Australian Government
Department of Industry, Innovation and Science

Preliminary Safety and Waste Acceptance Report of the National Radioactive Waste Management Facility (NRWMF)

July 2018

Executive Summary

This report provides preliminary safety and waste acceptance information for the proposed National Radioactive Waste Management Facility (NRWMF). The NRWMF will dispose of Australia's domestically produced Low Level Waste (LLW) in near-surface engineered disposal vaults, and store Intermediate Level Waste (ILW) in above ground custom-built buildings for a period of time (30 years) sufficient for the Australian Government to establish a permanent ILW disposal facility at a separate site, consistent with international obligations and best practice. The NRWMF will be operated for period of 100 years followed by an institutional control period of up to 300 years.

Three nominated sites in South Australia (Napandee and Lyndhurst near Kimba and Wallerberdina Station near Hawker) are currently undergoing a site selection process managed by the Australian Government Department of Industry, Innovation and Science ('the department'). This process includes extensive public consultation and physical site assessment.

A critical element in the consultative process is the provision of public information on how the NRWMF will be designed and operated to ensure waste is held and managed safely for the workers, the general public and the surrounding environment.

The NRWMF's design and operation will embody internationally accepted principles of radioactive waste management which recommends a multilayer "defence in depth" approach to safety. This approach first begins off-site through the application of strict Waste Acceptance Criteria (WAC) to control the types of wastes accepted, and the forms and packaging in which the waste will arrive. Further layers of defence in depth are provided by the engineered building and disposal vaults and the site characteristics.

For both ILW and LLW the waste packages (the treated waste and the waste container in combination) will require to be physically and chemically stable. All treated wastes (wasteforms) will be solid and non-dispersible, stable, non-reactive, non-flammable, and resistant to degradation over long timeframes. No containers of liquids will be accepted.

Each of the proposed sites has been assessed at a preliminarily level for physical and environmental characteristics, including risks associated with fire, flooding, seismic activity, surface and groundwater. This has found the seismic and flooding risks to be entirely manageable through appropriate engineering, construction and design solutions such as drainage, building materials used, methods that address the risks of ground shaking and deformation and potentially levies or bunds to further reduce flood risk. Further more detailed work on some site characteristics will be carried out as the project progresses and form important input into the safety assessment and design basis for the facility.

Strict radiological controls will be built into the design of the NRWMF to ensure there is no plausible path for radioactive waste or radiation to enter the surrounding environment and to ensure radiation levels immediately around the e vaults and storage buildings are safe for workers and visitors. All plausible risks will be assessed and managed to 'As Low as Reasonably Achievable (ALARA)' principle.

All waste will be kept above ground and multiple barriers used to result in 'defence in depth'. The LLW disposal packages will meet strict waste acceptance criteria. They will be securely sealed and deposited within specially developed concrete vaults, and when sealed inside the vault are fully isolated from rain and other environmental factors. ILW waste will be treated and packaged in well designed and constructed containers that provide containment and shielding. If more shielding is required this will be provided by an outer container (or overpack). The ILW will be stored in specifically designed storage buildings. The engineered structures around and underneath the disposal and storage structures will isolate and trap materials such as rainwater and resist environmental and human intrusion. All conventional waste materials and waste water leaving the NRWMF will first be tested and monitored for the possibility of contamination. The NRWMF will be supported by a comprehensive system of air, ground and water monitoring with results to be publically reported.

By design the radiation levels for NRWMF workers and visitors will be well below regulated levels at all times and there will be no effective additional radiation above background levels for anyone at or beyond the site boundary.

Industrial accidents (not involving radioactivity) are considered to be the most likely risk for worker safety and all equipment and procedures will meet all required workplace health and safety (WHS) standards. A strong safety culture and a comprehensive safety management system will also be implemented in the proposed NRWMF.

Security at the NRWMF will be assessed and maintained in accordance with regulatory requirements and the risks assessed by security agencies. At a minimum it will require full time security presence with secure areas inside the operational zone.

Generic risk evaluation of operational phase activities for LLW disposal and ILW storage was undertaken, following international best practice methodology. The risk evaluations presented in this report are preliminary in nature and based on the site and design related information available at the time of drafting this report. The risks from normal operations are evaluated as low and consistent with ALARA. The risks of fault or accident scenarios were assessed 'low' or 'very low'. Further risk assessment will be performed when the detailed design and further site characterisation information becomes available to update the risk evaluation.

Generic risk evaluation of the LLW post-closure phase (the period following 100 years of LLW operations and 300 years of institutional control) was undertaken, using international best practice scenarios and methodology. It is concluded from the preliminary safety evaluations and calculations of the proposed design that post-closure safety is achievable.

This preliminary safety and waste acceptance report will be refined and developed as further site characterisation data and design detail becomes available and incorporated into a future site specific safety case. The key safety features will be fully documented through a series of specialised technical reports: preliminary and a final safety case, and preliminary and then operating WAC. These documents will be further developed building on the assessments, risks and mitigation strategies in this report once a specific site has been identified, and will be subject to public consultation when licensing approval by the independent regulators is sought.

This report has been released as an initial draft for public information and comment. It is a dynamic document and will evolve as information, design and regulatory requirements become better understood. The department welcomes feedback on all aspects of the report.

Further information on the project can be found at www.radioactivewaste.gov.au and comments on this report can be emailed radioactivewaste@industry.gov.au.

Contents

1 Introduction

Over the past 70 years, Australia has accumulated an inventory of low and intermediate level radioactive waste (LLW and ILW respectively), to which a relatively modest amount will be added each year. This waste results from the production of nuclear medicines as well as from scientific and industrial applications (such as new medical equipment sterilisation, and sources used in industrial drilling). Currently, these wastes are stored in numerous sites across Australia, the most significant of which are nearing capacity. A national inventory of radioactive waste is currently being developed. The National Radioactive Waste Management Facility (NRWMF) project is intended to provide a single, purpose-built facility to safely manage Australia's existing (legacy) and future wastes and minimise the burden of responsibility passed on to future generations.

The NRWMF design process follows the relevant Australian codes and standards and regulatory guides, as well as international best practices, including International Atomic Energy Agency (IAEA) and Organisation for Economic Cooperation and Development (OECD) Nuclear Energy Agency (NEA) guidance that has been implemented in similar facilities in Europe, such as El Cabril in Spain and Centre de l'Aube in France. In most cases these facilities safely manage a waste inventory that is significantly larger and has higher levels of radioactivity than Australia's inventory.

It is intended that the NRWMF will receive and dispose of Australian LLW for up to 100 years. It will also provide consolidated interim storage of Australian ILW. The ILW storage buildings will be operational for 30 years, but will have a design life of 50 years to provide a contingency period for ILW recovery for disposal and for decommissioning the ILW stores. In this timeframe, a separate process for selecting a site and construction of a facility for the permanent disposal of ILW will be undertaken.

The NRWMF will only accept Australian LLW and ILW. It will not accept other countries' wastes, although it will receive the solid vitrified waste formed when ANSTO spent reactor fuel is reprocessed in France. Australia does not produce high level waste (HLW). The NRWMF project is at an early stage, with neither the site chosen nor the NRWMF design finalised. The identification of a preferred site and the development of the NRWMF design will be an iterative process, guided throughout by social, safety, technical, regulatory, environmental and economic considerations and feedback from public consultation.

As the NRWMF will be the permanent LLW disposal site safety needs to be assured. Following the LLW operations when all the vaults are closed and protected by a multi-layer cover system, they will be monitored for a maximum 300 year institutional control period (ICP). Over the ICP time period the radioactivity in the waste will have reduced sufficiently such that residual risk is reduced to below permissible levels for entering into the subsequent post-closure period, in accordance with international best practice.

The development, construction, operation and eventual closure of the NRWMF will be regulated by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). Nuclear safeguards aspects will be regulated by ASNO. A staged licensing process will be adopted. At key milestones (siting, construction and operation) the project will require a license from ARPANSA prior to moving to the next stage. It is likely that the NRWMF will require separate licences for LLW disposal and ILW storage. Each licence application will be supported by a safety case submission.

This report precedes and will inform the development of the preliminary safety cases and WAC. It brings together initial thinking on safety, design and waste acceptance along with the results of preliminary site assessments for each site. The full process of WAC, safety and design development is shown in Figure 1 below.

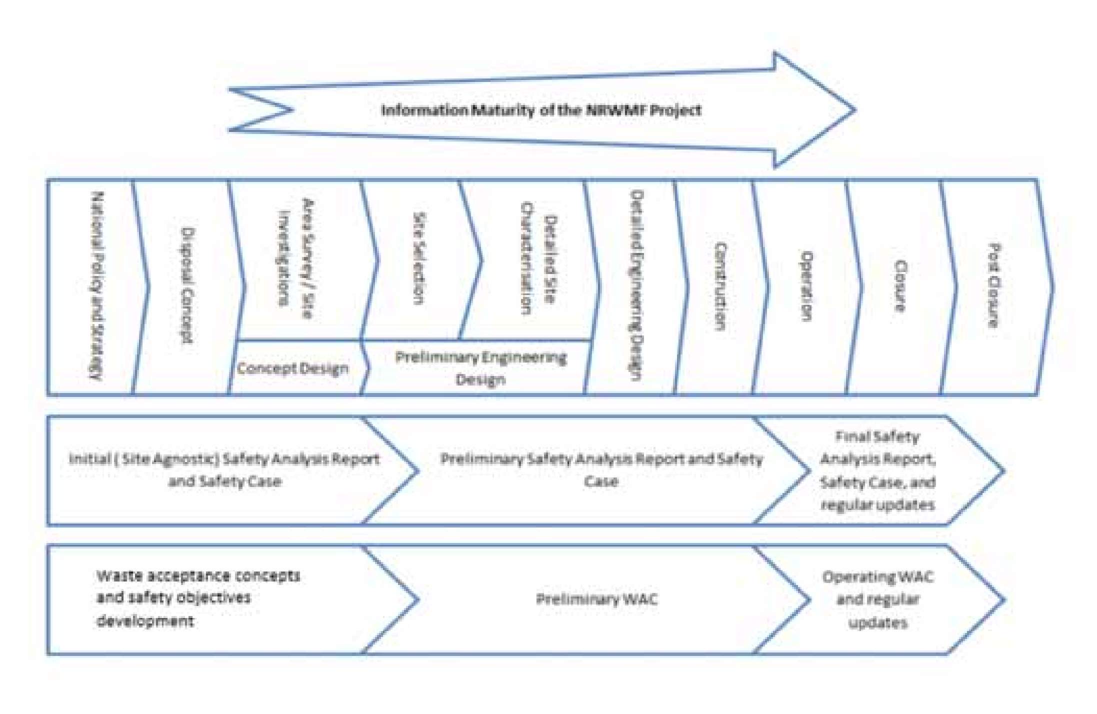


Figure 1: Development of NRWMF WAC, safety and operational design maturity with time

The rationale for this approach to development of the NRWMF is to:

- Take on board community concerns, by adopting a transparent, safety-led design process from the outset.
- Identify and incorporate international best practice.
- Inform the development of waste acceptance criteria for the NRWMF.
- Provide the Commonwealth Government with high confidence that the NRWMF can be safely constructed, operated and ultimately closed.
- Ensure the costings are informed by safety considerations.
- Consider the ARPANSA licensing requirements early in the project.

The Department of Industry Innovation and Science ('the department') has used highly respected experts from AECOM and ANSTO and other specialists to provide technical support in developing the project. The department invites comment on any aspect of the report.

1.1 Document Purpose and Structure

The purpose of this Safety and Waste Acceptance Report is to provide an overview of aspects of waste acceptance, the site investigations by AECOM to date and safety analyses undertaken by ANSTO for the department.

The report follows the following structure;

- Section 2 provides a site description and identifies important safety relevant site characteristics for the three nominated sites.
- Section 3 provides the generic safety principles which will be used in design and operation of the site
- Section 4 provides a description of the waste acceptance criteria, the waste acceptance process, examples of how waste might be treated/conditioned, and waste containers that would be used.
- Section 5 provides the current design thoughts for the site with layout and building diagrams and outlines safety functions of elements of the design.
- Section 6 provides an overview of the safety management systems for an NRWMF. It covers safety practices, considers their extent and implementation, and where in the organisation structure safety management responsibilities lie.
- Section 7 provides a summary of safety analyses for the operational and post closure periods.

- Section 8 provides overall conclusions.
- The Appendices provide the risk assessment tables, seismic categorisation, assessment methodology, and process flow diagrams.

1.1.1 Scope

The scope of this report includes:

- safety relevant aspects of preliminary geohydrology, seismicity, climate, fire and flood related site investigations carried out by AECOM across the three candidate sites
- generic WAC and the process for waste acceptance as developed by the department using an expert task group including Regulators, waste producers and industry experts - this includes physical, chemical and radiological factors for waste acceptance, a process diagram for waste acceptance, examples of treatment/conditioning/packaging processes and the waste container/transport container designs
- proposed safety and design features to manage site specific and generic environmental, radiological and industrial risks, and
- initial safety scenario analyses carried out for the department by ANSTO - this includes normal operating scenarios, fault (accident) events, and covers the operational phase (for LLW disposal and ILW storage) and post-closure phase of the LLW disposal vault system

2 Site Description

2.1 Location

At the start of the siting process landowners were invited to nominate potential sites to host the NRWMF. The department stipulated that an area of 100Ha would be required. Once potential sites were identified a process for initial investigation of site suitability and discussions with the local communities at suitable locations began. Where sufficient community support could not supportive be identified, sites were withdrawn from the siting process.

Currently three sites in South Australia are being considered - one at Wallerberdina Station, near Hawker, and two sites near Kimba, South Australia. A brief description of each site has been provided below. Further information of these sites, including site maps is available in the NRWMF website (http://www.radioactivewaste.gov.au/)

2.1.1 Wallerberdina Station

The Wallerberdina station site is at 377 Wallerberdina Road and located close to the Flinders Ranges, approximately 30km northwest of Hawker and 130km from Port Augusta. It is a 6,300-hectare property with a potential for a viable 100-hectare site development on the property which is close enough to the amenities of Hawker.

2.1.2 Napandee

The Napandee site is located approximately 20km west of Kimba. The site is close to a local township. The site offers sufficient land area for placement of a NRWMF, and no easements or paths of access cross the site. It has a 100 hectare area which is viable for NRWMF development.

2.1.3 Lyndhurst

The Lyndhurst site is located approximately 15km north-east of Kimba. The site is also close to a local township. The site offers sufficient land area for placement of a NRWMF and no easements cross the site. It has also a 100 hectare area which is viable for NRWMF development.

2.2 Site Characteristics

Site characterisation investigating the site geology, hydrogeology, geochemical properties and climatic conditions, has been undertaken for each of the three shortlisted sites.

Among other things, site geology and geohydrology determines how the sites natural characteristics determine the potential for radionuclides to migrate through the environment and provide natural barriers to further safety risks. If radiation were to be released from the NRWMF (a very unlikely scenario) migration could occur via soil to sub-surface aquifers and hence an understanding of the presence and nature of these is required in order to map potential exposure pathways and to assess likelihood.

Site geology and seismicity also informs the likely loads that might be imposed on the disposal vaults from ground movement, such as shaking, subsidence and earthquake events.

Geochemical properties are also important for understanding how the properties of the soils at the site will inhibit the potential for radionuclide migration and how they will ensure the longevity of the disposal system is not compromised in the future.

Over the very long-term, the barriers and isolation provided by the sites natural characteristics, provide the protection that ensures the safety of the surrounding environment.

The preliminary design work for the proposed NRWMF, which is not yet site specific, has taken account of the regional climatic conditions of the sites, such as rainfall, wind speed and direction and temperature variation. Risk-based standards are employed for site design to ensure that an acceptable level of risk is achieved. These standards set out expected design loads, but will be augmented with current site specific data once the preferred site is chosen. The site specific characteristics will be applied to the evaluation of all stages of the NRWMF: the construction, operational, institutional control and post-closure.

2.2.1 Site Characteristics

The following site characteristic information is provided by AECOM, which undertook preliminary analyses on behalf of the department'. If further information on specific site characteristics is required, this will be requested.

Table 1: Candidate Site Characteristics

Characteristics	Napandee	Lyndhurst	Wallerberdina
Background Radiation (in Becquerel per cubic metre – Bq/m^3)	10Bq/m^3 Well below ARPANSA Action Levels for workplaces (1,000 Bq/m^3) and households (200 Bq/m^3)	10Bq/m^3	12Bq/m^3
Climate Conditions	Annual rainfall: 348.3mm Average diurnal temperature range: 15°C Annual mean maximum temperature: 23.6°C Mean Minimum temperature: 10.3°C Mean wind Speed: 8.4km/h at 9am and 11.6km/h at 3pm.	Annual rainfall: 348.3mm Average diurnal temperature range: 15°C Annual mean maximum temperature: 23.6°C Mean Minimum: 10.3°C Mean wind Speed - 8.4km/h at 9am and 11.6km/h at 3pm.	Annual rainfall: 308.6mm Average diurnal temperature range - 15°C Annual mean maximum temperature: 25.2°C Mean Minimum: 10.7°C Mean wind Speed - 8.5km/h at 9am and 11.5km/h at 3pm.
Bushfire Risk	Vegetation on and surrounding the site (large patches of grassland and Mallee Mulga vegetation) are sufficiently distant and are unlikely to sustain a fully developed 100m wide fire front particularly if setbacks/areas of cleared vegetation are established around assets commensurate with their vulnerability to bushfire attack. There is no undue bushfire hazard.	The fuel load from vegetation (Mallee woodland directly to the northwest) does not present an undue bushfire hazard if appropriate low threat setbacks are established around assets commensurate with their vulnerability to bushfire attack and there is a provision for firefighting infrastructure.	The bushfire hazard is low and the site would only be exposed to a relatively low intensity grass or scrub fire that would not pose a significant hazard if appropriate bushfire protection measures are provided.
Soil Classification (based at this stage from literature and to be confirmed from field samples)	Soil Classification: Loam over poorly structure red clay or siliceous sand or calcareous loam over clay	Soil Classification: Loam over poorly structure red clay or siliceous sand	Soil Classification: Kandosol, Sandy Loam

Characteristics	Napandee	Lyndhurst	Wallerberdina
Sub-Surface Properties	Due to the depth to groundwater, lack of sub-surface features such as caverns, landform and slope of the site, it is unlikely that potential geohazards (such as soil liquefaction, slope instability, subsidence and long term-settlement) would occur on site. There is the possibility for collapsing soils however these can be mitigated in design (AS2870).	Due to the depth to groundwater, lack of sub-surface features such as caverns, landform and slope of the site, it is unlikely that potential geohazards (such as soil liquefaction, slope instability, subsidence and long term-settlement) would occur on site. There is the possibility for collapsing soils however these can be mitigated in design (AS2870).	Due to the depth to groundwater, lack of sub-surface features such as caverns, landform and slope of the site, it is unlikely that potential geohazards (such as soil liquefaction, slope instability, subsidence and long term-settlement) would occur on site. There is the possibility for expansive or collapsing soils however these can be mitigated in design (AS2870).
Seismic	The seismic hazard level is low based on review and interpretation of seismic data indicating with a high-level of confidence that potentially active faults in the foundation, near-surface faults beneath or near the foundation, and faults in the nearby area are not present (excluding the possibility of one-off faulting). Seismic hazards from ground shaking and deformation can be mitigated through design and implementation of structural engineering measures drawn from industry standards and methods.	The seismic hazard level is low based on review and interpretation of seismic data indicating with a high-level of confidence that potentially active faults in the foundation, near-surface faults beneath or near the foundation, and faults in the nearby area are not present (excluding the possibility of one-off faulting). Seismic hazards from ground shaking and deformation can be mitigated through design and implementation of structural engineering measures drawn from industry standards and methods.	The site seismic data indicates with a high-level confidence (excluding the possibility of one-off faulting) the absence of potentially active faults in the foundation, but the potential for near-surface faults beneath or near the foundation. The Western Range front faults are assumed to exist in the nearby area and further work is required to locate them. Seismic hazards from ground shaking and deformation can be mitigated through design and implementation of structural engineering measures drawn from industry standards and methods.

Characteristics	Napandee	Lyndhurst	Wallerberdina
Hydrology	There are no creek lines in the local area however drainage lines exist in the vicinity of the site and local drainage paths exist through the site. Drainage lines associated with a larger local catchment drains past the south-western corner of the site. There is no anecdotal evidence of waterlogging or runoff from localised or upstream catchments. At this stage of the assessment, any potential risks from the site hydrology are considered to be manageable, subject to flood modelling, through reasonably planned site and civil engineering works.	There are no creek lines in the local area. Drainage lines exist through the site and there is anecdotal evidence of periodic waterlogging. At this stage of the assessment, any potential risks from the site hydrology of are considered to be manageable, subject to flood modelling, through reasonably planned site and civil engineering works.	Drainage lines are present through the site. Hookina Creek passes through and outside the southern edge of Walleberdina Station, from around 3.5 km from the possible site location. A tributary of Hookina Creek is 1.5 km east of the site. Anecdotal evidence is that during the major episodic floods in 1955 and 2005 the floodwaters of Hookina Creek did not reach the site although water logging cannot be excluded. Initial flood modelling has indicated that parts of the site would be affected by certain categories of flood event. However, at this stage of the assessment, any potential risks from the site hydrology can be manageable through the civil engineering and where necessary, bunds and levees.
Groundwater	Groundwater in the water table aquifer was found to be present at depths >20 m below ground surface and as such would not impact on NRWMF buildings or their foundations. Groundwater is of no beneficial use due to its high salinity (up to that of seawater) and low yield.	Groundwater in the water table aquifer was found to be present at depths >10 m below ground surface and as such would not impact on NRWMF buildings or their foundations. Groundwater is of no beneficial use due to its high salinity (up to that of seawater) and low yield.	Groundwater in the water table aquifer was found to be present at depths >20 m below ground surface and as such would not impact on NRWMF buildings or their foundations. Groundwater is of brackish quality and reasonable yield.

2.3 Biosphere Characteristics

An understanding of the surrounding natural habitat will be acquired by studies for the three sites in order to understand potential impact of the NRWMF on flora and fauna and prepare for approvals applications under the environment protection and biodiversity and conservation (EPBC) legislation. The climate and geohydrology/

groundwater conditions have and will inform on-going risk assessments and the development of the NRWMF's safety case and physical design.

2.4 Demographic Characteristics

Demographic characteristics will provide an understanding of social and commercial environments that will surround and interact with the NRWMF. This is an important set of information in undertaking risk assessments and safety in design both in terms of refining operational and post-closure risks and mitigation strategies.

Understanding population density and distribution provides information on how local people may theoretically be impacted by the NRWMF during the operational period, institutional control period and post-closure. All three sites are well separated from sensitive land uses, being located a few kilometres to tens of kilometres away from existing residences, with a low risk of future residential development closer to the site within an area dominated by agricultural land use.

Further assessments will be undertaken once the preferred site is identified.

3 Design Safety Principles

The following safety principles will guide the design of the NRWMF:

- Justification of radiological exposures: A dedicated facility for the safe storage of ILW and disposal of LLW is required that incorporates international good practice, and improves the current ad hoc arrangements.
- Optimisation of Radiation Protection: Identification of radiological hazards will be managed through implementation of engineered controls to mitigate and reduce the risks and hazards and use of dose constraints. The principle of "as low as reasonably achievable" (ALARA) will be applied, with investigations for higher than acceptable doses, individual or collective.
- Dose Limits and Constraints: These are set following IAEA guidelines and the ARPANS Regulations (ARPANSA, Recommendations for Limiting Exposure to Ionizing Radiation, 1995).
- Defence in Depth: A hierarchy of controls achieved through design incorporating a multiple barrier approach, procedures/systems, and emergency arrangements, providing safety through diversity, redundancy in design and multiple layers of safety procedures.

The following key principles will guide nuclear safety at the NRWMF:

- No single process failure could credibly go undetected and result in significant impacts.
- The primary nuclear safety measures are passive.
- Secondary nuclear safety measures (both passive and active) are incorporated as defence in depth to further ensure safety through redundancy and diversity.
- The facility design will allow for inspection of materials subject to international safeguards convention.

3.1 Design Aspects

The safety of the public, employees, and protection of the environment in NRWMF design will be achieved through safety systems and features in the NRWMF design, including: the multi-barrier containment systems; contamination control areas; shielded ILW storage vaults; lifting devices; ventilation systems; personnel and environmental monitoring systems. These will be applied as required to the areas for waste reception, characterisation, treatment, and the waste package storage and disposal areas.

The NRWMF will comprise purpose-built structures. The designs will be built to comply with Australian standards as a minimum, and where required will meet specific nuclear hazard requirements. The designs will cater for site specific environmental conditions - including climate, geology, seismicity, flood and drainage characteristics, and ground conditions. The ILW storage buildings will provide shielding and containment.

Based on the concept design of the NRWMF, structures, systems and components (SSC) with safety critical functions, such as cranes, have been evaluated and radiation doses on failure estimated. In the preliminary assessment for the conceptual design, only the ILW store crane had a failure consequence of concern and further safety scenario analysis for this aspect is presented in Section 7.

Characteristics and quality requirements for construction materials will be specified (to meet their function) including: resistance to radiation damage; corrosion resistance; compatibility with the LLW and ILW container designs and transport container designs; and mechanical durability. The buildings and associated services (e.g. crane, electrical systems) in the NRWMF will be designed for safe decommissioning, minimising the volume and activity of any radioactive waste which requires management at the end of operations. Maintenance areas will be capable of handling significantly contaminated equipment. Out of specification waste packages will be safely stored in a quarantine area, prior to remediation.

Access controls at key locations on the site will contribute to safety and security on site.

Workplace health and safety in design will be addressed using a technique called Construction Hazard Assessment Implication Review (CHAIR) (Commission, 2001) to identify hazards and best practice for the civil works. Operational equipment will be designed to Australian Standards as a minimum, and where required meet additional requirements. Systems and items, such as cranes and lifting devices, will be appropriately designed and signed-off by experts.

The design working life has been set to 100 years for the LLW disposal vaults and 50 years for ILW storage buildings (conservative for a 30 year period for ILW storage) to align with the operational life of the NRWMF. Some operational equipment will have a shorter design life and need to be replaced during the operational period.

Designs for lab and cement grouting facilities will comply with Workplace Health and Safety (WHS) chemical safety standards. At this stage of the generic NRWMF design, the only chemicals used in notable quantities will be used for construction and for grouting, such as cement powders and additives.

The site waste systems will maximise containment, and provide for the testing of any potentially contaminated material. There will be no detectable environmental releases from normal NRWMF operations.

3.2 Codes and Standards

The principal legislation, codes and standards to be used in building the NRWMF are:

Legislation

- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, 1997
- National Radioactive Waste Management Act 2012
- Australian Radiation Protection and Nuclear Safety Act 1998
- Environment Protection and Biodiversity Conservation Act 1999
- Nuclear Non-Proliferation (Safeguards) Act 1987
- Other applicable State and Territory legislation

National regulations, codes and guides

- Environment Protection and Biodiversity Conservation Regulations 2000
- Australian Radiation Protection and Nuclear Safety Regulations, 1999
- ARPANSA, Licensing of Radioactive Waste Storage and Disposal Facilities, 2013
- National Road Transport Commission and Federal Office of Road Safety. Australian Dangerous Goods Code. 6th ed., 1998
- ARPANSA, Recommendations for Limiting Exposure to Ionizing Radiation (1995) and National Standard for Limiting Occupational Exposure to Ionizing Radiation (republished 2002) (RPS nº 1)
- ARPANSA, Code of Practice for the Safe Transport of Radioactive Material, 2008 (RPS nº 2)
- ARPANSA, Safety Guide for the Safe Transport of Radioactive Material, 2008 (RPS nº 2.1)
- ARPANSA, National Directory for Radiation protection, 2011 (RPS nº 6)
- ARPANSA, Code of Practice for the Security of Radioactive Sources, 2007 (RPS nº 11)
- ARPANSA, Safety Guide for the Predisposal Management of Radioactive Waste, 2008 (RPS nº 16)
- ARPANSA, Safety Guide Classification of Radioactive Waste, 2010 (RPS nº 20)
- IAEA SF1 Fundamental Safety Principles (republished 2002)
- IAEA Safety Standards for Disposal of Radioactive Waste,SSR-5
- IAEA-TECDOC-1347 Consideration of external events in the design of nuclear facilities other than nuclear power plants, with emphasis on earthquakes
- IAEA-TECDOC-1250, ‘Seismic design considerations of nuclear fuel cycle facilities’, October 2001
- ASME AG-1 Code on Nuclear Air and Gas Treatment
- ISO 17873 Nuclear facilities – Criteria for the design and operation of ventilation systems for nuclear installations other than nuclear reactors

International recommendations

- Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. General Safety Requirements No. GSR Part 3 (Interim edition), IAEA 2011
- Classification of Radioactive Waste. General Safety Guide (GSG-1), IAEA 2009

- Predisposal Management of Radioactive Waste for protecting people and the environment. General Safety Requirements No. GSR Part 5, IAEA 2009
- Storage of Radioactive Waste. Safety Guide No. WS-G-6.1. IAEA 2006
- The Management System for Facilities and Activities. Safety Requirements No. GS-R-3. IAEA 2006
- Management of Waste from the Use of Radioactive Material in Medicine, Industry, Agriculture, Research and Education. Safety Guide No. WS-G-2.7. IAEA 2005
- The Safety Case and Safety Assessment for the Disposal of Radioactive Waste for Protecting People and the Environment. Specific Safety Guide No. SSG-23, IAEA 2012
- Safety Standards Series No SSR-5 Disposal of Radioactive Waste Specific Safety Requirements, IAEA 2011
- ICRP Publication 77. Radiological Protection Policy for the Disposal of Radioactive Waste, 1997
- ICRP Publication 81. Radiation Protection Recommendations as Applied to the Disposal of Long-lived Radioactive Waste, 1998
- ICRP Publication 103. The 2007 Recommendations of the International Commission on Radiological Protection, 2007
- ICRP Publication 114. Environmental Protection: Transfer Parameters for Reference Animals and Plants, 2009

Other references

- 10 CFR 61 Licensing Requirements for Land Disposal of Radioactive Waste Nuclear Regulatory Commission (NRC)
- "Safety Assessment Methodologies for Near Surface Disposal Facilities. Results of a coordinated research project (ISAM)". Volume 1 y 2. IAEA 2004
- Features, Events and Processes (FEP's) for Geologic Disposal of Radioactive Waste. An International Database, Nuclear Energy Agency. OECD, Paris 2000
- Categorization of Radioactive Sources. Safety guide No. RS-G-1.9, IAEA 2005
- Dangerous Quantities of Radioactive Material (D-Values), EPR-D-Values 2006. Emergency Preparedness and Response, IAEA, August 2006
- Council Directive 99/31/EC of 26 April 1999 on the Landfill of Waste
- United Nations. Sources and Effects of Ionizing Radiation. UNSCEAR 2008 Report to the General Assembly, with Scientific Annexes Volume II: Scientific Annex E (2011)
- 10 CFR 72 "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste" (NRC)
- ANSTO WHS AS2310 ANSTO OHSE Standard - Radiation Safety
- ANSTO.WHS AG2509 ANSTO WHS Guide - Radiation Safety - Radiation and Contamination Control-Classification of Radiation and Contamination Areas, Radiation Protection

Civil Structures

- Building Code of Australia, including the National Construction Code (NCC) 2016
- AS 2243 - Safety in Laboratories
- AS 2982 - Laboratory Design and Construction
- AS 1170.4 - Earthquake Code

Mechanical Engineering

- AS 1668.2 - The Use of Ventilation and Air-conditioning in Buildings - Ventilation Design for Indoor Air Contaminant Control
- ANSTO Engineering and Technical Services - EP-07-05-09 - Active Ventilation Systems
- NVF/DG001 - Nuclear Industry Guidance - An Aid to the Design of Ventilation of Radioactive Areas
- AS 2243.8 - Safety in Laboratories - Fume Cupboards
- AS 1418 - Single failure-proof cranes
- AS1210 - Pressure Vessel Standard

Electrical Systems

- AS 3000 - Electrical Installations - Buildings, Structures and Premises
- AS 3100 - General Requirements for Electrical Equipment

Plumbing and Drainage

- AS 3500.1 - Water Supply Systems
- AS 3500.2 - Plumbing and Drainage Systems
- AS 3500.3 - Rainfall and Runoff

4 Waste Acceptance at the NRWMF

This section sets out the criteria and processes for acceptance of waste into the NRWMF. Illustrative treatment options are presented. Information about the waste container types expected to be used for packaging waste is included.

4.1 Waste Acceptance Criteria

At this early stage, generic Waste Acceptance Criteria (WAC) have been developed for LLW and ILW waste packages to aid facility design. The generic WAC criteria detail requirements with which LLW and ILW waste packages must comply to be accepted for management at the NRWMF. They form an important component of the NRWMF safety system. They are consistent with international best practice.

The WAC will be revised and further developed once a specific site is selected. The WAC will be a live document, revised and updated for the NRWMF site licensing process and throughout the site operations.

4.1.1 Physical Requirements

The waste package is the wasteform and the waste container in combination. There are requirements common to all waste packages:

- Wasteforms (the physical form of the waste following treatment/conditioning) must be physically solid and stable, non-reactive and non-flammable, and resistant to degradation.
- Containers of liquids are not accepted for management at the NRWMF.
- Wasteform volume will be minimised (through waste minimisation, before packaging during waste characterisation, and/or by volume reduction using compaction) and void spaces minimised.
- To confirm the source of waste packages and the contents, a unique waste package identifier/ barcode will be located at two separate locations on the waste container surface (ARPANSA requirements, RPS C-2).
- Waste packages to be stacked will use waste containers designed for that purpose.

There are waste type specific requirements:

- For ILW: including all disused sealed sources and safeguards material - the waste package identifier will be readable for an extended period of around 50 years.
- For ILW: including all disused sealed sources and safeguards material - container shielding can be used to comply with radiation dose requirement.
- For Safeguards material (any uranium, thorium or plutonium held in Australia subject to the Nuclear Non-Proliferation (Safeguards) Act 1987, regulated by ASNO): Australian Safeguards and Non-proliferation Office (ASNO) approval is required for conditioning - Safeguards material shall be available on request for international inspection.

4.1.2 Chemical Requirements

The WAC will require all LLW waste packages will be chemically stable and safe for disposal in the LLW vaults. Similarly, the ILW waste packages to be stored at the NRWMF will be chemically stable and safe. The WAC will require the treatment and/or limitation of chemicals with harmful properties, and will prevent dilution with non-waste material simply to meet the WAC.

The hazard categories which will be controlled are: reactive, explosive, oxidising, corrosive, chelating, chemotoxic and hazardous properties. The requirement is to make such materials passively safe (so the waste packages do not require human actions to be safe).

4.1.3 Radiological Requirements

Radioactivity in a waste is measured in Becquerel (Bq) the number of radioactive breakdowns (disintegrations) of atoms in the waste per second. This is expressed per gram weight of the waste (Bq/g) or, per square centimetre (Bq/cm^2) when the radiation is located on a surface. Radiation dose is measured in Sieverts (Sv), a unit which represents the biological effect of radiation, and is often expressed in thousandths or milli Sieverts (mSv).

The radiological requirements include common requirements for LLW and ILW waste package surface contamination ($\leq$ 4 Bq/cm^2 beta-gamma and $\leq$0.4 Bq/cm^2 alpha) to ensure surface contamination is very low.

Dose rate requirements for ILW and LLW transport packages (packages transported in the public domain may use further packaging to meet requirements) are:

- Non-exclusive use - restricted to ≤2mSv/h on surface, and ≤0.1mSv/h at 1 meter.
- Exclusive use – restricted to ≤10mSv/h on surface, and ≤0.1mSv/h at 1 meter.

Activity and dose limits are waste type specific and are provided in Table 2.

Table 2: Radioactivity limits specific waste package type

Type of waste	Radioactivity limits (based on current UK limits)	Dose limits
LLW	Radioactivity concentration not exceed 4,000 Bq/g alpha and 12,000 Bq/g beta/gamma emitting radionuclides Total package limit 4 GBq alpha or 12 GBq beta/gamma emitting radionuclides	≤2 mSv/hr at package external surface, and ≤0.1 mSv/hr at 1 metres.
ILW	Radioactivity levels greater than that for LLW, and heat generation rate of less than 2 kW/m^3	ILW in dual-purpose storage / transport containers ≤2 mSv/hr at package external surface, and ≤0.1 mSv/hr at 1 metres. ILW in to be stored in shielded vaults can have ≤100 Sv/hr at external surface. These packages are transported in shielded transport containers and unloaded and emplaced at the NRWMF
Short-lived Disused Sealed Sources	Total waste package radioactivity shall not exceed 400 GBq alpha and 1.2 TBq beta/gamma emitting radionuclides, decaying to Exemption Levels* over a 300 year period, which represents the LLW institutional control period, and so allows the safe disposal in LLW vaults. Radioactivity concentration limits do not apply to waste packages containing conditioned sealed sources. Radionuclide based total activity limits will be introduced in the Preliminary WAC.	≤2 mSv/hr at package external surface, and ≤0.1 mSv/hr at 1 metres.
Long-lived Disused Sealed Sources	Radioactivity concentration limits do not apply to packages containing long-lived sealed sources, sealed sources that will not decay to Exemption Levels over a 300 year period and so are stored and managed as ILW. The total activity shall comply with the transport classification given to the package, from the Code for the Safe Transport of Radioactive Material.	≤2 mSv/hr at package external surface, and ≤0.1 mSv/hr at 1 metres.
Safeguards Materials	Packaged Safeguards material shall meet radiological property criteria for ILW	≤2 mSv/hr at package external surface, and ≤0.1 mSv/hr at 1 metres.

*specified in Schedule 4 of the National Directory for Radiation Protection

4.1.4 Package Records

The WAC specifies that records are included for all packages, and that these are linked to a unique identifier on the surface of each waste package. The records will allow individual and collective package inventories to be identified and confirmed and compliance with regulatory requirements and safety aspects to be demonstrated. The information will be used to confirm and validate the safety assumptions used in the safety cases for the operational phase and the post closure phase. They will also allow waste packages to be tracked so that, if needed, a package can be retrieved for operational reasons.

The waste package records required are:

- the consigning organisation/person, the date of transfer from consignor to the NRWMF
- the unique ID of each waste package
- the weight of each waste package
- a description of physical, chemical, structural and biological properties for each waste package – and details of conditioning and packaging
- content of controlled substances (must be WAC compliant), description of the substances, and details of treatment
- the total activity and the reference date, the activity concentration of reportable nuclides and the reference date
- the contact dose rate and measurement date
- contamination clearance certificates showing surface contamination and measurement date
- the number of discrete disused sealed sources in the waste package - drawings and schematics of the sources, shielding and packaging material - source registration certificates / references for the sources in the package, including expired certificates or a declaration from the waste holder with the required information
- decay calculations that demonstrate whether the disused sealed source will decay to Exemption Levels within 300 years
- a nuclear safety assessment, and
- reporting information for Safeguards materials subject to Bi-Lateral Agreements.

4.1.5 Radioactive Waste Inventory

Radioactive waste is defined by the IAEA (IAEA, 1997) as 'material containing radioactivity in gaseous, liquid or solid form for which no further use is foreseen, and which is controlled as radioactive waste by a regulatory body'.

The classification of radioactive waste has been defined in international standards developed by the IAEA (IAEA, 2009). There are four general classes of radioactive waste – exempt waste (where the level of radioactivity is so low that it can be safely disposed in a normal landfill), low level waste (LLW), intermediate level waste (ILW) and high level waste (HLW). Australia does not have any high level waste, as spent reactor fuel is reprocessed abroad (and the resulting vitrified waste is classed as ILW). The inventory comprises best estimates of LLW and ILW and also includes waste/disused sealed sources. Disused sealed sources are classified into: short-lived disused sealed sources (safe for disposal with LLW); and long-lived disused sealed sources (which will be stored with ILW). The inventory also includes Safeguards material which will be stored with ILW.

An Australian Common National Inventory of Radioactive Waste (CNIRW – used to derive Table 3) is being developed as a consolidated database of all radioactive waste that requires management at the NRWMF. The inventory will be updated regularly to incorporate further information about the waste streams, such as the outcome of waste minimisation work and the choice of final waste treatment and waste packaging. The following table provides estimates of LLW for disposal and ILW for storage.

Table 3: Waste Inventory – legacy and future.

Waste types	Legacy (m^3)	Future (m^3)	Total (m^3)
ILW for storage (cubic metres – m^3)	1772	1920	3692
LLW for disposal (cubic metres – m^3)	4976	4886	9862

The waste streams making up the inventory can comprise a range of materials and items including general lab waste (paper and plastic and metal), decommissioning materials (rubble and metallic items), contaminated soils (such as those stored by CSIRO), contaminated ion exchange resins, liquid wastes from nuclear medicine production (planned to be turned into Synroc, a synthetic rock), solid waste from nuclear medicine processes (SUF Cup wastes) and waste radioactive sources (disused sealed sources in shielded containers).

4.2 Waste Treatment

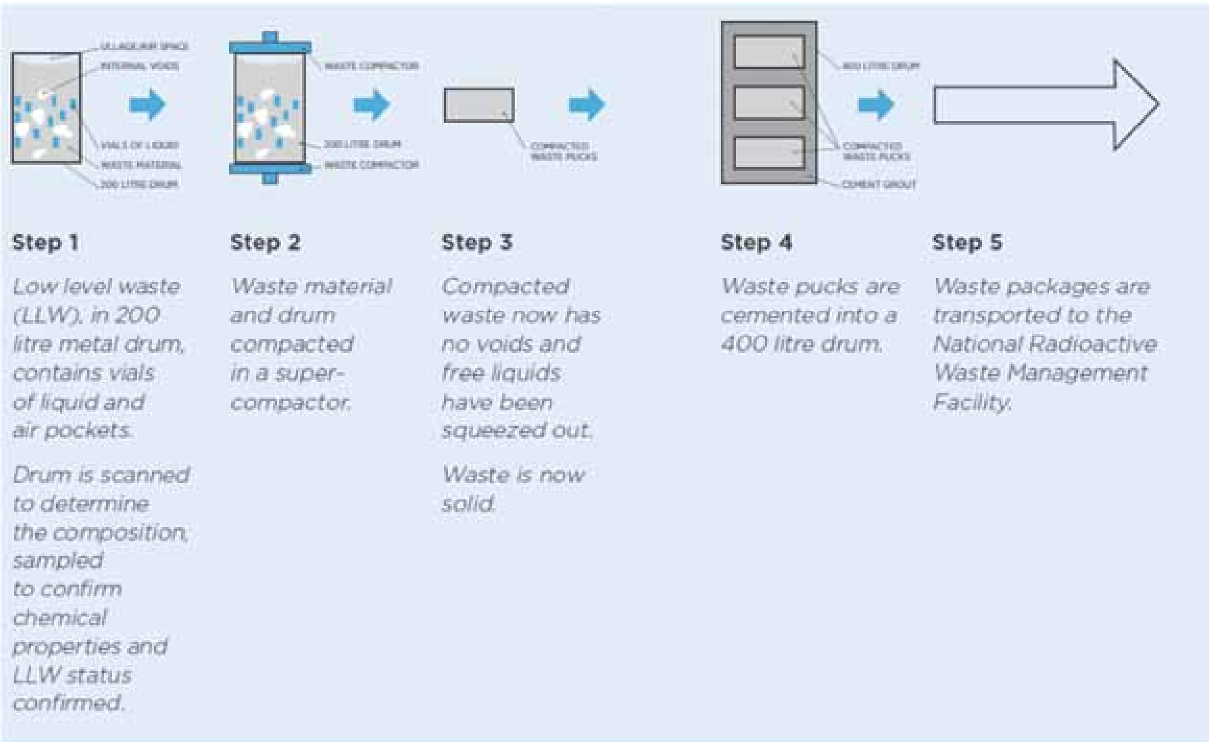
All wastes will be packaged and/or treated (conditioned) to meet the WAC. Potential ways of treating waste material to make it solid and non-dispersible, and meet the WAC, include:

- Thermal treatment of waste: For instance drying liquid or wet wastes to make them solid, then thermally treating them with additives to make them stable and fully WAC compliant. This is how ANSTO will transform the liquid ILW waste from nuclear medicine production to a stable solid Synroc wasteform. The Synroc wasteform is illustrated in Figure 2. Another example is vitrification of waste. When spent Opal reactor fuel is reprocessed the waste, left after the uranium is removed, is mixed with molten glass and poured into a stainless steel container resulting in a stable solid waste package (with the waste packages stored in TN-81's). The TN-81 containing vitrified waste packages currently stored at ANSTO is pictured in Figure 3.
- Immobilisation of waste in cement: Cement technology is well understood and widely used for radioactive waste conditioning. Waste is incorporated into a solid cement wasteform in a container (a steel drum or steel box). Cementing also treats a wide range of unwanted chemical properties (e.g. corrosive, flammable and reactive materials). It locks-in trace liquid and hazardous chemicals, so that the cemented waste packages then meet the WAC. For example ANSTO propose to treat the LLW general and laboratory waste (paper, plastic and metal objects) by crushing/compacting LLW wastes in drums, then cementing the pucks into another drum for disposal in the vaults. This treatment is illustrated in Figure 4.
- Sealing waste into robust sealed containers, often comprising multiple layers of containment, can also be a very effective way of packaging wastes, especially for storage. This method is often used for long-lived sealed sources.

Figure 2: Waste in Synroc can pre-treatment and cutaway showing processed Synroc

Figure 3: TN-81 at ANSTO containing vitrified ILW

Figure 4: Compaction and cementing of LLW general and laboratory waste



4.3 Waste Acceptance Process

Waste will only be accepted at the NRWMF if it meets all the conditions and criteria specified in the WAC.

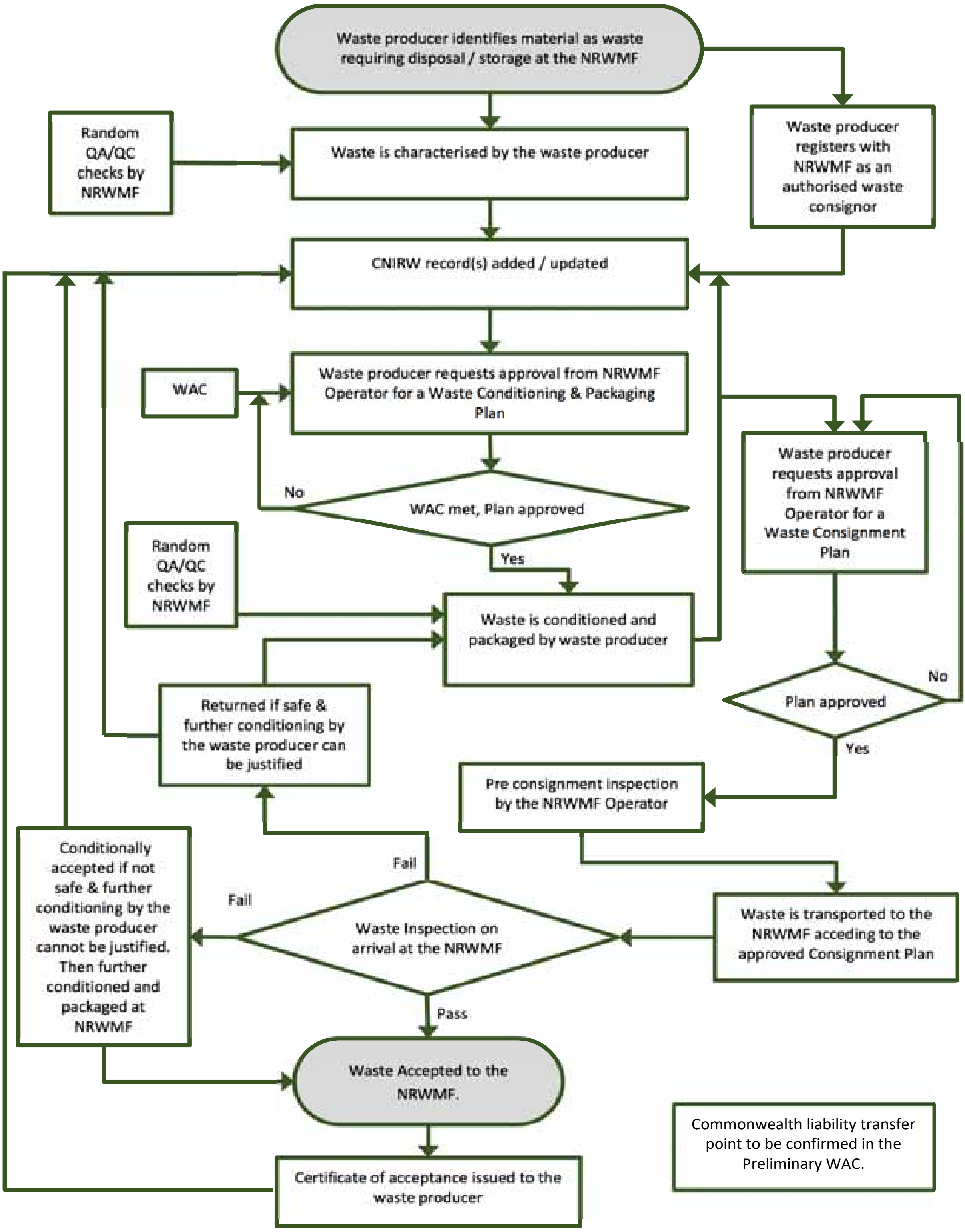
The waste acceptance procedure will ensure that:

- assessment starts at the time the waste producer develops options for waste treatment of a waste or waste stream,

- wastes are fully characterised and the chemical and other properties fully understood to aid the development of treatment options
- treatment and packaging processes are developed for all the CNIRW waste inventory
- the 'green light' is only given if the treatment process produces waste packages of consistent quality that meet the WAC (and so considered suitable for management at the NRWMF) — this will apply to all waste streams whether treated/packaged by the waste producer or at the NRWMF, and
- the waste treatment processes will be audited regularly to ensure the ongoing production of waste packages continues to meet quality criteria and the WAC.

A flow chart of the waste acceptance process is provided in Figure 5, on the following page.

Figure 5: Waste Acceptance Process flow diagram.



4.4 Waste Containers

The following tables summarise the range of waste containers to be used for disposal of LLW and storage of ILW at the NRWMF. The information presented here will be updated when the preliminary WAC document is developed.