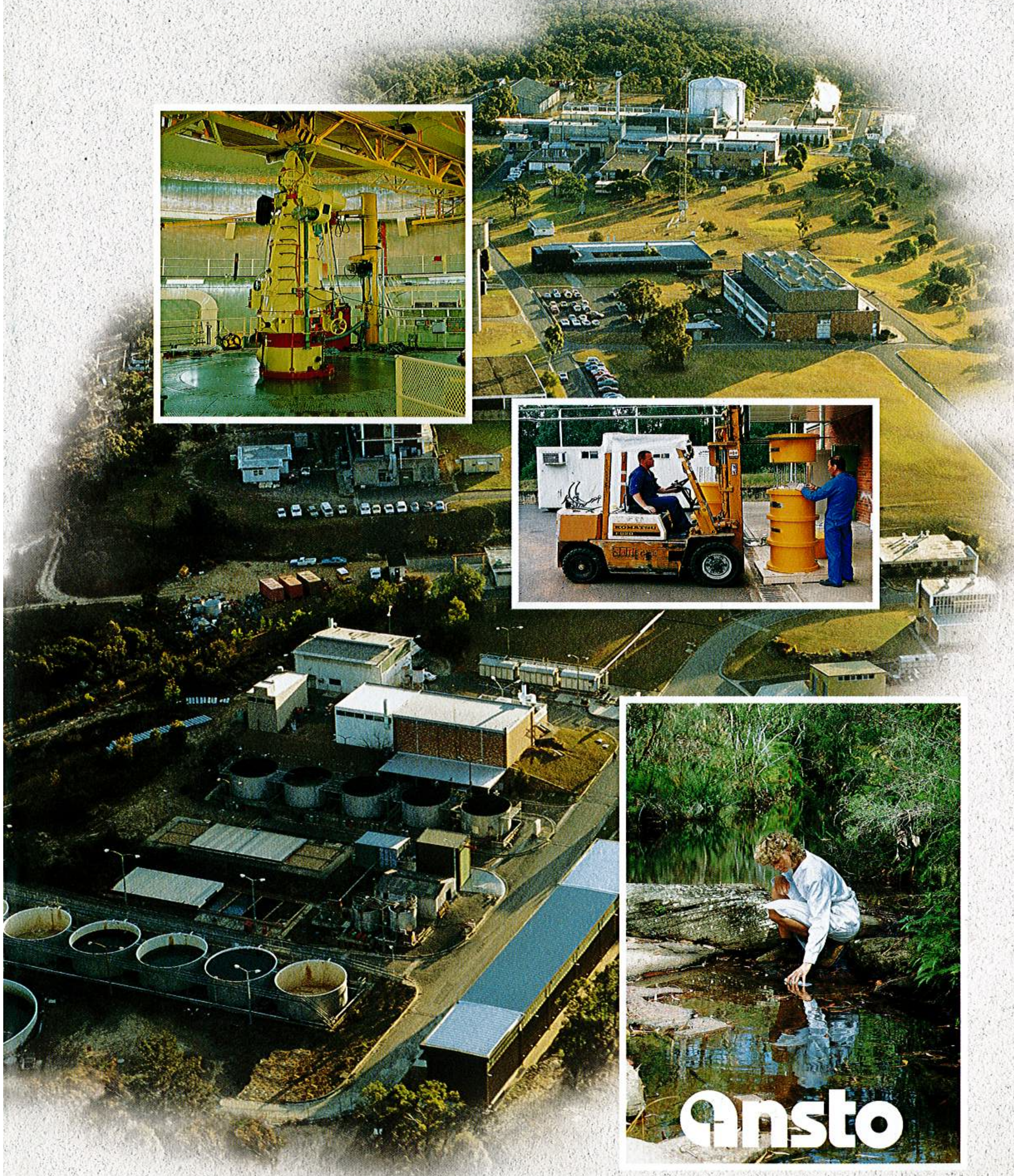
MANAGING RADIOACTIVE WASTES and SPENT REACTOR FUEL



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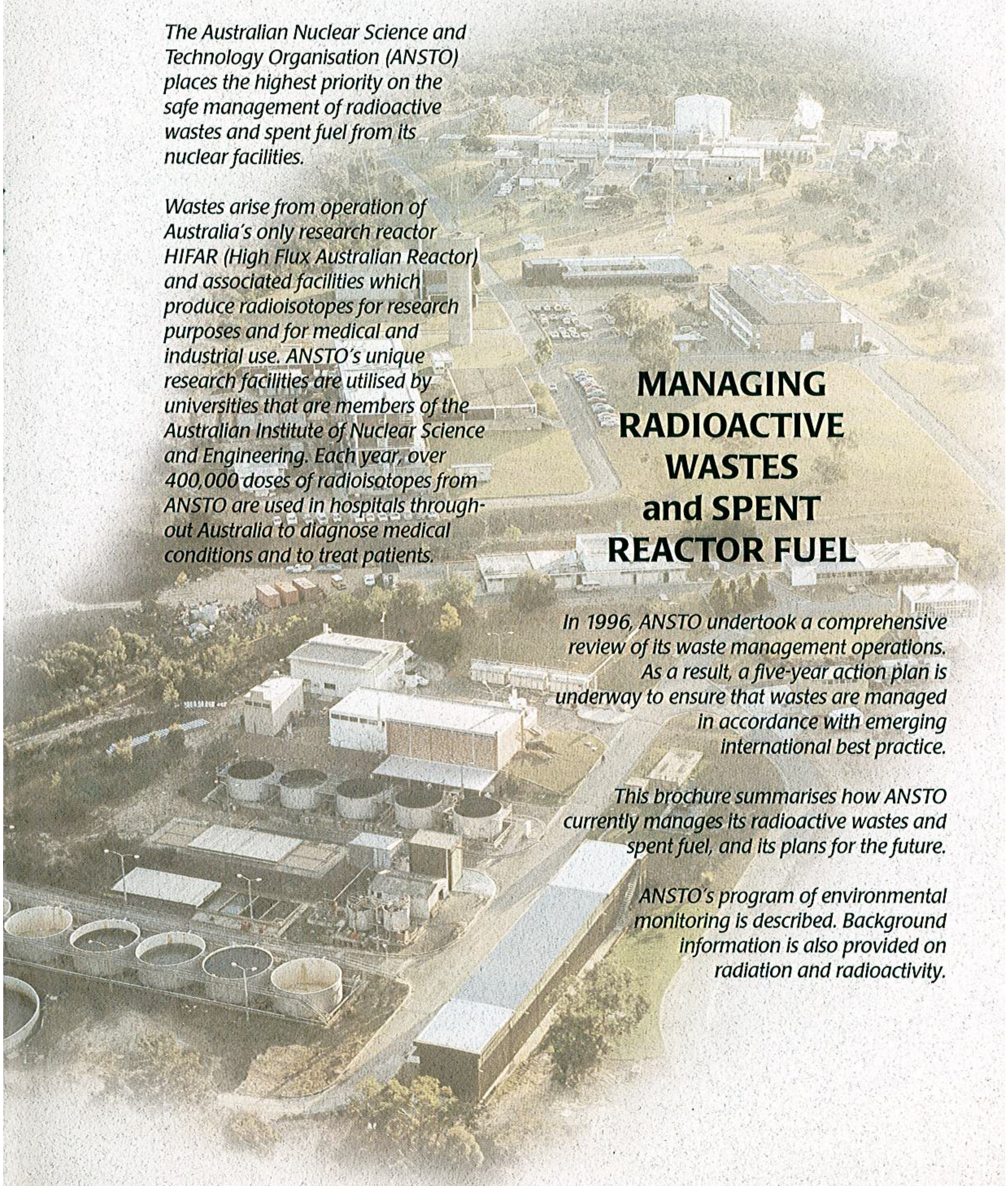


The Australian Nuclear Science and Technology Organisation (ANSTO) places the highest priority on the safe management of radioactive wastes and spent fuel from its nuclear facilities.

Wastes arise from operation of Australia's only research reactor HIFAR (High Flux Australian Reactor) and associated facilities which produce radioisotopes for research purposes and for medical and industrial use. ANSTO's unique research facilities are utilised by universities that are members of the Australian Institute of Nuclear Science and Engineering. Each year, over 400,000 doses of radioisotopes from ANSTO are used in hospitals throughout Australia to diagnose medical conditions and to treat patients.

MANAGING RADIOACTIVE WASTES and SPENT REACTOR FUEL

In 1996, ANSTO undertook a comprehensive review of its waste management operations. As a result, a five-year action plan is underway to ensure that wastes are managed in accordance with emerging international best practice.

This brochure summarises how ANSTO currently manages its radioactive wastes and spent fuel, and its plans for the future.

ANSTO's program of environmental monitoring is described. Background information is also provided on radiation and radioactivity.

Radiation

Radiation is emitted by natural and man-made substances.

Everyone is exposed to naturally occurring radiation. Its sources are as diverse as sunlight, radioactivity in the earth's minerals, the air we breathe, the food we eat, the water we drink and the buildings in which we work and live. Our own bodies contain naturally occurring radioactivity.

We also receive small doses of man-made radiation from X-rays, smoke detectors and the use of radioactive materials in medicine, industry and agriculture.

TYPES OF RADIATION

Radioactive materials give off three main types of ionising radiation:

Alpha (α) radiation is totally absorbed in thin materials such as paper. However, alpha-emitting radioactivity can be harmful if ingested.

Beta (β) radiation passes through paper but is absorbed by thicker materials. Materials containing beta radioactivity can deliver a radiation dose from inside or outside the body.

Gamma (γ) radiation is the most penetrating and can deliver a radiation dose from inside or outside the body.

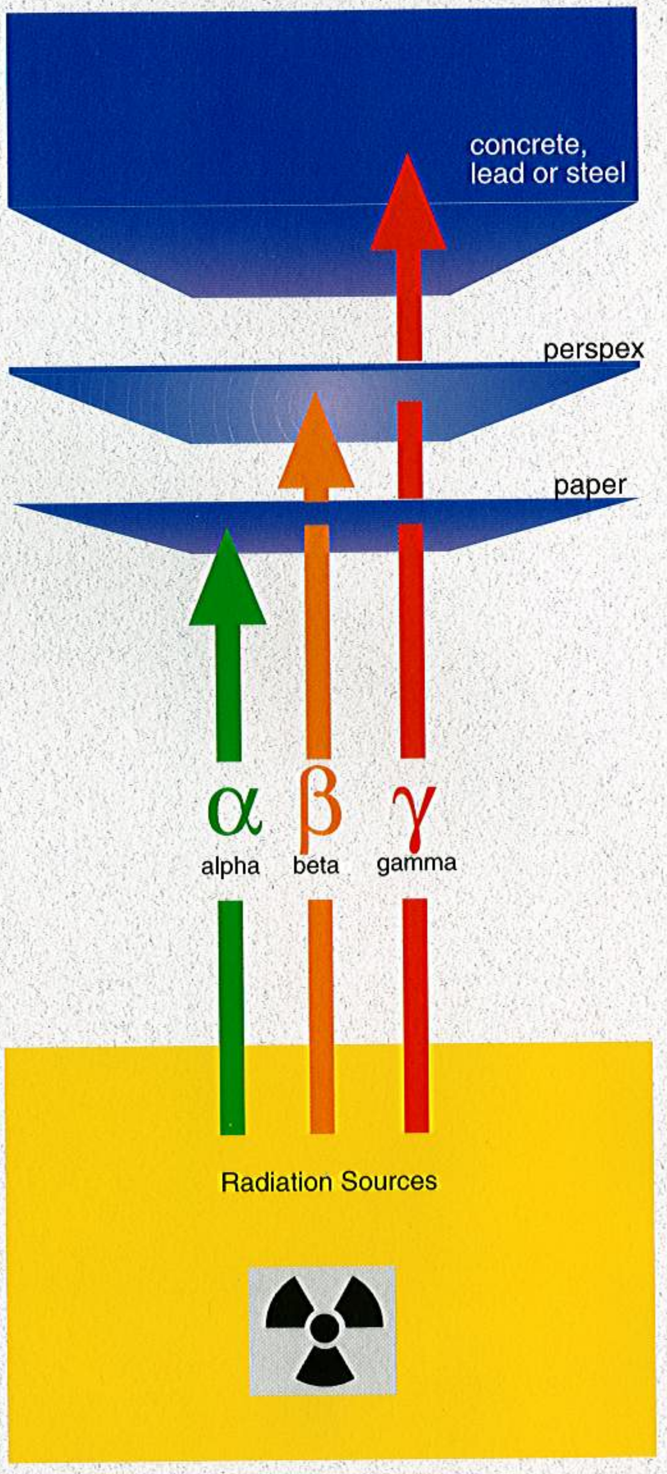
HALF-LIFE

Radioactive materials contain radioisotopes which decay with time. The rate of decay of a radioisotope is determined by its half-life: the time required for the radioactivity to be reduced by one-half. The half-lives of radioisotopes vary from fractions of seconds to billions of years. Examples of important radioisotopes are:

α emitter:
: uranium-238, naturally occurring with a half-life of 4.5 billion years

β emitter:
: carbon-14, naturally occuring and man-made with a half-life of 5700 years which makes it very useful for dating materials

γ emitter:
: technetium-99m, diagnostic medical radioisotope with a half-life of six hours.



Radiation Exposure Limits

In Australia, exposure to radiation is controlled by regulations based on recommendations of the International Commission on Radiological Protection (ICRP) and the National Health and Medical Research Council (NHMRC).

The units of radiation exposure are the sievert (Sv) or the millisievert (mSv), which is one thousandth of a sievert. The annual limit for radiation workers is 20 mSv.

The average natural radiation dose received by people across Australia is about 2 mSv per year. The annual limit of radiation exposure for the general public is an additional 1 mSv above this natural background. ANSTO manages its effluent and wastes to ensure that no member of the public exceeds these limits. In fact, the maximum radiation dose rate to members of the public from ANSTO operations is less than 0.01 mSv per year, which is one-hundredth of the annual limit.

In addition to meeting all legal requirements, ANSTO is committed to ensuring that radiation exposures from its operations are kept as low as reasonably achievable (the ALARA principle).

Waste Classification

Radioactive wastes can be classified in a number of ways. The physical form of the waste - solid, liquid or airborne - is important because it affects the mobility of waste in the environment. Radioactive wastes are also classified as low, intermediate or high, depending on their hazard to people.

Low level waste does not require shielding for protection of workers or the public during normal handling and transportation.

Intermediate level waste requires shielding for personal protection but generates negligible heat.

High level waste requires shielding and generates heat through radioactive decay.

Most of ANSTO's wastes are low level but small quantities of intermediate level wastes are also generated. ANSTO has no high level wastes.

The quantities of radioactive waste currently at the Lucas Heights Science and Technology Centre are very small compared with the amounts at many other nuclear facilities overseas, especially those in countries with a nuclear power program.

ANSTO's Radioactive Wastes and Spent Fuel (as at mid 1997)

Waste Type	Each Year	Total Inventory
Low level solid waste	150 drums*	5000 drums*
Intermediate level solid waste	1.5 cubic metres	200 cubic metres
Intermediate level liquid waste	300 litres	6500 litres
Spent fuel	37 elements	1630 elements

*200-litre capacity

Solid Wastes

Solid wastes containing low levels of radioactivity are produced in ANSTO laboratories where radioisotopes are handled. They include a variety of items such as tissues, disposable gloves and plastic tubing. Such wastes are collected in plastic-lined cardboard containers and then compacted into 200-litre steel drums. Typically, this reduces the waste volume by a factor of six.

Other types of solid waste include contaminated equipment, dried sludge from the treatment of liquid waste, and mineral wastes containing thorium and uranium.

About four tonnes of uranium and thorium metal scrap have been generated at Lucas Heights over a period of 35 years. These metals are stored under kerosene to prevent spontaneous combustion. ANSTO is converting this waste into a stable solid by controlled oxidation.

ANSTO produces small quantities of intermediate-level solid wastes. Examples include metal cans that have been irradiated in the HIFAR reactor, alumina columns used in the chemical processing of radioisotopes, and spent ion exchange resins used to purify the reactor's cooling water. These wastes are kept below ground in specially designed concrete pits.

The radioactivity in the waste drums at ANSTO is measured in a scanning system. During the scanning process, the drums are bar coded and the radionuclide content of each drum entered into a database to enable a complete record of ANSTO's radioactive wastes to be compiled.

Currently, ANSTO has about 5000 drums of low level waste and about 150 are generated each year. The drums are stored in a dedicated building on racks designed to withstand seismic forces. Over the last few years, ANSTO has been successful in reducing the amount of low level wastes produced each year.

Most of ANSTO's drummed waste is suitable for disposal in a repository for low level wastes. In some cases, the wastes will need to be conditioned, or specially packaged, prior to disposal. ANSTO is carrying out research into the use of cement for conditioning and immobilising such wastes.

The Australian Government, through the Department of Primary Industries and Energy, is currently in the process of selecting a site for a national repository for low level and short-lived, intermediate level radioactive wastes arising from a wide range of activities across Australia.

top left: loading wastes onto a conveyor for compacting

top: immobilising wastes in cement

right: scanning system for measuring radioactivity in drums

Waste Water

Each year, about 90,000 cubic metres of water are discharged from the Lucas Heights Science and Technology Centre. Most of this water comes from non-radioactive work areas. Only a small fraction of ANSTO's waste water, typically about 6000 cubic metres per year, requires treatment prior to discharge.

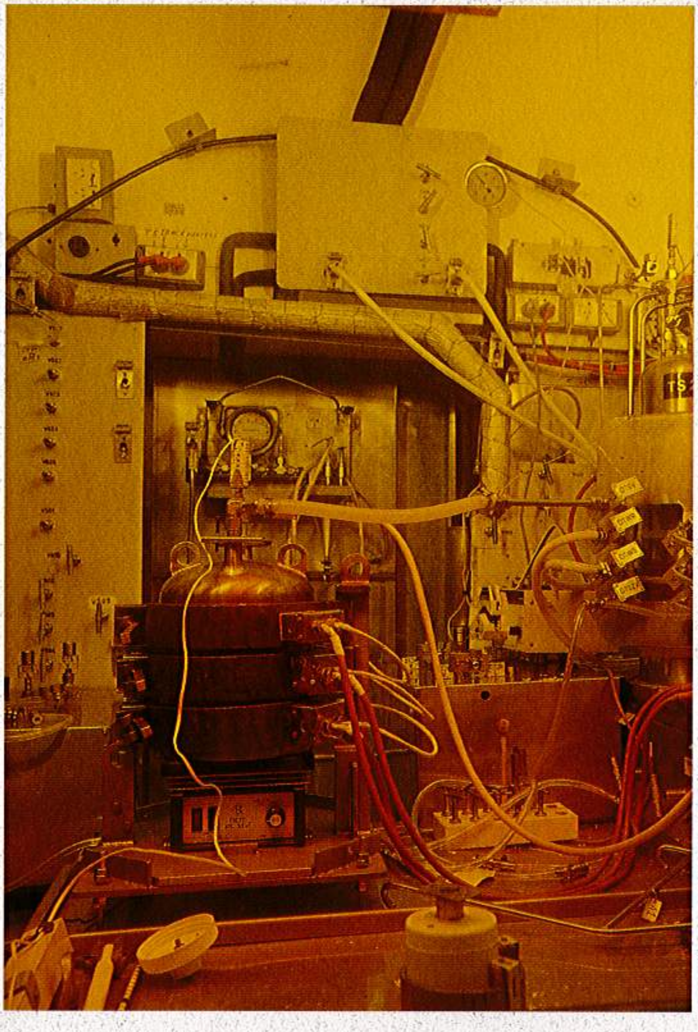
The treatment process involves adsorption of radioactivity onto a solid, followed by centrifuging to separate the solids from the liquid. The solids, which are slightly radioactive, are dried by solar evaporation and placed in 200-litre drums for storage.

The treated water is pumped into holding tanks and its radioactivity is measured. After being cleared for release, the water joins sewage from the Sutherland Shire and goes to the Cronulla Sewage Treatment Plant. After passing through this plant, the water is discharged to the ocean outfall at Potter Point on the Kurnell peninsula.

Before release from Lucas Heights, the water quality must satisfy two requirements set in ANSTO's Trade Waste Agreement with the Sydney Water Corporation. The first requirement is based on the *NSW Radioactive Substances Act (1959)*, as amended. The second requirement is that the average monthly concentrations of radioisotopes in the discharge are no more than 25 times the World Health Organisation standards for radioisotopes in drinking water. The factor of 25 is the measured dilution factor between the discharge point at Lucas Heights and the Cronulla Sewage Treatment Plant.

Annual discharges from Lucas Heights are typically only 20% - 50% of the prescribed limits.

The Australian Radiation Laboratory in Melbourne periodically measures the levels of radioactivity in the effluent to ensure compliance with these limits. Sydney Water Corporation also has access to ANSTO's liquid effluent system and carries out regular sampling for auditing purposes.



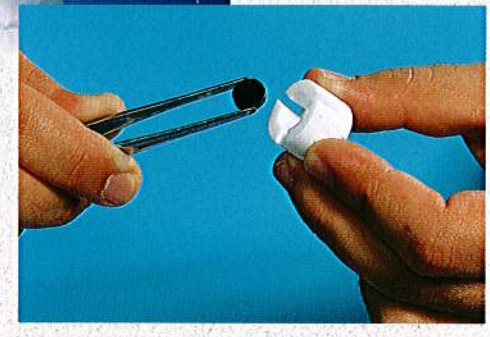
Intermediate Level Liquid Wastes

ANSTO produces radioisotopes for medical diagnoses in hospitals around Australia and in some overseas countries. The most widely used radioisotope is technetium-99m, which is produced from its parent, molybdenum-99.

At ANSTO molybdenum-99 is made by irradiating uranium dioxide pellets in the HIFAR reactor, dissolving the pellets in acid and chemically separating the molybdenum-99 from the other fission products. There are about 6500 litres of waste arising from this operation in storage at Lucas Heights. About 300 litres are produced each year.

Currently, the liquid waste is stored in shielded tanks. A project is underway to solidify this waste by chemical treatment and evaporation. The solid resulting from this process will be suitable for storage for at least 50 years.

ANSTO is working on a process to convert this solid into a durable form for indefinite storage or disposal. A number of options are being evaluated to achieve this objective, including incorporation into Synroc or cement.



top left: holding tanks where radioactivity is monitored to ensure compliance with discharge regulations

left: centrifuge for separation of solids from treated waste waters

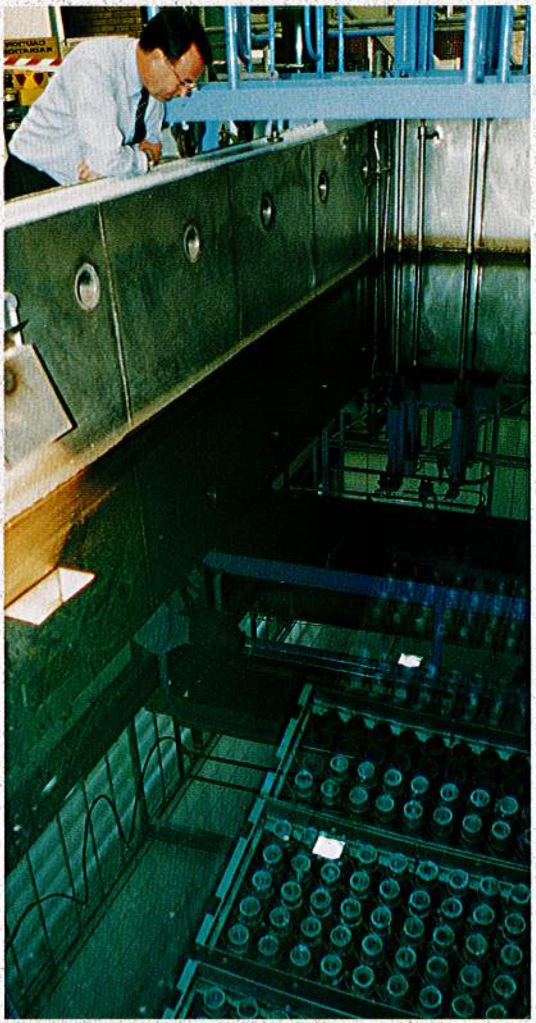
top right: hot cell equipment for solidification of intermediate level liquid wastes

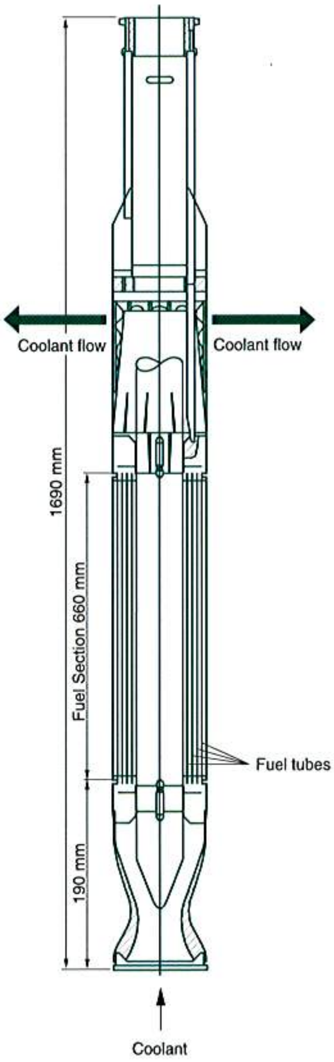
right: samples of cement and Synroc (far right) containing simulated waste from molybdenum-99 production being prepared for immersion tests in water to determine leachability

Management of HIFAR Spent Fuel

ANSTO's research reactor, HIFAR, is powered by 25 fuel elements each containing 280 grams of uranium. Every four weeks, three or four spent elements are removed from the reactor using a specially designed transfer flask and put into a small pond adjacent to the reactor. The heat and radioactivity in the spent fuel decrease rapidly.

After about one year, the fuel is transferred to another pond and the ends of each element, which do not contain any uranium, are cut off. The section that contains the uranium is stored under water for a further three to four years until the heat has decreased sufficiently to permit dry storage.

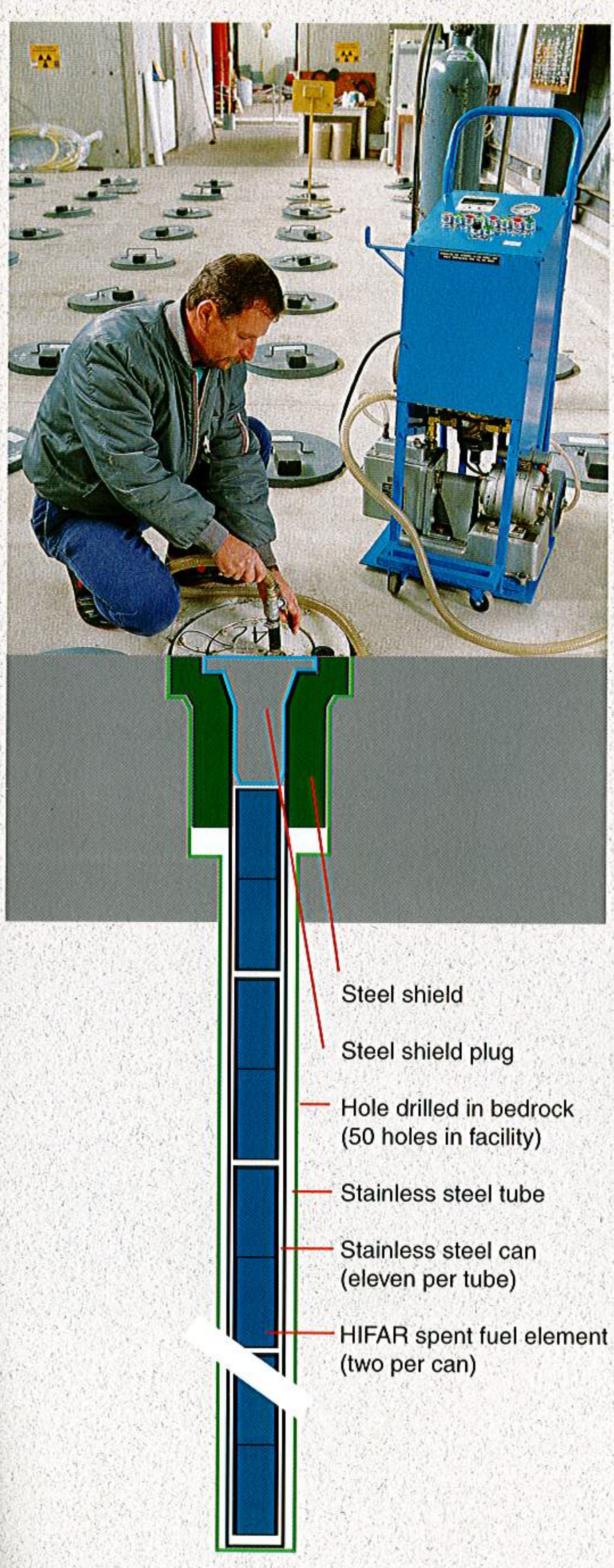




HIFAR fuel element

As of mid 1997, ANSTO had about 1630 spent fuel elements, most of which are kept in dry storage either in an engineered facility or in storage flasks. The spent fuel storage facilities are checked every three months by a safeguards inspector from the International Atomic Energy Agency.

ANSTO's in-ground fuel storage facility consists of 50 holes, 16 metres deep, each lined with a stainless steel tube sealed at each end. Each tube, which can hold up to 22 spent fuel elements, is filled with dry nitrogen gas to minimise corrosion of the fuel. An improved system for monitoring these tubes has recently been introduced.



As circumstances have permitted, ANSTO has returned spent fuel to its country of origin. Two shipments were made to Dounreay, Scotland: 150 elements in 1963 and 114 elements in 1996. Under the terms of the most recent contract, the waste from the processing of this fuel will be returned to Australia within 25 years.

During 1996, the United States Government announced it would accept all spent fuel of US origin from research reactors till 2006. As at mid 1997, ANSTO had 689 spent fuel elements of US origin. Preparations are in hand for shipment of some of these fuel elements back to the USA. The USA will take over ownership of the spent fuel and no wastes will be returned to Australia.

far left: transfer flask used to move spent HIFAR fuel

top left: after discharge from the reactor, the spent fuel is stored under water which provides cooling and shielding from radiation

top centre: monitoring in-ground fuel storage facility showing sectional diagram of one stainless steel tube containing spent fuel elements

top right: spent fuel being loaded for shipment

Airborne Emissions

During normal operation of nuclear and other industrial facilities, there are small emissions of airborne radioactivity to the environment. Most commonly, the emissions from nuclear facilities are radioisotopes that are gases (such as xenon and krypton) or volatile substances (such as iodine).

At ANSTO, charcoal traps are used to remove most of the volatile radioactivity from exhaust air. The air is then passed through high efficiency filters to remove fine particles prior to discharge to the ventilation stacks.

Releases of radioactivity via the stacks are continuously monitored. There are also four continuous sampling stations near the ANSTO site boundary. The Australian Radiation Laboratory independently checks ANSTO's measurements and calculations.

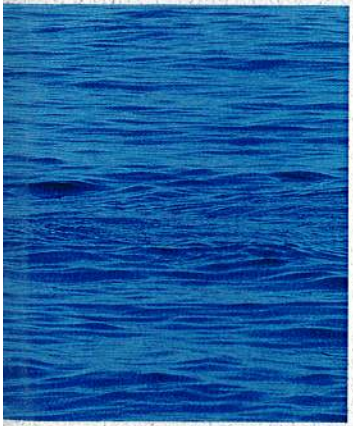
Away from the ANSTO site, the levels of radioactivity in air are too low to be measured.

A computer model has been developed which uses wind information gathered at Lucas Heights over many years to calculate radiation doses at various off-site locations, including the nearest residences. These calculations show that the dose rates to the public are less than 0.01 mSv which is one per cent of the allowable 1 mSv per year dose limit for the general public.

top left: monitoring ventilation stacks

right: an environmental scientist sampling water from a local creek

above: the ANSTO research vessel, *Imara*, sampling water off Potter Point



Environmental Monitoring

The main pathways by which radioactivity enters the environment from ANSTO's operations are:

- atmospheric discharges from stacks,
- discharge of waste water via the sewer to the Cronulla Sewage Treatment Plant and finally to the ocean outfall at Potter Point on the Kurnell peninsula.

In addition, there are two other potential pathways:

- migration from the Little Forest area (within ANSTO's 1.6 km buffer zone) where low level radioactive waste was buried in the 1960s, and
- accidental spillages which could be released from Lucas Heights, possibly through the storm water system. A collection system comprising bunds has been constructed to intercept such spillages.

To ensure that any releases to the environment via these pathways are below the limits set by regulatory authorities and international guidelines, ANSTO carries out a comprehensive program of environmental monitoring. Many different types of samples are taken on a regular basis. These include sand and soil samples, water from the Woronora River and various creeks (even though ANSTO does not discharge any materials into the Woronora River or any other natural water course), groundwater from the Little Forest burial area, sediments from stormwater drains, and seawater, fish, barnacles and algae from Potter Point.

Every year, ANSTO issues a publicly available report giving the results of the environmental monitoring. The levels of radionuclides in the environment from ANSTO's operations have always been very low and are of no radiological significance.

The levels of external radiation are measured along ANSTO's perimeter fence and at private homes at Barden Ridge, Engadine and Woronora. The external dose rates in private homes are about 1 mSv per year, which is similar to the Australian capital city average due to natural background radiation.

The Australian Radiation Laboratory (ARL) carries out independent monitoring and evaluation of effluent discharges. ARL may request samples from ANSTO, collect samples for analysis or audit ANSTO's procedures.

The effective operation of ANSTO's waste management operations, including environmental monitoring, is verified through oversight by the independent Safety Review Committee which reports annually to Parliament.

Future Commitment

In 1996, ANSTO embarked on an integrated five-year program, the Waste Management Action Plan, to ensure that ANSTO's wastes continue to be managed in a way that protects health and the environment.

The Action Plan includes the following tasks:

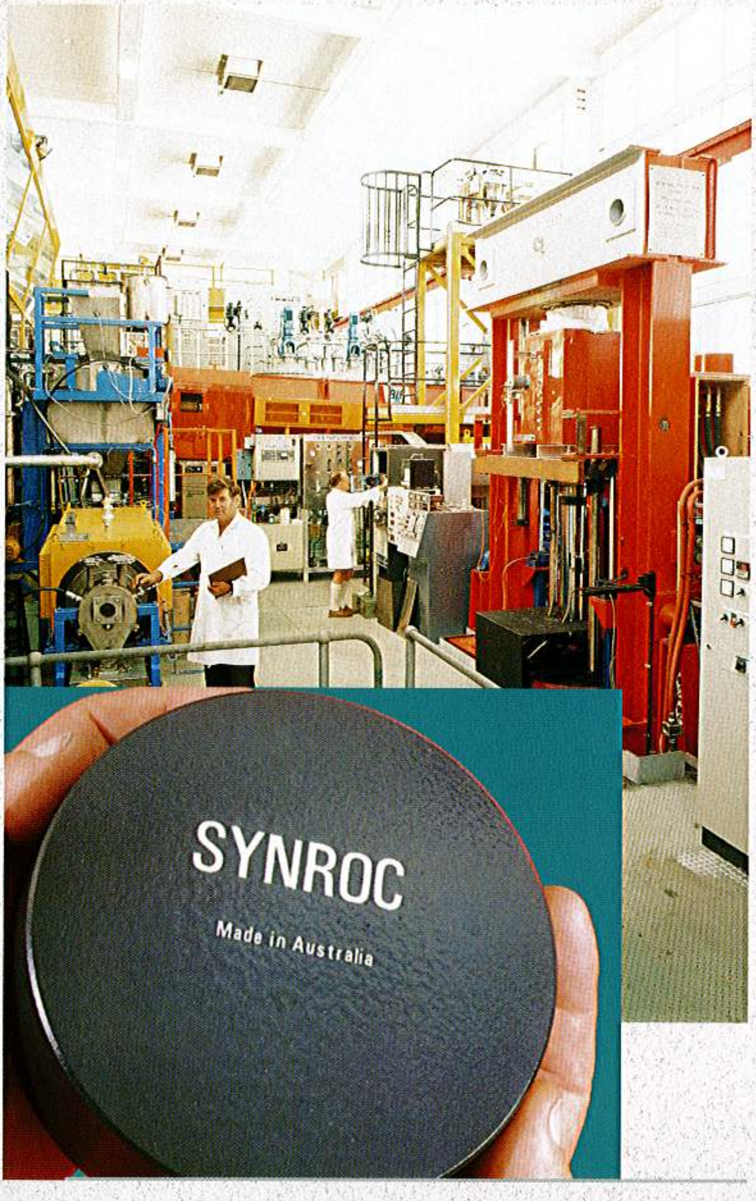
- compiling a complete inventory of all ANSTO's radioactive wastes
- solidifying ANSTO's intermediate level liquid wastes
- stabilising uranium and thorium metal scrap
- improving storage of ANSTO's solid wastes
- constructing a new facility for treatment of ANSTO's liquid effluent
- implementing a strategy for managing spent fuel
- developing packaging processes for ANSTO's radioactive wastes
- providing technical support for the establishment of a waste repository in Australia
- minimising the quantities of radioactive wastes generated and stored at the Lucas Heights Science and Technology Centre
- implementing the Action Plan using quality management systems based on International Standards, ISO 9001 and ISO 14001.

A major goal of the Action Plan is to achieve consistency by the year 2000 with best practice, as identified in the Radioactive Waste Safety Standards and Guidelines currently under development by the International Atomic Energy Agency.

Research & Development

ANSTO's waste management operations are supported by research staff who carry out strategic and applied research into the management of radioactive wastes.

ANSTO's scientists have played a leading role in the development of the Synroc process (conceived by the late Professor Ted Ringwood of the Australian National University) for immobilising high level nuclear wastes.



top left: equipment used for conversion of uranium and thorium into a stable form

above: Synroc demonstration plant
Synroc (inset) is a dense ceramic material made by hot pressing of waste mixed with rock-forming minerals

right: an ANSTO scientist uses a Raman spectrometer, a modern instrument used in waste management research

left: new rack system for storage of drums containing low level radioactive waste ansto

The following additional information is available on request:

ANSTO's Waste Management Policy
The waste management policy approved by the ANSTO Board in July 1995.

Environmental Review
A detailed technical review of radioactive waste management at ANSTO, completed in May 1996 (ANSTO Report /E 728).

Annual Environmental Survey
A report on the results of environmental and effluent monitoring at the Lucas Heights Science and Technology Centre and the nearby environs.

Ionising Radiation
The ANSTO leaflet, *Ionising Radiation,* has information on natural and man-made radiation and the levels at which they occur in the community.

ANSTO's Research Reactor
The leaflet, *ANSTO's Research Reactor*, includes information on services and research application, safety systems, operation and maintenance, spent fuel and regulatory framework.

Annual Reports
The safety and environmental performance of ANSTO matters is reported to the Australian Parliament each year in the annual reports of ANSTO and independent bodies: the Australian Radiation Laboratory, the Safety Review Committee and the Nuclear Safety Bureau.

For copies of ANSTO publications and further information, phone (02) 9717 3168 or write to ANSTO Communications, PMB 1, Menai, NSW 2234.

ANSTO's Internet Home Page: http://www.ansto.gov.au