MINISTRY OF DEFENCE

ASSOCIATED BRITISH PORTS SOUTHAMPTON

REPORT of ASSESSMENT of the HAZARD IDENTIFICATION & RISK EVALUATION

November 2007

Radiation (Emergency Preparedness & Public Information) Regulations Regulation 6 & Schedule 5

1. INTRODUCTION

The Radiation (Emergency Preparedness and Public Information) Regulations (REPPIR) 2001 (Reference 1) require Hazard Identification and Risk Evaluation (HIRE) be undertaken for any premises containing more than the quantity of radioactive material specified in the Regulations. This document is the Report of Assessment of the HIRE for the nuclear submarines, defined as premises under the Regulations, at the Associated British Ports Southampton Operational (formerly known as Z) berth. The Report of Assessment, together with such supporting information as deemed necessary by the Health and Safety Executive (HSE), is provided to enable the HSE to assess the risk to the health or safety of persons who could be affected by the work with ionising radiation undertaken at Southampton.

At present the only Nuclear Powered Warships (NPW) operated by the UK Government are Nuclear Powered Submarines. Therefore the terms NPW or Nuclear Powered Submarine are interchangeable throughout this report.

NOTE: Some sections of this report of assessment necessarily contain information in an abbreviated form and with limited technical detail. This has been done in the interest of national defence and public security and is in accordance with the agreement of the Health and Safety Executive (HSE) who have exercised their powers under regulation 16 (6) of REPPIR (Reference 1). The HSE have access to fuller, and more detailed and classified information to enable them to satisfy themselves on the acceptability of this assessment.

2. LOCATION AND ENVIRONMENT

2.1	**Operator Name:**	Commander-in-Chief Fleet, Ministry of Defence
2.2	**Operator Address:**	Ministry of Defence: (Sponsor: Naval Base Commander, HMNB Portsmouth, PO1 3LT)
2.3	**Address of Premises:**	ABP Southampton O/S Grid Ref: 38/39 Berth SU426095

2.4 **Commencement of Work:**

This is a supplementary submission made as part of the three annual review process, therefore work has already commenced at this location.

2.5 **History:**

2.5.1 The location of the berth in the Port of Southampton is at Lat 50° 53.00'N and Long 001° 23.69' W (OS 4426 1096). The City of Southampton has strong maritime links, with increasing cruise liner usage and cross channel ferries using the port. There is an influx of tourists to catch cruise and ferry sailings as well as those visitors interested in sailing small yachts especially at weekend between Spring and Autumn.

2.5.2 Across the water from the Southampton Western and Eastern Docks is the military port of Marchwood, the village of Hythe and the substantial Esso Oil Refinery at Fawley.

2.5.3 Travel to the City of Southampton has improved with good bus, rail and air links. The Business community provides an essential element of the economy of the area with many organisations having major establishments and headquarters in the area. Much investment has been made to modernise and improve the major shopping, sport and leisure facilities.

2.5.4 The total population of Southampton in 1995 was 206,598. Data from the 2001 Population Census indicates it has risen to 217000. The value in the 1991 Population Census was 207000. Hence, the population distribution is thought to remain fairly static over the approved period of the 2007 Berth Assessment.

2.6 **General Description:**

2.6.1 The Southampton Operational Berth comprise one approved alongside berth located at 38/39 berth Associated British Ports Southampton. Note that the approved berth would only be occupied with a single submarine. The meteorological conditions are typical South East England. Climatological / Meteorological information and data are contained in Annex B of the Southampton Berth Safety Statement for the Southampton Weather Centre. There are no new meteorological conditions and the data has not been changed from the 1983 Berth Assessment. During a submarine visit the current wind data will be requested on a daily basis from the Met. Office. A review of weather data from the web supports the weather trends reported. The geological and hydrographical conditions in the area are typical of this area of the UK and present no additional hazard to the NPW.

2.6.2 The top tier local authority responsible for the area surrounding the Port of Southampton berth is Southampton City Council.

2.6.3 The total population distribution extending to 2km from the Operational berth at Southampton is detailed in Table 1. These figures are based upon the latest National Census 2001 data and show that:

a. There is no resident population within 0.5 km of the Operational Berth.

b. The civilian population within 2 km of the Alongside berth is ~ 8,295.

	Distance from 38/39 Berth	
Sector	0 to 0.5 km	0.5 to 2.0 km
0-30 degrees	0	531
30-60 degrees	0	2200
60-90 degrees	0	2328
90-120 degrees	0	466
120-150 degrees	0	0
150-180 degrees	0	181
180-210 degrees	0	482
210-240 degrees	0	307
240-270 degrees	0	0
270-300 degrees	0	0
300-330 degrees	0	0
330-360 degrees	0	1797
Total	0	8295

Note: shaded sectors are those that are downwind of the berth with the wind in the predominantly prevailing direction (i.e. a South Westerly wind).

TABLE 1 Population Distribution by Sector out to 2 km from Alongside Operational Berth

3. ACTIVITIES ON THE PREMISES

Routine activities are carried out on board, consistent with an operational visit. The operation of the submarine pressurised water reactor is briefly described in Table 2 below. It has been established that no port activity would pose any additional threat to the safety of the Nuclear Powered Warship (NPW) and, hence, there would be no additional public risk beyond that from the NPW itself.

During the approaches to and from the Operational Berth at Southampton the NPW movements are strictly controlled through the Harbour Master to minimise the hazards to the NPW.

3.1 The Pressurised Water Reactor

A Royal Navy NPW is driven by steam turbine machinery. However, unlike a conventional steam driven vessel, which uses fossil fuels to fire its boilers, the source of heat is a nuclear reactor. The type of reactor used is known as a Pressurised Water Reactor (PWR).

The reactor core contains fuel modules and control rods. To achieve criticality, the state in which the reactor is able to provide useful power, the control rods are slowly withdrawn from the core until the fission reaction is established. The reactor is shut down by re-insertion of the control rods. The heat produced by the fission of the fuel is removed from the core by water contained in a sealed primary circuit. This water is pumped through steam generators where the heat is used to produce steam in a separate, secondary, circuit. It is this steam, which is used to provide power to the submarine. The primary circuit is kept under pressure to prevent the coolant water from boiling. This is shown schematically in Figure 1 below.

As well as heat, the fission process also produces radioactive fission products. Unlike some civilian power reactor designs where the minor release of fission products into the primary circuit can be tolerated, UK submarine fuel modules are designed differently to avoid any such release during normal operation and there has never been an instance when fission products have been released from the fuel. Although the fission products remain contained in the fuel, the gamma radiation they emit is highly penetrative and thus there is a need for shielding to be fitted around the core and to be built into the submarine's reactor compartment. The shielding installed in RN nuclear powered submarines reduces the radiation levels within the manned compartments of the submarine to very low levels. Indeed the average levels of radiation dose received by members of the crew from reactor operation are less than the average natural background levels received by the UK population.

The heat produced by the fission process would be sufficient to melt the fuel modules if they were not cooled. Even after shutdown the radioactive fission products continue to generate heat, known as decay heat, and cooling is still necessary. To overcome this, the submarine design incorporates a number of mechanisms that are able to supply cooling to the reactor.

Table 2 details the NPW fission product releases following a severe accident and the many containment barriers protecting the site workers and the public.

Premises	Description	Containment
Nuclear Powered Submarine	Pressurised Water Reactor (PWR). Fission of Uranium, contained in fuel elements, takes place in the reactor core. The resulting fission products, including radioactive isotopes of iodine, caesium and krypton, are contained within the fuel cladding. The heat generated by the fission process is removed from the core by water contained in a sealed circuit. This water is pumped through steam generators where the heat is transferred to a separate, secondary circuit.	**The fuel elements are contained within a high integrity cladding, designed to prevent the release of radioactive fission products. Should the cladding fail, the primary coolant system, a pressurised, sealed circuit, would contain the fission products. Beyond the primary coolant system, a third containment boundary exists which is designed and constructed to meet the rise in pressure that could result from a failure of the primary coolant system. The final containment boundary is the submarine pressure hull.**

TABLE 2 - Premises (NPW) with a Hazard Identification and Risk Evaluation

It can be seen that a major failure of containment is a very unlikely event but information required by REPPIR regulations has been provided to the NII wrt the maximum quantities of radioactive material that could be released should this safeguard suffer a catastrophic failure.

3.2 Southampton Operational Berths (Facility)

Nuclear safety at the berth is further assured by implementing the following controls:

a. No maintenance or repair work is permitted at either berth.

b. No weapons embarkation or disembarkation is permitted.

c. The transport of petroleum products by sea in the proximity of nuclear vessels is controlled.

d. No overhead crane movements are permitted.

e. The harbour Master is responsible for the safety of nuclear vessels whilst in transit.

f. The Harbour Master has control of the movement of commercial vessels using the port.

g. The Ministry of Defence Police control of security at the berth.

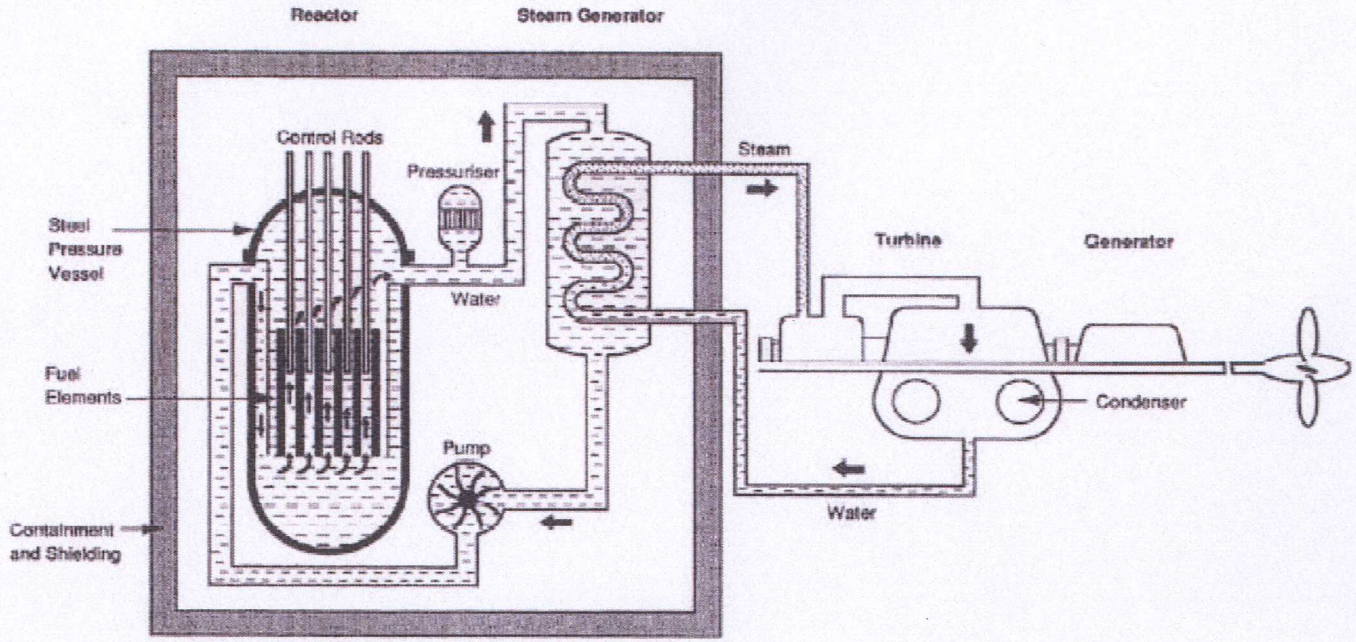


FIGURE 1 – Schematic Illustration of a Pressurised Water Reactor

4. SAFETY ASSESSMENT PROCESS

4.1 Internal Regulation

A nuclear powered submarine visiting the operational berth at the Port of Southampton, is not subject to licensing under the Nuclear Installations Act. For submarine reactor operations and nuclear weapon operations, the MOD operates an internal nuclear regulatory regime that mirrors the standards and procedures required by Nuclear Installations Inspectorate (NII) licensing approach.

4.2 Naval Pressurised Water Reactor (PWR)

The Design Authority for the Naval PWR, is charged with producing a generic submarine Reactor Plant Safety Case (SC) covering all classes of submarine. This safety justification is based on deterministic and probabilistic safety assessment of the PWR and its associated systems. The SC and supporting documents are independently peer reviewed and then subjected to Independent Nuclear Safety Assessment (INSA) by Serco Assurance. They produce a Nuclear Safety Clearance Document for each submarine with a class review, which is formally reviewed by the Defence Nuclear Safety Regulator (DNSR). When satisfied, DNSR issues a Letter of Consent to MOD's Central Plant Control Authority who authorises the operation of each submarine.

4.3 Safety Controls and Engineering Design

The containment arrangements for the UK submarine are common to all classes and are detailed in Table 2. In addition, there are engineered and procedural safeguards to prevent and mitigate reasonably foreseeable accident scenarios. All equipment is designed and constructed to a high specification, and undergoes thorough examination, testing and regular planned maintenance. Operation of all equipment is conducted according to approved operating procedures, by suitably qualified and experienced staff. The safety justifications for the equipment, its operation and any changes to these are subject to internal and external review.

4.4 Safety Management, Staffing and Training

The safety responsibilities of all personnel are defined in Submarine Operating Documentation. All submarine personnel and those MOD personnel that support the visit of a nuclear submarine to Portsmouth are suitably qualified and experienced for the work that they are expected to perform. A continuous process of audit and review is used to ensure that procedures remain current and effective. Minimum manning levels have been assessed and are documented in Submarine Operating Procedures and Safety Documentation. This ensures that there are adequate staff and resources available at all times to enable safe plant operation and provide a robust emergency response capability.

5. HAZARD IDENTIFICATION AND RISK EVALUATION

5.1 Submarine Reactor HIRE

The full range of potential accident scenarios has been analysed, the majority of which would not result in a release of radioactivity by virtue of the engineering and procedural safeguards described previously.

For a significant release to occur it is necessary for there to be a plant failure followed by breaches of the multiple containment barriers between the radioactive fission products contained within the fuel and the environment external to the submarine. These barriers are of high integrity and include the submarine hull, which is capable of withstanding very high pressures. The safety analysis has demonstrated that it is not reasonably foreseeable that such a failure could occur.

It is widely accepted that a reasonably foreseeable event is an event which may occur more frequently than about once in 100,000 years of operations, with a sensitivity study to ensure there are no sequences that may have serious consequences one decade lower in probability. The analysis of the Naval PWR plant has not identified any events that could give rise to a radiation emergency with a frequency of occurrence greater than that stated above, and has not identified any cliff-edge effects.

The accident sequence bounding in consequence which has been identified with a probability of some one in 1,000,000 years of operation, leads to some damage to the reactor core but with only a very small release to atmosphere through intact containment. For this accident sequence, the hazard arises predominantly from gamma shine from the hull.

6. NECESSITY FOR AN OPERATOR'S EMERGENCY PLAN

The assessment described in Section 5 concludes that the probability of any radiation emergency is less than one in 100,000 years of operation, which is on the limit of what would generally be regarded as reasonably foreseeable. However, on a precautionary basis it is concluded that an operator's emergency plan is required.

7. CONCLUSIONS

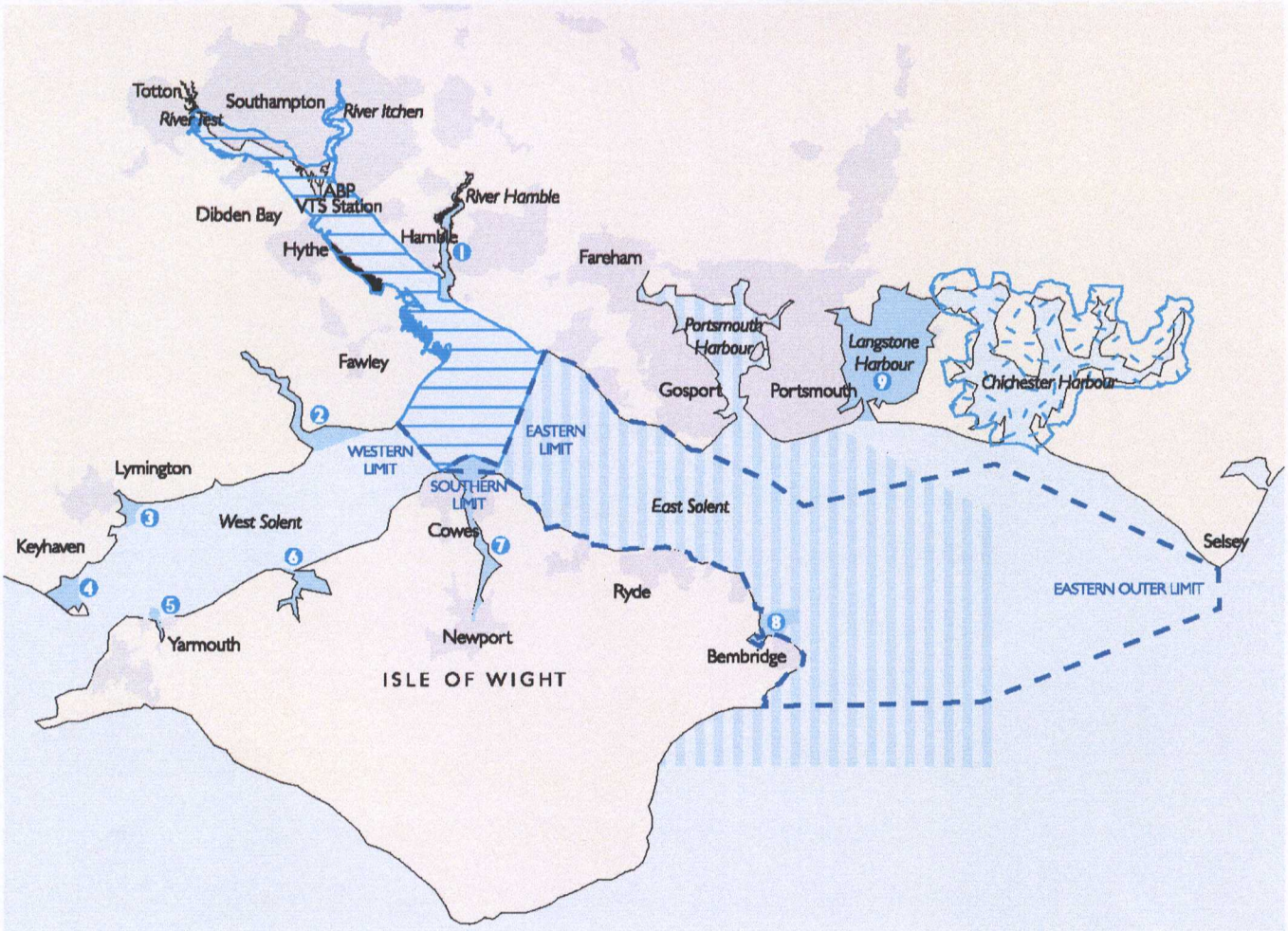
MOD has well-established engineering and procedural safeguards to prevent a radiation accident from occurring, and to limit the consequences of any accident that could occur. The safety management systems to ensure effective control of radioactive substances are regularly reviewed and audited.

A Hazard Identification and Risk Evaluation has been conducted for nuclear powered submarines using the Operational Berth at Southampton as required by the Regulations (Reference 1). The probabilities and consequences of the full range of potential accidents have been analysed, including the specific aspects associated with Southampton. These assessments have indicated that only a submarine reactor accident could lead to a radiation emergency.

Although any radiation emergency is on the limit of what would generally be regarded as reasonably foreseeable, on a precautionary basis it is concluded that an operator's emergency plan is required.

Annex A

FIGURE A1 - Map showing the Pilotage Area in the Solent and the extent of the Port of Southampton and the Dockyard Port of Portsmouth.



Pilotage Area

Port of Southampton

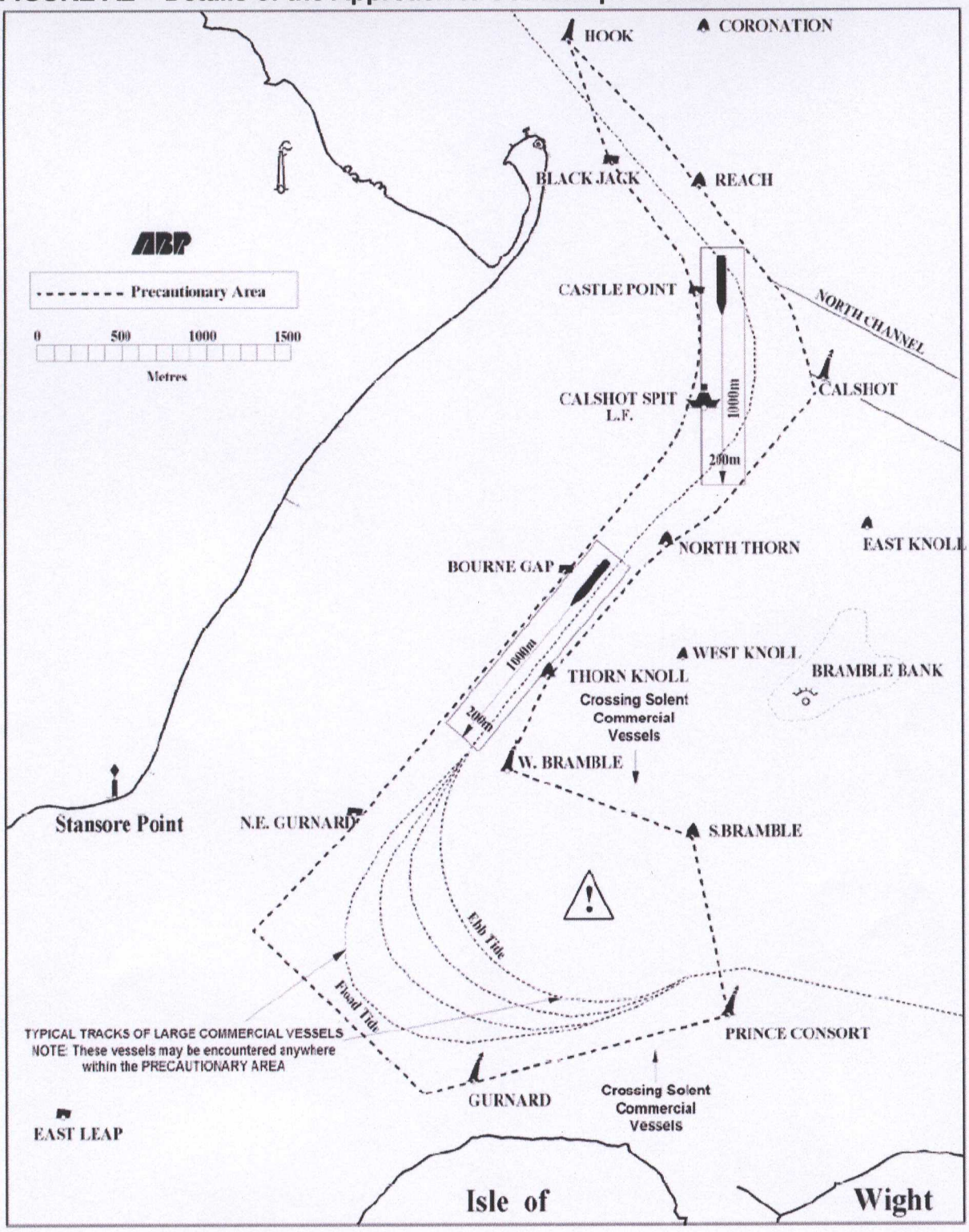
Dockyard Port of Portsmouth

Chichester Harbour Conservancy

Other Harbour Authorities

1. Hampshire County Council
2. Beaulieu River Management Company
3. Lymington Harbour Commissioners
4. Keyhaven River Committee
5. Yarmouth Harbour Commissioners
6. National Trust
7. Cowes Harbour Commissioners
8. Bembridge Harbour Improvement Company
9. Langstone Harbour Board

FIGURE A2 – Details of the Approach to Southampton Water



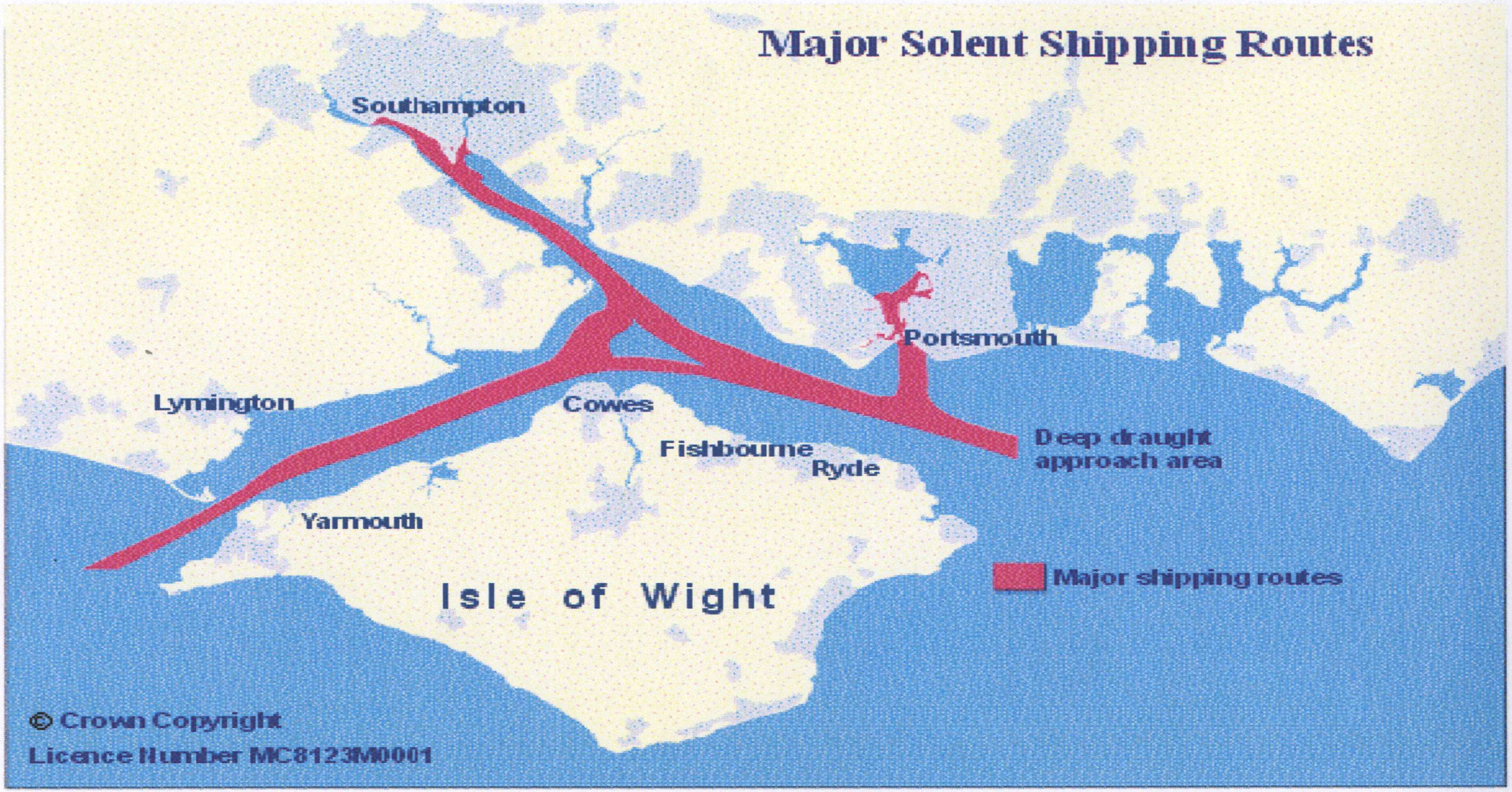


FIGURE A3 – Solent Shipping Routes showing Eastern and Western Approaches

REFERENCES:

1. The Radiation (Emergency Preparedness and Public Information) Regulations 2001

2. Southampton Off-Site Emergency Plan (SOTONSAFE) Version 4 September 2006.