Visit of the Radiological Protection Institute of Ireland to the Wylfa Nuclear Power Plant

Radiological Protection Institute of Ireland
An Instititúid Éireannach um Chosaint Raideolaíoch

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C.P. Hone
C.A. McMahon
P. McGinnity
P.A. Colgan
M. Kelly

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The cover picture and diagrams which appear in this report were kindly supplied by Magnox Electric

1. Introduction

An important statutory function of the Radiological Protection Institute of Ireland (RPII) is the provision of advice and information to Government on nuclear safety issues in nuclear facilities abroad and, in particular, on the potential impact on Ireland of accidents and other unplanned events at such facilities. The RPII is concerned to ensure that its advice and information is accurate, comprehensive and as up to date as possible. For these reasons it was decided that it would be useful for key staff members of the RPII, who are involved in preparing such advice and information, to visit Wylfa Nuclear Power Plant (Wylfa NPP) in Anglesey in North Wales.

The Wylfa NPP was selected for such a visit as it is the largest of the UK Magnox reactors, has the longest remaining projected operational life of the Magnox reactors and, at some 120 km from Dublin, is the closest nuclear site to Ireland (see Figure 1). It was also felt that a visit to a Magnox reactor site would in itself be a useful exercise in that Magnox reactors, which utilise graphite as a moderator and carbon dioxide as a coolant, are essentially unique to the UK.

The proposal to visit the Wylfa NPP was initially raised by the RPII with the UK regulator, the Nuclear Installations Inspectorate (NII). The NII site inspector for the Wylfa NPP subsequently raised the issue with the site manager who indicated that he would be happy for the RPII to visit. The visit took place within the framework of the ongoing contacts that the RPII has maintained over many years with the UK nuclear regulators and follows on from previous visits to the Sellafield reprocessing facility in 2000 and 2004 (Turvey and Hone, 2000; Colgan *et al.*, 2005).

The visit took place on the 23-24 October 2006 and included a half day meeting at which the management, regulation and operation of the facility were outlined. The principal topics covered were radioactive waste management, safety issues and the future of the Wylfa NPP. There was also a site tour which included the reactor building, the control room, the turbine hall and the simulator. Staff from Magnox Electric, which operates the Wylfa NPP, the NII and the UK Environment Agency (EA) participated in the visit.

Prior to the visit, the RPII had provided a list of the technical issues it wanted to discuss and all of these were considered in depth during the visit. For security reasons it was not possible for the NII to share detailed information with the RPII to allow it make its own assessment of the likely consequences for Ireland of a terrorist attack on the Wylfa NPP. However, given the interest of the Irish Government and public in the potential threat to Ireland as a result of a release from a nuclear reactor abroad, some general observations on site security and on the plant's ability to withstand a terrorist attack in the form of an aircraft intentionally crashed into the reactor building have been made. Due the restriction on discussing site security issues, neither Magnox Electric (the operator) nor the NII were in a position to comment on the observations and therefore the text dealing with these and related issues reflects solely the views of the RPII.

Figure 1

Location of Wylfa NPP and other UK nuclear reactor sites

2. The Wylfa NPP

2.1 Site management

The Wylfa NPP is operated by Magnox Electric, a part of the British Nuclear Group (BNG) that now belongs to the Nuclear Decommissioning Authority (NDA). Its role within the NDA framework is to produce electricity commercially until it ceases generation sometime in 2010. Following cessation of electricity generation, decommissioning will be carried out using protocols adopted by the NDA and approved by the regulators (the NII and the EA). Wylfa NPP is expected to earn approximately £1 billion for the NDA in electricity sales over its remaining life. This income will contribute to the cost of decommissioning and clean-up.

The Magnox Operating Programme is an integrated programme across nine nuclear sites aimed at the ultimate closure of all Magnox reactors and the reprocessing of the spent fuel from these reactors at Sellafield (BNG, 2006). The target date for completion of Magnox reprocessing is the end of 2012. This in turn requires electricity generation at the Wylfa NPP to end in 2010 and for all irradiated fuel contained in the two reactor cores and in storage at the site to be dispatched to Sellafield. Compliance with this timescale will be a key factor in the UK meeting its OSPAR commitments to reduce radioactive discharges to the marine environment from Sellafield by 2020.

2.2 Wylfa NPP and the local community

The Wylfa NPP is located on a rural coastal site on the north side of the island of Anglesey. The other main large industry on the island is an aluminium smelter which obtains its electricity from the Wylfa NPP. The Wylfa NPP is therefore both directly and indirectly a major employer in the region and it is understood that its existence is generally viewed very favourably by the local population.

The Wylfa NPP maintains close links with the local community through visits to its Information Centre. There is ongoing contact with a Site Stakeholder Group, local businesses, county and community councils and those responsible for local trade and tourism. In addition, good working relationships are fostered with schools on the island and further afield. For example, there were 129 educational visits to schools by station staff in 2005 and school project work has been undertaken at the station.

3. The Wylfa reactors

3.1 Description of the reactors

At the Wylfa site there are two 490 megawatt gas-cooled graphite-moderated reactors which first commenced operation in 1971. The fuel is contained within magnesium alloy (Magnox) cans, with eight cans in each of 6156 fuel channels giving a total uranium inventory of nearly 600 tonnes per reactor. Originally the reactor was designed to burn natural i.e. un-enriched uranium. However, it now uses some slightly enriched uranium which contains 0.8% of the fissile isotope uranium-235 compared with the 0.7% found in natural uranium. This is to compensate for the loss of graphite moderator, normally referred to as graphite degradation, which had previously been identified in the Oldbury reactors. An extensive testing and research programme was put in place at the Oldbury NPP to understand graphite degradation and its implications for reactor safety. This is further discussed in **Section 4.5 Graphite moderator deterioration**.

Magnox reactors have been constructed at 11 sites in the UK. All of these have now been closed, with the exception of the reactors at the Oldbury and Wylfa sites. The design of the Magnox reactors evolved with time and the Oldbury and Wylfa reactors were the only ones to be built with pre-stressed concrete pressure vessels. This design is considered to represent a significant improvement over the earlier Magnox reactors which had a steel pressure vessel which became brittle over its working life as a result of bombardment by neutrons through a process known as neutron induced embrittlement.

The fuel channels are stacked within a core of graphite bricks, weighing a total of 3800 tonnes, that acts as the moderator. Each reactor core is housed within a pre-stressed concrete pressure vessel whose internal diameter is 30 metres. The reactor cores are cooled by a flow of pressurised carbon dioxide gas that is circulated by electrically driven blowers at a pressure of 27.6 bars, i.e. 27.6 times atmospheric pressure. The mean temperatures at the bottom and the top of the core are 230°C and 370°C respectively, which is well below the melting point of the Magnox cans of 630°C. The coolant gas passes through a "once through" boiler that is divided into four circuits and is located within the annulus between the cylindrical core and spherical internal surface of the pressure vessel. The high-pressure steam at a temperature of 340°C from the boilers drives four main turbo alternators that generate around 980 megawatts of net electrical power. The steam is condensed in sea water cooled condensers. The main features of a Wylfa Magnox reactor are shown in Figure 2.

When operating at full power, the Wylfa NPP supplies some 40% of the electricity used in Wales.

3.2 Safety features

On a number of occasions in the past the RPII questioned the vulnerability of Magnox reactors, in particular those at Calder Hall on the Sellafield site and at Chapelcross in Scotland. The RPII was particularly concerned about the potential for a loss-of-coolant accident induced through a fracture in a coolant transfer pipe as a result of, for example, an earthquake or a terrorist attack.

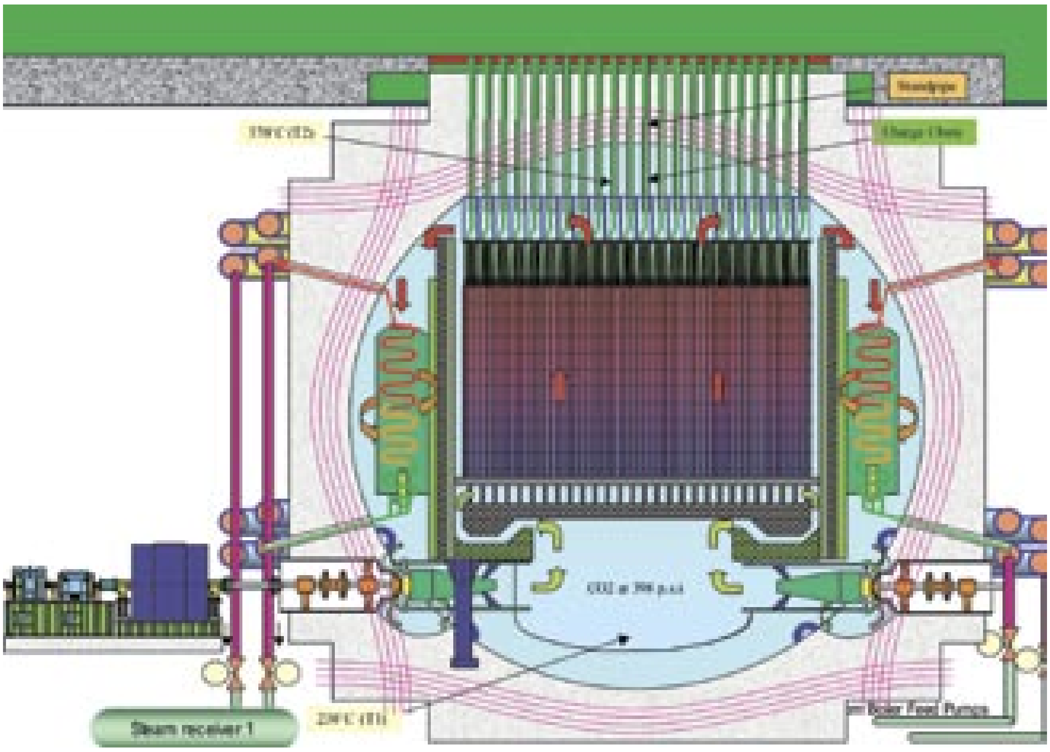
In the Wylfa and Oldbury reactors the pressure vessel is made of pre-stressed concrete about 4.5 metres thick and the boilers are located inside the pressure vessel. From a safety standpoint, this construction represents a significant improvement over the earlier Magnox reactors at Calder Hall and Chapelcross where the carbon dioxide coolant was delivered to the boilers via unprotected transfer pipes. The reactor pressure vessel is inspected every two years by an independent company on behalf of the insurers.

Although the Wylfa NPP design does not incorporate full secondary containment of the type encountered in the more modern light water reactors (LWRs), Magnox reactors have a power density that is about 1/20th of that of LWRs. This means that, in the unlikely event of a loss-of-coolant accident, there is considerably more time available to the operators to take action to remedy the situation.

The operators and the regulator (NII) share the view that full secondary containment is neither practical nor necessary for this type of Magnox reactor. In this regard, while it is difficult to compare the overall level of safety with western designed LWRs, a consideration of the design features and operating experience to date would suggest that they are at least as safe.

The reactors also incorporate a number of monitoring devices known as 'burst can detectors' (BCDs) to detect leakage from a burst Magnox fuel rod. The plant control systems are configured in such a way that if the leakage exceeds certain prescribed values the reactor will be shut down. The RPII team was advised that due to improvements in fuel manufacture, there has not been a BCD event for 15 years. Previously such events occurred at a frequency of about one per year.

Figure 2
Cutaway drawing showing main features of a Magnox reactor at the Wylfa site



4. Periodic Safety Reviews (PSRs)

The reactors were essentially designed according to 1960s safety criteria. However, for the last 20 years the operators are required under Condition 15 of the site licence issued by the NII (see **Section 6 Regulatory regime**), to carry out periodic safety reviews to assess the safety status of the plant against more modern safety standards. In the UK, PSRs are carried out once every ten years and the most recent PSR at the Wylfa NPP took place in 2004. The main issues addressed by these PSRs are described below.

4.1 Defence in depth

During the course of their operational life, the reactors have undergone a number of modifications to increase the number of operating parameters, which if not adhered to, will cause the reactor to shut down. This reduces the dependence on staff to ensure that the reactors are operating within specified limits for these parameters. Also, the level of redundancy in terms of safety features has been increased significantly. For example, prior to 1993 there were four electric cooling water feed pumps. However, in 1993 a diesel driven emergency pump was added to each reactor. Gravity fed water tanks can also supply cooling water for 24 hours. There are now essentially four independent cooling water supplies to extract heat from the reactors: the main feed system (1), the secondary feed system (2), the tertiary feed system (3) and the emergency feed system (4). If systems 3 or 4 need to be activated, the reactor will shut down automatically.

The carbon dioxide coolant is circulated by electrically driven blowers. Each reactor is equipped with four blowers but two are sufficient to maintain coolant circulation. Each blower is fitted with ac and dc backup "pony" motors to ensure circulation if the supply to the main motor should fail. The ac motors are supplied from the national grid. If the connection to the grid should fail, the dc motor will be connected to the plant's battery supply until the emergency gas turbines are started to ensure continued circulation. In addition two pony motors on each reactor can be supplied with electricity from emergency diesel generators. The RPII team was advised that the electrical equipment, in which a fault occurred and which resulted in diesel generator start-up failure at Forsmark NPP in Sweden in July 2006, is different to that used in the Wylfa reactors and that the same fault could not occur.

The reactor control rods are designed to be fail-safe in that they will fall into the core under gravity, if activated. Furthermore, some of the control rods incorporate articulated joints to ensure that they can still penetrate the core if the control rod channels should become distorted due to damage to the graphite. The insertion of one of the 153 high boron control rods, known as black control rods, will lead to automatic shutdown. Finally, if the control rods should fail the reactor can be shut down (permanently) by blowing boron oxide dust into the core.

The RPII team was advised that, should there be a loss of carbon dioxide coolant, the operators will have some 12 hours in which to restore the supply before core damage could occur, if the cooling circuit is intact; or about one hour if the cooling circuit is damaged.

4.2 Probabilistic Safety Analysis (PSA)

When nuclear reactors, such as those at the Wylfa NPP, were initially designed and built, safety assessments were mainly based on what is known as a deterministic approach in which it was assumed that critical operating parameters, such as coolant pressure, would not exceed certain defined values and hence that safety would be assured by designing the reactor to withstand these values.

PSA is used to predict the probability of system failures by combining what are believed to be representative failure rates for key components in the system, for example cooling pumps, pipes, seals, valves, etc. The assembly of information on failure rates is referred to as the reliability database. This information is obtained from studies of failure rates observed in practice, failure rates of the same or similar components in other situations, projected failure rates based on theoretical considerations, or a combination thereof.

PSA was introduced about 10 years ago at the Wylfa NPP and has resulted in further changes to the plant to improve safety. For example, the data control systems have been upgraded to improve the monitoring of plant performance.

Materials are also regularly inspected and sampled to ensure that they are still fit for purpose and that changes as a result of the environment in which they are used have not reduced their effectiveness, for example as result of corrosion or becoming brittle as a result of continuous bombardment by neutrons.

4.3 Seismic vulnerability

The UK lies in what is what is often referred to as a seismically "quiet" zone. As confirmed by studies of historical records from 1601 to 1955 (Davison, 1924; Karnik 1955), the probability of a severe earthquake is very much lower than in other parts of the world such as California, Iran or Japan. The worst earthquake reported in the UK between 1601 and 1955 occurred in Inverness in 1901 and had an estimated magnitude of 5.8 on the Richter scale. This is approximately ten times less severe than the recent earthquake in Japan which caused damage to the Kashiwazaki-Kariwa NPP, resulting in some minor radioactive releases.

Earthquakes of a 4.2 magnitude or higher strike the UK typically once every five years. Some recent such earthquakes occurred in Scotland in 1974, Wales in 1984, the West Midlands in 2002 and Kent in 2007. These measured 4.4, 5.4, 4.7 and 4.2 respectively on the Richter scale (BGS, 2007).

The ability of the Wylfa reactors to withstand earthquakes has been assessed using a methodology developed in the US by the Seismic Qualifications Utility Group (SQUG, 2001). This methodology has been used extensively in the US, where it is approved by the US Nuclear Regulatory Commission, as well as in the UK and mainland Europe. From this assessment it was concluded that an earthquake which might be expected to occur every 100 years would cause some damage, whereas a much more serious earthquake, which might be expected only once in 10,000 years would potentially render a number of plant items inoperable. Operation of the gas circulators might be compromised by such an earthquake, but the penetrations through which water and steam are supplied to and removed from the boiler located inside the pressure vessel would retain their integrity. The main reactor building structures would remain intact, but there would be local damage and ancillary structural items would collapse.

The ability of the reactors to withstand earthquakes has been improved over the years in operation. During the tour of the site, the RPII team was shown a number of examples of walls and other structures which have been upgraded for this purpose since 2001. Also the gas circulators are now physically shielded to prevent damage from falling objects or missiles. Access routes have also been upgraded to facilitate access to key areas following an earthquake.

This suggests that, unless the amount of other damage to the site was so severe as to prevent access to the reactor building to initiate emergency measures such as emergency cooling or to blow boron oxide dust into the core, a release to the atmosphere would be prevented. Upgrading the plant’s ability to withstand earthquakes should, by implication, also increase its ability to withstand terrorist attacks.

4.4 Upper superheater penetration restraints

There are a number of holes or penetrations in the pressure vessel for the pipes which transfer the superheated steam to the turbines and for the pipes which return the condensed steam to the boilers. The integrity of the pipe pressure vessel interface is critical to ensuring the integrity of the pressure vessel and preventing depressurisation.

As a result of the introduction of more sensitive inspection techniques, defects had been found in some superheater header welds in the region where they penetrate the reinforced concrete reactor pressure vessel. Extensive examination showed that the defects had been formed during the original construction welding process, rather than having developed during the operational lifetime of the plant. This led to the reactors being shut down to allow the operator consider how safety could be improved.

The operator demonstrated by analysis, supported by material sampling and testing, that the headers were fit for purpose without modification. Secondly, it was decided to fit restraints external to the reactor pressure vessel, such that if the welds did nevertheless fail, the headers would be secured in place with minimal gas leakage, thus complying with the conditions of the safety case. This upgrading was successfully implemented and the reactors returned to service following a shut-down of more than a year. These restraints were shown to the RPII team during the course of the visit.

4.5 Graphite moderator deterioration

The carbon dioxide coolant reacts chemically with the graphite moderator to produce carbon monoxide. This results in a slow reduction in the mass of the graphite. The RPII team was advised that the graphite is subjected to a rigorous inspection programme to ensure that the graphite remains fit for service and also that experience gained in assessing graphite degradation referred to earlier in relation to the Oldbury NPP is applied at the Wylfa NPP.

4.6 Condition of pressure vessel and coolant pipes

The RPII team was advised that PSRs have concluded that the reactor pressure vessel remains fit for service without modification. This conclusion also takes account of the leak before break concept, i.e. that a leak of coolant will always occur before a break in a coolant pipe. Carbon dioxide leakage testers have been fitted at strategic points to identify any leaks.

4.7 Mitigation of the consequences of a hot carbon dioxide or steam leak

Following the PSR, the plant was modified to vent hot gases and steam, which could potentially damage essential equipment, away from such equipment.

5. Reactor simulator

A full nuclear reactor simulator is located on the site. Training on the simulator is an NII requirement for all reactor operators, who also have to pass appropriate exams. These exams include tests to evaluate trainees' psychological suitability to operate reactors. Initial training of operators, which includes time on the simulator, normally takes about 18 months. The simulator is also used for training staff from the Oldbury NPP.

The simulator can be used to simulate both routine and non-routine events, for example disconnection from the grid. It is also used in emergency exercises and for refresher training.

6. Regulatory regime

Like all nuclear power stations, and other types of nuclear installation in the UK, the operator of the Wylfa NPP is required by the Nuclear Installations Act (1965) to hold a nuclear site licence issued by the Health and Safety Executive (HSE). The issuing of licences, enforcement of conditions attached thereto and inspection of licensed sites is the responsibility of the Nuclear Installations Inspectorate (NII) which is a division of the HSE. The main features of the licensing system are as follows:

- The Nuclear Installations Act empowers the NII to attach conditions to the site licence in the interests of safety, or with respect to the handling, treatment and disposal of nuclear material.
- NII has developed a standard set of 36 licence conditions, which are applicable to all nuclear installations.
- While some of the licence conditions place direct requirements on the operator (e.g. to establish a nuclear safety committee, including at least one independent member, to advise it), many of them require the licensee to "make and implement adequate arrangements" to control various aspects of the operation of the site (e.g. modifications to the plant, or examination, inspection, maintenance and testing). This allows the licensee to tailor the arrangements to the particular plant and conditions. However, many of the arrangements are then formally approved by the Executive, which means they cannot be changed without its agreement.
- NII site inspectors visit sites regularly to check compliance with the licence conditions.
- Licence conditions require the licensee to obtain formal consent from the NII in a number of instances e.g. to restart a reactor after its mandatory shutdown for maintenance and inspection, or to carry out modifications which impact on safety.
- The NII is authorised to issue improvement notices, instruct a licensee to shut down a reactor and to prosecute a licensee for violations of licence conditions or other relevant legislation.

A licence may be revoked by the NII or surrendered by the licensee. However, in either event, the licensee will remain responsible for the safety of activities on the site. This "period of responsibility" can end only when a new licence has been granted for the site or the NII is satisfied that in its opinion there has ceased to be any danger from ionising radiations from anything on the site.

In 1993 an incident occurred at the Wylfa NPP that, according to the NII, demonstrated a "blatant failure of safety culture" (Nuper, 1993). The NII, successfully prosecuted the station's parent company over management of the incident in which part of the reactor's refuelling gear fell into a fuel channel. The reactor subsequently continued operation for nine hours before being shut down. It was the failure to shut the reactor immediately which led to the prosecution, amid accusations that the operators had risked a meltdown - accusations which were rejected by the judge who heard the case. The incident itself was rated level 2 on the IAEA International Nuclear Event Scale (INES). This rating means that there had been 'significant failure in safety provisions but safety back-up systems would have been able to cope with any failure which may have occurred'. The Court imposed a fine of £250,000 and £138,000 costs.

There have been no other reported incidents which, in the view of the NII, justified prosecution. Moreover, the current site culture reflects, in the view of the NII, the significant improvements that have been made since that date.

During the course of the visit the NII made available documents indicating that the management is responsive to external advice and has a good working relationship with it and other regulators. This, according to the NII, permits it, wherever possible, to exert influence by working through what it describes as a "preventative partnership" and not direct enforcement. During the course of the visit the RPII team noted that there appeared to be a strong emphasis on safety culture, staff training, transparent and conservative decision making and blame-free event reporting.

An independent committee of experts, the Nuclear Safety Advisory Committee (NuSAC) has been established by the UK Government to monitor all licensees' safety performance, including the operators of the Wylfa NPP, as well as the regulatory process. NuSAC also advises the UK Health and Safety Commission (HSC) and, if appropriate, the relevant government ministers of any concerns that it has been unable to resolve by discussion with the licensees and/or the regulator.

NuSAC has regular meetings with the NII and issues annual reports that deal with issues on a generic level. While specific visit reports are normally not published as they contain confidential information, some details of a visit by NuSAC to Wylfa in September 2005 are available (BNG, 2005).

Radioactive discharges to the environment are regulated by the Environment Agency. This issue is discussed in greater depth in **Section 8 Discharges to the environment**.

7. Spent fuel storage

Magnox fuel and its cladding are chemically unstable and spent fuel is normally, following a period of storage at the reactor site, sent to Sellafield for reprocessing. In contrast to the other Magnox reactor sites where the fuel is stored under water, at the Wylfa site it is dry stored in tubes filled with carbon dioxide and cooled by natural air circulation.

The store is located mid-way between the two reactors. Spent fuel is removed from the top of the reactor, which is known as the reactor charge face level, and transferred horizontally to the spent fuel store without shutting down the reactors. There is no buffer store to provide an initial cooling off period between removal from the reactor and loading into the store. The individual Magnox fuel elements are stacked 12 high in each of the storage tubes. The total capacity of the cells is over 20,000 fuel elements.

There is also another dry storage area, which was previously used for temporarily storing spent fuel following its removal from the store referred to above before it was sent to Sellafield for reprocessing. In 1990, it was discovered that a number of spent fuel elements in this store had been affected by a roof leak, resulting in corrosion of the Magnox cladding. Magnox Electric has been developing special equipment to enable these elements to be removed and placed in special canisters. This will enable them to be dispatched off site for further treatment while minimising the spread of contamination. As the project is now approaching implementation on site, the NII has been holding regular meetings with the project team to monitor progress and development of the detailed safety case. It is understood that currently 16 damaged fuel elements remain in this store.

8. Discharges to the environment

The Wylfa site has adopted the following Environmental Objectives:

- Prevent pollution of the marine environment from oil, chemicals and radioactive discharges;
- Minimise emissions of air pollutants;
- Minimise water usage and electricity consumption;
- Minimise waste arisings and maximise recycling; and
- Maintain the Environmental Management System.

The Environment Agency (EA) regulates the disposal of radioactive waste to land, sea and air from all nuclear sites in England and Wales, including from the Wylfa site. Authorisations are issued under the Radioactive Substances Act, 1993. The Certificates of Authorisation permit the disposal of specified radioactive wastes from the site subject to limitations and conditions, as well as setting additional requirements in relation to process and environmental improvements and research. The Environment Agency has brought one enforcement action against the operators of the Wylfa NPP in 1999. This was related to a chemical rather than a radiological issue.

Environmental discharges from nuclear power plants, such as those on the Wylfa site, are significantly lower than from nuclear reprocessing plants such as Sellafield. For example, in 2005 the liquid discharges of tritium (radioactive hydrogen) from the Wylfa site were 8.52 terabecquerels (TBq), whereas 20,000 TBq was discharged in liquid waste from the Sellafield site in the same year. The liquid discharges from the Wylfa site are dominated by tritium (99% of the total activity discharged in liquid waste). The inert gas argon-41 dominates (>80%) the aerial releases. The annual liquid and aerial discharges have never exceeded the annual site limits on discharges set by the EA. As the activity discharged in a given year depends on the number of plant outages and boiler leaks, the activity limits set by the EA are expressed in terms of an activity concentration together with an annual limit on the total volume of liquid waste discharged. The main source of the tritium discharged is moisture in the reactor gas circuit. Once the water has been drained out it is stored for six months on-site before discharge. This is to allow a reduction in the activity of sulphur-35, which has a half-life of 87 days, in the liquid waste. Sulphur-35 is more radiotoxic than tritium.

Liquid wastes are sampled and analysed using liquid scintillation counting to assess their tritium content. Detailed analysis is also performed to check for other radionuclides, particularly sulphur-35 and caesium-137. An increase in the ratio of caesium-137 to sulphur-35 has been identified in recent years and this has been traced to traces of caesium-137 remaining in spent fuel flasks being returned from the Sellafield Reprocessing Plant.

Aerial emissions are routinely analysed and are found to contain small amounts of argon-41 from residual impurities in coolant air, carbon-14 arising from oxidation of graphite in the reactor, sulphur-35 from activation of sulphide impurities, tritium from moisture in the reactor gas circuit, and beta-emitting particulates (predominately cobalt-60) from dust in the gas stream that gets activated during passage through the reactor. The emissions to the air from the plant are monitored and reported to the Environment Agency to ensure they comply with the limits set. As these aerial discharges could contaminate the surrounding land and so enter the food chain, an environmental monitoring programme is operated both by the site operator and by national agencies.

Model predictions of doses which could be incurred by the critical group who live in the local area and consume local foods (particularly locally grown vegetables) suggest a maximum dose of 60 microsievert (μSv) per year. The annual dose limit for members of the public is 1 millisievert (mSv) (1000 μSv). Actual doses to the critical group from consumption of local foods have been assessed by the Food Standards Agency, and are estimated to be less than 5 μSv which represents 0.5% of the annual dose limit for members of the public.

The environmental monitoring programme on-site and off-site involves the analysis of air, soil, herbage, milk and marine samples. The level of radioactive particulate matter in the air is measured using dry cloth collectors (“Tez shades”). Marine monitoring includes analysis of silt, seaweed, locally caught fish, crabs, lobsters and winkles. Gamma and beta dose rates are also measured on the local beach. The average gamma dose rate is 80 nanogray (nGy) per hour i.e. similar to typical background dose rates due to natural radioactivity in sand. The concentrations of artificial radionuclides in the local marine environment are dominated by the effect of Sellafield discharges. Sulphur-35 and carbon-14 have been detected in milk samples; sulphur-35 concentrations in milk from a farm close to the site and one distant from the site are identical.

In addition to collection and analysis of environmental samples, gamma dose rate monitors and thermoluminescent dosemeters (TLDs) are used to assess the ambient doses on and off the site. A TLD monitoring network is set up in rings around the site at distances of 5, 10 and 30 kilometres. Routine monitoring indicates that dose rates recorded at the site fence are the same as those recorded on the other side of Anglesey. In the event of an emergency, this monitoring network could be used to assess off-site external radiation doses to the public.

In preparation for decommissioning of the plant, environmental surveys of contaminated areas of the site have been started. To date, some hydrocarbon contamination has been identified but no radioactive contamination has been found.

Solid waste arising from Wyfla is disposed of via a number of different routes. Where possible, non-contaminated waste such as paper, wood, steel, building rubble and plastic is recycled. Non-contaminated waste that cannot be recycled is sent to landfill. Radioactively contaminated waste is sent to the low-level waste disposal facility at Drigg in Cumbria. In 2005, 109 cubic metres of low level solid waste was sent from the Wylfa site to Drigg. Very low level radioactive waste (VLW) is incinerated on-site to reduce its volume by 98% prior to disposal at Drigg.

9. Radiation exposure of workers

About 200 of the staff and contractors are subject to individual dose assessment on the basis they are considered liable to receive doses in excess of the dose limit for a member of the public of 1 mSv per year. The occupational doses received by the majority of these workers are close to or below the limit of detection. The maximum occupational doses received by workers at the site are received by the team working inside the pressure vessel during maintenance outages. About 40 workers would work in the pressure vessel during an outage, and of these 10-15 workers per year typically receive doses of 3-5 mSv, which can be compared to the annual dose limit for radiation workers of 20 mSv.

As a result of previous studies, internal doses to workers during normal plant operation are known to be extremely low and so routine biological monitoring is not considered necessary.

10. Site security

A strict regime for controlling access to sensitive parts of the site, e.g. control room, reactor building, spent fuel store, is in place. Even NII and EA staff require clearance to enter such areas. As visitors, the RPII team was obliged to be accompanied by a staff member of the station at all times. Security police are armed and there are high fences to discourage intruders. Prior to 11th September 2001 the station allowed visitors into the sensitive parts of the site, including the reactor building. However, the RPII team was advised that this practice is not considered compatible with the more rigid security regime that obtains since that date.

11. Emergency arrangements

11.1 Introduction

In the UK, the Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR) implement the articles on intervention in cases of radiation emergency in European Council Directive 96/29/Euratom (also known as the Basic Safety Standards Directive). REPPIR also partly implements Council Directive 89/618/Euratom (Public Information Directive). REPPIR place legal requirements on all sites (including nuclear power plants) using ionising radiation and local authorities with a nuclear site or sites in its area. Nuclear site operators must carry out risk assessments to identify and assess all reasonably foreseeable radiation emergencies and prepare and test on-site emergency arrangements. In addition, the site operator must provide information to the local authority to enable the local authority to prepare an off-site emergency plan. The off-site plans must be produced in consultation with emergency responders for the site. The arrangements for responding to emergencies at all civil nuclear sites are coordinated and agreed by the Nuclear Emergency Planning and Liaison Group (NEPLG) which brings together representatives of responding Agencies and nuclear operators and is chaired by the Department of Trade and Industry (DTI).

As well as the REPPIR Regulations, one of the standard licence conditions applied by the NII requires that nuclear site operators have adequate arrangements in place to respond effectively to any incident ranging from a minor on-site event to a significant release of radioactive material. Under this licence condition, employees of the site are required to be properly trained and emergency arrangements must be exercised regularly. The arrangements are subject to approval by the NII and, once approved, no alteration or amendment can be made to the approved arrangements without NII approval.

The stated aim of the emergency planning arrangements at the Wylfa site is to protect "Public, Personnel, Plant and Environment".

For all nuclear sites where there is potential for an off-site release of radioactivity that would require implementation of protective measures, detailed emergency planning zones (DEPZ) are designated around the site. The DEPZ is based on the reference accident as identified during the risk assessment. Once the details of the reference accident have been accepted by the NII, then the size of the DEPZ is determined for evacuation, sheltering, and administration of stable iodine. It is the role of the NII to determine the size of DEPZ and this is done using computer simulations of the reference accident. The simulations are used to predict the distances from the site at which the Emergency Reference Levels set by the UK Health Protection Agency (UK HPA) might be exceeded. If an accident larger than the reasonably foreseeable event were to occur, there are arrangements for extending the DEPZ.

The DEPZ around the Wylfa site extends to a radius of 1.6 km from the plant and contains 98 homes with approximately 300 permanent residents as well as an open-access coastal pathway. There was no pre-distribution of iodine tablets at the time of the RPII visit but it was planned to pre-distribute iodine tablets to all households in the DEPZ in early 2007. For the DEPZ and an additional 10 km radius, further arrangements for distribution of iodine tablets are in place if required. The contact details of all local residents in the DEPZ are gathered via Community Nurses. In the event of a serious accident, notification arrangements for these local residents are in place.

In an emergency, protective measures would be introduced based on the criteria (intervention levels) advised by the UK HPA. Derived Action Levels for air concentrations are used to make the decision to introduce protective measures. For example, a predicted air concentration of 10^5 Bq/m^3 for total beta/gamma activity indicates that evacuation from the DEPZ should be considered. This corresponds to an effective dose of 30 mSv. The advice on protective actions would also be based on wind direction and speed and, in the event of an emergency, automatic contact would be established with the UK Met Office. In addition, there are 10 m and 50 m height wind direction monitors on site. Once an environmental release had occurred more detailed analysis, using techniques such as gamma spectrometry, would be used to refine the prognosis and identify the population groups that might receive the highest doses (critical groups).

The NII requires emergency arrangements to be tested regularly and three levels of exercise are specified. Level 1 exercises are tests of a nuclear operator's on-site arrangements and are witnessed and assessed by NII. Level 1 exercises are held annually at each nuclear installation site. Level 2 exercises test off-site response plans made under the REPPIR Regulations and are aimed primarily at demonstrating the adequacy of the arrangements that have been made by the local authority to deal with the off-site aspects of the emergency, particularly the functioning of the Off-Site Facility (OSF). Level 2 exercises are also assessed by NII. Each year, one level 2 exercise is chosen as a level 3 exercise to rehearse the wider involvement of central government in addition to the functioning of the OSF. The Wylfa site organises annual Level 1 exercises and last held a Level 2 exercise in December 2004. The next Level 2 exercise at the Wylfa site is planned for early 2008. In addition to the Level 1 exercises, the Wylfa site holds five internal exercises every year to cover the five different shift teams operating there. Each year more than 75% of staff must be exercised, but normally more than 90% staff coverage is achieved. The on-site control room simulator is used in exercises.

11.2 On-site and off-site emergency response

The Wylfa Event Management Centre is designed to coordinate the response to any event on-site. In the event of a nuclear incident or accident on-site, the Centre coordinates the on-site response. The on-site coordination team includes representatives from the police, fire and ambulance services, a reactor physicist, and a health physicist. In addition to three on-site centres, there are two off-site centres. One of these is operated and would be used by BNG and the other is a local emergency centre at Colwyn Bay Police Headquarters. There is also a central control point for all Magnox nuclear power plants at Barnwood which provides a central emergency support centre and can take over off-site management of any emergency, if required. Since the RPII visit we have been advised that the Wylfa Event Management Centre is now accredited to ISO 14001.

The main function of the off-site facility is to decide on the actions to be taken off-site to protect the public, to ensure that those actions are implemented effectively and to ensure that authoritative information and advice is given to the public. All TV and radio stations in Wales have been briefed to broadcast the advice issued from the off-site facility.

The off-site response would be coordinated by a group that includes representatives of all organisations with responsibilities for dealing with the emergency. These include the Site Operator, the Police, the Welsh Assembly Government, the Local Authority, the Health Authority, Local Water Company and the Fire and Ambulance services. In addition, Government Departments and Agencies, including the Department of the Environment, Food and Rural Affairs (DEFRA), DTI, HPA, NII, EA and the Food Standards Agency, would also be represented. The representatives would provide links with their organisations and be responsible for ensuring that adequate information and advice were available to both the off-site and at the emergency control centres of their respective organisations. In the emergency phase of the event, the Chief Police Constable would act as what is known as the Gold Commander for the emergency. The Local Authority would become the Gold Commander after this point.

If a site emergency is declared, the relevant national agencies are automatically notified via the Site Event Reporting System. The Police are notified via a dedicated hotline and other emergency services (fire and ambulance services) are also notified. For the first 90 minutes of an emergency the on-site emergency centre also deals with the off-site emergency arrangements. After this time, the off-site control centre will be in operation and would take over all off-site arrangements.

Magnox Electric has adopted automatic, precautionary advice to shelter within the Detailed Emergency Planning Zone (DEPZ) as the first response to the declaration of a nuclear emergency. If a Magnox site such as Wylfa declares a nuclear emergency, the first advice from the police would be that all those within the DEPZ should “go in, stay in, tune in”.

11.3 Emergency monitoring

In addition to the area radiation monitors across the plant, the site perimeter is ringed by 16 radiation monitors. These would detect any emissions from the plant and the data from these monitors are fed automatically into the emergency control centres. The Wylfa site has two mobile mini-laboratories available at all times.

12. Decommissioning and future of the site

The Wylfa reactors are currently scheduled to close in April 2010. Closure may be deferred to the end of 2010 if Magnox Electric can ensure the transfer of all spent fuel to Sellafield in time for reprocessing to be completed by the end of 2012. The recent operational problems at the Magnox fuel reprocessing plant at Sellafield may have an impact on the precise closure date. Reprocessing of Magnox fuel is due to come to an end both because of NII safety concerns in relation to the Magnox reprocessing plant and also to ensure the UK’s international commitments in relation to the OSPAR Convention are met.

Decommissioning of the site will be the responsibility of the Nuclear Decommissioning Authority (NDA). The rate at which fuel is removed will, to a large extent, be governed by the availability of the defuelling equipment and to a lesser extent the need to restrict worker doses. The currently envisaged milestones for decommissioning the plant may, therefore, be summarised as follows:

2010	Cease operation
2012	All fuel removed
2021	Care and maintenance preparation completed
2125	Final site clearance and remediation completed, site returned to "brown field" status

It should be noted that 99.9% of the hazard will be removed once the fuel leaves the site. The need to delay final site clearance is governed by the need to allow the more hazardous activation products, in particular cobalt-60 with a half-life of five years, to decay and so limit worker doses.

It is expected that an intermediate level waste store (ILW) will be erected on the site. Also, as in the case of other Magnox and Advanced gas-cooled reactors, management of the graphite core will provide particular challenges.

Finally, it should be noted that the Wylfa site could be selected as a location for a new nuclear power plant. As indicated in **Section 2 The Wylfa NPP**, the Wylfa NPP being a major employer in the region, is generally viewed very favourably by the local population and hence any plans to replace the existing reactors with new ones would probably be received positively. However, it is worth noting that a report commissioned by the UK Department of Trade and Industry (DTI, 2006) on siting new nuclear reactors indicates that the Welsh Assembly Government would support an extension of the planned lifetime of the Wylfa reactors but is not in favour of any nuclear new build in Wales. Furthermore, according to siting criteria used in the same report, the Wylfa site would not be prioritised for new nuclear build because of its physical location in relation to the UK National Grid.

13. Impact of the Wylfa NPP on Ireland

13.1 Routine operations and radioactive discharges

As discussed in **Section 8 Discharges to the environment** routine discharges from nuclear reactors are significantly lower than from nuclear reprocessing plants such as Sellafield. Radioactive discharges from nuclear power plants consist primarily of radionuclides such as tritium, carbon-14, sulphur-35 and argon-41. These have low dose coefficients and therefore routine discharges involving small amounts of radioactivity give rise to low doses if the radionuclides are inhaled or ingested. On the other hand, discharges from nuclear reprocessing plants also include radionuclides such as caesium-137 and plutonium which have higher dose coefficients and are released in much larger amounts. This means that authorised discharges from nuclear reprocessing plants such as Sellafield normally result in larger radiation doses to the public than is the case for authorised discharges from operating nuclear reactors.

There are both liquid discharges into the Irish Sea and gaseous aerial emissions from the Wylfa NPP. The results of ongoing environmental programmes operated under the control of the Magnox Electric and by independent UK agencies confirm that the level of discharge is extremely low and often below the limit of detection. Furthermore, the discharge authorisations set by the Environment Agency have never been breached. While radioactivity is present in samples taken from the Irish Sea close to the site, the source of this radioactivity is predominantly Sellafield and not the Wylfa NPP itself.

Because of the massive shielding around the reactor core the external ambient dose rates are very low. The results of ongoing monitoring confirm that the dose rates at the site perimeter fence are similar to those found on the rest of the island of Anglesey.

It is therefore clear that the impact of routine operations at the Wylfa NPP on Ireland is negligible. Radiation doses in Ireland from the consumption of fish and shellfish caught in the Irish Sea are dominated by the discharges from Sellafield; these doses have no significant health impact and the doses attributable to discharges from the Wylfa NPP are even lower (Ryan *et al.*, 2007).

13.2 Terrorist threats

It is clear that a major release of radioactivity can occur only if the pressure vessel is breached, as a result of, for example, a heavy aircraft crash. For security reasons there are no publicly available studies on large aircraft impact on UK nuclear power plants. Some information from studies on this issue is in the public domain in Germany (RSK, 2001) and the US (NEI, 2002), but these have focused on light water reactors. In addition, Electricité de France has produced a statement to the effect that it believes that its plants would withstand a terrorist attack involving a heavy aircraft crash. However, it has not published a report on the issue.

The publicly available information would suggest that for light water reactors, the probability of an aircraft breaching the containment is low and that in the case of more recent reactor designs the containment structures would remain intact. Although caution needs to be exercised when applying these conclusions to other reactor types, it should be noted that the concrete reactor pressure vessel in the Wylfa reactors is significantly thicker than the combined thickness of concrete which is typically found in the biological shield and secondary containment of light water reactors.

Likewise it is not possible to make any realistic assessment of the risk of a release if serious, widespread and irreparable damage was inflicted on the plant cooling system and/or the instrumentation and control systems, including the control room. However, given the combination of redundancy and the time available to introduce emergency backup, it may reasonably be concluded that the risk of such an event is low.

The subject of potential terrorist threats to fuel stores on nuclear sites has also been of concern to regulators and utilities since the events of 11th September 2001. While we could not assess this threat for the Wylfa reactors, the RPII believes that such an event could cause very serious local contamination. However, the geographical extent of the contamination would probably be much more limited than in the case of a release from the reactor core. This is because the high pressure and temperature within the core would make it easier to propel uncontained material higher into the atmosphere where it is more easily dispersed. One would also anticipate that there could be discharges of radioactivity into the environment of the Irish Sea and that, with time, these would reach the Irish coast.

13.3 The Wylfa NPP reference accident

13.3.1 Introduction

The likelihood and seriousness of a range of accident scenarios, which could result in the release of radionuclides from the Wylfa site, were discussed during the course of the visit. For such a release to occur the pre-stressed concrete pressure vessel would have to be compromised. This can occur either due to a failure of an existing channel in the pressure vessel used for fuelling, cooling, steam generation and other functions or to a new leak in some way related to an accident.

As in any engineering project where safety is of paramount importance, operators and regulators of nuclear power plants aim to minimise the likelihood of faults occurring by conservative design, by the mode of operation, and by adequate maintenance, inspection and testing. Despite this it is inevitable that faults will occur. A plant must be capable of continuing to operate safely even in such circumstances. This is achieved by ensuring inherent safety in the design concept, defence-in-depth and the provision of effective safety systems.

Nuclear power plants are, therefore, designed to cope with a wide range of potential accidents (known as ‘design basis accidents’ or DBAs), but it may not be reasonably practicable to make design provision against the more unlikely accidents. According to the NII’s Safety Assessment Principles (SAPs) for Nuclear Plants (HSE, 2006), the analysis of accident conditions follows two complementary approaches: deterministic and probabilistic. The former determines the fault tolerance of the plant, the effectiveness of its safety systems and, for more serious accidents, normally referred to as beyond design basis, the likely off-site consequences. The complementary probabilistic safety analysis (PSA), which addresses the full range of possible accidents, provides a quantitative indication of the frequency of occurrence of a fault and the consequences of the fault.

13.3.2 The Wylfa NPP reference accident and its implications for Ireland

All nuclear sites in the UK are required by law to define a bounding reference accident scenario for the purposes of off-site emergency planning. The reference accident must be based on the concept of the worst credible accident, which is reasonably foreseeable at the site, taking into account all of the facilities on the site. The NII must approve the reference accident for each nuclear site and this is then used as the basis for emergency planning, both on and off-site (see **Section 11 Emergency arrangements**).

Some years prior to the site visit, the RPII was advised by British Nuclear Fuels plc (BNFL) - the then operator of the Wylfa NPP - of the details, estimated releases and off-site doses of the reference accident. This involved a single channel fire in a breached circuit leading to a depressurisation and a fire in a fuel channel. The event is initiated by a component falling off an automatic grab during maintenance or refuelling.

Depressurisation to the cooling circuit then takes place via a 15-inch diameter standpipe closure which cannot be closed as a result of the fault. According to the operator this is the postulated worst depressurisation of a Magnox reactor at the Wylfa site. Atmospheric pressure is estimated to be reached in approximately 30 minutes. It is assumed that the reactor trips immediately following the start of the fault.

The part which falls from the grab would also cause a partial blockage of the flow of CO_2 gas coolant in the fuel channel causing a build up of heat, resulting in melting of the Magnox (magnesium alloy) fuel cans followed by ignition of the Magnox cladding and the enclosed uranium fuel elements within the channel (a single channel fire). The fire is assumed to occur at the time the pressure in the circuit reaches atmospheric pressure, and to burn for approximately 7.5 hours. It is also assumed that four of the total of eight fuel elements in the fuel channel are oxidised.

The RPII was advised that the predicted frequency of a single channel fire occurring in a depressurised circuit is estimated to be less than 10^{-7} per reactor year. According to the NII SAPs, a detailed assessment of the consequences of accidents with a probability of occurrence of less than 10^{-7} per reactor year is not required. This is in line with international practice (IAEA, 2001; IAEA, 2003). While the operator would normally carry out some limited work on such scenarios, they do not form part of the safety case that supports the operating licence issued by the NII.

The potential consequences for Ireland of an accident of this type occurring at the Wylfa NPP have been simulated by the RPII. Radionuclide airborne activity concentrations, deposition of radioactive particles and radiation doses at a point in central Dublin, a distance of approximately 120 km from the Wylfa NPP, have been calculated. The transport and fallout from a plume of radioactive particles and gases which comprise the release was simulated using an atmospheric dispersion model. This model uses weather forecast data from Met Éireann as an input. A 'worst case' scenario was identified by independently modelling releases at three-hourly intervals over an entire year. Once identified, the worst case was investigated in further detail.

The transfer of radioactive material through the food chain was simulated using a nuclear food and dose model. Doses from the following pathways were considered: internal doses from inhalation of the plume as it passes overhead and from ingestion of contaminated foodstuffs; and external doses from gamma radiation emitted from airborne and deposited radioactive material. The results of the RPII calculations are presented in Table 1. For the ingestion and ground gamma pathways, doses have been integrated over a period up to 50 years whereas the other two pathways are only important during the passage of the plume containing the radioactivity.

Table 1

RPII calculated doses on the east coast of Ireland for a 'worst case' scenario based on the Wylfa NPP reference accident

	Effective Dose (μSv)		
	Adult	**Child[1]**	**Infant**
Inhalation	0.4	0.6	0.7
Ingestion	42	41	126
Cloud Gamma	<0.1	<0.1	<0.1
Ground Gamma	10	11	11
Total	53	53	138

[1] *10 year old*

For comparison, the annual average dose from all sources of radiation received by members of the Irish public is estimated to be 3.62 mSv (or 3620 μSv). This value is currently being re-assessed and initial indications are that the annual average individual dose may be somewhat higher.

The postulated doses do not exceed the intervention levels for urgent protective actions recommended by the RPII in line with international advice. Therefore, in the event of the reference accident occurring, evacuation, sheltering or administration of stable iodine tablets would not be recommended.

From Table 1 it is clear that the majority of the total dose would be expected to arise from ingestion of radioactively contaminated food. The majority of this dose would be received in the first year following the accident as contamination levels are known to decrease significantly with time in most foodstuffs after initial deposition. To complement the ingestion dose assessment, activity concentrations of radioiodine and radiocaesium in two representative food types, namely milk and seasonal leafy vegetables, are presented in Table 2. These have been calculated using a suite of models available to the RPII and used routinely in emergency preparedness exercises.

The activity concentrations have been compared with the appropriate European Commission action levels, or maximum permitted levels (MPLs) for radionuclides which would apply for food destined for the marketplace in the event of a nuclear accident. The two food types selected are normally locally produced and, assuming that deposition takes place during the pasture and vegetable growing seasons in Ireland, would be expected to demonstrate evidence of contamination soon after the accident. Although the MPLs are not exceeded, the activity concentrations are not insignificant, especially for the case of radioiodine in leafy vegetables where levels could reach 73% of the MPL.

The effect of countermeasures – actions taken by authorities to mitigate the consequences of an accident – have not been considered in the RPII analysis. However, most of the ingestion dose could be averted by the restriction of sale of contaminated food and other measures taken to reduce transfer of radioactivity to food products. While countermeasures are highly effective, their implementation may not always be straightforward and there will normally be some associated economic costs. Experience elsewhere suggests that, even in cases where the MPLs are not exceeded, the economic consequences from the stigma of food that is contaminated with radioactivity can be considerable.

Table 2

Activity concentrations in milk and leafy vegetables and related EC action levels (RPII Data)

Radionuclide Group	**Concentration (Bq/kg)**	**EC MPL (Bq/kg)**
Milk		
Radioiodine	105	500
Radiocaesium	17	1000
Leafy Vegetables		
Radioiodine	1460	2000
Radiocaesium	103	1250

13.4 More serious accident scenarios

As described in the previous section, the Wylfa NPP reference accident assumes that half of the fuel elements in a single channel are oxidised. If all of the fuel elements were oxidised the off-site doses would be at most doubled and, according to both the RPII and BNFL analyses, would still be well below the level which would justify urgent emergency intervention such as administration of stable iodine tablets and sheltering.

The possibility of a fire in a single channel spreading to adjacent channels was also discussed. According to BNG, the normal gas cooling of these channels would be sufficient to remove the additional heat. Even in the event of a loss of coolant, the RPII was assured that natural circulation of air would be sufficient for a period of time long enough (tens of hours) to bring post trip cooling systems into operation.

The likelihood of a full rather than partial blockage of carbon dioxide coolant in the channel was also discussed. According to BNG, analysis has demonstrated that only a partial blockage causing a build-up of heat in line with that described by the reference accident scenario is possible.

More general depressurisation events which could lead to a significant external release of radioactivity were also discussed. The probability of the pre-stressed concrete pressure vessel being punctured is not readily quantifiable but is considered to be extremely low. According to BNG, for an existing penetration to fail and result in a release, multiple events would have to occur. That is, there would have to be a significant incident such an earthquake affecting the reactor coupled with a defect in a penetration. When the probabilities of multiple events are calculated, the total probability rapidly decreases below 10^{-7}. This is a level of risk at which detailed analysis of the consequences of the accident is no longer required by the NII.

14. Conclusions

The RPII welcomed the opportunity to visit the Wylfa NPP and to discuss a range of safety issues with the operator and with the regulators. The main conclusions from the visit may be summarised as follows:

- The reactors at both the Wylfa and Oldbury sites are designed to higher standards than the earlier Magnox reactors. Since commissioning in 1971, the reactors have been the subject to a number of upgrades in particular in relation to the level of redundancy in safety systems.

- Following completion of the most recent Periodic Safety Review (PSR) in 2004, a number of modifications were implemented to improve the ability of the Wylfa NPP to withstand earthquakes. While the PSR is a planned event that was independent of the events of 11th September 2001, the upgrading that took place would be expected to increase the ability of the reactors to withstand a terrorist attack.

- From a combination of the site visit and discussions with key staff, it would appear that a good safety culture exists at the Wylfa NPP. There is strong evidence from several industries that a good safety culture is an important element in minimising the number of incidents and accidents that take place and also the seriousness of those that do occur.

- The UK nuclear regulator accepts that the worst credible accident at the Wylfa NPP is a single channel fuel fire following depressurisation of a cooling circuit. Such an accident would not be expected to lead to contamination levels in foodstuffs grown in Ireland in excess of the maximum permitted levels (MPLs) for a realistic weather situation. However, given that such a release could in principle result in easily detectable levels of contamination in foodstuffs, it could have a significant negative impact on the sale of, and public confidence in, such products and hence on the agri-food and related industries. The reference accident for the Wylfa NPP would not result in doses in Ireland which would justify evacuation, sheltering or the use of stable iodine prophylaxis but it could nonetheless have considerable economic consequences.

- It was not possible to quantify the risk of a major release from the reactors as a result of an external event such as a major earthquake or terrorist attack. However, bearing in mind the massive construction of the reactors and the upgrading that has been implemented to mitigate the impact of serious earthquakes, it may be stated with a high degree of confidence that, in the event of either a serious earthquake or terrorist attack, the probability of such a release occurring is very low.

- Routine operations at the Wylfa NPP result in both liquid discharges into the Irish Sea and gaseous aerial emissions. Close to the reactor site, the concentrations of radioactivity in the marine environment are dominated by discharges from Sellafield and at the site boundary the levels of environmental radioactivity are similar to those on other parts of Anglesey. Consequently it can be concluded that the routine operations at the Wylfa NPP give rise to radiation doses in Ireland that are extremely low and of no health significance.

- It would appear that the local community is, broadly speaking, positively disposed towards operations at the Wylfa site. It is likely, therefore, that following closure in 2010 it would support or even lobby for the building of a replacement nuclear power station on the same site. However, recently published documents do not prioritise the Wylfa site as a location for the construction of any future nuclear reactor.

15. Acknowledgements

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Radiological Protection Institute of Ireland
An Institiúid Éireannach um Chosaint Raideolaíoch

Contact Us

Radiological Protection Institute of Ireland
3 Clonskeagh Square
Dublin 14
Ireland

Tel: 01 2697766
Fax: 01 2697437
E-mail: rpii@rpii.ie
Web: www.rpii.ie

Opening hours: 9:00am to 5:00pm