract administration services, business development, technology transfer and licensing, intellectual property management and management of information technology systems.

Also critical is the development and communication of effective strategy and governance processes that help to guide CSIRO staff in fulfilling their duties, focus key management decisions and nurture valuable relationships with key stakeholders.

Mapping CSIRO's Programs to Research Groups and Portfolios

The research groups contribute to government programs by taking responsibility for a number of research portfolios as shown in Table 2.1.

Table 2.1: CSIRO's portfolios as at June 2010

CSIRO Budget Programs				
CSIRO Operating Groups	Program 1 National Research Flagships	Program 2 Core Research and Services	Program 3 Science Outreach	Program 4 National Research Infrastructure
Agribusiness[a]	• Food Futures • Preventative Health • Sustainable Agriculture	• Entomology • Food and Nutritional Sciences • Livestock Industries • Plant Industry		• Australian Animal Health Laboratory
Energy	• Energy Transformed • Wealth from Oceans	• Coal Technology • Petroleum and Geothermal		
Environment	• Climate Adaptation • Water for a Healthy Country	• Biodiversity • Marine and Atmospheric Research		• Marine National Facility • National Biological Collections
Information Sciences		• Astronomy • ASKAP • Digital Technologies and Services		• Australia Telescope National Facility Operations • Canberra Deep Space Communication Complex
Manufacturing, Materials and Minerals	• Future Manufacturing • Light Metals • Minerals Down Under	• Materials Science and Engineering • Molecular and Health Technologies [b]		
Corporate			• Discovery Centre • CSIRO Education • **CSIRO** PUBLISHING	

[a] *Agribusiness was renamed Food, Health and Life Science Industries from July 2010. Entomology and Sustainable Ecosystems merged to become Ecosystem Sciences.*

[b] *Molecular and Health Technologies merged into Materials Science and Engineering from July 2010.*

Enterprise performance

CSIRO's enterprise performance is measured against the five elements of the CSIRO strategy outlined on page 2. To put the strategy into effect in 2009–10, CSIRO's Operational Plan identified 15 key organisational objectives requiring focused executive action. Progress against these objectives is summarised in Table 2.2.

Table 2.2 Progress against key organisational objectives 2009–10

Key organisational objectives	Summary of progress
Delivering on national challenges	
Sharpen delivery through a focus on goals and leadership of the National Research Flagships.	Significant progress has been made towards achieving this objective, activities this year include: • The Sustainable Agriculture Flagship commenced operations on 1 July 2009. The new Flagship addresses agricultural productivity and food security in a resource/carbon constrained world – see pages 34–35. • CSIRO's research in the Energy area was repositioned during the year. The Energy Transformed Flagship (ETF) now focuses solely on alternative energy research, see pages 22–23. Coal research moved to a new Coal Technology Portfolio. Gas and geothermal activities ETF and Wealth from Oceans Flagship relocated to a new Petroleum and Geothermal Portfolio. • All Flagships have a roadmap that broadly communicates the path towards their goal. The current position on each roadmap is provided on pages 21–39. • Independent expert reviews of five Flagships – Food Futures; Light Metals; Minerals Down Under; Preventative Health; and Water for a Healthy Country – were conducted as planned. Review outcomes were largely positive and indicated that scientific work in Flagships were of a high standard, see pages 18–19.
Grow Flagship impact through partnerships with greater focus on global, national and small to medium enterprise partners.	This year we focused on identifying opportunities for partnerships with government and industry. As a result: • Flagships have secured significant opportunities including an alliance with Orica Ltd, a renewal of the BLUElink (ocean forecasting system) program, further work on sustainable yields (water resource assessment projects) and a significant titanium project with General Electric Company. • Four new Flagship Collaboration Fund Clusters were established, involving four international universities and 12 national universities, see page 176–178. • Future project opportunities have been identified out to the year 2020. Over 70 per cent of the concepts are aligned with Flagships. CSIRO's executive and commercial communities are now working to pursue these opportunities.

Key organisational objectives	Summary of progress
Increase the rigour and external ownership of CSIRO's broad direction setting by more inclusive involvement of key NIS stakeholders.	The broad direction setting document is the key document used to guide decision-making in relation to science investments and is reconsidered annually as the first part of the investment process. In 2010, CSIRO conducted an extensive process of engaging directly with external stakeholders in relation to future trends in the social and technology field. This included engagement with stakeholders across government, community and industry sectors. The process was led by the Chief Executive Officer and Board members and was very well received by participants. The document used to facilitate these discussions – *Megatrends and megashocks: A new view of our future world* – has been published, see: www.csiro.au/news/Megatrends-and-megashocks-a-new-view-of-our-future-world.html. The outcomes from this stakeholder engagement will be fed into the science investment processes for the 2011–12 financial year.
Exploring new horizons	
Increase CSIRO's capacity to explore 'new horizon' science. Establish and nurture mechanisms to catalyse more interaction between CSIRO's diverse set of capabilities with a view to exploring novel science opportunities and applications.	To grow CSIRO's capacity to explore 'new horizon' science we aim to increase funding to our capability development funds, transformational capability platforms (TCPs) and our science excellence scheme. This year: • the TCPs continued to operate effectively although the targeted increase in funding was not achieved. All four TCPs are now well established with an exciting program of research connecting scientists across multiple Divisions, see page 106. • the Office of the Chief Executive's Science Excellence Scheme continues to provide a successful mechanism for attracting and nurturing scientists in CSIRO. Funding targets were met in 2009–10 and will increase in 2010–11 to take on responsibility for the administration of the Science and Industry Endowment Fund (SIEF) scholarships and fellowships. • CSIRO continues to grow the number of postgraduate scholarships and the postdoctoral fellowships to a five-year high, see page 58. CSIRO encourages interaction amongst staff through a number of initiatives such as 'communities of practice'. This year CSIRO developed communities of practice across research areas and corporate functions to connect staff working across 56 sites. These communities met regularly, often using web-related technologies to discuss developments in their areas of focus. They also hold CSIRO-wide conferences and workshops.

Key organisational objectives	Summary of progress
Conducting science with impact	
Increase alignment of capability with our strategy and goals.	The science investment prioritisation for the 2010–11 direct research budgets was conducted during December 2009 – May 2010 and resulted in a number of significant shifts in investment. A smaller funding envelope resulted in reduced funding for some research Themes and put pressure on direct capability investment. Information from external Divisional and Flagship reviews was used to inform decisions on which Themes would receive reduced funding.
Increase adoption of our science for National and Global impact.	Increasing the adoption of CSIRO science is an ongoing objective. A key step is to carefully plan for impact and monitor and evaluate progress. Activities undertaken in 2009–10 towards this objective include: • Reviewing the potential use of the SAP 'Research Project Management' module to integrate our planning and monitoring processes. This work is ongoing. • The Board Commercial Committee approved an external and commercial engagement policy and guidelines. This policy provides a framework and supporting material to improve CSIRO's approach to engaging externally. The guidelines cover transactions and contract approvals, governance, delivery and capability identification and pricing.
Build enduring and meaningful partnerships across the NIS to ensure effective translation of CSIRO research into impact.	In 2009–10, we undertook to position CSIRO as a leader in climate modelling, marine research and clean/green technologies. During the year, we developed several major partnerships in these research areas. For example: • The Bureau of Metrology and CSIRO have led the ongoing development of the Australian Community Climate and Earth-System Simulator (ACCESS), which is now the accepted national platform for earth system simulation. • CSIRO continues to play a vital part in the Integrated Marine Observing System (IMOS), Marine Biodiversity Hub and the Great Barrier Reef 'eReefs' pilot project. • CSIRO has signed a Collaboration Framework Agreement with agencies in China and Japan to foster research collaboration into coal bed methane production.

Key organisational objectives	Summary of progress
Harnessing One-CSIRO	
Implement strategies to deliver zero harm in the CSIRO workplace and a carbon neutral footprint for the Organisation.	Initiatives for the creation of a zero harm safety environment and progression of the Environmental Sustainability Strategy are on track. Activities this year included: • a review of health, safety and environment (HSE) services to improve delivery • health, safety and environment training for 250 CSIRO leaders • the completion of energy, water and waste audits • the installation of an environmental data management system • the introduction of green power supply arrangements to increase green power use from 15 per cent in 2009 to 25 per cent in 2012, see page 101.
Create a consistent set of values across CSIRO which underpin a safe, innovative, responsive and collaborative working environment.	Activities to embed a values compass (see page 108), in CSIRO are on track and include the integration of the values into Human Resources management systems, such as rewards, recruitment, development and personal performance appraisals.
Deliver strategies to ensure a resilient and sustainable organisation.	Activities undertaken this year to ensure that CSIRO remains a resilient and sustainable organisation included: • implementation of planned changes to the communications and commercialisation functions to improve service delivery • a 'national footprint' project which has provided a clear picture of CSIRO's current infrastructure and partnerships across Australia and identified opportunities to establish strong capability partnerships into the future • a detailed study of CSIRO capital expenditure requirements. A Capital Management Plan will now be prepared to guide future capital expenditure allocations • the development of an improved framework for commercial engagement including standards and guidelines which are being rolled out across CSIRO.
Develop 2011–2015 Strategic Plan and approach to the 2011–2015 Quadrennium Funding Agreement (QFA)	A QFA steering committee and working group met regularly to coordinate preparation of the CSIRO Program Review, the 2011–15 Strategy and related communication and stakeholder engagement activities. The Program Review is on track for completion in September 2010 and the Strategy in the first half of 2011.

Key organisational objectives	Summary of progress
Building our people, capability and scientific excellence	
Establish an appropriate balance of investment between capability development and Portfolio delivery.	CSIRO must continue to develop and maintain high-quality research capabilities (including world-class scientists, facilities and collaborative relationships). Most capability is developed in the course of pursuing the objectives of our challenging research Themes. In addition, around 11 per cent of CSIRO research funding is directed towards direct capability funding via three mechanisms: transformational capability platforms (TCPs), Divisional capability development funds and Office of the Chief Executive Science Team. Total expenditure on direct capability investments was around eight per cent. Targets were met for the Science Team's capability development activities, but funding for Divisional capability development funds and transformational capability platforms fell below target.
Build effective workforce plans to ensure alignment of capability with strategy.	Most CSIRO Business Units (Divisions and Corporate functions) have now developed and implemented comprehensive Capability Development and Workforce Plans. These documents specifically address succession planning issues and the creation of capability development funds.
Through new leadership, increase CSIRO's focus on the development and maintenance of national facilities and collections.	During 2009–10, the major National Biological Collections, (see pages 66–74) have been managed together as a stream within CSIRO's newly formed Biodiversity portfolio. Dr Joanne Daly has been appointed to a new role, commencing early 2010–11 to establish a strategic framework and sustainable investment model for managing the collections.

Program 1– National Research Flagships

The National Research Flagships program addresses major national challenges and opportunities through large-scale multidisciplinary research partnerships. One of the largest research endeavours ever undertaken in Australia, Flagships extend traditional models of science to deliver scientific solutions to advance Australia's most pressing national objectives.

Recognising that complex challenges requires collaboration of the best and brightest researchers, the Flagships form partnerships with Australian Universities and publicly funded research institutions, the private sector and selected international organisations.

Flagships target clearly defined goals, framed from a deep analysis of the needs of people and enterprises. Flagships operate on a large-scale and long timeframes and have a strong focus on adoption and impact. Ten Flagships were operational in 2009–10.

The work and achievements of each Flagship is showcased on pages 20–39.

Flagship	Launched	Page
Climate Adaptation Flagship	July 2008	20
Energy Transformed Flagship	October 2003	22
Food Futures Flagship	March 2004	24
Future Manufacturing Flagship	September 2009	26
Light Metals Flagship	June 2003	28
Minerals Down Under Flagship	May 2008	30
Preventative Health Flagship	September 2003	32
Sustainable Agriculture Flagship	February 2010	34
Water for a Healthy Country Flagship	May 2004	36
Wealth from Oceans Flagship	August 2004	38

National Research Flagships: Key Performance Indicators (KPIs)

The following pages provide a report on the key performance indicators set for the National Research Flagships Program in the Portfolio Budget Statements.

KPI 1 – Evidence of growing economic, social, environmental and intangible benefits through demonstrated adoption of Flagship outputs.

KPI 2 – Maintain or increase the number of publications.

KPI 3 – Maintain or increase financial support by Flagship partners.

KPI 4 – Maintain customer satisfaction.

KPI 5 – Investment of the Flagship collaboration funds as per agreed guidelines.

Improve your health with CSIRO's new barley

After nearly 12 years of research, CSIRO has produced BARLEYmax™ – a natural wholegrain developed specifically to provide enhanced nutritional benefits for Australians.

In the late 1990s, CSIRO researchers developed a diverse collection of new barley variants in a project originally aimed at understanding the role of plant hormones.

The potential of this collection, together with CSIRO's research on understanding the genetic pathways of starch biosynthesis to create new barley types, was recognised and barleys with diverse starches and other dietary fibre components were identified. From this work came *BARLEYmax* – a grain with high levels of resistant starch and the potential to improve health.

Under the Food Futures National Research Flagship, an extensive program of experimental studies and human trials found a range of foods with *BARLEYmax* as their key ingredient had a low glycemic index and produced positive changes in a range of biomarkers of bowel health.

With twice the dietary fibre of current grains, four times the resistant starch and a low glycemic index, *BARLEYmax* offers many potential health benefits for the consumer. It also improves texture and enhances flavour with a pleasant 'nutty' taste distinguishing it from other grains.

BARLEYmax grains are having impact along the value chain (by providing speciality grains on farm that command premium prices, providing new opportunities in food product manufacturing, and delivering potential health impact for consumers) and have the potential to add significant value to the Australian economy, well in excess of $100 million per annum.

Two *BARLEYmax* breakfast cereals, developed by an Australian food manufacturer, are now available on supermarket shelves across Australia and a range of additional products is planned.

BARLEYmax is low GI and has twice the dietary fibre and four times the resistant starch of current grains. Credit: Carl Davies

'*BARLEYmax* offers many potential health benefits for the consumer.'

KPI 1 – Evidence of growing economic, social, environmental and intangible benefits through demonstrated adoption of Flagship outputs.

A variety of methods are used to demonstrate the adoption and impact of CSIRO's products and services including user surveys, economic analysis and testimonials. Benefits may be economic, social or environmental and may or may not be expressed in dollar terms.

Independent evaluations of a small sample of CSIRO activities concluded with high confidence that CSIRO is delivering high-value for money. This value consists of a mix of benefits already flowing and a substantially richer set of forward opportunities for Australia to deal better with major risks and opportunities.

In 2010, CSIRO contracted ACIL Tasman to undertake an independent evaluation of the impact and value of CSIRO's activities. ACIL Tasman undertook an impact assessment of 12 case studies. The case studies are broadly representative of the range of activities undertaken by CSIRO in fulfilling its major roles. ACIL Tasman found that:

- CSIRO is delivering high-value for money. This value consists of a mix of benefits already flowing – through commercialisation arrangements, improved Australian industry competitiveness and more soundly-based policy development and Government investment – and a substantially richer set of forward opportunities for Australia to deal better with major risks and opportunities.
- CSIRO has beneficially changed the structure of Australia's innovation capabilities, as well as adding to the scale and scope of research and development efforts. CSIRO's involvement has allowed for greater concentration of multidisciplinary skills on important challenges for Australia.
- CSIRO has extracted high-value from years of capability development – while adding capability for future innovation.
- Focusing on activity and resultant outcomes over the last few years, where the level of investment in CSIRO has been around $5 billion (about two-thirds of this direct Government funding), the value of the outcomes and impacts has almost certainly been of the order of several tens of billions of dollars, with substantial upside potential.

Specific case study and vignette impacts and inferred values that underpin ACIL Tasman's estimates are given in the Table 2.3. More detailed treatments of the following case studies are included throughout this report:

- Resistant starch grains (Barley*max*™) – page 13
- Climate change adaptation – page 75
- Murray-Darling Basin research – page 85
- Prawn breeding – page 89

Table 2.3: Impact assessment case studies

Case study	Explanation
Climate Adaptation Flagship	High-value from reduced costs of dealing with climate pressures, and increased insurance against limited international mitigation response. Conservative value of $2 billion plus.
Prawn breeding and novel feed supplementation	Value of increases delivered in prawn yield of $430 million plus options to extend to other species. Royalty streams and export potential from the feeds; possible contribution to wild fish stock conservation values.
Cement substitutes and novel products	Plausible royalty streams of tens to hundreds of millions of dollars on competitive niche products underwriting the risks in pursuing a major opportunity for low-cost reduction in carbon dioxide emissions from cement production, in Australia and globally.
Murray-Darling Basin Sustainable Yields Project	Conservative estimate of $2.8 billion linked to more efficient deployment of the investment of funds already committed to buyback and water infrastructure efficiencies.
Resistant starch grains	Improved health outcomes for Australia from products already entering markets, plus expansion of Australian agriculture into grains that can command price premiums. Very conservative value estimate of $100 million, plausibly several times as much.
Titanium within Light Metals	With commercial partnerships in place, opportunities for TiRO and product fabrication suggests significant strengthening above an earlier ACIL Tasman assessment value of $275 million plus.
The UltraBattery	Commercialisation in place for automotive and stationary applications will support returns to CSIRO, with plausible revenue streams valued at tens of millions of dollars. More speculative, but potentially very high-value, via accelerated moves to lower emission vehicles and more effective use of renewables.
Agricultural Production System sIMulator (APSIM) and other agricultural production decision support systems	Immediate value through use by researchers to identify key risks, and ways of managing them and communicating these results to farmers. High potential for flow-on economic, social and environmental benefits.
Mapping undersea mineral deposits	Immediate cultural and policy value and longer term potentially high-value in supporting commercial off-shore exploration.
Biochar	CSIRO adding to a field now receiving substantial attention. Plausible role for biochar as a substantial contributor to lower cost abatement, given its complementarity with several aspects of farm production and with steel production, with potential value of many billions of dollars under a carbon target policy.

Case study	Explanation
Cross-CSIRO climate work	Currently the subject of an active proposal for a major coordinated program of activities that could deliver very high-value, but this value has not been explicitly quantified. Examined as an example of options for future evolution of the CSIRO portfolio, in this case covering adaptation, mitigation and forecasting.
Radio astronomy and the Square Kilometre Array (SKA)	High-value for Australia if wanting to participate in big science projects in a cost-effective way. This is a project where Australia appears competitive as a site for locating the international facility, with potentially large value in overseas contributions to remote area infrastructure, plus on-going employment. Net tangible value likely in excess of $150 million, in addition to the value of the science.

Source: ACIL Tasman (2010) Assessing the impact and value of CSIRO

KPI 2 – Maintain or increase the number of publications

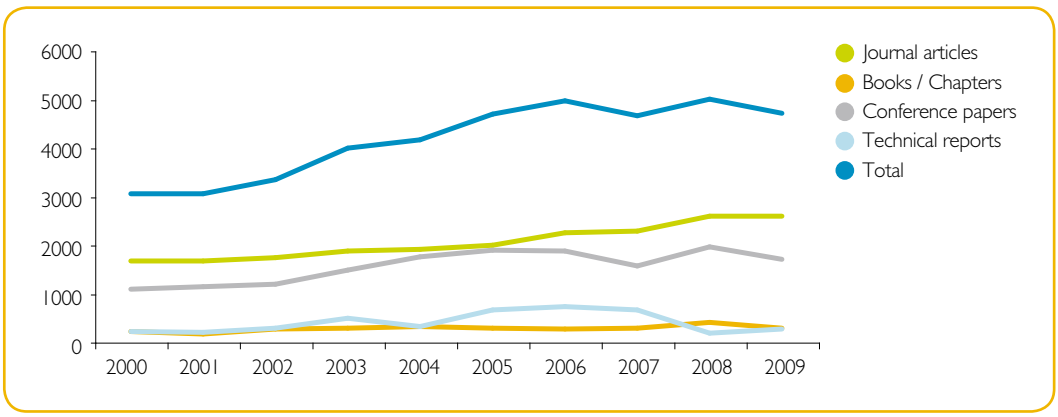
Where publications are defined as journal articles, books, book chapters, conference papers and technical reports.

The number of publications produced by CSIRO trended upward from 2000 to 2006. Since that time, journal articles have continued to increase while other categories of publications have been more variable year on year.

Figure 2.2 shows the trend in publication numbers for Program 1 and Program 2 combined. Roll out of a new electronic publications repository, 'e-Publish', began in 2009–10. When fully functional, e-Publish will enable publication numbers for each Program to be separately identified. Publication data for the last five years are provided in Appendix 6 (see page 190), which also includes data on the production of patents and other forms of intellectual property over the same period.

CSIRO's journal publication count represents 5.4 per cent of Australian scientific publications (down from 5.7 per cent in 2008–09 and 6.0 per cent in 2007–08). CSIRO is the eighth ranked Australian institution (in terms of publications) and its world ranking is 218 of 4,122 institutions (204 of 3,974 in 2008–09).

Figure 2.2: Number of publications by type



The total number of publications by CSIRO authors in leading journals *Nature*, *Nature* affiliates (e.g. *Nature Biotechnology, Nature Genetics*), *Science,* and *Proceedings of the National Academy of Sciences USA* for the past six years has remained relatively constant at around 20.

CSIRO's joint publications have increased over the past five years, both nationally and internationally. Joint publications with Australian universities have increased, from 478 publications in 2005 to 790 publications in 2009. Joint publications with our major international collaborators increased from 675 publications in 2005 to 1,156 in 2009.

KPI 3 – Maintain or increase financial support by Flagship partners

Amount of external revenue received by Flagships in real terms (constant 2008–09 $million)

Flagship partners continue to increase their financial support to National Research Flagships see Figure 2.3. Financial support increased by 33 per cent between 2008–09 and 2009–10.

CSIRO's total investment in the National Research Flagships is around $550 million. Of this, 31 per cent is from external partners. In contrast, in 2003–04 external revenue to Flagships accounted for seven per cent of total revenue.

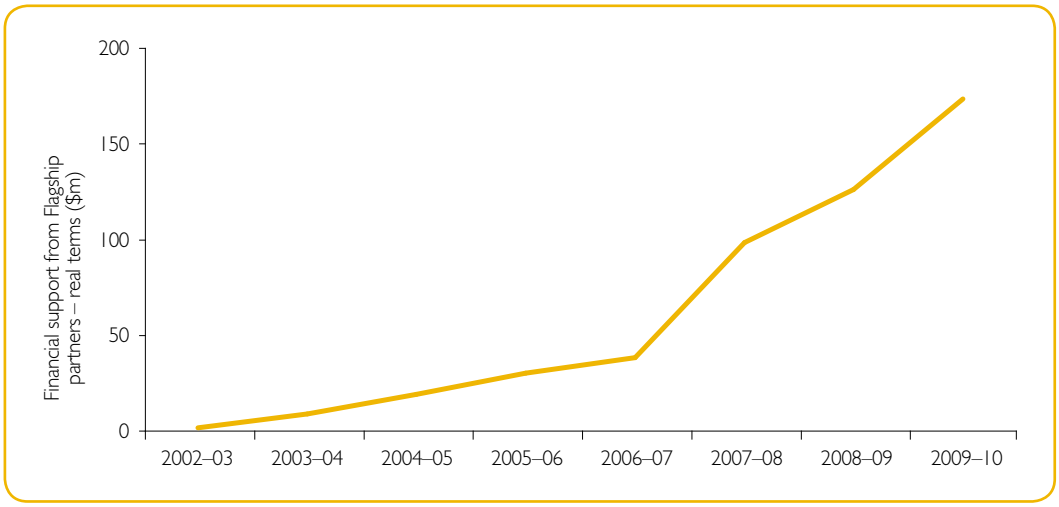
KPI 4 – Maintain customer satisfaction

Improve customer feedback based on customer value survey and qualitative feedback through client and stakeholder interviews.

Customers and stakeholders are satisfied with the professionalism and quality of CSIRO work. Areas for improvement include stakeholder communication and relationship management with partners.

Customer satisfaction, for Program 1 and Program 2 combined, has been determined through client and stakeholder interviews conducted by CSIRO senior executives who had no existing relationship with the client. Key findings of the interviews are:

Figure 2.3: Financial support from Flagship partners



- The feedback from clients and partners has been positive about the interview process and the willingness of CSIRO to listen and engage.
- At senior executive levels, relationships are positive and either stable or improving.
- The level of business with partners could grow.
- Engagement with partners should be more consistent and coordinated.
- Senior executive level strategic dialogue with their counterparts is important.

Additionally, in 2009–10 interviews were undertaken by an independent company with senior CSIRO stakeholders within the Australian Government, industry, peak body and university sectors. The key findings were that stakeholders rated CSIRO's professionalism and quality of work highly and rated their understanding of CSIRO's strategic direction as fair.

Over the past few years CSIRO has been carefully considering feedback to identify key areas of improvement in terms of how it engages externally. This has resulted in a number of improvements including more streamlined contracting, legal and approval processes. More recently the Board Commercial Committee approved a new external and commercial engagement policy and supporting guidelines which is currently in the process of being implemented. This policy puts in place a framework and supporting material in relation to transactions and contract approvals, governance, delivery and capability identification, and pricing.

CSIRO has recently initiated an external review to help identify the future operating model for relationship management and Business Development at CSIRO, and to map out the resources and changes required.

KPI 5 – Investment of the Flagship Collaboration Funds as per agreed guidelines

Investment of Flagship Collaboration Funds in 2009–10 was consistent with the agreed guidelines.

Collaboration is a key principle of the Flagship initiative. To develop collaborative partnerships, the Australian Government allocated $114.5 million over seven years to a Flagship Collaboration Fund. The Flagship Collaboration Fund includes a contestable collaborative research program (which offers funding for Flagship clusters and projects), visiting fellowships and postgraduate scholarships. For more information see: www.csiro.au/org/FlagshipCollaborationFundOverview.html

At the end of 2009–10, around $56 million has been disbursed from the Flagship Collaboration Fund. Overall, 84 per cent of the initial $114 million has been committed to scholarships, fellowships, projects and clusters.

In 2009–10, four new clusters involving 16 national and international universities and industry partners were approved for funding. See Appendix 1, (page 176) for a full list of Flagship Collaboration Clusters.

Additionally, a review of the Flagship Collaboration Fund was undertaken in 2010. Results are given on page 103.

External, expert reviews

To maximise the likelihood of achieving the planned outputs and outcomes of the National Research Flagships Program, CSIRO has instituted a program of Flagship reviews by external, expert review committees. This rigorous and independent process involves a review of each National Research Flagship,

three to four years after it is established, by independent experts, from both Australia and overseas. The reviews are prospective and output and outcome oriented. Results of the reviews are considered and responded to by senior research leaders and implementation of each Flagship's response to the recommendations is monitored by the CSIRO Executive.

Five Flagships were reviewed in 2009–10: Food Futures, Light Metals, Minerals Down Under, Preventative Health and Water for a Healthy Country.

The overall findings of review panels were positive and there were a number of common findings. All review panels found that Flagships were successful in bringing together multidisciplinary teams of expert researchers to achieve the goals of Flagship research Themes. The scientific work was generally of a high standard and panels commented frequently on the Flagship's world-leading quality.

For all Flagships external collaborators and stakeholders were extremely positive about their interactions with Flagships. The operation of Flagship Collaboration Fund programs (see pages 176–178), involving capability teams in universities and elsewhere, was a strong point. In those cases where a Flagship research Theme had progressed along the development path in collaboration with industry, even to the first commercial activities, there were positive statements from review panels about the need for Flagships and their special role in delivery of outcomes from discoveries.

However, review panels also commented on the need for CSIRO to better balance the shorter term emphasis on delivery of outcomes and the longer term continuing development of research capabilities of the highest quality.

Climate Adaptation Flagship

Flagship goal:

To equip Australia with practical and effective adaptation options to climate change and variability and in doing so create $3 billion per annum in net benefits by 2030.

Research expenditure 2009–10: $42.8 million

Overview

Research by the Climate Adaptation Flagship ensures Australia can effectively adapt to the impacts of climate change and variability. CSIRO's leading scientists are working in partnership with governments, industries and communities to address this urgent national challenge. The Flagship is developing regional and national scale climate change projections and vulnerability assessments to support adaptation.

The Flagship is addressing urban coastal vulnerability in settlements by creating design, infrastructure and management solutions to enhance adaptive capacity. We are developing conservation strategies to maximise resilience in marine and terrestrial ecosystems and effective adaptation options for Australia's primary industries and rural regions. We also support the information needs of our neighbours in the Asia–Pacific in their efforts to adapt to climate change.

Achievements 2009–10

Climate Adaptation Futures International Conference

The first major international conference to focus solely on climate impacts and adaptation was held in Australia, co-hosted by the Climate Adaptation Flagship and the National Climate Change Adaptation Research Facility. Over 1,000 scientists and decision-makers showcased practical examples of government, industry and the community working with science to make decisions in the face of uncertainty about climate change impacts.

Practical climate adaptation for Australian primary industries

More than 30 authors contributed to *Adapting Agriculture to Climate Change: Preparing Australian Agriculture, Forestry and Fisheries for the Future*. Already in its second printing, the book is proving to be an invaluable resource to Australian primary industries. It describes the consequences of climate change in eleven sectors and outlines practical actions to adapt to the impacts and harness the opportunities from a changing climate.

Improving climate change projections for Indonesia

CSIRO and the Indonesian Bureau of Meteorology have converted broad-scale climate change projections for south-east Asia into local-scale regional information. This assists Indonesian agencies to make better informed decisions about how to respond to potential impacts from climate changes.

Integrated assessments for south-east Queensland

Flagship scientists are developing new climate change projections and adaptation response scenarios through the South East Queensland Climate Adaptation Research Initiative. Bringing together key local research partners and stakeholders, the initiative has modelled how local energy demand is impacted by climate, and conducted first-pass vulnerability studies on human health, biodiversity, flooding and coastal hazards.

East Lake urban edge

CSIRO and the Australian Capital Territory government completed a detailed study that included climate impacts for wetlands at the urban edge. Based on the interface between an urban development area and the conservation value of the Jerrabomberra Wetlands Nature Reserve, the project developed a set of guiding principles and design considerations useful for other wetlands in urban renewal areas.

Adapting today's management for tomorrow's weeds

CSIRO has applied climate projections for the South Australian Department of Water, Land and Biodiversity Conservation to examine how weeds may shift in range across the State up to 2080. The project provided detailed profiles for 13 weed species and identified options to adapt management strategies to tackle emerging weed challenges.

Climate Adaptation Flagship Roadmap

	Short term 1–3 years		Medium term 4–9 years	Long term 10+ years
Pathways to adaptation	Define new approaches to vulnerability and adaptation assessments.	Adaptive capacity of communities and industries assessed; innovative approaches to climate projections.	Identify social and economic adaptation outcomes within different sectors and regions.	Biophysical, social and institutional dimensions of adaptive capacity more effective for Australia.
Sustainable cities and coasts	Development of methods to assess climate risk and vulnerability in cities and coasts, and community adaptive capacity and governance.		Flexible models of utilities, social sciences and governance for climate adapted urban planning and management.	Planning, design, infrastructure, management and governance solutions for Australia's cities and coasts responding to climate change.
Managing species and natural ecosystems	Studies of regions, single species and simple species interactions.	Greater model realism. Focus on threats and tools to assist natural resource managers.	Complex studies of biotic interactions and community ecology. Refine tools for ecosystem managers.	Deliver adaptation options to protect Australia's marine and terrestrial species and ecosystems from the impacts of climate change.
Adaptive primary industries, enterprises and communities	Improve analysis of interaction between climate drivers and management responses on farms.	Develop technologies and practices for local industry adaptation.	Shifts in vulnerability to climate change understood. Identify when transformational options may be needed.	Adaptation strategies provide economic benefit and improved livelihoods for primary industries, enterprises and communities.

Current Position

Energy Transformed Flagship

Flagship goal:

To halve greenhouse gas emissions and double the efficiency of the nation's new energy generation, supply and end use.

Research expenditure 2009–10: $35.1 million

Overview

Much of Australia's continuing growth and way of life is underpinned by access to affordable, secure and sustainable energy sources for electricity and transport. These two sectors combined, however, contribute 69 per cent of Australia's greenhouse gas emissions.

To secure Australia's environmental, economic and social wellbeing, it is imperative that we move quickly to identify pathways and solutions that will help reduce greenhouse gas emissions and improve energy security. This objective can only be achieved in close collaboration with industry, research organisations and government. The Energy Transformed Flagship, since its inception, has been a catalyst for this broad collaboration.

In 2009–10, the Flagship underwent a restructure, including the appointment of a new Director, Dr Alex Wonhas. The restructure focused the Flagship on renewable and alternate energy systems.

Achievements 2009–10

Australian zero emission house launched

Australia's Zero Emission House designed to fit the lifestyle, climate and budget of a typical middle income family, showcases off-the-shelf building and renewable energy generation technologies, and 'smart' energy management technologies.

Energy use in buildings is responsible for 26 per cent of Australia's greenhouse gas emissions – half of these emissions are from the residential housing sector. If all the new houses built in Australia between 2011 and 2020 were zero emission houses, 62 million tonnes of greenhouse gas emissions would be saved. The house was designed and built with partners Henley Property Group, Sustainability Victoria, and Delfin Lend Lease (see: www.csiro.au/science/Australian-Zero-Emission-House.html).

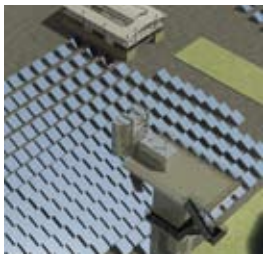
UltraBattery: no ordinary battery

CSIRO's UltraBattery is a cost-effective, longer lasting, efficient alternative to traditional batteries for hybrid electric vehicles and renewable energy storage.

In August 2009, the US Government granted East Penn Manufacturing, licensee of the technology in North America and Canada, US$32.5 million to accelerate the development of the battery for automotive use.

With regard to the UltraBattery's renewable energy storage applications, East Penn bought CSIRO start-up company Ecoult. As part of the agreement, CSIRO will receive royalties from the sale of UltraBattery products. (see: www.csiro.au/science/Ultra-Battery.html).

New solar tower and research facility under construction



In 2010, construction began on a new solar tower and research facility at CSIRO's National Solar Energy Centre in Newcastle, New South Wales. The new solar thermal field will pave the way for solar power of the future – solar power that only requires the sun and air to create electricity. Unlike most solar thermal power stations, CSIRO's Solar Brayton technology does not need water. This technology is therefore suited to many parts of Australia, and the world, which receive minimal rainfall (see: www.csiro.au/science/Solar-Brayton-Cycle.html).

Intelligent grid report into distributed energy

The Intelligent Grid report was the culmination of a three year research program examining the social, technological, environmental and economic value of distributed energy use in Australia. Distributed energy is a term that describes technologies and systems which provide local generation of electrical power (distributed generation), energy efficiency and management of when and how energy is used (demand management).

The ground-breaking report found the value of wide-scale deployment of distributed energy solutions could be as much as $130 billion by 2050 and that water usage associated with energy generation could be reduced by up to 75 per cent (see: www.csiro.au/resources/IG-report.html).

Energy Transformed Flagship Roadmap

	Short term 1–3 years	Medium term 4–9 years	Long term 10+ years
Carbon Futures	Develop models and reports to inform policy, industry and research; Undertake social attitude mapping; Hold a stakeholder energy forum.	Hold transport sector stakeholder forums; Undertake longitudinal and larger population social analysis studies; Commercialise software; Initiate integrated carbon assessment service.	Move to a low-carbon future by providing the tools and data to understand the technical and economic challenges for the stationary and energy sectors to 2020.
Sustainable Stationary Energy and Transport	Develop technologies for low-cost solar power production and energy storage. Prioritise potential fuel crops for large-scale, sustainable biofuels production.	Demonstrate significant technologies at pilot scale, with industry and government support.	Drive the cost-effective take-up of renewable electricity and transport fuels in Australia to 2020 and beyond and maximise the long-term renewables uptake to 2050.
Local Energy Systems	Develop low-emission distributed energy technologies. Identify and begin engagement with partners.	Develop distributed generation and efficiency options model to inform government and industry. Commercialise technologies.	Reduce greenhouse gas emissions by driving the uptake of distributed energy solutions, demand reduction and energy efficiency measures to 2020.

Current Position

Energy Transformed was restructured in July 2009 which resulted in a reduction and change of themes from four to three.

Food Futures Flagship

Flagship goal:

To transform the international competitiveness of the Australian agrifood sector, adding $3 billion annually, by applying frontier technologies to high potential industries.

Research expenditure 2009–10: $37.2 million

Overview

The Food Futures Flagship is working towards its goal by utilising a unique mix of CSIRO's in-house science capability, coupled with specialist input from strategically selected external partners and collaborators.

The Flagship is working along the value chain all the way from the farm to the consumer. It is achieving impact through the application of classical and molecular based breeding technologies to deliver new high-yielding and value-added grain, livestock and aquaculture species to farmers and the food industry. Consumers are benefiting through a supply of high-quality food products containing healthier food ingredients.

The Flagship's research teams form collaborative partnerships across CSIRO and with other research organisations and industry, to develop innovative technologies that will enhance existing agrifood industries and create new opportunities for Australia.

Achievements 2009–10

BARLEYmax™ launched

Breakfast cereals containing the BARLEYmax™ grain were launched into major supermarkets across Australia in August 2009. The *BARLEYmax* technology has been licensed for grain production to Austgrains Pty Ltd and for breakfast cereal manufacture to Popina Food Services. *BARLEYmax* contains twice the dietary fibre and four times the resistant starch of competitor grains and improves bowel and metabolic health (see case study page 13).

Prawn yields more than doubled

Ongoing research with elite stocks of selectively bred Black Tiger prawns has resulted in a step change in commercial performance and the generation of world record harvests. At one 50 hectare Gold Coast farm, the average pond harvest in 2010 was over 17 tonnes per hectare – more than double the best yield achieved anywhere in the world for farmed Black Tiger prawns (see case study page 89).

Cybernose® advances

Several major advances have been made towards delivering the *Cybernose*® – a device that can accurately detect and identify specific odours by combining the chemosensing ability of insects, such as the silkworm moth, with advanced engineering. The Flagship has developed ways of making

sensor proteins 'on demand' and can signal to an optoelectronic instrument when a specific chemical is detected. Sensitivity is approximately 1,000 times better than competing technologies.

Reducing salt and sugar

Two technologies have been developed that will allow sauce and soup manufacturers to reduce salt and sugar by up to 30 per cent without affecting the quality or taste of the final product. This research program is designed to significantly reduce salt and sugar levels to meet consumer demand and regulatory requirements, while still maintaining ingredient functionality and sensory quality.

Aquaculture feed from plant waste

Continued work with the novel aquafeed ingredient *Novacq*™, derived from low-value plant waste, has demonstrated a 50 per cent improved growth rate in farmed prawns compared with conventional fishmeal-based aquaculture feed products. This will dramatically improve returns to Australian prawn farmers and underpin the development of a new aquafeed ingredient production industry in Australia.

Crop yields increased

Research involving the genes that control starch development in cereal grains has led to the discovery of a novel way to increase grain yield and plant size in wheat crops. Reducing the expression of the glucan water dikinase gene in wheat, using CSIRO's RNAi technology, caused an unexpected beneficial change in plant growth and development. This work is now undergoing field trials and has major potential for increasing crop yield and improving sustainability.

Food Futures Flagship Roadmap

	Short term 1–3 years	Medium term 4–9 years	Long term 10+ years
Future grains	Optimise carbohydrate in grains, optimise omega-3 oils in plants and investigate genetic traits for improved quality and nutrition.	Combine beneficial traits for farmers and consumers, breed and commercialise long chain omega-3 oils in plants, and commercialise quality and nutrition traits.	Increase returns to Australia by $550 million per annum through enhanced grain quality attributes and human health benefits.
Breed engineering	Animal management systems adopted and breeding technology developed with commercial partners.	Industry adoption of testes cell transfer techniques, success of aquatic breeds and novel feeds and optimal genetics in livestock and aquaculture.	Boost the value of Australia's animal-based food industries by $350 million per annum for beef and $550 million per annum for seafood.
Designed food and biomaterials	Low fat foods, bioactives and separations achieved, biopolymer formulation rules created and naturally structured foods developed.	Design rules for new biomaterials and processing, healthier low-energy foods designed and commercialised.	Design healthier foods and reduce food production waste, increasing the value of Australian agrifood industry by $700 million per annum.
Quality biosensors	Development of test technology, odours predicting grape and wine quality identified.	Biosensor developed and adoption commenced in defence domain. Applications for food safety and quality in development. Flavour potential of wine grapes optimised.	Develop biosensor and improve current technology to optimise flavour in food and beverage value chain, adding $750 million per annum.

Current Position

Future Manufacturing Flagship

Flagship goal:

To provide transformational innovation for the Australian manufacturing industry, enabling outcomes that will ensure global competitiveness, enhance the manufacturing value chain and deliver high-value, export-oriented, environmentally sustainable products and services.

Research expenditure 2009–10: $32.6 million

Overview

CSIRO's Future Manufacturing Flagship will provide innovative technologies and materials to grow new manufacturing businesses, renew existing industries and help the Australian manufacturing sector address major national challenges such as energy, health, climate and waste.

The Australian manufacturing industry operates in a highly competitive global marketplace, with increasing competition from low-cost producers, global sourcing, fewer supply chains and the emergence of low-cost base economies, such as global manufacturing centres.

To address these challenges the Flagship, working with industry partners, is focusing on emerging manufacturing opportunities in flexible electronics, cleantech manufacturing and biomedical manufacturing. The Flagship is adopting an holistic approach that encompasses innovation together with market integration, to streamline the innovation pathway for Australian manufacturing, crucial to improving future competitiveness. Such an approach will support new, high technology green jobs of the future.

Achievements 2009–10

World record efficiency for organic solar cells

The Flagship, along with international partners in the Victorian Organic Solar Cell Consortium, have achieved world leading results for a new class of dyes used to develop thin film, solid-state, dye-sensitised solar cells. Researchers have achieved an energy conversion efficiency of 5.8 per cent which is an improvement of 14 per cent on previously reported results. Flexible organic solar cells are much cheaper and more efficient to produce. The technology has the potential to replace silicon in the next generation of solar collectors, enabling opportunities for new printing industries based on flexible electronics.

New lightweight concrete reduces greenhouse gases

Flagship scientists have developed a new lightweight, environmentally friendly geopolymer concrete material that will substantially reduce greenhouse gas emissions. For every 1,000-kilogram of manufactured concrete, geopolymer concrete uses 27 per cent less embodied energy, produces 50 per cent less carbon emissions and lessens the impact on the environment by 22 per cent compared to an equivalent Portland cement product. Geopolymer products are lightweight, fire-, blast- and acid-resistant, they are extremely strong and can also be used as an adhesive. Future development will see geopolymers applied to a wide range of cement products and applications.

New device helps diagnose colon disorders

Working closely with clinical research colleagues at the University of New South Wales and the St George Hospital in Sydney, the Flagship has developed a new device for the investigation of colon disorders such as chronic constipation. Based on optical fibre sensors, this new device provides significantly more information than previous technologies and promises to unravel the abnormalities that underpin the condition. Constipation is estimated to cost the global health system well in excess of US$7 billion per year, so potentially there are significant savings in overall health care by using this device. The project received the 2009 St George Hospital Clinical Research Project of the Year award.

Future Manufacturing Flagship Roadmap

	Short term 1–3 years	Medium term 4–9 years	Long term 10+ years
Biomedical manufacturing	Identify key market prospects for Australian biomedical manufacturing industry. Develop platform technologies.	Products gain appropriate regulatory approval and enter market.	Growth in the Australian biomedical manufacturing sector.
Cleantech manufacturing	Identify technologies for economically and environmentally sustainable construction materials and processes.	Deploy new platform technologies in partnership with industry.	Sustainable environmentally-conscious manufacturing in Australia.
Flexible electronics	New materials discovery. Device prototype optimisation and ruggedisation and scale-up.	Translate discoveries to create vibrant manufacturing industries based on flexible electronics.	Creation and growth of world-leading Australian companies in flexible electronics.

Current Position

The Future Manufacturing Flagship research portfolio was reduced from four Themes to three due to the transfer of the Nanosafety Theme to CSIRO's Advanced Materials Transformational Capability Platform in December 2009.

Light Metals Flagship

Flagship goal:

To lead a global revolution in light metals, doubling export income and generating significant new industries for Australia by the 2020s while reducing environmental impact.

Research expenditure 2009–10: $34.9 million

Overview

The Light Metals Flagship is exploring new ways to produce alumina, aluminium, magnesium and titanium, and the products made from them, so that manufacturers can reduce costs and greenhouse gas emissions and improve performance. The Flagship aims to make Australia the world leader in sustainable light metals production and manufacturing.

To do this, the Flagship relies on collaboration with industry and other research organisations, both in Australia and overseas. We work with associations such as AMIRA (an independent association of minerals companies), the Alumina Technical Panel, the Aluminium Association of Australia, the Australian and North American Die Casting Associations, and the International Titanium Association, as well as delivering leading light metals research through Cooperative Research Centres (CRCs).

The Flagship faces significant challenges in developing titanium and magnesium metal production industries for Australia. The globalised management of resource companies means that, increasingly, decisions on technology uptake and implementation are made outside Australia, and are subject to global economic constraints. To ensure that our technologies benefit Australia we need to present their advantages to a global audience.

Achievements 2009–10

Clearing the air

Sophisticated atmospheric chemistry measurements and meteorological modelling by CSIRO scientists helped resolve air quality concerns for a rural community in Western Australia. Working with the Western Australian Environment Protection Authority and the Wagerup Alumina refinery, CSIRO clarified the relationship between highly localised odour events, atmospheric conditions and refinery emission plumes, and helped the company to identify ways to reduce and avoid odour events.

Sustaining Australia's alumina exports

CSIRO research to improve the yield and quality of alumina particles, delivered through AMIRA, has provided potential annual savings of $150 million to the Australian alumina industry. Collectively the technologies offer a four per cent increase in asset utilisation. Process improvements from CSIRO help the Australian industry maintain its global position as the world's second biggest producer of alumina, and support annual export earnings of between $6–7 billion dollars.

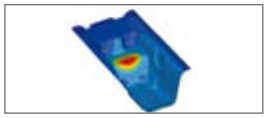
Reducing the cost of aluminium car parts

Nissan Casting Australia Pty Ltd (NCAP), Australia's largest exporter of aluminium automotive castings, is using CSIRO's CASTvac™ technology to improve productivity. CASTvac™ helps reduce costs associated with maintaining casting moulds (dies) and has been a significant contributor in NCAP maintaining its position as a major global car part supplier. CASTvac™ was developed by CSIRO in collaboration with the CAST CRC.

Titanium pipe plant for Australia

Frontline Australasia, a Victorian supplier to the automotive, aircraft and defence industries, has signed an agreement with CSIRO to establish a pilot plant for direct manufacturing of continuous seamless titanium pipe using cold spray. Assisted by an AusIndustry Climate Ready grant, Frontline and CSIRO scientists are further developing this application of cold spray technology. The pilot plant is expected to be the first Australian facility for fabrication of high integrity titanium items.

Safer mould shape eliminates hot splashes



CSIRO researchers have devised a safer, longer-lasting aluminium ingot mould design for Tomago Aluminium. The new design reduces ingot solidification time, improves mould life, and prevents boiling coolant water splashing onto molten aluminium in newly filled moulds.

Light Metals Flagship Roadmap

	Short term 1–3 years	Medium term 4–9 years	Long term 10+ years
Alumina	Develop more efficient and environmentally friendly production processes which support the existing alumina industry.	Scale-up of commercialisation of alternatives.	Building on Australia's bauxite resources to grow the share of global alumina production to 50%.
Aluminium production	Determine options for alternative paradigms. Identify response plans to reduce greenhouse emissions.	Develop more efficient cells and/or alternative production methods.	Reduce the global greenhouse impact (CO_2 equiv.) by 30% whilst improving cost-effectiveness.
Magnesium production	Improve electrolytic technology to enable a competitive smelter. Determine options for alternative paradigms.	Develop more asset efficient cells and/or alternative production methods.	Growth of a lowest cost quartile Australian Magnesium Industry to 20 kilotonnes per annum.
Aluminium and magnesium manufacturing	Develop processes and alloys for new cast and fabricated products.	Integrate process performance and alloy properties to reduce cost and weight.	Technologies that support internationally competitive semi-finished product and component industries in Australia.
Titanium	Define and trial pathways for reducing the cost of Ti production by 50%. Establish novel methods of fabrication and applications to enhance downstream industry.	Scale-up successful technologies. Complete integrated Ti plant.	Creation of a world scale (20kt pa) titanium industry, based on continuous processing and integrated with downstream manufacturing, in Australia.

Current Position

The 200 kilotonnes per annum goal for magnesium production has been revised to 20 kilotonnes in recognition of the changed industry outlook since Flagship inception. This is aligned with the outcomes of the 2009 external review of the Flagship.

Minerals Down Under Flagship

Flagship goal:

To assist the Australian minerals industry exploit new resources with an in-situ value of $1 trillion by the year 2030, and to more than double the size of the associated services and technology sector to $10 billion a year by 2015.

Research expenditure 2009–10: $77.5 million

Overview

The Minerals Down Under National Research Flagship focuses on technical challenges facing Australia's minerals industry.

This industry is central to the Australian economy, supplying raw materials, mining technologies and services around the world. However, Australia is facing mounting global competition while new deposits are not being found fast enough to replace those being extracted. Many of Australia's deposits are experiencing declining grades resulting in increased production costs, increased handling of ores with higher levels of impurities and increasing environmental pressure.

Working with numerous industry and research collaborators, the Flagship is helping to transform the economic and environmental performance of the Australian minerals industry through new concepts and technologies.

Achievements 2009–10

New technology for sustainable processing of slags

CSIRO researchers have developed a new method for treating slag, a waste residue from iron and steel making. The process could help the cement, iron and steel industries develop sustainable practices and derive value from waste. It could potentially reduce Australia's greenhouse gas emissions by about 1.8 million tonnes and save up to three billion litres of water each year.

Mineral maps of Australia

One of the Flagship's goals to enhance exploration effort is a new suite of publicly available 2D and 3D mineral maps of the Australian continent. This goal is now achievable with the development of new satellite, airborne and drill core logging hyperspectral technologies and related geoscience information processing and delivery systems.

Automated mining

In collaboration with industry, CSIRO is developing automated systems and telerobotic technologies to operate facilities at remote sites from one central location. Other developments include hard rock cutting, mine slope design global standards and automated mapping. These technologies offer improved safety, greater efficiency and increased productivity.

Automated analysis of minerals in iron ore

A new optical analysis system to automate identification of minerals and textures in iron ore. recognises minerals and ore textures based on colour and reflectance, hardness, porosity and mineral associations. The system removes the subjectivity associated with manual classification.

Recovering gold

CSIRO has developed a non-cyanide leaching and recovery process for some gold ores based on thiosulfate, and is assisting a major gold company to evaluate it. If successful, this will be the world's first demonstration of a thiosulfate leaching and resin in pulp process for recovering gold.

New analyser cuts complexity

Two x-ray based technologies have been combined to develop a new on-line analyser with nearly half the cost and complexity of using both. It combines the best of X-ray diffraction (XRD) and X-ray fluorescence (XRF), and can measure different elements and minerals, suiting it to a wide range of applications and industries.

Minerals Down Under Flagship Roadmap

	Short term 1–3 years	Medium term 4–9 years	Long term 10+ years
Driving sustainability through systems innovation	Develop concepts to reduce greenhouse gas and water use. Assess the implications of plausible futures.	Proof of concept for new eco-efficient technologies. New planning tools to support social licence to operate.	Demonstration of whole system approach. Social negotiation tools embedded in technology and project development.
Discovering Australia's mineral resources	Identify new exploration tools. Enable data interoperability. Build multi-party collaborations.	New 3D exploration tools developed and applied to buried deposits and new Greenfield sites.	3D visualisation, modelling and targeting embedded as an industry standard leading to new discoveries.
Transforming the future mine	Engagement with industry to develop innovative mining concepts and establish investment.	Field trials of novel automated continuous selective mining systems and integrated lightweight drill systems.	Adoption of new drilling, rock extraction and sorting systems. A vibrant mining technology services sector.
Securing the future of Australia's carbon steel materials industry	Develop infrastructure for precision iron ore and coke characterisation. Build relationships with industry.	Beneficiation and agglomeration process improvements being commissioned with resulting efficiency gains.	Low grade iron ores gaining traction in the Australian export market.
Creating wealth through advanced processing technologies	Laboratory testing of new ore characterisation, ore concentration and mineral/metal extraction techniques.	Continuous improvement of existing plant. Pilot plant and field trials of new techniques.	New ore reserves on-stream In-situ leaching viable. Australian mineral processing technology preferred.
Transforming productivity through on-line analysis	Collaborative projects for concept development. Technology trials with industry.	Industry partnerships for platform development. Spin-offs and commercialisation.	On-line analysis embedded in Australian operations with significant efficiency gains and reduced cut-off grades.

Current Position

CSIRO research in exploration, mining, mineral processing, minerals-related sustainability and metal production is now managed by the Minerals Down Under Flagship. The Light Metals Flagship retains light metals processing and production research. Minerals Down Under has expanded into an $80 million a year research portfolio with enhanced ability to facilitate larger scale projects, while providing a single CSIRO point-of-contact for most resource related activities.

Preventative Health Flagship

Flagship goal:

To improve the health and wellbeing of Australians and save $2 billion in annual direct health costs by 2020 through the prevention and early detection of disease.

Research expenditure 2009–10: $40.8 million

Overview

The Preventative Health Flagship is addressing our national health challenges in colorectal cancer and gut health; neurodegenerative diseases, mental disorders and brain health; and obesity and health.

In addressing these national health challenges, Flagship research teams are focusing on the early detection of neurodegenerative disease with imaging and physics. They are researching better methods of screening for, and early detection of, colorectal cancer. The teams are investigating new protective foods and how diet and lifestyle contribute to disease. The Flagship is working on better ways to monitor and measure health, including personalised nutritional and lifestyle approaches to disease prevention.

The Preventative Health Flagship is focusing on three specific targets to achieve its goal:

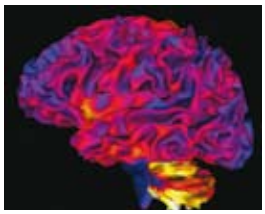
- Reduce colorectal cancer incidence by ten per cent, increase the five-year survival rate from 58 per cent to 65 per cent and lower by ten per cent the risk of inflammatory and infectious gut disease in Australia by 2020 through prevention and early diagnosis.
- Delay the onset of Alzheimer's and other neurodegenerative diseases in Australia by five years by 2020 through early detection and prevention, including lifestyle changes.
- Reduce the impact of obesity and associated complications on Australian adults and children by 2020, through the development and adoption of cost-effective, evidence-based lifestyle programs, novel food approaches and therapeutics.

Achievements 2009–10

Cutting-edge colonoscopy simulator

Colorectal cancer is a serious concern in Australia. Current figures indicate one in 22 Australians will develop colorectal cancer during their lives, one of the highest rates in the world. The Preventative Health Flagship, with collaborators, has developed a colonoscopy simulator which enables trainees to interact with accurate computer-based simulations of the human colon, allowing this complex procedure to be taught with no risk to patients. The simulator was developed by the Preventative Health Flagship in conjunction with the Australian e-Health Research Centre – a joint venture between CSIRO and the Queensland Government – and Ecole Polytechnique Fédérale de Lausanne in Switzerland. It was licensed to Swedish company, Surgical Science AB, which develops medical training tools using 'virtual' technologies.

Uncovering the early stages of Alzheimer's disease



CSIRO's Preventative Health Flagship established The Australian Imaging Biomarkers and Lifestyle Flagship Study of Ageing in 2006, in partnership with the University of Melbourne, the Mental Health Research Institute of Victoria, Edith Cowan University and Neurosciences Australia.

A major study stemming from this collaboration has provided new insights into the loss of structure in regions of the brain and its potential association with Alzheimer's disease. The findings suggest a build-up of deposits of the protein amyloid-beta in a region of the brain known as the temporal inferior cortex. The region is connected to the hippocampus, which is involved in memory. The results indicate that the increased accumulation of amyloid in the temporal inferior cortex disrupts connections with the hippocampus, causing the neurons to die. By helping better understand the mechanisms involved in the progression of the disease, the study may guide the development of new strategies for early diagnoses.

CSIRO Wellbeing Plan for Kids

The Flagship, in collaboration with Penguin Publishing, has released a publication to help families make healthy food and lifestyle choices for the all important formative years of growth. The *CSIRO Wellbeing Plan for Kids* provides families with guidance on children's activity and nutrition. The contents were developed following CSIRO's analysis of children's dietary intakes in the 2007 National Nutrition and Physical Activity Survey with the Commonwealth Department of Health and Ageing.

Preventative Health Flagship Roadmap

	Short term 1–3 years	Medium term 4–9 years	Long term 10+ years
Colorectal Cancer & Gut Health	New knowledge, Early Detection & Prevention, CRC & IBD.	Translation into marketable Diagnostics and Protective Foods.	Reduced morbidity and mortality from CRC & IBD in Australia.
Neurodegenerative Diseases	New knowledge about the aetiology and early detection of neurodegenerative disease.	Develop and commercialise neuroprotective agents and biomarkers for early detection and prevention.	Delay the onset of Alzheimer's and other neurodegenerative diseases in Australia by five years.
Obesity & Health	New evidence based lifecycle strategies for healthy weight – molecules to translation.	Establish programs to influence Australians' lifestyle behaviour through ICT systems, identify lead compounds for fat and energy regulation and design foods for satiety/low metabolic impact.	Healthier lifecycle eating behaviours, reduced impact of obesity and its complications.

Current Position

Sustainable Agriculture Flagship

Flagship goal:

To secure Australian agricultural and forest industries by increasing productivity by 50 per cent and reducing net carbon emissions intensity by at least 50 per cent by 2030.

Research expenditure 2009–10: $66 million

Overview

Australia's agricultural and forest industries have big challenges ahead to balance competing demands to increase production, reduce environmental footprints, mitigate greenhouse gas emissions and provide carbon biosequestration options.

The international demand for food is destined to increase in line with forecast rises in population and shifts in diet. At the same time, farmers are challenged with greater costs and/or reduced availability of nutrients, water and energy inputs.

Agriculture and forestry must achieve environmental, productivity and economic targets to ensure the sustainability of Australia's rural land use for future generations. Maintaining and enhancing healthy soils and ecosystems and developing eco-efficient agriculture and forestry are fundamental to these challenges.

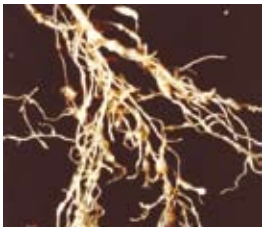
The Flagship was launched in February 2010, and is addressing these challenges in partnership with Australian industry, communities and government, as well as internationally, as part of Australia's contribution to global food security.

Achievements 2009–10

Storing greenhouse gases in rural Australia

The Flagship delivered an analysis of the potential for greenhouse gases to be stored or mitigated by changes in rural land use. The report provides the best available scientific information on mitigation strategies and carbon storage options for agriculture, forestry and rural land. This report was prepared for the Queensland Premier's Council on Climate Change (see: www.csiro.au/resources/carbon-and-rural-land-use-report.html).

Getting to the root of soil biological health



Root diseases cost the grains industry between $100–200 million a year, depending on seasonal conditions. The Flagship and its partners have found crops such as cotton, cereals and canola, can alter root zone microbiology in different ways. The Flagship is applying new molecular approaches to boost soil biological health. Researchers are developing crop specific beneficial micro-organisms which hold promise in lifting farm productivity and improving the efficiency of water and fertiliser use.

Sustainable development for Northern Australia

The Flagship took the lead in CSIRO's delivery of a comprehensive national science review on natural resource development in Northern Australia. Delivered to the Australian Government and the Northern Australia Land and Water Taskforce, the review investigated a range of climatic, land use, hydrological, conservation, Indigenous and governance issues and the complex interactions that occur. The review now informs planning and policy in government and industry (see: www.csiro.au/resources/Northern-Australia-Sustainable-Development.html).

Less water more food

In a significant national collaboration, the Flagship with the Grains Research and Development Corporation, industry partners and 19 regional farmer groups, is investigating new methods to increase water use efficiency on Australian grain farms. Early results have revealed how careful management of summer fallows can significantly preserve soil water and increase water use efficiency (see: www.csiro.au/science/Water-Use-Efficiency.html).

Sustainable Agriculture Flagship Roadmap

	Short term 1–3 years	Medium term 4–9 years	Long term 10+ years
Reducing net greenhouse gas emissions while increasing storage of new carbon in our lands	Assess mitigation practices and technologies in key industries, regions and systems.	Develop 'breakthrough' mitigation practices and technologies.	Profitable agricultural practices that contribute to GHG abatement are adopted by land managers.
	Develop greenhouse gas measurement, accounting and bio-sequestration support packages.	Total system greenhouse gas outcomes for different management, history, climate and soil combinations quantified with defined uncertainty and co-benefit assessment.	New carbon sinks created giving net increase in carbon sequestration with environmental and production benefits.
	Support national policy decisions and international frameworks on land use management for carbon storage and greenhouse gas mitigation.	Conduit for science and integration for industry and government.	National dialogue, policy and action are informed by robust science.
Advancing agricultural productivity and environmental health	Identify challenges and prospects for food and fibre productivity increases in key industries, regions and systems.	Direct links between genetics, breeding and farming systems research underpin accelerated improvements in food & fibre productivity.	Step-change in productivity achieved via industry adoption of agro-ecological innovations for 'smart' food and fibre production systems.
	Characterise resource and labour-use, soil and water constraints to sustained productivity.	Integrated whole-farm analyses support diverse sustainable enterprise options for efficient resource management.	More sustainable production practices adopted with gap between farm and benchmark resource-use efficiency significantly narrowed.
	Evaluate agro-ecological tradeoffs in farming systems for potential to improve productivity and NRM outcomes.	Assess environmental impacts of emerging productivity and mitigation practices, technologies and policies.	New markets developed and in use for effective on-farm environmental and biodiversity stewardship schemes.
Informing land use planning, policy and natural resource management	Observation of current status and historic change in key land management drivers.	Develop life-cycle based sustainability assessments for agri-food value chains.	Multi-scale temporal assessment of land use change.
	Enhance national soil and terrain data systems.	Triple bottom line modelling framework for land use systems.	International system for forest and carbon tracking.
Addressing global food and fibre security challenges through partnerships at home and abroad	Deliver enhanced science and impact via an integrated approach to international project portfolio.	Deepen partnerships with international R&D institutions leading to enhanced capacity building.	Monitoring and evaluation confirm realised sustainable livelihood benefits in target regions.

Current Position

Water for a Healthy Country Flagship

Flagship goal:

To provide Australians with solutions for water resource management, creating economic gains while protecting or restoring our major water ecosystems.

Research expenditure 2009-10: $93.2 million

Overview

The Water for a Healthy Country Flagship is addressing one of Australia's most pressing natural resource issues, the sustainable management of our water resources. The Flagship is Australia's largest research partnership focused on water in Australia. As demand for water increases, climate changes, and as economically and environmentally viable storage sites dwindle, Australia is looking to new strategies that manage demand, increase efficiency, re-use wastewater and allow water to be traded. Our science is informing the decisions on where and how to best invest in these options and is providing enabling technologies.

CSIRO's research is supporting some of the major water policy and strategies at national and regional scales including the National Water Initiative, the Reef Water Quality Protection Plan, the Living Murray Initiative, the Water for the Future Program and the Murray-Darling Basin Plan.

Achievements 2009–10

South Eastern Australian Climate Initiative

The South Eastern Australian Climate Initiative is a partnership between CSIRO and Australian and Victorian government research and policy agencies. The partnership aims to improve our understanding and projections of climate impacts on water availability in south-eastern Australia. The research will allow for better management and planning for the impacts of climate change and variability on water resources.

National guidelines for managed aquifer recharge

The Flagship provided knowledge to assist the National Water Commission to develop national guidelines for managed aquifer recharge in Australia. Managed aquifer recharge involves adding recycled water to an underground reservoir for storage and improved water quality. By developing guidelines for this process the Flagship is helping water managers ensure the safety of this innovative and environmentally-friendly treatment process.

Ecological outcomes for the Murray River

Flagship research is providing information that will allow water managers to improve delivery of environmental water to wetlands of international significance in the Murray-Darling Basin. The Murray-Darling Basin Floodplain Inundation Model will allow water managers to ensure water flows can be tailored to maximise environmental outcomes.

National standard for water data exchange

The Flagship and the Bureau of Meteorology have developed a new data transfer format which is enabling the Bureau to produce a clearer picture of Australia's water resources. The Water Data Transfer Format allows more than 200 data providers to efficiently provide more than six million electronic data files to the Bureau annually. This research will streamline the development of state-of-the-art water resources assessment and accounting systems.

Future sustainability of Australia's water resources

In 2008, the Council of Australian Governments commissioned CSIRO to undertake three new sustainable yields projects for northern Australia, south-west Western Australia and Tasmania. The projects have delivered the most comprehensive and complex water assessments undertaken for each of the regions. This knowledge is fundamental to the sustainable management of water in these three regions for current and future developments and for a future affected by climate change.

Water for a Healthy Country Flagship Roadmap

	Short term 1–3 years		Medium term 4–9 years	Long term 10+ years
Urban Water	Develop new tools and technologies for sustainable integrated management of water systems and infrastructure from city/regional to household level.	Inform state and national urban water policy through applied research of integrated urban water systems technologies.	Decision support systems, system performance knowledge, and new water management technologies to plan and deliver sustainable integrated urban water services.	To provide socially acceptable, affordable and environmentally beneficial management solutions for Australia's urban water systems.
Integrated Water Information Systems	In partnership with the Bureau of Meteorology, develop water reporting and forecasting tools. Develop sensor networks to improve real-time monitoring.	Enable water information interoperability through research investments in standards development, web service integration, semantic web and model interoperability.	Widely accessible national water information network based on open standards. Reporting and forecasting tools used in water demand regions.	Establish the platform for an Australia-wide network of integrated water information systems that deliver water accounts, assessments and forecasts.
Healthy Water Ecosystems	Establish a network of integrated models and evaluation tools and embed these in the adaptive management of high-priority water ecosystems.	Inland and coastal water ecosystems managed through the use of integrated knowledge platforms.	Significantly reduced long-term impacts of pollutants and changed flow regimes in priority water ecosystems.	To provide the knowledge to protect or restore Australia's major water ecosystems while enabling sustainable use of water resources.
Regional Water	Enable water savings in irrigation systems, and establish improved water efficiency and sustainability through improved surface and groundwater management options.	Develop options for improved institutional water use arrangements and evaluation of their economic, social and environmental consequences.	Achieve greater water supply certainty, enhanced substitution options, and improved productivity through integrated management of river basins and aquifers.	To provide systems knowledge and analysis tools for river basins and aquifers to ensure water security for all users.

Current Position

For the purposes of clarity, the Flagship has re-named the WRON Theme to the Integrated Water Information Systems Theme, which describes CSIRO's contribution to the original vision.

The Better Basin Future Theme has been renamed the Regional Water Theme. The new name is a clearer and simpler description of the Theme's research activities for both partners and stakeholders.

Wealth from Oceans Flagship

Flagship goal:

To position Australia by 2020 as an international benchmark in the delivery of economic, social and environmental wealth based on leadership in understanding ocean systems and processes.

Research expenditure 2009–10: $63.3 million

Overview

Australia is a marine nation, with one of the largest ocean territories in the world and a predominantly coastal population. CSIRO's Wealth from Oceans Flagship is focused on understanding our oceans and their biodiversity, resources and relationships with the climate system. The Flagship delivers science that enables governments, industries and communities to derive increased, sustainable benefits from Australia's ocean resources, while ensuring the conservation of Australia's marine biodiversity and coastal communities. It provides CSIRO's contribution towards national challenges where oceans play a central role.

The Flagship's core partners are Commonwealth and state government departments and agencies, where our science informs policy development and assists policy implementation across various sectors, such as oceans, environment, energy, fisheries and tourism. The Flagship also partners with industry and national and international universities, and participates in global collaborations.

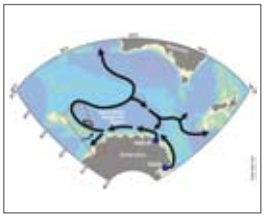
In 2009–10, the Flagship refocused and consolidated its research program. Many of the Flagship's general hydrocarbon projects moved to CSIRO's newly formed Petroleum and Geothermal Portfolio and the parent theme, Blue GDP, was closed. In addition, three older themes were rolled into two new ones (see Roadmap). The Flagship retains its interactions with the oil and gas sector through developing new technologies for offshore energy discovery. It is also building tools and frameworks to assist the industry develop more objective, robust and streamlined developmental approval processes.

Achievements 2009–10

World interest in Australian fishery impact method

An Australian method for assessing the environmental impact of marine fisheries has been adopted in the US, Canada, Ecuador and the Western and Central Pacific, and by the international eco-labelling organisation, the Marine Stewardship Council. The Flagship's ecological risk assessment method considers fish species that have been caught by accident, as well as threatened, endangered and protected species and their habitat. It contributes to the strategic assessment of fisheries and flags priorities for research, data collection, monitoring and management.

Massive Southern Ocean current discovered



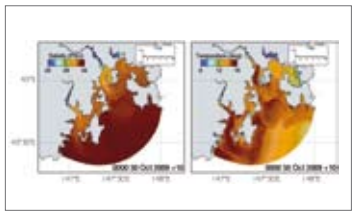
The Flagship, in collaboration with Hokkaido University, Japan, and the Antarctic Climate and Ecosystem Cooperative Research Centre, discovered a deep ocean current with a volume equivalent to 40 Amazon Rivers. The current is near the Kerguelen plateau in Antarctica, about 4,200 kilometres south-west of Perth. It is more than three kilometres below the surface and is an important pathway in understanding the global network of ocean currents that influence climate, now and in the future.

Finding sunken vessels; tracking oil slicks

BLUElink – the ocean forecasting system developed with the Bureau of Meteorology and the Royal Australian Navy – helped in the Australian and Queensland Governments' successful search for the Australian Hospital Ship *Centaur*, which was torpedoed in May 1943. The Flagship provided information to the expedition leader, David Mearns, about the unusual ocean conditions when the ship was sunk to focus the search area, and BLUElink forecasts to help him plan the search schedule.

BLUElink was also used by the Australian Maritime Safety Authority to monitor the oil slick following the Montara well blowout and spill in the Timor Sea.

Modelling coasts to support management



Decision-makers in several coastal regions of Australia are implementing the Flagship's sophisticated three-dimensional models that integrate biological and physical information. In south-east Tasmania, model results feed directly into sustainable aquaculture planning and have been incorporated into the Derwent Estuary water quality improvement plans. Through the South East Queensland Healthy Waterways Partnership, the Flagship is extending its water quality models to incorporate socio-economic interactions and world-leading ecosystem models and has engaged with stakeholders through workshops and interviews. This will aid planning in response to likely sea-level rises and coastal demographic changes.

Wealth from Oceans Flagship Roadmap

	Short term 1–3 years	Medium term 4–9 years	Long term 10+ years
The Dynamic Ocean	Gaps opportunities identified; tools, models being developed; partners committing funding.	Improved ocean-climate prediction; reliable forecasting systems operational; delivery to clients and public.	Oceans-climate knowledge delivering social, environmental and financial wealth to Australians.
Our Resilient Coastal Australia	New improved tools for: coastal observing networks; environmental assessment processes; management strategy evaluation; marine industries.	New coastal assessment tools implemented; multiple use management strategies applied; new technologies commercialised with industry.	Productive, resilient, sustainably managed coasts; new, environmentally friendly technologies delivering revenue to marine industries.
Sustainable Ocean Ecosystems and Living Resources	New, multidisciplinary, integrated tools underway for: sustainable commercial fisheries, spatial management, biodiversity conservation, threatened species assessment.	Integrated tools for ecosystem based fisheries management. National biodiversity management program including threatened species protection.	Australian and regional fisheries economically and environmentally sustainable; conservation and sustainable management of Australia's marine biodiversity.

Current Position

The Dynamic Ocean is one of the foundation themes of Wealth from Oceans and after nearly seven years is delivering outcomes and major impact nationally and internationally. The new themes build on prior portfolio knowledge, however, Our Resilient Coastal Australia represents a new focus and direction for CSIRO so is less advanced along its delivery path than Sustainable Ocean Ecosystems and Living Resources.

Program 2 – Core Research and Services

CSIRO's core research and services portfolios deliver new and improved technologies, management systems, intermediate and final products, catalyst services for business, advice relevant to policy development, and new knowledge and skills that benefit industry, the environment and community wellbeing.

Achievements from the core research and service portfolios are showcased on pages 48–57. Thirteen core research and services Portfolios were operational in 2009–10. They were, by Research Group:

Agribusiness Group[6]

Entomology

Integrates diverse biological sciences, from the level of the gene to the ecosystem, to deliver the knowledge needed for biosecurity and bioindustries.

Livestock Industries

Provides research solutions to increase the total factor productivity of Australia's livestock industries and to protect them against the threat of new and emerging diseases.

Food and Nutritional Sciences

Conducts research on food processing and food to support the health of the Australian community and the sustainability and viability of the Australian food industry.

Plant Industry

Promotes profitable and sustainable agrifood, fibre and horticultural industries through innovation and the development of new plant products.

[6] *Agribusiness was renamed Food, Health and Life Science Industries from July 2010. Entomology merged with Sustainable Ecosystems to become Ecosystem Sciences within the Environment Group.*

Energy Group

Coal Technology

Maximises the benefits from Australia's coal resources in an environmentally and socially responsible manner.

Petroleum and Geothermal

Supports a smooth transition to Australia's clean and secure energy future by optimising oil and gas exploration and production, and demonstrating the feasibility of geothermal energy use in Australia.

Environment Group

Biodiversity

Provides the data, tools and integrating knowledge to underpin a collective national effort to help halt biodiversity decline in Australia by 2020 and reverse this decline by 2035.

Marine and Atmospheric Research

Provides the earth-system science that creates new knowledge of Australia's climate, supports adaptation responses to increasing climate change and variability, and advises on mitigation strategies.

Information Sciences Group

Astronomy

Furthers the advancement of knowledge and understanding of the universe, to ensure the continuing world-class nature of the Australia Telescope and to exploit its unique southern location and technological advantages.

Australian Square Kilometre Array Pathfinder

Maximises returns to Australian science and industry through its participation in the international Square Kilometre Array (SKA) project and development of the Australian SKA Pathfinder.

Digital Technologies and Services

Provides the digital technologies and services that underpin national efforts in the delivery of globally competitive outcomes for society, government and industry.

Manufacturing, Materials and Minerals Group

Materials Science and Engineering

To transform existing Australian manufacturing industries to provide them with a sustainable, globally competitive future.

Molecular and Health Technologies[7]

Develops new technologies, with a focus on novel biological and chemical materials, to transform industries and improve health and wellbeing.

Core Research and Services: Key Performance Indicators

The following pages provide a report on the key performance indicators set for the Core Research and Services Program in the Portfolio Budget Statements and some additional indicators set in the CSIRO Operational Plan

KPI 1 – Evidence of economic, social, environmental and intangible benefits through demonstrated adoption of research outputs.

KPI 2 – Maintain or increase the number of refereed publications.

KPI 3 – Maintain customer satisfaction.

KPI 4 – Maintain or improve science excellence in CSIRO research capabilities

[7] *Molecular and Health Technologies merged into Materials Science and Engineering from July 2010.*

Additional indicators from the Operational Plan

PI 5 – Journal articles per researcher.

PI 6 – Proportion of journal publications in top-quartile journals.

PI 7 – Citations per paper compared to world rate.

PI 8 – Total citations compared to world rate

KPI 1 – Evidence of growing economic, social, environmental and intangible benefits through demonstrated adoption of Core Research outputs

For information on this performance indicator, see the achievements on pages 48–57 and the report on KPI 1 in Program 1, Page 14.

KPI 2 – Maintain or increase the number of publications and KPI 3 – Maintain customer satisfaction

For information on these performance indicators see pages 16–18.

KPI 4 – Maintain or improve science excellence in CSIRO research capabilities (proportion of capabilities rated benchmark or strong)

Independent review panels provide an assessment of the international competitive position of CSIRO Capabilities. This is done along two dimensions – in the international research community and the extent to which CSIRO's research results provide the scientific/technical means for leadership for those organisations adopting and using them.

The proportion of capabilities rated 'benchmark' or 'strong' in Round Two assessment is 63 per cent for industry dimension, 55 per cent for research / community dimension and 43 per cent when the two dimensions are combined.

A few factors complicate the reporting of this metric. First, in round one 17 Divisions were assessed between 2005 and 2007, see Figure 2.4. Round two commenced in late 2008. So far capabilities from 12 Divisions have been assessed, see Figure 2.5. A full comparison of results is difficult to undertake until the second round of assessments is complete. Capability groupings have also changed between the two rounds of assessment which further complicates direct comparisons.

Additionally, capabilities are made up of people, scientific infrastructure and relationships. Any change in the capabilities position may be due to any combination of these factors.

Overall the review panels were impressed with the quality of science across all the Divisions reviewed, see pages 106–107. The review panels found that the Divisions had strong capability areas of expertise, which were world-class in many parts of their programs. Some panels commented on deficiencies in research

Figure 2.4 – Capability assessments – Round 1

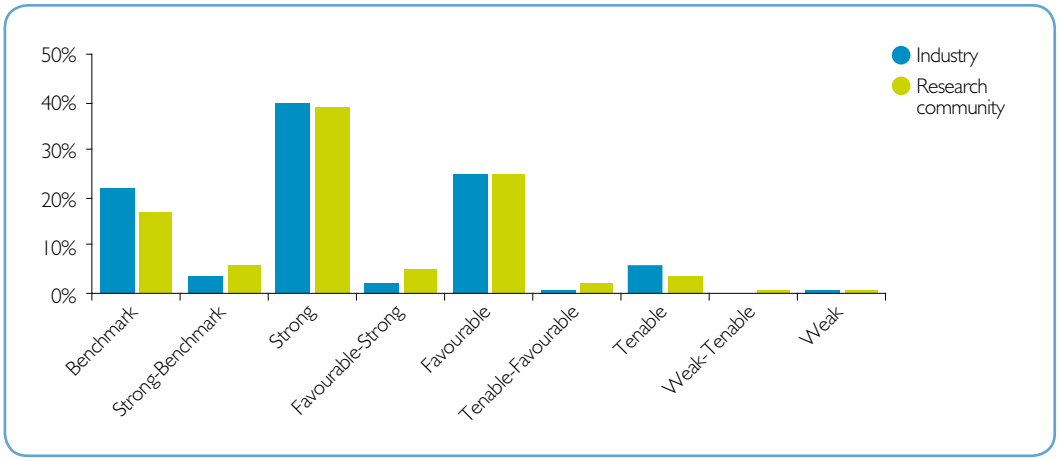
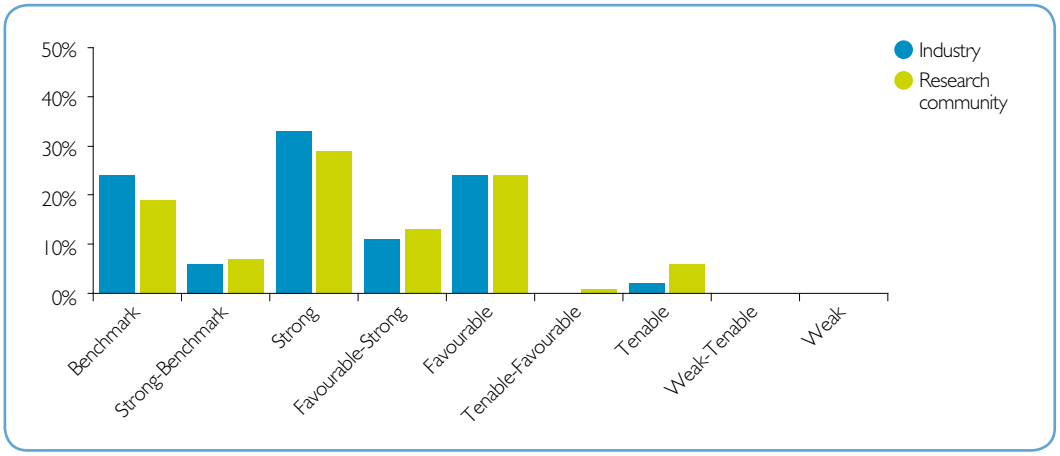


Figure 2.5 – Capability assessments – Round 2



infrastructure which was limiting CSIRO's research. Others commented on the need for increased investment in building new priority areas of research capability.

PI5 – Journal Articles per researcher

Journal articles are defined as articles and other items published as part of a journal (for example, an editorial or book review). Researcher is a staff member classified as research scientists/engineer + research manager + research consultant + senior specialist.

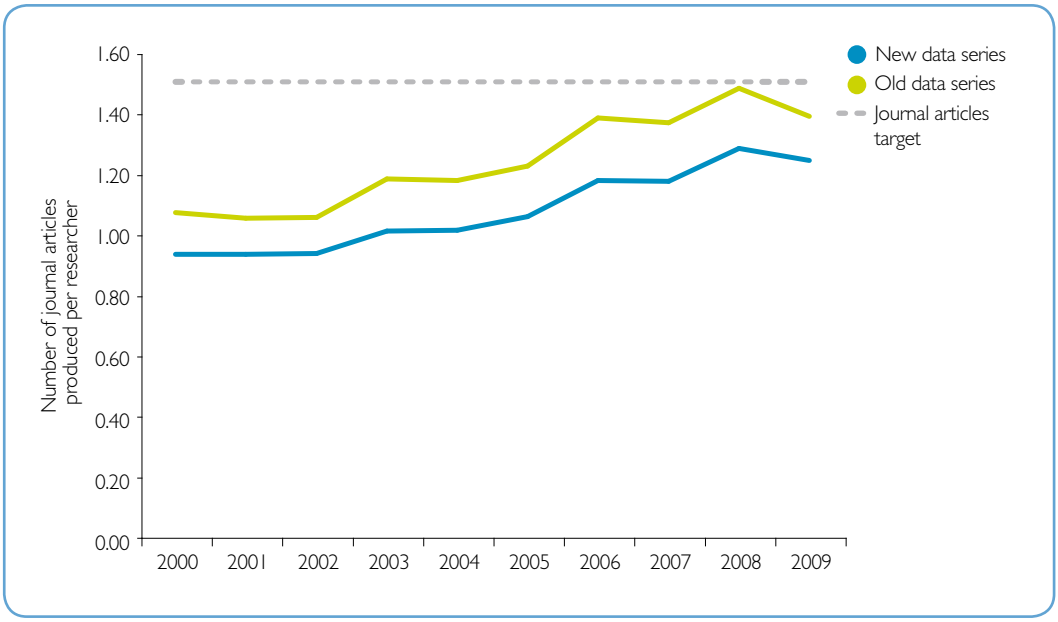
The number of journal articles per researcher has been trending upward toward the target of 1.5, albeit with a slight drop to 1.24 articles per researcher in 2009.

The method of calculation for this indicator has changed from the 2008–09 Annual Report. Previously researcher was defined as staff with a principal functional area of research scientist/engineer only. For comparative purposes Figure 2.6 shows the result using both the old and new indicators.

PI6 – Proportion of journal publications in top-quartile journals

Journals are divided into four equal groups or quartiles based on their average citation per publication rates over a five year period. An independent bibliometric analysis is conducted by the Australian National University (ANU) to determine the proportion of all CSIRO journal publications in each quartile.

Figure 2.6: Number of journal articles produced per researcher



The proportion of all CSIRO journal publications in the top-quartile between 1999 and 2003 was 33 per cent.

For the period 1999–2003 the proportion of CSIRO journal publications in the top-quartile (33 per cent) is slightly lower than the total Australian proportion (36 per cent) see Figure 2.7. However, CSIRO is at a disadvantage in this comparison as the full Thomson SCI journal set is used. The top quartile of this full journal set includes many high impact medical science journals. Medical science is an area in which CSIRO has little activity, with the overwhelming majority of medical science research in Australia being carried out in universities, medical research institutes and hospitals.

CSIRO has contracted the ANU to undertake another bibliometric analysis of CSIRO publications, which will provide an update to this performance indicator.

PI7 – Citations per paper compared to world rate in each research field

CSIRO is at least ten per cent above the world average citation rate in each of the 14 research fields in which it is in the top one per cent of global institutions.

Total citations are the default indicator commonly used to rank Institutions performance. In 2009–10, CSIRO ranked (by total citations) in the top one per cent of leading scientific institutions in 14 of the 22 research fields. These fields and their world rankings for 2004–05 and 2009–10 are given in Table 2.4.

Figure 2.7: Journal articles per quartile

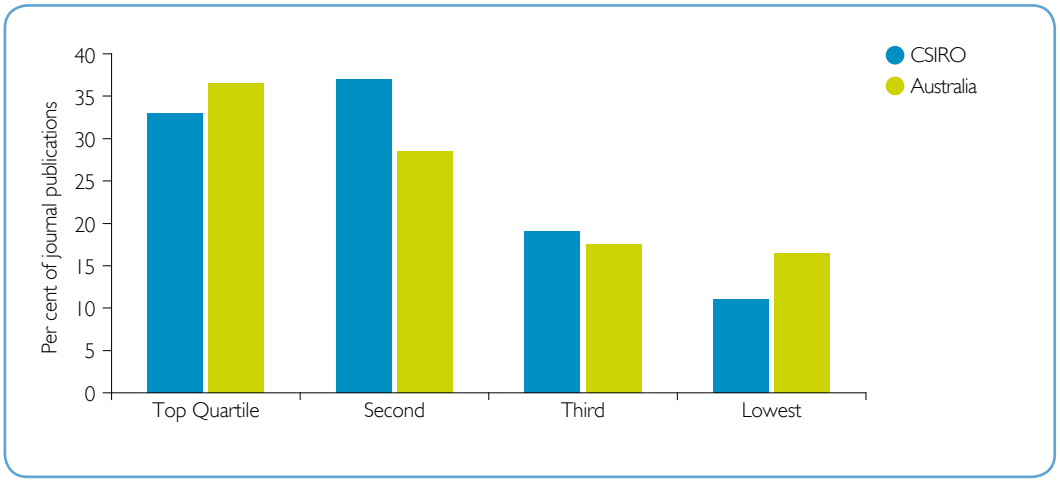


Table 2.4 – Citation rate by research field

Research field	CSIRO rate	World rate	Difference (%)
Geosciences	17.09	8.83	94
Plant and Animal Science	12.83	7.1	81
Chemistry	17.54	10.26	71
Clinical Medicine	19.83	12.02	65
Environment/Ecology	16.24	10.24	59
Engineering	6.81	4.27	59
Social Sciences	6.33	4.23	50
Materials Science	9.19	6.29	46
Computer Science	4.72	3.32	42
Agricultural Sciences	9.06	6.42	41
Biology and Biochemistry	19.47	16.09	21
Space Science	15.87	13.36	19
Molecular Biology and Genetics	27.67	24.08	15
Microbiology	15.8	14.11	12

Source: Thomson-Reuters/ISI Essential Science Indicators: May 2010[8]

PI8 – Total citations per paper compared to world rate

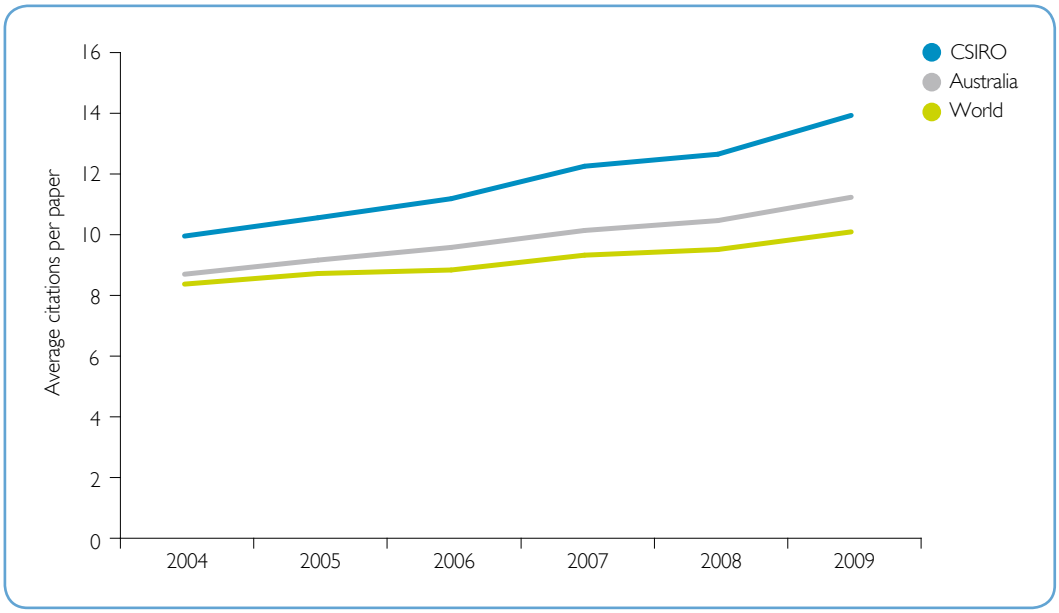
Average citation rate is the average number of total citations (utility) per published paper (productivity) and is the most accurate measure of scientific impact. The data was updated as of 1 May 2010 to cover a ten-year + two-month period, 1 January 2000 – 28 February 2010.

The average citation rate for CSIRO journal articles continues to increase and is currently 13.83 citations per paper. This is 38 per cent above the world rate of 9.99 citations per paper, close to our target of 40 per cent.

CSIRO's citation rate has also increased at a rate greater than the Australian average of 11.14 and the world average of 9.99, see Figure 2.8. According to ISI Essential Science Indicators, CSIRO has the highest average number of citations per paper of the Australian research institutions that publish across a broad range of research fields.

[8] *Data updated as 1 May 2010 to cover a ten-year and two month period, 1 January 2000–28 February 2010.*

Figure 2.8: Average citations per paper



Source: Thomson-Reuters/ISI Essential Science Indicators: May 2010[9]

[9] *Data updated as 1 May 2010 to cover a ten-year and two month period, 1 January 2000–28 February 2010.*

CSIRO's WLAN now used in electronic devices worldwide

CSIRO's pioneering work in radio astronomy led the way to what is now the most popular way to connect computers without wires. That work involved complex mathematics known as 'Fast Fourier Transforms', as well as detailed knowledge about radio waves and their behaviour in different environments. Indoor environments are particularly difficult for the rapid exchange of large amounts of data using radio waves.

To solve these problems, CSIRO invented the technology behind most high-speed wireless local area networks (known as Wi-Fi). The technology underpins the wireless communication system found in almost every laptop computer and associated wireless device produced today and is used in homes and offices around the world. The invention and the widespread adoption of the technology has enabled a global revolution in mobile computing and in the way we live and work.

Following settlements of patent litigation in the US, CSIRO's patent is now licensed to 15 companies, including Hewlett-Packard, Intel, Dell, Toshiba, ASUS, Microsoft and Nintendo, under confidential terms. The revenue arising from these settlements to October 2009 was approximately $205 million.

Forecasters* predict that there are likely to be more than three billion devices sold worldwide over the next several years using the technology invented by CSIRO scientists.

* *Source: In-Stat LLC Wireless LAN Market Estimates and Forecast by Device 2009–2014*

The 'Fast Fourier Transform' processor chip was originally developed in the mid 1980s to help radio astronomers find exploding black holes in the universe. That early work led to CSIRO inventing a technology that is now used in almost every wireless local area network (Wi-Fi) device in the world, including laptop computers, smart phones and game consoles. Credit: Denis Redfern

Agribusiness[10]

Research group aim:

To achieve outcomes for Australia along the value chain of food and fibre production for economic, social and environmental benefits. The Agribusiness Group strives for excellence in animal, plant and microbial sciences to deliver enduring solutions in agriculture, food, health and the environment.

Group expenditure (excluding Flagships) 2009–10: $208.7 million

Overview

The Agribusiness Group is seeking to address two grand challenges over the next decade:

- Global food security – feeding the world under increasing resource constraints.
- Keeping people healthy in a changing world.

To address these challenges, the Group draws on rapid progress in the biological sciences globally and integrates with advances in other science fields such as informatics and biomaterials across CSIRO.

We apply these across the food value chain to address issues of productivity, biosecurity, sustainable resource use, and focus on areas where food provides solutions to preventative health and wellbeing issues.

The Group is rebuilding our national leadership position in food science and nutrition and maintains a strong focus on biosecurity, including zoonotic diseases, which are those which can pass from animals to humans. This will ensure our national preparedness for the emergence of human diseases of animal origin.

Achievements 2009–10[11]

Silk from insects

CSIRO scientists are researching silks from insects to help determine their effectiveness as new sources of biopolymers. The aim is to discover new protein materials with exceptional functional characteristics including extreme toughness and durability. Silks produced by many invertebrates are comprised of large proteins with repetitive amino acid sequences that are difficult to reproduce artificially.

Before silks can be utilised or reproduced, the sequence of underlying proteins and their functions need to be identified. CSIRO scientists are leaders in this research and are the first group to have produced mimics of 'natural' silk proteins artificially and fabricated these into silk fibres. This breakthrough has been possible because our scientists have discovered novel silk genes. Possible uses include tough, lightweight textiles and, because of their biocompatibility, medical applications, such as sutures, artificial tendons and ligaments.

[10] *The Agribusiness Group became the Food, Health and Life Science Industries Group on 1 July 2010.*
[11] *Excludes Flagship achievements. This Group manages the Food Futures Flagship, the Preventative Health Flagship and the Sustainable Agriculture Flagship, see Program 1, page 24, 32 and 34.*

Salt tolerant wheat

Salinity is one of the most significant environmental issues facing Australia today. In a major breakthrough for wheat farmers in salt-affected areas, CSIRO researchers have developed a salt tolerant durum wheat that yields 25 per cent more grain than the parent variety in saline soils. Recent field trials in northern New South Wales proved that durum wheat varieties containing new salt tolerant genes outperformed the other varieties in salty areas. Although durum wheat is less salt tolerant than bread wheat, it attracts a premium price because of its superior pasta making qualities.

Food safety book helps manufacturers

CSIRO PUBLISHING and CSIRO's food safety researchers published *Make It Safe: A Guide to Food Safety*, which provides small-scale food manufacturers with a practical guide to controlling food safety risks. The book translates sometimes complex descriptions of food safety practices and requirements into simple, easy-to-understand English. The book complements CSIRO's research that helps Australia's largest manufacturing sector continue to produce and export some of the world's safest food.

Female only chickens

Scientists have solved the long-standing mystery of what determines sex development in chickens. CSIRO and the University of Melbourne's Murdoch Children's Research Institute have discovered a gene – DMRT1 – and confirmed its role in the development of male chickens. This discovery, published in the scientific journal *Nature*, has major potential applications in the poultry industry. It is of particular interest to the egg industry, whose lack of requirement for male chickens presents a challenge globally for animal welfare.

Breakthrough in fight against the Hendra virus

A new treatment developed to combat the deadly Hendra virus is showing great potential in saving the lives of infected people. In a world first, a scientific team from CSIRO and the US have demonstrated that administering human monoclonal antibodies after exposure to the Nipah virus, which is closely related to the Hendra virus, protected animals under experimental conditions. This research suggests that an effective treatment for Hendra virus infections in humans should be possible, given the very strong cross-reactive activity this antibody has against Hendra virus.

Energy

Research group aim:

To develop and apply leading-edge energy research that meets Australian needs in order to reduce greenhouse gas emissions, ensure energy security and create wealth from energy.

Group expenditure (excluding Flagships) 2009–10: $83.45 million

Overview

Powering the future is arguably the greatest environmental, economic and social challenge we have to resolve in the early decades of the 21st century. To meet this challenge, our energy research portfolio aims to accelerate large-scale emission cuts while ensuring a smooth transition to a new energy future.

To facilitate our aims, the Energy Group underwent some structural changes in 2009–10 with the merger of two high-performing Divisions – CSIRO Exploration and Mining and CSIRO Petroleum Resources – to form the Division of CSIRO Earth Science and Resource Engineering. The Group also saw the Energy Transformed Flagship sharpen its focus on renewables and energy efficiency and the creation of the Coal Technology portfolio and the Petroleum and Geothermal portfolio. These changes affected the Wealth from Oceans Flagship structure which consolidated its focus on understanding our oceans and their biodiversity, resources and relationships with the climate system.

CSIRO energy's research covers emerging stationary and transport energy technology options including solar, geothermal, smart grids and energy storage. It also emphasises the relevance of gas as the transitional cleaner fossil fuel and carbon capture and storage, both providing energy security and wealth, as well as supporting and enabling the path towards a clean energy future. In addition to developing technology solutions, we are also developing sophisticated models to help paint a picture of our energy pathways, and working with community groups to inform and empower individuals ways to reduce their greenhouse gas emissions.

Achievements 2009–10[12]

New centre for geothermal energy development

The Western Australian Geothermal Centre of Excellence (WAGCOE) – a new centre to develop geothermal energy – was launched in Perth in December 2009. This joint venture is currently focused on using low temperature heat from the Perth basin to generate geothermal energy.

In June 2010, CSIRO also received significant funding to support the demonstration of geothermal technologies to heat and cool the Pawsey Centre, a high performance computing facility, and the adjacent Australian Resources Research Centre in Perth. Over the past year, WAGCOE scientists have undertaken a comprehensive study of the site and the underlying hot sedimentary aquifers, to determine their suitability for geothermal applications. The results from the data acquisition and detailed geological, engineering and financial modelling were a key element of the

[12] *Excludes Flagship achievements. This Group manages the Energy Transformed Flagship and the Wealth from Oceans Flagship, see Program 1, page 22 and 38.*

successful funding bid. The initiative will make the Pawsey Centre site one of Australia's largest direct heat use geothermal demonstration program sites (see: www.csiro.au/partnerships/WAGCOE.html).

World's miners adopt CSIRO technology

CSIRO's longwall mining technology has been adopted by five of the world's major longwall mining equipment manufacturers. Underground longwall coal mining involves large machines cutting into the coalface. Automation of some of the processes increases mine productivity and moves miners away from hazardous, noisy and dusty environments. An Australian Coal Association Research Program study showed that CSIRO's technology can result in the production of an additional 435,000 tonnes of coal per year, per longwall and a conservative five per cent increase in the cutting rate.

New technique to remove oil trapped in quartz

CSIRO researchers have developed a world first technique using lasers to remove oil, unaltered, from petroleum trapped in fluid-filled cavities within quartz. Analysis of petroleum trapped in these cavities, called inclusions, can help determine where the oil came from and therefore improve oil exploration efforts.

The technique enables the petroleum in each inclusion to be analysed for its unique geochemical make-up, which is not possible using the conventional method of fluid-inclusion analysis. This technology will enhance our understanding of how oil reservoirs are filled with petroleum, leading to more effective petroleum exploration (see: www.csiro.au/science/Laser-drills-the-way-to-oil.html).

Progress in underground carbon storage

The effective storage of carbon dioxide is an important factor in reducing greenhouse gas emissions. CSIRO played a significant role in a demonstration of carbon dioxide storage through its engagement in the Cooperative Research Centre for Greenhouse Gas Technologies Otway Project in south-western Victoria in August 2009. More than 65,000 tonnes of carbon dioxide was safely injected and stored in a depleted gas reservoir, with comprehensive monitoring verifying that the injected carbon dioxide was securely contained. CSIRO has begun modelling research for Stage 2 of the Otway project.

Environment

Research group aim:

To develop and apply leading-edge environmental research that will underpin the economic, environmental and social future of Australia.

Group expenditure (excluding Flagships) 2009–10: $78.6 million

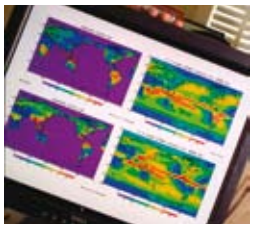
Overview

Australians have stewardship of a beautiful, diverse and unique environment. The cumulative consequences of the last 200 years of development of natural resources leave us with a legacy of environmental challenges. The future of Australia, the Asia-Pacific region, and indeed the whole world, is also being re-shaped by the forces of climate change and variability, natural resource quality and security, technological revolution, trade reform, poverty alleviation and national security concerns.

CSIRO's response to these challenges and opportunities involves the application of enhanced systems understanding as well as the development and deployment of new technologies, processes and services. CSIRO's Environment Group is doing this by boosting our understanding of the operation and interaction of entire ecosystems, regional economies, and societies. We aim to deliver the highest quality scientific research that will result in a more internationally competitive and sustainable Australia.

Achievements 2009–10[13]

Forecasting the weather more accurately



Every day Australians access the latest weather information which is the product of a partnership between CSIRO and the Bureau of Meteorology. The Australian Community Climate Earth-System Simulator (ACCESS) is a modelling system developed to deliver more reliable, timely and accurate forecasts of weather and climate for the future health, safety and prosperity of Australians. Through better assimilation of data, particularly those from satellites, ACCESS is providing improved weather forecasts.

New research vessel

In May 2009, the Australian Government dedicated $120 million for a new ocean-going research vessel. The new 85-metre vessel to be called *The Investigator* will more than double Australia's ocean climate and geoscience research capability. It will support activities across a range of disciplines in oceanographic, climate, geological, fisheries and ecosystem research. *The Investigator* is being designed, built and commissioned by CSIRO through the Future Research Vessel Project, as part of the Super Science Initiative and financed from the Education Investment Fund.

[13] *Excludes Flagship achievements. This Group manages the Climate Adaptation Flagship and the Water for a Healthy Country Flagship, see Program 1, page 20 and 36.*

New Indian Ocean Marine Research Centre

The new Indian Ocean Marine Research Centre based at The University of Western Australia (UWA) will be home to 240 world-class researchers from CSIRO, the Australian Institute for Marine Science and UWA. Marine scientists and engineers at the centre will investigate climate change, the sustainable use of marine resources, conserving marine biodiversity, coastal zone management and security and safety.

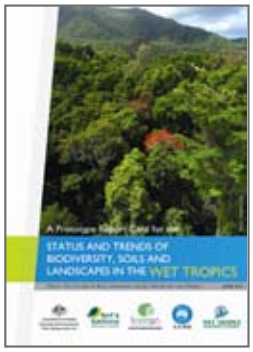
The Atlas of Living Australia

The Atlas of Living Australia consists of 20 million specimens and observations of Australian wildlife records. It is a collaborative Australian government funded initiative focused on making biodiversity information more accessible and useable online. *The Atlas of Living Australia* is a repository of linked information not previously available to the public on biodiversity research, literature, observations, maps and images. *The Atlas of Living Australia* aims to, over time, allow people across Australia to contribute sightings and pictures of plants and animals into the Atlas themselves. The first public release of online tools will be in October 2010.

Saving grasslands from extinction

Formerly widespread, only one per cent of pre-European temperate grasslands now remain. CSIRO researchers have used population simulation models to show that adding new genetic material to small populations of temperate grasslands can rescue them from extinction. CSIRO scientists are working with the New South Wales National Parks and Wildlife Service to develop a genetic management plan for the species.

Report card for Wet Tropics



CSIRO has developed a prototype report card for the biodiversity, soils and landscape assets of the Wet Tropics of North Queensland. The report card gives marks for their present condition based on expert opinion and the most recent available data. The report card highlights information gaps and makes recommendations on how these should be filled. The report card will inform the policies, plans and activities of a wide range of sectors, both public and private.

Information Sciences

Research group aim:

To work with partners to solve national challenges, drive the productivity of Australian industries, and deliver public good outcomes through the innovative application of mathematical, statistical, information and communication sciences and technologies.

Group expenditure (excluding Flagships) 2009–10: $110 million

Overview

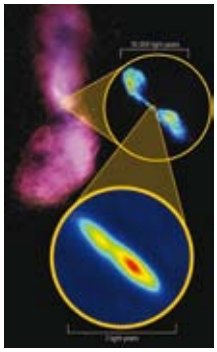
The Information Sciences Group contains the core of CSIRO's research focus in the data intensive sciences and services, providing Australia with world-class capabilities in Information and Communication Technologies (ICT), Mathematical Sciences, Astronomy and Space Science that are deployed through a collaborative partnering approach. The Group plays a key role in enabling CSIRO's multidisciplinary science across Outcome Domain portfolios and Flagship programs.

The Group is the national leader for e-enabling scientific research endeavours through a data-intensive approach. Through implementation of the eResearch Strategy, the way we conduct research at CSIRO is changing, enabling researchers to actively collaborate and share resources globally, and engage in cross-disciplinary research. The eResearch strategy supports research tackling 'big science' challenges and associated data management requirements.

The Group operates two world-class National Facilities in Astronomy and Space Science on behalf of the Australian Government.

Achievements 2009–10

First signal received by future telescope



The first of 36 antennas that will make up the Australian Square Kilometre Array Pathfinder (ASKAP) was assembled in January 2010 at the Murchison Radio-astronomy Observatory in the mid-west region of Western Australia.

By April 2010, the first ASKAP antenna was linked to existing CSIRO antennas in New South Wales and a new antenna in New Zealand to act as one giant telescope, linking up over a distance of 5,500 kilometres for the first time. The linked telescope was used to peer into the heart of a galaxy called Centaurus A. The construction of ASKAP's remaining antennas will proceed quickly with the complete ASKAP system expected to be finished by 2013. Once built, the ASKAP will be operated by CSIRO as part of the Australia Telescope National Facility.

CSIRO's graphics processing unit supercomputer

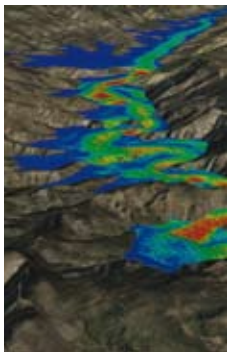
CSIRO's latest supercomputer cluster combines traditional central processing units with more powerful graphics processing units (GPUs) to provide a world-class computational and simulation science facility which will advance priority CSIRO science. CSIRO scientists are already utilising the power and speed of the GPU cluster in the areas of biotechnology

image analysis, materials science, computational fluid dynamics and environmental modelling. CSIRO has fostered a close collaboration with GPU developer NVIDIA who has recognised CSIRO as a 2010 Research Centre as part of an international program.

Relieving the electronic health records headache

CSIRO is helping the National E-Health Transition Authority (NEHTA) with Australia's electronic health record rollout. Inaccurate or missing data in patient records has resulted in people being hospitalised unnecessarily, and wasting an estimated 25 per cent of clinicians' time. NEHTA is implementing an internationally agreed standard for the dictionary of clinical terms used in electronic health records software, called SNOMED CT. Software developed by the Australian e-Health Research Centre is helping to translate terms in the myriad of existing health information systems to terms which are in SNOMED CT.

Modelling how dams break



CSIRO mathematicians are creating computational models of events like dam breaks and tsunamis to assist with planning for and understanding these phenomena. Catastrophic events such as these can have serious economic, environmental and humanitarian effects. CSIRO, working with the Chinese Academy of Surveying and Mapping is visualising and assessing the risks of a major dam break. Many dams in China lie upstream from densely populated towns which are at risk of collapse from structural failure or earthquakes. CSIRO has used its software to model the hypothetical collapse of the Geheyan Dam in China, which holds up to 3.12 billion cubic metres of water. The highly accurate models have been essential as part of risk and disaster management for the academy.

Remote-access meters can cut your energy costs

CSIRO's new web-based smart metering system enables householders, small businesses and electricity retailers to remotely control energy use over a broadband Internet connection. The aim is to help small scale energy users cut energy use, costs and carbon emissions. CSIRO has worked with energy service company, Energy Response, and hardware designer, Saturn South, to develop a system able to aggregate a large number of smaller users. The system will give householders the flexibility to cut back their electricity use at times when it is needed elsewhere on the grid.

Opals set to shine with new grading technology

CSIRO developed the Gemmological Digital Analyser™ with a consortium of Australian opal miners to assess the complex colour characteristics and grade of cut and polished opal. Its development has been a very significant achievement for the opal industry, eliminating errors from human assessments and increasing the reliability of opal prices for both the miner and consumer.

Manufacturing, Materials and Minerals

Research group aim:

To help grow Australia's wealth by fostering increased efficiency and supporting business and job creation in an environmentally and socially responsible manner.

Group expenditure (excluding Flagships) 2009–10: $113.6 million

Overview

The focus of the Manufacturing, Materials and Minerals Group is to grow a high-value, globally competitive sustainable manufacturing sector and help address Australia's key national challenges and opportunities in the minerals sector.

The Group's research supports industries that are responsible for around 18 per cent of Australia's gross domestic product. Despite the global financial crisis, manufacturing still employs over one million Australians and contributed exports worth $81.4 billion in 2009. Business expenditure on research and development in manufacturing in Australia is higher than for any other sector.

CSIRO supports manufacturing with a portfolio of technologies in sustainable manufacturing, automotive/aerospace, smarter textiles, health technologies and light metals. We are working to supply improved processes and new technologies to generate new products and new companies, and stimulate the growth of green jobs.

CSIRO supports the minerals industry by helping to transform its economic and environmental performance through novel concepts and technologies from exploration to mining and processing.

Achievements 2009–10[14]

CSIRO technologies help grow international sales

CSIRO is helping an Australian equipment manufacturer to compete in the global market. CSIRO's improved pouring and casting technologies enabled o.d.t. Engineering's ingot casting machines to operate faster, providing a 20 per cent increase in productivity, and sparking commercial interest both within Australia and internationally. CSIRO partners with o.d.t. Engineering through the CAST CRC.

Fast and accurate measurement of cotton

A testing device designed to improve the quality of fibre produced by Australian cotton growers has been developed by CSIRO, with support from the Cotton Research Development Corporation and the Cotton Catchment Communities CRC. The 'Cottonscope' automatically and rapidly measures cotton fibre maturity, directly and accurately, enabling optimum harvesting time and prediction of final quality of cotton fabrics. The device has been licensed to start-up Australian company Cottonscope Pty Ltd.

[14] *Excludes Flagship achievements. This Group manages the Future Manufacturing Flagship, the Light Metals Flagship and the Minerals Down Under Flagship, see Program 1, page 26, 28 and 30.*

Recovering materials from waste

Researchers have developed a new high throughput process that extracts precious and hazardous metals from waste materials and therefore the environment. Working in partnership with the Korea Institute of Geoscience and Mineral Resources, scientists are enabling cost-effective recovery of high-value metals from waste materials such as batteries, electronic and electrical goods.

Computing boost for mineral explorers

Mineral explorers have found it difficult to access publicly available geological data held in different databases around Australia. To address this challenge, CSIRO and partners have developed the AuScope Grid. The Grid provides tools for explorers to access and analyse large volumes of existing exploration data over the Internet. This is the first time in the world such technology has been successfully deployed.

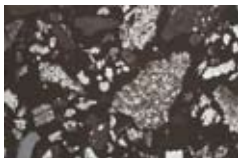
Science masters the mix

CSIRO's Rotated Arc Mixer (RAM), an industrial mixer with the ability to mix thick fluids such as paints, foods, cosmetics or explosives has been commercialised by Tasweld Engineering, with the assistance of the Advanced Manufacturing Cooperative Research Centre and the Victorian Centre for Advanced Materials Manufacturing. The RAM consumes 60 to 90 per cent less energy than conventional devices, while retaining or improving performance levels.

RAFT creates new materials

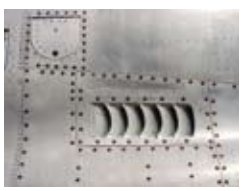
A breakthrough polymer technology developed by CSIRO dubbed RAFT, allows new materials to be designed to exactly fit customers' requirements. Applications for the technology will include intelligent drug delivery, biocompatible materials, paints and coating to meet stricter environmental guidelines, targeted personal care and cosmetics, synthetic rubbers, additives to promote fuel efficiency and ink jet media.

Removing phosphorus from iron ore



As Australia mines its high grade iron ore deposits, we need to find ways to make lower value, high-phosphorus iron ores more attractive to steel producers. CSIRO researchers are developing cost-effective processes to reduce phosphorus levels. This could increase the attractiveness of eight billion tonnes of high-phosphorus ore close to existing mines.

Self-healing coatings for the aerospace industry



A new coating system that 'self-repairs' has the potential to replace conventional chromate based coating systems in the aerospace industry. Developed in partnership with the Delft University of Technology and the Netherlands Institute of Applied Scientific Research, the high performance, multi-functional coating system lowers the environmental footprint of the process, while also allowing the coating to 'self repair'.

Program 3 – Science Outreach: Education and Scientific Publishing

Communicating scientific research helps raise the profile of science and CSIRO within the community. CSIRO conducts a range of science education programs for primary and secondary school students and their teachers and the public and hosts the CSIRO Discovery Centre in Canberra.

CSIRO's postgraduate scholarship program provides opportunities in science and engineering for outstanding graduates who enrol at Australian tertiary institutions as full-time postgraduate students for research leading to the award of a PhD. PhD students at CSIRO are co-supervised by a university, allowing students to maintain and develop their university connections while being exposed to research in a working environment, see Table 2.5. Some CSIRO Divisions have collaborative arrangements with universities to foster PhD studies in particular areas – for example CSIRO Marine and Atmospheric Research and the University of Tasmania run a joint PhD Program.

Table 2.5: Science outreach: CSIRO's postgraduate students

Sponsored postgraduates[a]	2005–06	2006–07	2007–08	2008–09	2009–10
PhD	259	256	241	338	375
Masters	8	4	18	9	13
Honours	10	16	13	17	25
Total	**277**	**276**	**272**	**364**	**413[b]**

Supervised postgraduates[a]	2005–06	2006–07	2007–08	2008–09	2009–10
PhD	352	582	523	629	733
Masters	40	31	48	56	47
Honours	31	61	63	58	60
Total	**423**	**674**	**634**	**743**	**840**
Postdoctoral Fellows	290	294	301	304	330

[a] As at 31 May each year. A student may be either sponsored, supervised or both. The total number of individual students sponsored and/or supervised as at 31 May 2010 was 840, including more than 75 supervised in collaboration with CRCs and 56 through the Flagship Collaboration Fund. See glossary page 211 for definition of sponsorship and supervision.

[b] Includes 147 students fully sponsored and 266 students partially sponsored by CSIRO.

CarbonKids: teaching kids about climate change

In August 2009, students and teachers from 16 Canberra schools gathered at Forrest Primary School to celebrate the national launch of CSIRO Education's new CarbonKids education program. CarbonKids is a program for schools committed to tackling climate change. The program offers a range of ideas and activities for the early, primary and middle years of schooling. The program was piloted in 26 schools across Australia with funding support from Shell.

Like most of the schools involved in the trial, the Canberra schools integrated a selection of climate change curriculum resources into their existing school curriculum framework, putting a climate change focus on existing units. Students also developed an understanding of how to reduce greenhouse gas emissions in their schools and local communities and how planting trees absorbs carbon from the atmosphere. The schools engaged students, teachers, parents and other members of the community to evaluate their carbon footprint and develop a better understanding of the science behind climate change.

An external evaluation showed that the CarbonKids program 'met a significant need in schools for improving teaching and learning about the science of climate change and its implications (such as carbon reduction and sustainability)'. Through a heavy focus on critical literacy, numeracy, cultural awareness and open-investigations, the program inspired values, skills and a deep understanding of our need to mitigate and adapt to the effects of global warming.

With funding from Bayer, CarbonKids will engage an additional 90 schools and continue to develop new classroom resources for students to discuss and investigate a range of social, economic and scientific issues related to climate change.

Students involved in the sequestration of carbon. Credit: The Department of the Environment, Water, Heritage and the Arts

'...the program inspired values, skills and a deep understanding of our need to mitigate and adapt to the effects of global warming.'

CSIRO also operates **CSIRO** PUBLISHING as an independent science and technology publisher with a global reputation for quality products and services covering a wide range of scientific disciplines, including agriculture, chemistry, the plant and animal sciences, and environmental management.

Science Outreach – Education: Key Performance Indicators

CSIRO continued to enhance its profile delivering a diverse range of outreach programs. A summary of performance for these programs against the 2009–10 Portfolio Budget Statements key performance indicators follows.

KPI 1 – Utilisation of science outreach programs.

KPI 2 – Awareness of science by CSIRO stakeholders.

KPI 3 – Evidence of success of participants in the Science Outreach programs.

KPI 1: Utilisation of science outreach programs

Utilisation as shown by the number of participants and users of each science outreach program and the proportion of uptake within the target groups.

The utilisation of most science outreach programs continues to increase. Participation in CSIRO Discovery Centre increased by 17 per cent, Science by Email increased by 18 per cent and Creativity in Science and Technology increased by five per cent. Participation in other programs remained stable or fell slightly. Visitation and participation numbers are shown in Table 2.6.

CSIRO Education continues to offer a range of valued programs to teachers and students. The regional centres saw similar numbers of students as last year and Science by Email continued to increase its readership. In 2009, the CarbonKids pilot program was implemented and

Table 2.6: Science outreach: visitation and participation numbers

Science outreach program	2005	2006	2007	2008	2009
Parkes radio telescope	109,879	94,305	104,783	92,369	112,342
Canberra Deep Space Communication Complex	63,615	65,467	62,162	67,538	67,582
CSIRO Science Education Centres	363,463	369,919	383,499	390,947	386,500
CSIRO Discovery Centre	50,235	60,581	73,772	80,555	94,365
Double Helix Science Club	16,813	18,945	19,545	20,253	19,656
Science by Email	13,915	20,689	28,516	29,560	34,933
Creativity in Science and Technology (CREST)	5,549	6,509	5,999	8,355	8,801
BHP Billiton Science Awards	604	2,677	4,103	2,568	3,114

the Scientists in Schools program reached 1,473 teacher-scientist partnerships and introduced the sub-program, Mathematicians in Schools. *SCOPE*, the national weekly science TV program is now broadcast on Saturday mornings, where it reaches a higher proportion of young people. The program is now available for purchase for use by teachers in the classroom or at home. The book, *Polar Eyes*, was shortlisted for the Children's Book Council of Australia's Book of the Year.

CSIRO's Parkes radio telescope has been visited by over half a million people in the last five years. 6,500 visitors attended the CSIRO Parkes Observatory Open Weekend in July 2009, which won the Parkes Shire Australia Day Award for Community Event of the Year.

KPI 2: Awareness of science by CSIRO stakeholders

A community awareness survey identified CSIRO as well known in the community. Unprompted, 70 per cent of respondents identified CSIRO as a leading player in Australian Research.

A community attitudes survey, undertaken by an independent organisation[15] found that CSIRO is seen by the community as a leading player in research in Australia with CSIRO mentioned unprompted by 70 per cent of the community when asked to name organisations doing science and research in Australia compared to five per cent for universities and six per cent for health research organisations (prompted awareness was 96 per cent for CSIRO, and 25 and 21 per cent respectively for universities and health research organisations). In an unrelated 2009 survey of Australians' trust in people and organisations in relation to information about science and technology, CSIRO was the highest rated organisation.[16]

[15] *CSIRO – Community Attitudes Research Ogilvy Illumination, August 2010.*

[16] *Swinburne University of Technology, National Technology and Society Monitor, 2009, p11.*

KPI 3: Evidence of success of participants in the Science Outreach programs

Demand for science outreach programs such as CarbonKids and Scientists in Schools continues to grow. Independent evaluations on several science outreach programs concluded that these programs provided positive experiences for the participants.

An external review of Scientists in Schools gave an extremely positive view of the impact on all participants, with students more engaged, teachers more confident and scientists feeling rewarded and motivated. Other external reviews for CarbonKids and Maths by Email were equally positive. Maths by Email started in March 2010 and had already gained 5,461 subscribers by 30 June. CarbonKids is in great demand with the evaluation demonstrating a strong impact on teachers and students. Two winners from the BHP Billiton Science Awards attended the International Science and Engineering Fair in the USA and one student gained a third place in his category.

'I learnt from CREST that there is never one answer to a problem and that you have to keep trying. When you succeed it is very rewarding and the area is so broad you constantly learn new things and face new challenges.' (Rhianna, student)

CSIRO's Discovery Centre supports communication and education activities by promoting an understanding and appreciation of research. School children from every state and territory in Australia visit the centre and this number is growing annually, as many schools make multiple repeat visits. Discovery's unique and very popular 90 minute minds-on, hands-on program gives students an insight into CSIRO's work and the value of research to Australian

society. During 2009–10, new exhibitions were completed to showcase our research into climate change and water.

'Through the activities of teachers using the CarbonKids Program, their students' knowledge, skills and attitudes in relation to the science of climate change and practical actions to reduce carbon has significantly increased.' (Independent evaluator in 2009)

The Canberra Deep Space Communication Complex receives data from and sends commands to over 40 robotic spacecraft exploring the Solar System and beyond. During 2009, the Complex celebrated the 40th anniversary of Apollo XI and its role in that history-making endeavour. Highlights also included the 'Hello from Earth' project which reached a worldwide audience contributing messages transmitted to a distant planet and Jupiter: Project 24, which engaged students and the public in 'live' radio astronomy science during the International Year of Astronomy.

Science Outreach – Scientific Publishing: Key Performance Indicators

CSIRO PUBLISHING is an information business operating within CSIRO on a commercial basis on behalf of authors and customers in Australia and overseas. A summary of performance against the 2009–10 Portfolio Budget Statement key performance indicators follows.

KPI 4 – International reach and impact of published journals.

KPI 5 – Add 50 new book titles.

KPI 6 – Positive net profit outcome from **CSIRO** PUBLISHING.

CREST supports students undertaking open ended science investigations. Credit: Mandy Timmers

KPI 4: International reach and impact of published journals

Continue to grow the International reach and impact for the 25 Journals published in partnership with the Australian Academy of Science and other societies.

International submissions continue to grow at 20 per cent annually and the drive for quality saw impact factors, as measured by the Institute for Scientific Information, continue to improve.

Twenty-six peer-reviewed research journals were published during the financial year in partnership with the Australian Academy of Science and other societies.

Multimedia products continue to deliver web-based science and maths learning opportunities for the national schools curriculum through partnerships with the Academy of Science and an educational publisher. CSIRO's film archive is being digitised to make content accessible within CSIRO, to commercial outlets and for a general audience through YouTube.

Two magazines are published by **CSIRO** PUBLISHING: *ECOS* which offers leadership and better understanding in the sustainability area for schools and general readers and *Preview* which is the official magazine of the Australian Society of Exploration Geophysicists.

KPI 5: Add 50 new book titles

Number of new book titles added to the wide-ranging backlist of over 1,200 publications targeting both Australian and international readers.

Forty-seven new books were published during the year, with three other titles rescheduled to the first quarter of 2010–11.

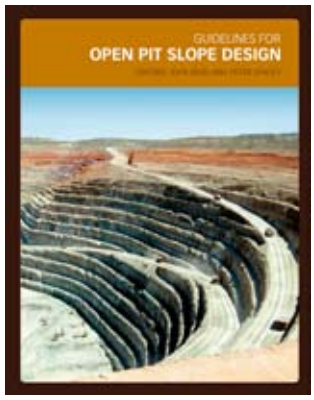
Forty-seven new books were published during the year with reference works such as *Guidelines for Open Pit Slope Design*, *Adapting Agriculture to Climate Change*, *Make it Safe: A Guide to Food Safety* and *Australia's Biodiversity and Climate Change* making significant contributions to industry and / or the understanding of key issues. Other works such as *Out of the Scientist's Garden*, *Dry Times* and *Contested Country* have been both critical and financial success stories with the broader Australian community.

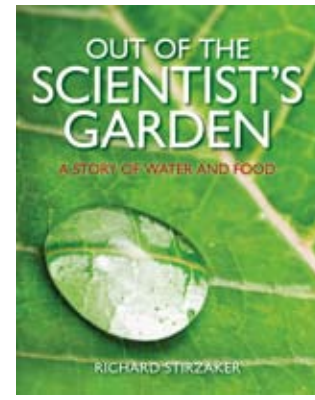
The shift to digital content and services across the business continues with the release of our first eBook collection of 160 titles the most exciting development during the year. The collection is being enthusiastically taken up by libraries and is available to all CSIRO staff through arrangements with our own library services.

KPI 6: Positive net profit outcome from **CSIRO** PUBLISHING

A positive net profit of $755,000 was delivered. This is an improvement of around eight per cent from 2008–09.

CSIRO PUBLISHING successfully managed the potentially negative impact of the global financial crisis on the information community to deliver a 'best ever' net revenue result of $755,000 for the year. Strategies to sustain international subscriptions proved to be particularly successful with the focus on quality product and first rate service to customers, delivering revenue of $11.4 million.





Guidelines for Open Pit Slope Design edited by John Read and Peter Stacey
Cover and text design by James Kelly, cover photo courtesy AngloGold Ashanti Australia Ltd

ECOS 154 featuring an update on renewable energy progress in Australia.
Design by James Kelly, cover photo Horizon Power

Out of the Scientist's Garden by Richard Stirzaker
Cover and text design by James Kelly, cover iStockphoto.

CSIRO and social media

During 2009, CSIRO launched an integrated social media presence to introduce the Organisation to a diverse new audience and support the communication of CSIRO science in an easily accessible and engaging format.

Comprising a Facebook Fan page, YouTube Channel, and podcast and vodcast series, CSIRO's social media is used to promote the breadth of our research along with other activities, such as education and recruitment. All the social media platforms are integrated to maximise reach and draw people to each channel and CSIRO's website. While social media allows CSIRO to reach people of all ages, it offers a particular opportunity to reach younger audiences – our future scientists and decision makers.

With more than 3,377 fans, the Facebook Fan page continues to grow in popularity and a vibrant community with a genuine interest in CSIRO has started to emerge. CSIRO's YouTube channel has so far attracted more than 150 subscribers and over 120,000 video views, while podcast downloads for the year reached 362,665 and vodcast downloads reached 33,448.

'Great vodcasts. Well made and great watching. Keep it up.'

'Thank you indeed for posting so much useful research here on YT, a great way to spread information of significance.'

CSIRO's in-house journalist, Glen Paul, at work in the studio. CSIRO's podcasts were downloaded 362,665 times in 2009–10 and are popular on iTunes. Credit: David McClenaghan

Program 4 – National Research Infrastructure: National Facilities and Collections

CSIRO manages two types of national research infrastructure on behalf of the nation; National Research Facilities and National Biological Collections. CSIRO hosts three major National Research Facilities and over 30 other research facilities, such as the Riverside Life Sciences Centre and the Australian Resources Research Centre. As well as the National Biological Collections we manage several national reference collections, including the National Tree Seed Collection and the Scientific Marine Data Collection.

National Research Facilities

CSIRO operates a range of specialised laboratories, scientific and testing equipment, and other research facilities which are available for use by both Australian and international researchers. The three major National Research Facilities are:

- **The Australian Animal Health Laboratory (AAHL)** – located in Geelong, Victoria, is a national centre of excellence in disease diagnosis, research and policy advice in animal health. It is Australia's front line defence, helping to protect Australia from the threat of exotic and emerging animal diseases.
- **The Australia Telescope National Facility (ATNF)** – is operated and managed by CSIRO's Division of Astronomy and Space Science and is made up of radio telescopes at three observatories, near the towns of Parkes, Coonabarabran and Narrabri in New South Wales. A fourth telescope, the next generation Australian Square Kilometre Array Pathfinder (ASKAP) is currently being built at the Murchison Radio-astronomy Observatory in Western Australia and will consist of 36 antennas. Once fully complete, the ASKAP will also be operated by CSIRO as part of the Australia Telescope National Facility. Construction of ASKAP was on track during 2009–10 with the first antenna built and used in early scientific research. About 90 per cent of radio astronomy research in Australia is undertaken using the Australia Telescope.
- **The Marine National Facility (MNF)** – is made up of a 66 metre blue-water research vessel, *Southern Surveyor*, a package of unique scientific equipment and instrumentation, and a collection of 25 years of marine data. It has the scientific, technical and administrative expertise required to safely, effectively and efficiently manage an ocean-going research platform. The *Southern Surveyor* is particularly suited to multidisciplinary research projects in the deep oceans surrounding Australia. CSIRO is managing a major project to design and build a new state of the art research vessel, *The Investigator,* scheduled to be operational in 2012.

National Biological Collections

CSIRO is the custodian of several collections of animal and plant specimens that contribute to the discovery, inventory, understanding and conservation of Australia's plant and animal biodiversity, these include the:

- Australian National Insect Collection (ANIC), specialising in Australian insects
- Australian National Wildlife Collection (ANWC), specialising in land vertebrates
- Australian National Fish Collection (ANFC), specialising in marine fishes
- Australian National Herbarium (ANH), specialising in native plants and weeds

Together, these collections support a significant part of the country's taxonomic, genetic, agricultural and ecological research. They are vital resources for conservation and the development of sustainable land and marine management systems. Good science and sound decisions on biodiversity and natural resource management require correct identification of Australia's native species.

National Research Infrastructure – National Facilities and Collections: Key Performance Indicators

This section provides a summary of performance against the 2009–10 Portfolio Budget Statement key performance indicators, for the National Facilities and Collections.

KPI 1 – Utilisation of the National Research Infrastructure.

KPI 2 – Maintenance and operation of National Research Infrastructure.

KPI 3 – Proportion of National Biological Collections digitised and available to the public.

KPI 4 – Coverage of National Biological Collections.

KPI 5 – Demonstrated response to national events.

KPI 6 – Demonstrated high-quality scientific contributions in support of National Research Flagships, CSIRO Core Research and external users.

KPI 7 – The AAHL Collaborative Biosecurity Research Facility is built and operated in accordance with the NCRIS/CSIRO agreement.

KPI 1: Utilisation of National Research Infrastructure

As shown by the number of loans, visitor days, research days, observation time and operational time.

Use of the National Facilities and Collections by the Australian and international scientific community continues to grow. The national research infrastructure managed by CSIRO provides significant and growing support to Australian and international researchers.

As in previous years, the **Australian Animal Health Laboratory** (AAHL) has remained operational 24 hours a day, seven days a week. During the financial year, significant engineering work has been undertaken including a completion of the air handling and effluent treatment systems upgrades, the replacement of chillers and the introduction of a new computerised central management system. Work is underway to complete the 350 square metres of additional Physical Containment Level 4 (highest level of biocontainment) laboratories.

The **Australia Telescope National Facility** (ATNF) exceeded its target of 70 per cent of time allocated for astronomical observations, while the time lost during scheduled observations from equipment failure was below five per cent. Twenty-four per cent of telescope time was allocated to ATNF staff, 23 per cent to other Australian researchers and 53 per cent to international researchers. More information can be found in the ATNF's Annual Report at: www.atnf.csiro.au/AR2009

The **Marine National Facility** (MNF) provided 177 days of ship time grants out of 250 days requested. Internationally, scientists from Russia, Fiji, Vanuatu, United States, New Zealand, France and Germany utilised the facilities of the MNF. New funding will provide a step change in capacity and capability of the MNF, bringing the available sea days from 180 to approximately 300. This will enhance the opportunity for Australian scientists and their international collaborators to undertake research. More information can be found in the MNF Annual Report at: www.marine.csiro.au/nationalfacility

Combined, the **National Biological Collections** dispatched over 29,300 specimens in 147 outward going loans, sent around 3,800 tissue samples through 44 grants, hosted 186 visitors for a combined total of 713 research days and hosted 57 tours with a total of 597 people.

KPI 2: Maintenance and operation of National Research Infrastructure

All National Research Infrastructure maintained and operated to relevant international standards.

National Research Infrastructure managed by CSIRO continues to be maintained and operated at international standards. National facilities and collections remain a key strategic initiative for CSIRO.

National Research Facilities

AAHL continued to operate at the highest level of bio-containment, ensuring the physical containment of highly pathogenic organisms. The laboratory has maintained full national accreditation (ISO 17025) and environmental accreditation (ISO 140001), and has met all the Office of the Gene Technology Regulator, Security Sensitive Biological Agents and Australian Quarantine Inspection Service requirements for operation. It should be noted that a number of these regulations have been considerably enhanced following the escape of equine influenza virus from an Australian quarantine station. AAHL has fully complied with these additional requirements.

The **ATNF** continues to be the most productive and powerful radio astronomy facility in the Southern hemisphere. Demand for its use from internationally prominent astronomers within and outside Australia remains high. Over one hundred papers using ATNF data were published in refereed journals in the last year. In 2008, (the latest year for which the analysis has been made) the ATNF ranked second internationally for radio astronomy papers in major journals. New instrumentation to maintain performance at the standard of comparable international facilities continues to be installed on the telescopes. A high rate of availability for astronomy was maintained despite undertaking a major upgrade of the Compact Array during the year.

In 2009–10, the **MNF** received new funding of $6 million over three years for a new program of enhanced maintenance on the RV *Southern Surveyor*. This program will maintain the reliability of the 40-year old vessel to international standards until a new state-of-the-art blue-water research vessel can be delivered. The 2009–10 Federal Budget provided $120 million for the replacement of Australia's Marine National Facility. The new vessel will provide a major boost to marine research in Australia. It will be commissioned in 2012–13 and has been named *The Investigator*.

National Biological Collections

All the collections are housed in purpose-built facilities and are stored, curated and managed according to international standards.

The **Australian National Insect Collection** (ANIC) is the first collection in Australia to trial 'whole-drawer' specimen imaging, with a view to providing users with 'virtual' access to the ANIC's collection of over ten million specimens.

The **Australian National Wildlife Collection** (ANWC) has upgraded its database, has acquired new bird specimens from the Northern Territory following an expedition, and has received a private egg collection as a cultural gift.

The **Australian National Herbarium** (ANH) has eliminated a 25-year backlog of unprocessed collections, with a resultant increase in specimens and data available for research.

The **Australian National Fish Collection** (ANFC) submitted its 10,000th tissue for barcoding as part of the international Fish Barcode of Life Initiative (FISH-BOL).

KPI 3: Proportion of Collections digitised and available to the public

Percentages vary from collection to collection and are dependent on the diversity of organisms and size of collections. Five per cent of the ANIC is digitised, 86 per cent of the ANWC, 100 per cent of the ANFC and 76 per cent of the ANH.

All 350,000 **ANIC** digitised specimen records are available publicly through the ANIC specimen database (see: anic.ento.csiro.au/database/index.aspx), OZCAM (see link above), the Global Biodiversity Information Facility (GBIF) *(see:* data.gbif.org/welcome.htm) and Zipcode Zoo (see: www.zipcodezoo.com/). As with the ANFC, it is anticipated that the *Atlas of Living Australia* will facilitate more records being made available for interrogation by users of the specimen data.

The *Atlas of Living Australia* project was expanded in 2009–10 under a national project managed by CSIRO and will facilitate a step-change in online availability of collection information nationally.

Of the 112,581 digitised records for **ANWC**, 109,335 records are available publicly through OZCAM (see above link) on a manual provision basis. This will change to dynamic online provision from the ANWC database by December 2010.

The majority of **ANH** Australian specimen records are digitised, with a 100 per cent available through *Australia's Virtual Herbarium* (see: www.ersa.edu.au/avh/) and soon through the *Atlas of Living Australia* (see: www.ala.org.au/). Images of Australian plants are also available via the *Australian Plant Image Index* (see: www.anbg.gov.au/anbg/photo-collection/photo.index.html), a comprehensive collection of over 25,000 images.

All 48,130 **ANFC** specimen records are digitised, with 57 per cent available through the Online Zoological Collections of Australian Museums (see: www.ozcam.gov.au/) and BioMaps (see: www.biomaps.net.au/biomaps2/). The *Atlas of Living Australia* will result in a greater proportion of the data being available. The ANFC contains the Photographic Index of Australian Fishes, which is the largest collection of images of Australasian fishes. More than 2,000 images are available to the public via CSIRO's Scienceimage online (see: www.scienceimage.csiro.au/).

KPI 4: Coverage of National Biological Collections

Per cent of known species covered in each National Biological Collection.

Overall coverage is estimated at approximately 70 per cent for the ANIC and ANH, 50 per cent for the ANFC and 55 per cent for the ANWC.

Percentage coverage of each national biological collection provides an estimation of how well the natural diversity of each group of organisms is represented within the collections. Easily observed organisms such as butterflies, birds and some plants are better represented than other less obvious groups, such as some insects and fishes.

KPI 5: Demonstrated response to national events.

AAHL continued to ensure that all diagnostic requests for an exotic disease exclusion, (a test that excludes a particular disease) had a 24 hour turn around time or less.

AAHL conducted approximately 42,000 tests in the reporting year on around 24,000 samples. The majority of these related to both diagnosis and surveillance work on the influenza virus, however there were a significant number of exclusions for Hendra virus, including a number of positive cases. AAHL undertook an external

post mortem on a horse with Hendra using full biosecurity suits, a new operational activity for the laboratory.

Research has continued to focus on developing more effective control strategies for avian influenza and on risk mitigation for Hendra virus, whilst maintaining a significant number of projects on emerging diseases in general. The first case of atypical scrapie, a brain disease of sheep, was diagnosed at AAHL in March 2010 and confirmed at the World Reference Laboratory, UK. This is a rare disease of sheep, entirely different to scrapie with no trade or human health implications.

KPI 6: Demonstrated high-quality scientific contributions in support of National Research Flagships, CSIRO Core Research and external users

National Research Infrastructure continues to provide positive contributions to the research of CSIRO and external users.

See pages 70–74 for examples of National Research Infrastructure contributions to support CSIRO's research.

KPI 7: The AAHL Collaborative Biosecurity Research Facility is built and operated in accordance with the NCRIS/CSIRO agreement

At AAHL, work is now well underway on the construction of a new specialised pathogen containment level four laboratory.

Funded by the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS), the AAHL Collaborative Biosecurity Research Facility (ACBRF) will enable international researchers to work on those diseases that affect both humans and animals and for which there are currently no treatments.

It is anticipated that this laboratory will open in late 2010. Design plans have now been completed for the new ACBRF insectary and construction work will commence in July 2010, with the completion of all NCRIS work by June 2011. Access arrangements, fees and training requirements for NCRIS users are now available. A specialised training facility for the site has been completed and utilised as part of an AAHL held international biosafety training course.

Scientific contributions of CSIRO's National Research Infrastructure

This section highlights some of the contributions to science achieved through the National Facilities and Collections.

Australian Animal Health Laboratory

The AAHL continues to focus on key emerging diseases of livestock and people, undertaking underpinning research that enables Australia to better manage the risks associated with these diseases. This year, there has been a continuing focus on avian and porcine influenza, Hendra virus, Newcastle Disease of poultry and the identification of a case of atypical scrapie, a

Reducing the Australian Animal Health Laboratory's environmental footprint

CSIRO's Australian Animal Health Laboratory (AAHL) in Geelong, Victoria has made significant changes to the way the facility operates in order to reduce the facility's environmental footprint. Prior to the upgrades, AAHL's air intake system ran continuously with fans drawing on a significant amount of power to function. Old steam boilers and hot water generators were inefficient, with water consumption being of major concern.

Over a five year period, a multi-million dollar project focused on progressively upgrading and replacing the facility's engineering plant and equipment whilst concurrently maintaining AAHL's functional operations. Various modifications to extend the life of the facility by installing state-of-the art equipment were undertaken.

AAHL's heating system now has an average operating efficiency of 75 per cent compared to the original steam boilers which had only 50 per cent. Fans now operate with a variable speed drive at the minimum speed necessary to provide the required air flow and pressure, significantly reducing energy usage. AAHL recently announced a natural gas consumption saving of more than 25 per cent over a five year period. Overall, equipment upgrades have resulted in a 40 per cent reduction in the facility's energy and gas consumption helping us reduce our environmental footprint.

The Australian Animal Health Laboratory at Geelong, Victoria. Credit: CSIRO

brain disease of sheep. All requirements listed in the Memorandum of Understanding between AAHL and the Department of Agriculture, Fisheries and Forestry have been fully met. AAHL organised and held a major international symposium on Foot and Mouth Disease (FMD), providing up-to-date information on national and international approaches to managing the risks associated with FMD.

Australia Telescope National Facility

The Australian Square Kilometre Array Pathfinder (ASKAP) is a program within CSIRO to build a world-class radio telescope in the mid-west of Western Australia. It will be operated by CSIRO as part of the Australia Telescope National Facility. ASKAP, as well as being a next generation telescope in its own right, will provide an important test-bed for the future Square Kilometre Array (SKA) project. The SKA project is a proposal by the international community to develop a future radio telescope that will have capabilities in excess of ASKAP. Combining speed and sensitivity, the ASKAP telescope will be a world leading survey instrument, operational in 2013.

Following recommendations provided by an international panel of expert astronomers, ten major science projects, representing 363 scientists from 131 institutions, have been selected for ASKAP's first five years of operations.

Of the ten projects' scientists, 33 per cent are from Australia and New Zealand, 30 per cent from North America, 28 per cent from Europe, and nine per cent from elsewhere in the world. This response illustrates the international interest in the ASKAP program and its potential to help cast light on fundamental physics and processes at work in the Universe.

Marine Research Vessel, *Southern Surveyor*

During 2009–10, *Southern Surveyor* research voyages included explorations by University of Tasmania geoscientists in the South Pacific. Through deep sea tectonic studies, their research aims to improve the understanding of Australia's geological history.

As part of climate change research, CSIRO was granted voyage time in the Tasman Sea to study how nutrients control oceanic primary productivity and carbon uptake. Similarly, Antarctic climate and ecosystem scientists conducted voyages in the Southern Ocean to

deploy and service moorings which measure the transfer of carbon dioxide from the atmosphere to the surface and deeper ocean waters. Further studies by CSIRO and University of Western Australia scientists studied the impact of climate variability on nutrient transfer across the continental shelf and human and climate-induced changes on Ningaloo Reef in Western Australia. More information can be found at: www.marine.csiro.au/nationalfacility/

Australian National Insect Collection

To support Australian biosecurity, the ANIC employs officers from the Australian Quarantine and Inspection Service (AQIS) and the Department of Agriculture, Fisheries and Forestry (DAFF) who provide rapid response assistance when urgent identification of an insect is required. Using remote diagnostics via a web-based technology, insects can be speedily identified, saving time and resources. This is particularly important in a quarantine setting where response time is crucial to the outcome.

The AQIS Officer facilitates interactions between AQIS and the ANIC, giving AQIS the ability to utilise the collection and gain advice from taxonomic specialists, both of which are invaluable tools in making quarantine decisions and ultimately protecting Australia's biosecurity.

Australian National Wildlife Collection

The ANWC received a major boost with the purchase of a Micro CT scanner which will greatly enhance research into Australian mammal fauna. This exciting new research tool opens new ways of studying specimens of sometimes tiny mammals, such as many small bats and carnivorous marsupials. Whether they have been preserved whole in alcohol or traditionally dried, researchers can now obtain staggeringly detailed three dimensional images of skull morphology. The potential for uses in other groups of organisms is immense.

Australian National Fish Collection

The Australian National Fish Collection (ANFC) underpins research in the Wealth from Oceans Flagship and the Climate Adaptation Flagship, providing expertise in fish identification, biodiversity and biogeography. Specimens from the ANFC have helped resolve taxonomic problems across the Indo-Pacific region and the Southern Ocean.

The revision of the Australian Handfishes (Brachionichthyidae) resulted in the description of three new genera and nine new species and was published in *Zootaxa*. At least ten species new to science were discovered in the first ever comprehensive survey of Borneo's sharks and rays, in a collaborative project between the governments of the United States, Malaysia, Indonesia and Australia, and funded by the National Science Foundation. *Sharks and Rays of Borneo* identifies the features, size, distribution, local common names, habitat, biology and conservation status of 118 species.

Australian National Herbarium

The ANH and the Centre for Plant Biodiversity Research is researching the biology of three species of threatened orchid to secure their survival in the face of major roadworks in the Buladelah area on the north coast of New South Wales. This work is focused on relocating affected orchid populations to alternative sites prior to the construction of major roadworks. The project also has wider implications for research into threatened species conservation, translocation and orchid biology, habitat preferences, pollination strategies, natural versus human-assisted regeneration, and the isolation, identification and establishment of associations between the orchid's roots and fungi, which is an essential process for orchid seed germination.

CSIRO's approach to climate change adaptation

Australia is particularly vulnerable to many of the climatic changes projected by CSIRO and other international scientists. Our water supplies, coastal settlements, agriculture and natural ecosystems are especially affected by climate change. In fact we have been assessed as one of the developed nations most vulnerable to climate change.

CSIRO's Climate Adaptation Flagship brings together a wide range of skills and capabilities to help Australia adapt to a changing climate. Our researchers provide the scientific basis to support sound adaptation decisions by government, industry and communities. We aim to minimise the negative consequences of climate change and climate variability and take advantage of new opportunities that may arise.

For agriculture our research is developing strategies for mixed cropping and grazing systems Australia-wide to adapt to projected climate change and other business pressures. By combining information from real mixed cropping systems with expected climate change impacts, farmers can identify management options to offset negative impacts.

A Flagship Collaboration Cluster is assessing the benefits of coastal adaptation. The South East Queensland Climate Adaptation Research Initiative is investigating a range of options to reduce the population at risk of inundation in low lying coastal areas.

Flagship scientists led a project to develop the Marine Climate Change Impacts and Adaptation Report Card for Australia. It communicates observed and expected changes together with key adaptation options for environmental and resource managers and anyone with recreational and financial interests in our coasts and oceans.

By equipping Australia with practical and effective options to adapt to climate change and variability the Flagship aims to create $3 billion per annum in net benefits by 2030.

Coastal inundation will be more frequent as sea level rises. Credit: Liese Coulter

Awards and honours

Outstanding performance in research is also recognised by various international and national award schemes. Here are just a few examples of awards and honours granted in 2009–10 that are a further demonstration of our effectiveness in research and its application in industry and the community.

Order of Australia

Member (AM)

Dr Ian Grey (Process Science and Engineering) for service to science, particularly in the field of mineralogy as a crystallographer, and to the mineral sands export industry.

Dr Roger Laurence Kitching (Formerly, Entomology) for service to conservation science as an academic, researcher and educator, particularly in the field of tropical rainforest ecology and ecosystem management.

Medal (OAM)

Dr Robert (Bob) Anderssen (Mathematics, Informatics and Statistics) for services to mathematical and information sciences in Australia.

Prime Minister's Prizes for Science

Prime Minister's Prize for Science

Dr John O'Sullivan (Astronomy and Space Science) for achievements in astronomy and wireless technologies.

Malcolm McIntosh Prize for Physical Scientist of the Year

Dr Amanda Barnard (Materials Science and Engineering) for major contributions to the field of nanoscience.

The Sir Ian Clunies Ross Award 2010

Dr John O'Sullivan and **team, Mr Graham Daniels, Mr John Deane, Mr Diet Ostry** and **Dr Terry Percival** (Astronomy and Space Science, ICT Centre, National ICT Australia) were awarded the *Australian Academy of Technological Sciences and Engineering Clunies Ross Award* for the invention of the technology behind most high-speed wireless local area networks (WLANs). Their invention and the widespread adoption of WLAN technology helped enable a global revolution in mobile computing and in the way we live and work.

Australian Museum Eureka Prizes 2009

Dr Debbie Abbs, Dr Kathy McInnes and **Dr Ben Preston** (Marine and Atmospheric Research) were part of the Cities Adapting to Climate Change team that won the *NSW Department of Environment and Climate Change Eureka Prize Innovative Solutions to Climate Change* prize. The team were awarded the prestigious prize for developing an innovative, transferable method for assessing regional climate change vulnerability in cities.

Dr Kishore Prayaga and **team**, **Dr Max Mariasegaram** and **Ms Stephanie Sinclair** (Livestock Industries) were awarded the *Research that Contributes to Animal Protection Eureka Prize* for the development of a simple genetic test which has the potential to end the need for the painful practice of dehorning cattle in Australia.

Dr Nick Cutmore and **team, Dr Yi Liu, Dr Brian Sowerby** and **Dr James Tickner** (Process Science and Engineering) and the Air Cargo Scanner team won the *Outstanding Science in Support of Defence or National Security Eureka Prize* for the novel air cargo scanning technology which will improve air cargo security.

CSIRO Chairman's Medal

The Chairman's Medal honours the most exceptional research in CSIRO and is awarded to the scientist or team whose research is of national or international importance in advancing scientific knowledge, technology application or commercialisation.

The winners of the *2009 Chairman's Medal* were **Dr John O'Sullivan** (team leader) and the **Wireless Local Area Network (WLAN) team.** The team received the medal for delivering major technical benefits to Australia and the world and substantial returns to CSIRO from the WLAN technology now underpinning wireless communication systems in over one billion products world-wide.

Further information on CSIRO Awards can be found at: http://www.csiro.au/news/CSIRO-Medal-winners.html

The CSIRO Medal for Lifetime Achievement

The CSIRO Medal for Lifetime Achievement is awarded to individuals who have a record of sustained and meritorious achievement over a prolonged period of CSIRO service.

Dr Ezio Rizzardo (Molecular and Health Technologies) for seminal contributions to polymer science and pioneering work in controlled free radical polymerisation which has revolutionised the way polymers are made,

Winners of the Chairman's Medal: the WLAN team (back row) Mr Diethelm Ostry, Mr Denis Redfern, Dr Hajime Suzuki, Mr Graham Daniels, Mr John Deane, Mr Nigel Poole, Dr Megan Clark, Dr Jack Steele, Dr Dennis Cooper, Ms Sarah Spencer. Front row: Ms Julie Berwick, Ms May Ling Goode, Mr Terry Healy, Ms Katrina O'Leary, Dr John Stocker, Dr John O'Sullivan, Ms Julie Filazzola, Ms Debbie Davis. Credit: Leo Farrell

Winner of the CSIRO Lifetime Achievement Medal, Dr Ezio Rizzardo (middle) with Dr John Stocker (Chairman) (left) and Dr Megan Clark (Chief Executive) (right). Photo: Leo Farrell

Winner of the CSIRO Lifetime Achievement Medal, Dr Warwick Wilson (middle) with Dr John Stocker (Chairman) (left) and Dr Megan Clark (Chief Executive) (right). Photo: Leo Farrell

leading to the development of new generations of polymeric materials in the field of electronics, healthcare and biotechnology.

Dr Warwick Wilson (Astronomy and Space Science) for inspirational leadership spanning 27 years and ensuring consistent development and delivery of benchmark research instrumentation that has helped establish and maintain CSIRO's position as a world leader in the field of radio astronomy.

Fellows of Societies

Dr Tom Beer (Marine and Atmospheric Research) was elected an Honorary Member of the *Hungarian Academy of Sciences*.

Dr Jeremy Burdon (Plant Industry) and **Dr Frank de Hoog** (Mathematics, Informatics and Statistics) were elected as Fellows of the *Australian Academy of Technological Sciences and Engineering*.

Dr John Oakeshott (Entomology) was elected a Fellow of the *Australian Academy of Science*.

Dr Mike Raupach (Marine and Atmospheric Research) was elected a Fellow of the *American Geophysical Union*.

Dr Ezio Rizzardo (Molecular and Health Technologies) was elected a Fellow of the *Royal Society*.