The ANSTO Research Reactor
Lucas Heights

Strategy for off-site iodine distribution

October 2003
### Table of Contents

<table>
<thead>
<tr>
<th>Details</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXECUTIVE SUMMARY</td>
<td>3</td>
</tr>
<tr>
<td>1. Purpose</td>
<td>5</td>
</tr>
<tr>
<td>2. Background</td>
<td>5</td>
</tr>
<tr>
<td>3. Context</td>
<td>6</td>
</tr>
<tr>
<td>3.1 Problem definition</td>
<td>6</td>
</tr>
<tr>
<td>3.2 Emergency risk management framework</td>
<td>6</td>
</tr>
<tr>
<td>a) Stakeholders</td>
<td>6</td>
</tr>
<tr>
<td>b) Legislation and Policy</td>
<td>6</td>
</tr>
<tr>
<td>c) Geopolitical Context</td>
<td>7</td>
</tr>
<tr>
<td>3.3 Risk Evaluation Criteria</td>
<td>7</td>
</tr>
<tr>
<td>4. Risk Identification</td>
<td>8</td>
</tr>
<tr>
<td>4.1. Hazard</td>
<td>8</td>
</tr>
<tr>
<td>4.2. Community and Environment</td>
<td>8</td>
</tr>
<tr>
<td>a) Defining the population at risk</td>
<td>8</td>
</tr>
<tr>
<td>i) Selection of a generic intervention level for sensitive groups</td>
<td>8</td>
</tr>
<tr>
<td>ii) Determining the emergency planning zones</td>
<td>10</td>
</tr>
<tr>
<td>iii) Summary of possible affected population</td>
<td>15</td>
</tr>
<tr>
<td>5. Risk Analysis and Evaluation</td>
<td>17</td>
</tr>
<tr>
<td>5.1. Radiological Emergency Scenarios</td>
<td>17</td>
</tr>
<tr>
<td>5.2. Likelihood and consequence analysis</td>
<td>18</td>
</tr>
<tr>
<td>6. Risk Treatment</td>
<td>19</td>
</tr>
<tr>
<td>6.1. Prevention</td>
<td>19</td>
</tr>
<tr>
<td>6.2. Preparedness</td>
<td>19</td>
</tr>
<tr>
<td>6.3. Response</td>
<td>19</td>
</tr>
<tr>
<td>a) Options for Distribution of Iodine</td>
<td>20</td>
</tr>
<tr>
<td>i) Pre-distribution</td>
<td>20</td>
</tr>
<tr>
<td>ii) Provision of iodine through pharmacies</td>
<td>21</td>
</tr>
<tr>
<td>iii) Evacuation</td>
<td>21</td>
</tr>
<tr>
<td>iv) Discussion re options</td>
<td>22</td>
</tr>
<tr>
<td>b) Response recommendations</td>
<td>23</td>
</tr>
<tr>
<td>c) Response measures and logistics</td>
<td>23</td>
</tr>
<tr>
<td>d) Procedure for the Administration of Iodine</td>
<td>24</td>
</tr>
<tr>
<td>6.4 Recovery</td>
<td>25</td>
</tr>
<tr>
<td>7. Monitor and Review</td>
<td>26</td>
</tr>
<tr>
<td>8. Communicate and Consult.</td>
<td>26</td>
</tr>
<tr>
<td>ANEXURES</td>
<td>27</td>
</tr>
<tr>
<td>(1) Dosages of Iodine and Potassium Iodide (KI)</td>
<td>27</td>
</tr>
<tr>
<td>(2) Record of Administration of Iodine</td>
<td>28</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>29</td>
</tr>
</tbody>
</table>
Executive Summary

This paper outlines a policy position for NSW Health, in regard to the distribution of iodine in the vicinity of the Australian Nuclear and Science Technology Organisation (ANSTO) Research Reactor at Lucas Heights.

The paper applies emergency risk management principles and includes a review of international literature, incorporates recommendations from statutory authorities, assesses specific local conditions and facility infrastructure as well as available risk assessments.

Based on the best current evidence available, NSW Health holds the following positions, in regard to the management of the off-site consequences of a large-scale incident at the ANSTO site.

- That the likelihood of an incident requiring intervention with iodine is extremely remote;
- That deterministic effects will never be reached;
- The recommended generic intervention level of 100mGy for adults will not be reached and as such, adults, other than pregnant and lactating women, will not require iodine prophylaxis, in any circumstances, outside Zone 1 (fence line);
- That an accepted generic intervention level of 10mGy averted dose to the thyroid in neonates, infants, children, adolescents and pregnant and lactating women could theoretically be reached but only with prolonged exposure, (greater than 12 hours) very close to the source of radiation;
- In the unlikely event of a worst case scenario where 10mGy averted dose to the thyroid could be reached, reducing the exposure period (<12 hours) and increasing the distance from the source (>3km) will obviate the need for iodine prophylaxis;
That a generic intervention level of 10mGy avertable dose to the thyroid in neonates, infants, children, adolescents to 18 years and pregnant and lactating women, in lieu of 30mGy, be accepted. This is in accordance with the World Health Organisation (WHO, 1999) recommendations and introduces a further element of safety (SAFETY ELEMENT 1);

- That the Zone 2 area (Urgent Protective Action Planning Zone) be extended to 3km., beyond which iodine prophylaxis will not be necessary (SAFETY ELEMENT 2);

- That a staged evacuation be undertaken of Zone 2 up to 3km and that this is preferable to an iodine pre-distribution strategy by reducing the exposure period, the radiation exposure to an individual and the resultant risk. This reduces both the level of radiation exposure as well as the length of time of exposure, thus introducing a further element of safety (SAFETY ELEMENT 3);

- That the Sutherland Shire community should be advised that aqueous iodine solution is currently available without prescription through pharmacies.
1. Purpose:

There is significant debate in regard to the management of possible emergencies at the Australian Nuclear Science and Technology Organisation (ANSTO) site, at Lucas Heights, particularly with respect to the potential requirement for the administration of iodine. The debate has primarily centred on the appropriate generic intervention levels at which iodine prophylaxis may be required and the mechanism by which iodine can be made available to the community, if necessary.

This paper outlines a policy position for NSW Health, following a review of the international literature, incorporating recommendations from statutory authorities, specific local conditions and facility infrastructure and available risk assessments.

2. Background:

Emergency risk management principles (Emergency Management Australia, 1999 and NSW State Emergency Management Management Committee, 2001) have been utilised to undertake the policy review position.
3. Context

3.1 Problem definition

- Assess the potential impact of an incident/accident or emergency at the ANSTO site.
- Define the generic intervention levels for iodine prophylaxis.
- Define the potentially affected community demographic.
- Describe the process for administration of iodine to any potentially affected community members, if necessary.

3.2 Emergency risk management framework

a) Stakeholders

- Community members in the Sutherland Shire
- Sutherland Shire Council
- Green peace
- Nuclear Reactor Taskforce
- People Against a Nuclear Reactor (PANR)
- Sydney People Against a New Nuclear Reactor (SPANNR)
- The Greens
- Australian Conservation Foundation
- Doctors Against War
- NSW Government and emergency services organisations, including NSW Health, Ambulance Service of NSW, NSW Police, NSW Fire Brigades and the Environmental Protection Agency.
- Commonwealth Agencies, including the Australian Nuclear Science and Technology Organisation (ANSTO) and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA).

b) Legislation and Policy

Emergency management legislative responsibilities for NSW Health and the Ambulance Service of NSW are found under the State Emergency and Rescue Management Act (1989) as amended, through the relevant functional area plan (HEALTHPLAN, 1997). Specific responsibilities in regard to possible emergencies at the ANSTO site are listed within the document “ANSTO, Response Plan for Accidents and Incidents at ANSTO/LHSTC” (May 2002). Specific responsibilities include the provision for the safe distribution and storage of stable iodine tablets. (Ibid, Section 5).
Specifically;

- “The Ambulance Service is responsible for maintaining stocks of iodine tablets and arranging for their distribution as necessary under the direction of the Director, Counter Disaster and Planning, NSW Department of Health, or delegate”. (ANSTO, 2002). This person will normally be the State Health Service Functional Area Coordinator (State HSFAC).

- "The NSW Department of Health is responsible for coordinating and controlling the mobilisation of all health responses to accidents or incidents when this Plan is activated. This includes authorising, where necessary, the distribution of stable iodine tablets held by the Ambulance Service of NSW". (ANSTO, 2002)

c) Geopolitical context

The review is undertaken in the context of the current terrorist threat environment.

3.3 Risk Evaluation Criteria

- Impact of possible radiation hazard on community;
- Consequence and likelihood assessment;
- Literature review to identify appropriate generic intervention levels;
- Information from the safety regulator (ARPANSA);
- Community risk perception.
4 Risk Identification

4.1 Hazard

Radioactive material containing iodine 131\(^{131}\)I and other radioisotopes requiring intervention with iodine, to avert the risk of thyroid carcinoma in an affected population.

4.2 Community and Environment

The Sutherland Shire in Sydney’s south has some 215,028 persons resident in the area. (Australian Bureau of Statistics, 2001). It is important to note that there are no permanent residential areas within the 1.6km radius buffer. Between 1.6 and 3km from the reactor, the population is estimated to be 13,000 and at approximately 5km radius, the population is estimated at between 30,000-40,000. Based on interpolations from Census data within the Sutherland Shire, the number of persons under 18 would be approximately 26% of the total population.

a) Defining the population at risk

The World Health Organisation (1999) reported that following the Chernobyl reactor incident there was increase in cancer of the thyroid. According to the World Health Organisation’s (WHO) guidelines (1999) those at risk, in order of greatest susceptibility, are:

- Neonates (birth to 1 month)
- Children (1 month to 3 years of age)
- Children (3 to 12 years of age)
- Pregnant and lactating women
- Adolescents (12 to 18 years of age)
- Adults (18 to 40 years of age)

The administration of iodine has been recommended at certain doses of radiation, through either ingestion or inhalation, to reduce the uptake of radioactive iodine isotopes by the thyroid gland.

i) Selection of a Generic Intervention Level for Sensitive Groups:

**Background information on Health effects of radiation**

Absorbed dose is measured in grays (Gy). The milligray (mGy) is more commonly used. One gray corresponds to one joule of radiation energy deposited in one kilogram of matter. A whole body dose of 3 to 5 Gy will result in 50% mortality, in one to two months. ("deterministic effect" of ionising radiation). (http://www.arpansa.gov.au)

The stochastic model (in WHO, 1999) determines that the relationship between the absorbed dose and the risk of thyroid cancer is assumed to be linear with radiation dose.
When radiation interacts with living tissue the effect it has varies with the type of radiation. To allow for this, the absorbed dose in grays is multiplied by a tissue weighting factor and the new dose is called the equivalent dose, with units of sieverts (Sv). A one milligray dose of alpha particles is equal to 20 mSv of equivalent dose. A further factor is applied to allow for the differences in radiation sensitivity between organs. This is the tissue weighting factor and the new dose is called effective dose, with units of sievert. The thyroid has a tissue weighting factor of 0.05, so 1 mSv equivalent dose to thyroid is equal to 0.05 mSv effective dose. For the purposes of internal consistency units of milliGray have been used to evaluate data, throughout this review.

*Intervention level assessment*

The International Atomic Energy Agency (IAEA, 1996) recommends a generic intervention level of 100 mGy for all age groups. The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), (2002), recommends an intervention level for neonates, children and pregnant and lactating women at 30 mGy. The World Health Organisation, (1999) recommends a generic intervention level for neonates, infants, children, adolescents under 18 years and pregnant and lactating women at 10 mGy averted dose to the thyroid.

While ARPANSA (2002) recommends an avertable dose to the thyroid of 30 mGy to trigger provision of iodide prophylaxis to children, this is three times higher than the WHO (1999) guidelines. ARPANSA base this recommendation on “the basis that risk per unit is of the order of a factor of three between children aged under ten years at exposure and older children”, and have thus divided the generic intervention level of 100 mGy by three (Ibid Annex A p54).

Review of the Belarus incidence in regard to the excess relative risk (ERR) for thyroid cancer (Cardis, 1999) indicates that infants (<1year) exposed to radioactive iodine are twice as likely to develop thyroid cancer as 2-3 year olds, and 16 times as likely as 8-9 year olds. It should be noted that the ERR represents the ratios against spontaneous thyroid carcinoma rates, which are very low for young children (estimated at 0.6 per million per year for children 0 to 4 years). In regard to annualised excess absolute risk (EAR) estimates for exposure under 15 years, these range from $4.4 \times 10^{-6}$/Gy/yr (Ron, E, 1995) to $2.3 \times 10^{-4}$/Gy/yr (Jacob, P 1998), with Ron et al noting that younger children are at significantly greater risk than older children. The WHO excess absolute risk (EAR) for children is $10^{-2}$/Gy This represents an absolute risk of 1% per Gray for 50 years post exposure, as data from the Hiroshima Life Span Study (in UNSCEAR, 2000) and the Chernobyl incident demonstrate that EAR for both external and internal exposure is close to constant. It is important to note that this data also demonstrates little excess absolute risk (EAR) for thyroid cancer if exposure occurs for those over 20 years of age, and virtually no risk for those over 40 years of age.
As the relationship between absorbed dose and risk of thyroid cancer is assumed to be linear (Stochastic model), then use of the recommended (ARPANSA) 30mGy guideline is equivalent to increasing lifetime risk of thyroid cancer in exposed children by three compared to adoption of the WHO 10mGy guideline. This represents a risk of 3 per ten thousand compared to 1 per ten thousand. It should be noted that the risk of spontaneous thyroid cancer in the general population over a 50 year period is 2 per thousand, so the additional risk for exposure to either 10mGy or 30mGy is still extremely low.

However, WHO has recommended an intervention level of 10mGy (averted dose) for iodine prophylaxis to susceptible population groups, which include children (at least to 15, possibly including adolescents to 18 years < 70kg), and pregnant and lactating women. While it is accepted that this represents an extremely conservative intervention point based on risk assessment, adopting the WHO recommendation allows for an added element of safety to be introduced into emergency planning.

**SAFETY ELEMENT 1**

*It is recommended that a generic intervention level of 10mGy avertable dose to the thyroid in neonates, infants, children, adolescents to 18 years and pregnant and lactating women, in lieu of 30mGy or 100mGy, be accepted, thus introducing a further element of safety*

**ii) Determining the Emergency Planning Zones:**

Emergency planning zones are determined from recommendations prepared by the International Atomic Energy Agency, (1996) and vary depending upon the source.

The IAEA divides the response areas into three zones based on the radius from the incident site. Note that this area will vary depending upon wind conditions and may therefore only threaten a narrow wedge of the zone.

The Zones are:

- Precautionary Action Zone (Zone 1);
- Urgent Protective Action Planning Zone (Zone 2);
- Longer Term Protective Action Planning Zone (Zone 3).

The distances from the centre of the occurrence vary with the power of the source and are, for Zone 1:

- Reactors with power greater than 100 MW 3 – 5 km
- Reactors 2 MW to 100 MW on-site
- Reactors of power less than 2 MW on-site

The ANSTO HIFAR reactor, at 10MW, is in the second category, which is between 2MW and 100 MW.

It should also be noted that the HIFAR reactor is a research reactor operating at a thermal power level of 10 megawatts compared to power reactors in the United
States and Europe operating at more than 3,000 megawatts thermal. Examples of such facilities are found in Table 1.

**Table 1: Nuclear Power Reactors**

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>Reactor Name</th>
<th>Reactor Type</th>
<th>Electric Power (MWe)</th>
<th>Thermal Power (MWTh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NETHERLANDS</td>
<td>Borssele</td>
<td>PWR</td>
<td>481</td>
<td>1366</td>
</tr>
<tr>
<td>BELGIUM</td>
<td>Tihange-3</td>
<td>PWR</td>
<td>1054</td>
<td>2988</td>
</tr>
<tr>
<td>UNITED STATES</td>
<td>Salem-1</td>
<td>PWR</td>
<td>1149</td>
<td>3411</td>
</tr>
<tr>
<td>GERMANY</td>
<td>Brokdorf</td>
<td>PWR</td>
<td>1365</td>
<td>3765</td>
</tr>
<tr>
<td>FRANCE</td>
<td>Civaux-1</td>
<td>PWR</td>
<td>1516</td>
<td>4250</td>
</tr>
<tr>
<td>SWEDEN</td>
<td>Forsmark-1</td>
<td>BWR</td>
<td>1004</td>
<td>2928</td>
</tr>
<tr>
<td>UNITED STATES</td>
<td>Limerick-1</td>
<td>BWR</td>
<td>1092</td>
<td>3293</td>
</tr>
<tr>
<td>SWITZERLAND</td>
<td>Leibstadt</td>
<td>BWR</td>
<td>1135</td>
<td>3012</td>
</tr>
<tr>
<td>JAPAN</td>
<td>Kashiwazaki-6</td>
<td>BWR</td>
<td>1356</td>
<td>3926</td>
</tr>
<tr>
<td>CANADA</td>
<td>Darlington-1</td>
<td>PHWR (CANDU)</td>
<td>935</td>
<td>2774</td>
</tr>
<tr>
<td>RUSSIA</td>
<td>Smolensk-1</td>
<td>RBMK</td>
<td>1000</td>
<td>3200</td>
</tr>
<tr>
<td>RUSSIA</td>
<td>Kalinin-1</td>
<td>VVER</td>
<td>1000</td>
<td>3000</td>
</tr>
</tbody>
</table>

Table is sorted by reactor type:
PWR = Pressurised water reactor
BWR = Boiling water reactor
PHWR = Pressurised heavy water reactor (also called CANDU)
RBMK = Chernobyl-type graphite moderated, water cooled unit
VVER = Russian pressurised water reactor (PWR) design.

It should also be noted that the new reactor proposed for Lucas Heights is only 20MW, still at the lower end of the IAEA scale. (http://www.arpansa.gov.au)

On the basis of the IAEA assessment, the highest ‘at risk’ zone is considered to be within a radius of 1.62km (1 mile) of the reactor at Lucas Heights. There are no dwellings within this zone. (Map 1, below).
MAP 1 ANSTO Site (Precautionary Action Zone, Zone 1)
It should also be noted that the Urgent Protection Zone (UPZ) or Zone 2 for a HIFAR power level reactor is considered to be in the order of 0.5 to 2.0 km.

Current emergency planning arrangements extend the zone to a radius of 2.5 km. (ANSTO, 2002)

A review of the international practice, in regard to buffer zones around other research reactors, is found in Table 2, following. (Senate of Australia, 1998).

It is important to note that the HIFAR reactor has a substantially larger buffer zone arrangement than other international research reactors, and as described above should not be benchmarked against large high powered reactors as found in the United States and Europe (Table 1, above).

Considerable debate has ensued in regard to the amount of radioactivity that might disperse from the site in particular incidents.

A number of scenarios have been proposed evaluating the likelihood of radioactive material, containing $^{131}$I, or other isotopes being dispersed to a point where an intervention would be necessary. ARPANSA has undertaken a modelling process to review the possible levels of radiation in worst-case scenarios, including a terrorist attack. ARPANSA has briefed NSW Health in regard to these scenarios but has advised that for security reasons, the quantitative details are not for publication.

Following a detailed review of the literature and based on the best current evidence available, the following points can be made;

- Deterministic effects will not be reached;
- The recommended generic intervention level of 100mGy for adults will not be reached and as such, adults, other than pregnant and lactating women, will not require iodine prophylaxis, in any circumstances outside Zone 1 (fence line);
- An accepted generic intervention level of 10mGy averted dose to the thyroid in neonates, infants, children, adolescents and pregnant and lactating women could theoretically be reached but only with prolonged exposure, (greater than 12 hours) very close to the source of radiation.
- In the unlikely event of a worst case scenario where 10mGy averted dose to the thyroid could be reached, reducing the exposure period (<12 hours) and increasing the distance from the source (>3km) will obviate the need for iodine prophylaxis.
### TABLE 2 EXAMPLES OF BUFFER ZONES AT OVERSEAS RESEARCH REACTORS

<table>
<thead>
<tr>
<th>REACTOR AND POWER</th>
<th>LOCATION</th>
<th>BUFFER ZONE RADIUS</th>
<th>SURROUNDING POPULATION*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HIFAR 10 MW</strong></td>
<td>Lucas Heights. 30 km south west of the centre of Sydney.</td>
<td>1.6 km radius.</td>
<td>No permanent residential development inside 1.6 km radius. Between 1.6 and 3 km the population is estimated to be 13,000. Between 3 km and 8 km 65,000 residents.</td>
</tr>
<tr>
<td><strong>NABS 20 MW</strong></td>
<td>National Institute of Science and Technology, Gaithersburg, 30 km north west of Washington DC, USA.</td>
<td>Nearest site boundary to reactor is 400 m. Nearest housing is less than 500 m.</td>
<td>Between 500 m and 1.6 km radius 7,000 residents; between 1.6 and 3.2 km radius 25,000 residents and between 3.2 and 8.0 km 130,000 residents. US Nuclear Regulatory Commission approved power upgrade in 1983 from 10 MW to 20 MW, taking account of population growth projections.</td>
</tr>
<tr>
<td><strong>MITR-II 5 MW</strong></td>
<td>Cambridge, Massachusetts, USA, within urban and commercial area of Boston.</td>
<td>No buffer zone</td>
<td>Boston has a population of 2.8 million people.</td>
</tr>
<tr>
<td><strong>Orphee - 14 MW</strong></td>
<td>20 km south west of Paris, France.</td>
<td>Within a nuclear research establishment that includes the 70 MW test reactor, Osiris.</td>
<td>200 persons within 1 km radius, over 1000 between 1 km and 2 km radius. Numbers rise rapidly beyond this as Paris outskirts are reached.</td>
</tr>
<tr>
<td><strong>HFR - 57 MW</strong></td>
<td>2.5 km south of the centre of Grenoble, France.</td>
<td>Within Institute Laue-Langevin, a nuclear research establishment.</td>
<td>Grenoble is a city of 389,000 people. There is a substantial population across the River Isère, a few hundred metres from the reactor.</td>
</tr>
<tr>
<td><strong>FRM-2 20 MW</strong></td>
<td>15 km north of the centre of Munich, Germany.</td>
<td>Located on campus of Technical University of Munich. No buffer zone.</td>
<td>Urban areas surround the campus. City of Munich population is 1.2 million with a further 1 million in the neighbouring areas.</td>
</tr>
<tr>
<td><strong>BER-2 10 MW</strong></td>
<td>20 km southwest of Berlin, 4 km from Potsdam, Germany.</td>
<td>500 m.</td>
<td>1200 persons living between 500 m and 1 km, 5,600 persons between 1 and 2 km</td>
</tr>
</tbody>
</table>

*Note: The population estimates are generally derived from 1990 or earlier data and as such are underestimates.

**iii) Summary of possible affected population**

- Persons under 18, as well as pregnant and lactating women within 3 km of the reactor core.

**SAFETY ELEMENT 2**

- *It is recommended that the Zone 2 area (Urgent Protective Action Planning Zone) be extended to 3 km, beyond which iodine prophylaxis will not be necessary.*
This 3.0 km zone (Map 2) includes the localities, or parts of the localities, of:

- Barden Ridge
- Engadine
- Heathcote
- Lucas Heights
- North Engadine

The Sutherland Shire Local Emergency Management Committee holds an up-to-date list of schools and child care/minding centres in the locality.
MAP 2 CURRENT AND PROPOSED ANSTO ZONING BUFFERS
5 Risk Analysis and Evaluation

5.1 Radiological Emergency Scenarios

ARPANSA (2002) notes six scenarios that would be relevant for Australia. These include:

- Uncontrolled releases of radioactive contaminants from a nuclear research reactor, with dispersal of the contaminants over a region downwind from the reactor site;
- Uncontrolled release from the nuclear reactor on a visiting ship, with dispersion of the contaminants over a region downwind from the ship and into the harbour;
- ‘Burn-up’ of a nuclear reactor in a satellite out of control in re-entry to the earth’s atmosphere, where contaminants might be distributed over a long, narrow region of several thousand square kilometres of the land;
- The destruction of a high activity, sealed source and the consequent dispersion of contaminants into the immediate vicinity and thus contaminating the environment and products used by the population;
- Uncontrolled releases from unsealed radioactive materials; and
- Terrorist activity resulting in the dispersal of radioactive or nuclear material.
5.2 Likelihood and consequence analysis

In reviewing the specific impact of events surrounding the ANSTO site, a number of scenarios have been proposed.

The accepted practice in Australia for the reference incident of a “meltdown” scenario (loss of coolant accident or a reactivity insertion), would only occur following multiple safety system failure and is extremely unlikely.

The possibility of a natural disaster, such as an earthquake, leading to a fire and destruction of the reactor is extremely unlikely.

Given the current geo-political situation, the possibility of a terrorist attack should be considered. A number of terrorist threat scenarios have been examined. The details of most of these scenarios are not available for security reasons. However, the ability for a successful terrorist attack against the plant, leading to an exposed core or with a fire and dynamic plume is regarded as unlikely.

In reviewing the possibility of a catastrophic event at the site, weather and environmental factors would also have to be considered prior to affectation of a particular community cohort.

In regard to consequence, a small cohort of up to 13,000 persons may be affected to the extent that an intervention with iodine may be necessary in the unlikely event of prolonged exposure.

However, the risk assessment must also be placed in the context of the remote likelihood of a serious incident at the HIFAR reactor (annualised risk assessment of $10^{-4}$). This risk must also be assessed in the context of the necessity for abnormal weather conditions and non-prevailing wind patterns at the time of a release, the fact that radioactive iodine must be present and that young children would have to remain very close to the reactor for many hours. This is further reinforced incorporating the consequence analysis, described above (pp9-10) as exposure to 10mGy results in an excess absolute risk for thyroid cancer of $10^{-8}$ over 50 years. As a result, the current risk to a child in the immediate vicinity of ANSTO for developing additional cases of thyroid cancer (beyond normal population incidence) could be described as $10^{-8}$ over a 50 year period (1 in 100 million chance).

However, perception of risk in the community is significant and mental health and psychological consequences should not be underestimated in such an emergency and these consequences for some sections of the community would be regarded as high.
6 Risk Treatment

6.1 Prevention

The ANSTO site is owned and operated by the Commonwealth. NSW Health continues to work with other agencies and supports a “whole-of-government” approach to the management of emergencies. NSW Health maintains a preventative stance particularly in regard to public health preparedness but is not primarily responsible for security of the site.

6.2 Preparedness

The maintenance of this plan and its regular exercising and testing is the primary preparedness role. The importance of “whole-of-government” planning is emphasised. Maintaining stockpiles of materiel and ensuring logistic support for emergencies is a core commitment. Ensuring multi-agency and community liaison is also important.

While an intervention with iodine is unlikely, even in a worst case scenario, a stockpile of iodine is held by NSW Health to ensure appropriate contingency planning. (Locations not stated for security reasons).

6.3 Response

As described above, NSW Health has a key role in the response to major emergencies and disasters, including possible incidents at the ANSTO site. This particularly applies to consequence management (also applicable to recovery, below) and in the mitigation of such events.

There has been considerable debate as to whether iodine should be pre-distributed to the community or whether current arrangements are adequate.
a) Options for Distribution of Iodine

There are three feasible options:

- Active pre-distribution to all those households in the Zone 2 area; and shield in place.
- Providing stocks of iodine through pharmacies.
- Holding of stocks of iodine in the locality, evacuation of the Zone 2 area and the administration of iodine at an evacuation centre designated by the Sutherland Shire LEOCON (Local Emergency Operations Controller).

i) Pre-distribution

**Advantages**

- Iodine is available immediately if the generic intervention level is reached.

**Disadvantages**

- There is no control of the iodine administration process;
- There is no guarantee that the iodine will be taken appropriately, particularly relevant in the paediatric population;
- There is no safe means of ensuring that casual visitors to the area are given the iodine when necessary;
- There are significant dose variations within the paediatric population especially relevant for neonates. (ARPANSA, 2002:56);
- Tablets may be incorrectly stored, misplaced or taken inappropriately;
- It would be very difficult to ensure that there is adequate medical follow-up of residents;
- “Pre-distribution of stable iodine tablets can be helpful in specific circumstances, although widespread pre-distribution to individual households is not advised”. (ARPANSA 2002:A (e)).
ii) Provision of iodine through pharmacies

*Advantages*

- Concerned residents can gain access to iodine if required;
- Reduces logistic complexity of pre-distribution.
- Dosages advised by NSW Health.

*Disadvantages*

- Nil.

iii) Evacuation

*Advantages*

- Good control of location, numbers and currency of iodine preparations;
- All those at possible risk would receive appropriate interventions;
- Families will be kept together;
- Casual visitors will be included;
- Record keeping is more precise;
- The availability of medical and nursing staff will ensure the monitoring of residents health and safety;
- Residents can be constantly updated by public health professionals in regard to the incident status.

*Disadvantages*

- Possible time delay may occur in administering iodine, if it were necessary
- Evacuation logistics.
iv) Discussion re options

Pre-distribution and sheltering in place has its own problems.

Even with a pre-distribution strategy, in the unlikely event of the need for an intervention, not everyone will necessarily have access to iodine at the time of an emergency.

Proponents of pre-distribution cite the need for early intervention with iodine when necessary. The World Health Organisation (1999) also notes that, "the effectiveness of the prophylaxis is very high where the iodine is given up to four hours after exposure".

However, an evacuation strategy of the population cohort potentially affected (however small the risk), maximises the safety margin. The potentially affected population requiring evacuation (3km) is less than 13,000 and a timely evacuation is achievable. The number of persons under 18 is estimated to be approximately one quarter of that number (just over 3,000). Moving people away from the source significantly reduces any likelihood for the need to administer iodine. The best evidence available is that evacuation to outside a 3km radius from the source will obviate the need for iodine administration, even in a worse case scenario.

Clearly, the amount of radiation exposure is determined both by the length of time that an individual is exposed to the radiation source and their proximity to the source.

Following discussions with the Therapeutic Goods Administration (TGA) and the Pharmaceutical Branch of NSW Health, aqueous iodine solution has been identified in Schedule 2 of the NSW Poisons List and is therefore available from pharmacies without a prescription. One manufacturer (Biotech International) has indicated that the product is manufactured with a shelf life of 2 years and is available in 100ml or 500ml pack sizes. The cost of the 100ml pack is approximately US$6 (AU$11) wholesale. (Federal Drug Authority, USA, 2001, Micromedex, 2003)

Aqueous iodine solution contains 5% iodine and 10% potassium iodide, which is equivalent to 130mg total iodine/ml or 8mg iodide per drop. The recommended doses of this solution are found at Annex A.

While NSW Health is of the view that iodine administration will be unnecessary, the availability of aqueous iodine, with acceptable efficacy, ensures community access to this preparation. No medical practitioner prescription is necessary under the relevant legislation.

The role of NSW Health is to provide dosage advice available to pharmacies holding the product.
b) Response recommendations

SAFETY ELEMENT 3

- It is recommended that a staged evacuation be undertaken of Zone 2 up to 3km and that this is preferable to an iodine pre-distribution strategy by reducing the exposure period, the radiation exposure to an individual and the resultant risk.

  This reduces both the level of radiation exposure as well as the length of time of exposure, thus introducing a further element of safety.

C) Response measures and logistics

- "ANSTO will assume the primary responsibility for the off-site monitoring of emissions or spillage resulting from an accident or incident". (ANSTO, 2002).

- ANSTO will notify the Police Site Controller or Local Emergency Operations Controller (LEOCON) of all levels. (Ibid, 2002)

- The Police Site Controller or the Local Emergency Operations Controller (LEOCON) will keep the NSW Health representative informed of the situation and in particular whether there are any of the radioisotopes associated with radioactive iodine present. These will include:

  - $^{131}$I
  - $^{132}$I
  - $^{133}$I
  - $^{135}$I
  - $^{132}$Te

- Those to be evacuated, in accordance with the Sutherland Local Area Command Emergency Evacuation Plan, will be identified and evacuated to a designated centre. The evacuation would proceed under the direction of Police, in a staged fashion based on radiological monitoring data and meteorological conditions.

- The Sutherland Local Area Command holds a current list of evacuation centres. They have not been stated in this document for security reasons. The LEOCON will select evacuation centres on the basis of meteorological data such as wind direction, scientific data supplied by ANSTO and the numbers of residents to be evacuated.
• The State Health Services Functional Area Co-ordinator (HSFAC) will notify the Ambulance Service of NSW of the evacuation centres to which an appropriate number of Health medical teams will be deployed.

• Each Health team should include;
  - Emergency physician;
  - Public health physician;
  - Mental health consultant;
  - Pharmacist;
  - Registered nurse.

• While timely evacuation of Zone 2 will obviate the requirement for iodine administration, the State HSFAC can access a stockpile of iodine tablets in the unlikely event that a child or pregnant woman suffered prolonged exposure close to the reactor.

d) Procedure for the Administration of Iodine

• Triage will be carried out to ensure that those at most risk such as the youngest children will be dosed first;

• Family groups should remain together;

• Each person requiring iodine administration is to have a completed identification and administration record;

• Individuals or families are to be given the information sheet on iodine and any questions answered;

• Dosage and time administered must be entered on the form at the time of administration;

• Iodine is administered according to the dose required as detailed;

• Special care is to be taken with dosage levels for neonates, and follow up and monitoring is suggested.
6.4 Recovery

The recovery phase will also be important and will include managing the affected community and the environment.

During this phase the assessment of environmental contamination or the restriction of contaminated foodstuff may be required to minimise additional exposure to radioactive iodine, although modelling does not suggest the need for this based upon current recommended intervention levels for ground or agricultural contamination.

Public health strategies will include ensuring the short, medium and long-term follow up of the potentially affected community. Close liaison with other agencies is important.

Mental health consequences will need to be closely assessed and managed in partnership with other government and non-government agencies.
7. Monitor and Review

These arrangements should be a part of an ongoing monitoring and review process. In particular, it is recommended that a regular exercise be undertaken to ensure the integrity and relevance of the plan.

8. Communicate and consult

It will be important to effectively communicate the findings in this position paper to all stakeholders.

A process of ongoing consultation should occur, particularly following further monitoring and review phases of the plan.
### ANNEXURE 1

Table 1 – Dosage of Iodine

<table>
<thead>
<tr>
<th>Category</th>
<th>Fraction of 100mg Tablet</th>
<th>Iodine Dose (Equivalent mass of iodine)</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonates (birth to 1 month)</td>
<td>1/8</td>
<td>12.5 mg</td>
<td>Single dose</td>
</tr>
<tr>
<td>Children (1 month to 3 years of age)</td>
<td>1/4</td>
<td>25 mg</td>
<td>Single dose</td>
</tr>
<tr>
<td>Children (3 to 12 years of age)</td>
<td>1/2</td>
<td>50 mg</td>
<td>Single dose</td>
</tr>
<tr>
<td>Pregnant and lactating women</td>
<td>1</td>
<td>100 mg</td>
<td>Single dose</td>
</tr>
<tr>
<td>Adolescents (13 to 18 years of age)</td>
<td>1</td>
<td>100 mg</td>
<td>Single dose</td>
</tr>
<tr>
<td>Adults (18 to 40 years of age)</td>
<td>1</td>
<td>100 mg</td>
<td>Single dose</td>
</tr>
<tr>
<td>Adults (&gt;40 years of age)</td>
<td>1</td>
<td>100 mg</td>
<td>Single dose</td>
</tr>
<tr>
<td>Emergency workers in area</td>
<td>1</td>
<td>100 mg (Equivalent mass of iodine)</td>
<td>Daily to 10 days maximum</td>
</tr>
</tbody>
</table>

**Note:** That the Iodine tablets are Schedule Two items of the Standard for Uniform Scheduling of Drugs and Poisons as published by the Therapeutic Goods Administration.

**Schedule 2** items are:

> ‘Substances which are dangerous to life if misused or carelessly handled, but which should be available to the public for therapeutic use or other purposes without undue restriction’. (Poisons and Therapeutic Goods Act 1966 No 31)

Table 2. Dosage of Potassium Iodide (KI)

<table>
<thead>
<tr>
<th>Category</th>
<th>Fraction of 100mg Tablet</th>
<th>Dose Potassium Iodide</th>
<th>Aqueous iodine solution</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonates (birth to 1 month)</td>
<td>1/8</td>
<td>16 mg</td>
<td>2 drops</td>
<td>Single dose</td>
</tr>
<tr>
<td>Children (1 month to 3 years of age)</td>
<td>1/4</td>
<td>32 mg</td>
<td>4 drops</td>
<td>Single dose</td>
</tr>
<tr>
<td>Children (3 to 12 years of age)</td>
<td>1/2</td>
<td>65 mg</td>
<td>8 drops</td>
<td>Single dose</td>
</tr>
<tr>
<td>Pregnant and lactating women</td>
<td>1</td>
<td>130 mg</td>
<td>16 drops</td>
<td>Single dose</td>
</tr>
<tr>
<td>Adolescents (13 to 18 years of age)</td>
<td>1</td>
<td>130 mg</td>
<td>16 drops</td>
<td>Single dose</td>
</tr>
<tr>
<td>Adults (18 to 40 years of age)</td>
<td>1</td>
<td>130 mg</td>
<td>16 drops</td>
<td>Single dose</td>
</tr>
<tr>
<td>Adults (&gt;40 years of age)</td>
<td>1</td>
<td>130 mg</td>
<td>16 drops</td>
<td>Single dose</td>
</tr>
<tr>
<td>Emergency workers in area</td>
<td>1</td>
<td>130 mg</td>
<td>16 drops</td>
<td>Daily to 10 days maximum</td>
</tr>
</tbody>
</table>
ANNEXURE 2

RECORD OF ADMINISTRATION OF IODINE

TO BE COMPLETED AND CHECKED BEFORE ADMINISTRATION OF ORAL IODINE TABLET or LIQUID.

<table>
<thead>
<tr>
<th>Contraindications for use of Iodine (WHO 1999)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Past or present thyroid disease (e.g. active hyperthyroidism)</td>
</tr>
<tr>
<td>• Known iodine hypersensitivity</td>
</tr>
<tr>
<td>• Dermatitis herpetiformis</td>
</tr>
<tr>
<td>• History of vasculitis.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Family Name</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Given Name</td>
<td></td>
</tr>
<tr>
<td>Address</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Telephone Number</th>
<th>Home:</th>
<th>Mobile:</th>
<th>Work number:</th>
</tr>
</thead>
</table>

| Date of Birth |  |

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Neonate □ (Birth to 1 month)</th>
<th>Child □ (1 month to 3 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Child □ (3 to 12 years)</td>
<td>Adolescent □ (13 to 18 years)</td>
</tr>
<tr>
<td></td>
<td>Adult □ (19 to 40 years)</td>
<td>Adult □ (&gt;40 years)</td>
</tr>
</tbody>
</table>

| Gender | MALE □ | FEMALE □ |

<table>
<thead>
<tr>
<th>Pregnant/ Lactating?</th>
<th>YES □</th>
<th>NO □</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iodine Allergy?</td>
<td>YES □</td>
<td>NO □</td>
</tr>
</tbody>
</table>

| Iodine dose Administered | 12.5 mg □ | 25 mg □ |
|                         | 50 mg □   | 100 mg □ |

<table>
<thead>
<tr>
<th>Time Given</th>
<th>By Whom</th>
</tr>
</thead>
</table>
REFERENCES


- International Atomic Energy Agency (IAEA-TECDOC-953)


- NSW Health (1997). NSW HEALTHPLAN.

- NSW Health, Pharmaceutical Services Branch (Mr John Lumby, Director) personal correspondence June 2003.


