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CONSULTING AUSTRALIA

UNIVERSITY OF SYDNEY - ENGINEERING SCHOOL LABORATORY STAGE 1

Dangerous Goods Report

Date: 20 November 2018

Document Number: LCE14119-010

DOCUMENT ISSUE REGISTER

PROJECT NAME: UNIVERSITY OF SYDNEY - ENGINEERING SCHOOL LABORATORY STAGE 1

PROJECT REF: LCE14119-0016 Dangerous Goods Report

REVISION	DESCRIPTION	DATE ISSUED	AUTHOR	REVIEWED
A	Preliminary	23.03.2018	ZC/AC	JC
B	Issue for comments	31.08.2018	ZC/RM	AC
C	Revised based on comments provided	20.11.18	ZC	AC

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1. INTRODUCTION

The University of Sydney is currently delivering Stage 1 of the Engineering Technology Precinct (ETP) Project. Stage 1 includes redevelopment of the existing Electrical Engineering (J03) Building into a new multi storey combined teaching and research laboratory.

The proposed new laboratory development will form a major component of the ETP dangerous and hazardous goods receipt, management and distribution network. This will be facilitated though construction of a new large vehicle delivery connected to a dedicated dangerous goods bulk storage and handling zone. To facilitate these works, the project will be required to modify existing building structures and landscaped areas. An indicative area plan has been provided in Figure 1.

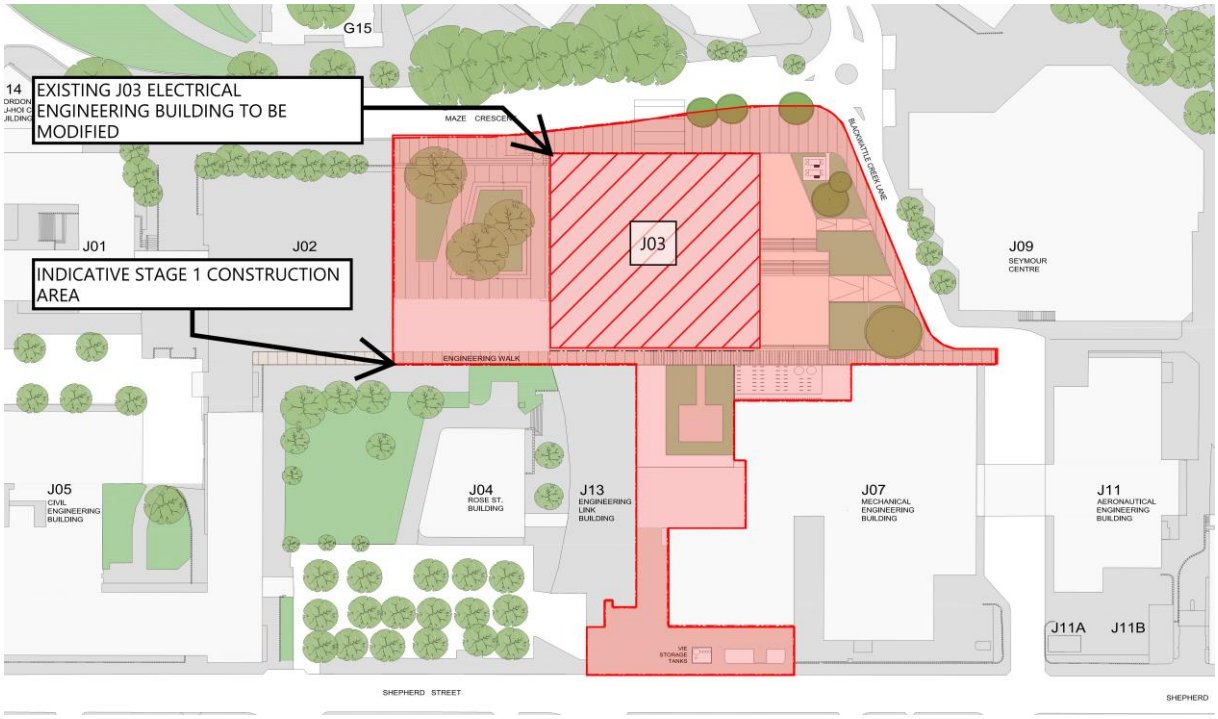

Figure 1 - Indicative Project Area Plan.

Lucid Consulting have been engaged by Laing O'Rourke to form part of the technical design team and provide consultancy services for the storage and handling of dangerous goods within the new J03 Laboratory Building.

1.1 PURPOSE

The purpose of this report is to provide an overview of the requirements for storage and handling of dangerous goods required for facility operations. This report will provide advice on the storage of dangerous goods within the ground level bulk store and cabinet storage within laboratories.

In addition to storage, the risk assessment and hazard analysis will incorporate the transportation and handling of dangerous goods entering, exiting and within the J03 laboratory building.

This report has been developed in accordance with the SEPP 33 report prepared by CETEC in November 2017. Preliminary Hazard Analysis and design principles are outlined within this report.

1.2 SCOPE

The scope of this report comprises: -

- Review and application of Australian Standards requirements.
- Summary of proposed dangerous goods storage types and quantities and handling arrangements operated by the Biomedical & Materials and Chemical Engineering Departments.

- Proposed excluded dangerous goods classes based on existing quantities. These classes are excluded to assist with determination of acceptable storage quantities.
- Overview of proposed hazardous zoning to be applied within J03 and the external stores, including Bulk Stores, Intermediate Stores, and Laboratory Storage.
- Review of Preliminary Hazard Analysis (PHA) presented in the SEPP 33 and presentation of Final Hazard Analysis framework.
- Preliminary and final dangerous good storage quantity calculations.
- Defining the Australian Codes and Standards limitations and tranches for storage and handling of dangerous goods, to assist with facility user operational proposed and design outcomes.
- Review of the current design limitations and constraints. The report will also provide commentary on how these limitations have been managed within the overall project strategy.
- Definition of Fire Fighting Equipment required to serve Class 3 dangerous goods storage areas.

1.3 SOURCES AND LIMITATIONS

This report has been prepared based on the following sources of information:

- Preliminary Hazard Analysis of the Proposed New Engineering Precinct Building Following SEPP 33 Protocol - Version 1.2 by CETEC dated 30th November
- Principal Project Requirements:
  - Volume 6.1a Functional Brief: Research
  - Volume 6.1b Functional Brief: Teaching and Learning
  - Volume 7.6 Chemical Dangerous Goods and HAZMAT Requirements
  - Volume 7.12 Physical Containment Requirements
  - Volume 7.17 Acoustic Requirements
  - Volume 7.18a EMI RFI Vibration Requirements
  - Volume 8.07 CIS Building and Architecture Requirements
- 2017 The University of Sydney DG Notification – Engineering
- Schedule 3 – Volume 6-3 Hazards Register
- Scope of Works Engineering Transformation Project – Stage 1 For Contract dated 19 December 2017
- Dangerous Goods Depots (Ref: WHS_CHE_GUI_1.1)
- Combined Chemical Inventories provided by the University of Sydney
- User group meeting workshops
- Engineering Precinct - Summary of DG current holdings May 2018_V2_EXTRACT.xlsx
- The advice presented within this report aligns with the University of Sydney requirements and guidelines

This report is subject to limitations as follows:

- This report presents an overview of the requirements for the storage and handling of dangerous goods within the proposed new J03 laboratory building. Further detailed design and assessment shall be completed by others.
- This report excludes operational, safety, personnel safety and emergency management, further detailed assessment is to be conducted by others.

- The proposed systems have been based on the conceptual Architectural design. Detailed review of engineering services documentation and system requirements is not included within this report.
- Dangerous goods storage volumes and allowances have been determined using the information provided by the University of Sydney. Lucid has not completed an audit of the existing site and laboratory spaces.
- Excludes quantities from existing J07 and J07A External stores.
- Excludes consideration of dangerous goods accessibility for users outside of new Stage 1 development.
- The report does not provide advice on the frequency and operations of external dangerous goods delivery and transportation. It is understood that where this is completed by an external agency, an independent risk assessment will be completed, furthermore, internal transportation of dangerous goods shall be reviewed as part of a separate engagement.
- This report provides advice for the base building storage and handling of dangerous goods in accordance with the Australian Codes and Standards. The report does not consider a bespoke services design or building arrangement.
- No Hazard Operability Study, Fire safety study, construction safety study or Emergency plans were provided to Lucid, limiting the full integration of hazards-related assessment process to the documents listed above.

1.4 RELEVANT STANDARDS AND CODES

Australian Codes and Standards requirements that have been applied as a part of the dangerous goods assessment comprise: -

Title	Index	Revision
National Construction Code, Volume 1 (Building Code of Australia)	NCC	2016
The use of ventilation and air-conditioning in buildings – Mechanical Ventilation	AS 1668.2	2012
Storage and handling of bulk cryogenic liquids	AS 1894	1997
Storage and handling of flammable and combustible liquids	AS 1940	2017
Anhydrous Ammonia – Storage and handling	AS/NZS 2022	2003
Safety in laboratories – Storage of chemicals	AS/NZS 2243.10	2004
Laboratory design and construction	AS 2982	2010
Storage and handling of corrosive substances	AS 3780	2008
The storage and handling of mixed classes of dangerous goods, in packages and intermediate bulk containers	AS 3833	2007
Storage and handling of gases in cylinders	AS 4332	2004
Explosive atmospheres – Part 10.1: Classification of areas – Explosive gas atmospheres	AS/NZS 60079.10.1	2009

Australian Code for the Transport of Dangerous Goods by Road or Rail, Edition 7.5	ADG	2017
NSW Government Code of Practice – Storage and Handling of Dangerous Goods.	-	2005
NOHSC Exposure standards for atmospheric contaminants in the workplace	NOHSC:1003	1995

Table 1 - Reference Standards and Codes

2. STAKEHOLDER CONSULTATION PROCESS

Lucid have attended and contributed to User Group (UG) workshops that have progressed DG discussions. These workshops have enabled a greater understanding of University and user requirements. Workshops have been coordinated by the Project Architect (Cox Architecture) and Principle Contractor (Laing O'Rourke).

An overview of the stakeholder consultation process is provided.

- ***UG Meeting ETP Stage 1 J03 Building - Stacking Model Presentation – 14th December 2017***

  Lucid were introduced to the User Group at this workshop. This workshop discussed the proposed building arrangement and proposed method of dangerous goods storage and handling for the site. The workshop provided an overview of User Group expectations and commenced the flow of manifest/inventory information.

- ***Site walk through of J01 and J07 – 19th December 2017***

  A walk through of the existing J01 and J07 laboratory and storage areas was undertaken. The walkthrough was convened for the design team to develop an understanding of current site operations.

- ***UG Meeting ETP Stage 1 J03 Building – Dangerous Goods - 23rd January 2018***

  The purpose of this meeting was to present and discuss the proposed dangerous goods storage throughout the new laboratory building. Lucid presented dangerous goods registers to the User Group. Registers have been developed using existing manifest information. It was identified that Lucid had not received all manifest information and that missing information would significantly compromise the accuracy of Lucid advice.

  It was agreed at the meeting that Lucid advice shall nominate specific dangerous goods classes that will be excluded from bulk storage consideration (refer Section 4.2). The exclusion of dangerous goods classes enabled calculation of the proposed maximum storage quantities in accordance with the Australian Standard AS2243.10-2004.

- ***UG Meeting ETP Stage 1 J03 Building – Support User Group (SUG) Meeting – 19th February 2018***

  Lucid calculated proposed maximum dangerous goods storage quantities and distributed the calculations to project stakeholders and the technical design team prior to the meeting. Quantities were used to coordinate the required minimum room dimensions of the dedicated stores, and to assist the Architect in defining the Level 1 storage arrangement. Proposed storage quantities were presented to the user group. The user group advised that the maximum permitted storage quantities for Class 3 Flammable Liquids and Class 8 Corrosives may be restrictive for the buildings intended use (distribution terminal for the ETP). Lucid advised that alternative Australian Standards including AS1940 and AS3780, may be applied to calculate maximum storage quantities for Class 3 and Class 8 materials. It was agreed that the alternative approach shall be investigated, and the consequence associated with this approach be incorporated in the risk assessment. Cox Architecture presented layout options for the Level 1 Storage and Handling Area. These options and the proposed layout arrangements are presented in Section 7. The User Group discussed the suitability and availability of

the external structures for utilisation of bulk gas storage and identified this as a potential risk. It was summarised that the level 1 arrangement should consider the use of internal gas bottle storage. This has been incorporated in the arrangements presented in Section 7.

- ***UG Meeting ETP Stage 1 J03 Building – Support User Group (SUG) Meeting – 23rd May 2018***
  A new design approach was advised for a flexible generic layout, with worst case overlays for biology and chemistry. Lucid were advised that the University prefers one central point for delivery and distribution of dangerous goods, and J03 Loading dock may serve as this. Option 4 was noted as the preferred loading dock arrangement. It was also noted that Chemistry and Biochemical will be the major uses of the storage facility as the have the highest demand for Dangerous Goods.

- ***UG Meeting ETP Stage 1 J03 Building – Working Technical Group Presentation – 31st October 2018***

  Lucid presented to University of Sydney External Reviewer on technical approach to 30% design development and planning forward to 70% design development including review of additional Class 3 storage and revised DG quantities.

- ***UG Meeting ETP Stage 1 J03 Building – Support User Group (SUG) Meeting – 1st August 2018***
  It was advised that minor, naturally occurring radioactive materials were to be stored within a radioactive store in J03 loading dock. Lucid was also provided with revised dangerous goods quantities, in response Lucid advised on increased construction requirements and issued a memorandum to confirm these revised quantities. A new layout for the loading dock was presented in this meeting.

- ***UG Meeting ETP Stage 1 J03 Building – Working Technical Group Presentation – 31st October 2018***

  Lucid presented to University of Sydney CIS on technical approach from 30% design development to 70% design development, as well as planning forward to 90% Design development. Presentation was forwarded to external technical reviewer who was unable to attend.

- ***UG Meeting ETP Stage 1 J03 Building – Support User Group (SUG) Meeting – 7th November 2018***

  A revised loading dock layout was presented and discussed in the user group and the goods handling brief was introduced to the user group. The goods handling brief has been reviewed by Jeff Freeman, Lucid and Hoslab. FF&E was also discussed in the user group. Cox to provide detailed design within goods handling brief and 70& 100% design development documentation based on goods handling brief. Goods handling brief to be endorsed by University of Sydney CIS.

3. SUMMARY OF EXISTING

3.1 EXISTING BUILDINGS AND OPERATIONS

The University of Sydney Engineering and Technology Precinct (ETP) is located at the Camperdown campus. It is understood that the follows building user groups and laboratory teams will be integrated into the new J03 laboratory, these comprise: -

- J01 – Chemical Engineering.
- J03 – Electrical Engineering.
- G08 – Molecular Bioscience Building.

To enable construction and integration of the new J03 laboratory building the J07 building and J07A storage areas will affected. J07 is currently located between the proposed new J03 laboratory and bulk delivery location, as part of the new building a portion of J07 shall be removed to facilitate delivery access. Furthermore, due to the new dedicated storage being provided with J03, the J07A storage areas may be modified and used for an alternative purpose.

Dangerous goods storage is provided in a combination of intermediate bulk stores and laboratory stores. The primary bulk stores within existing Building J01 comprise: -

- J01-02-249-2.3-00 – Dangerous Goods Class 2.3 (Toxic Gas).
- J01-02-P205-2.3-00 – Dangerous Goods Class 2.3 (Toxic Gas).
- J01-02-P206-3-00 – Dangerous Goods Class 3 (Flammable Liquid).
- J01-02-P207-2.1-00 – Dangerous Goods Class 2.1 (Flammable Gas).
- J01-02-P208-2.1-00 – Dangerous Goods Class 2.1 (Flammable Gas).

The bulk storage locations in Building J07 and J07A comprise: -

- J07-01-S151-2.1-00 – Dangerous Goods Class 2.1 (Flammable Gas).
- J07A-01-P100-3-00 – Dangerous Goods Class 3 (Flammable Liquid).

The dangerous goods stored at these locations are accessible to local building users, and for users located in the Engineering and Technology Precinct (ETP).

3.2 EXISTING DANGEROUS GOODS STORAGE PROCESS

The University operates multiple independent storage areas throughout the ETP. The larger stores operate as receipt locations for bulk deliveries for repackaging and distribution to building stores.

The University and Research departments operated local laboratory storage using dedicated cabinets, on shelving and fridges.

During the site inspection, completed 19 December 2017, it was advised that the Chemical Engineering Department operate a process for dangerous goods delivery directly to the bulk storage area of J03. Goods are transferred from the J03 bulk storage to the local intermediate store and for distribution to laboratory spaces.

The Biomedical and Materials Engineering Building users accept delivery of materials directly and distribute materials to internal laboratory storage.

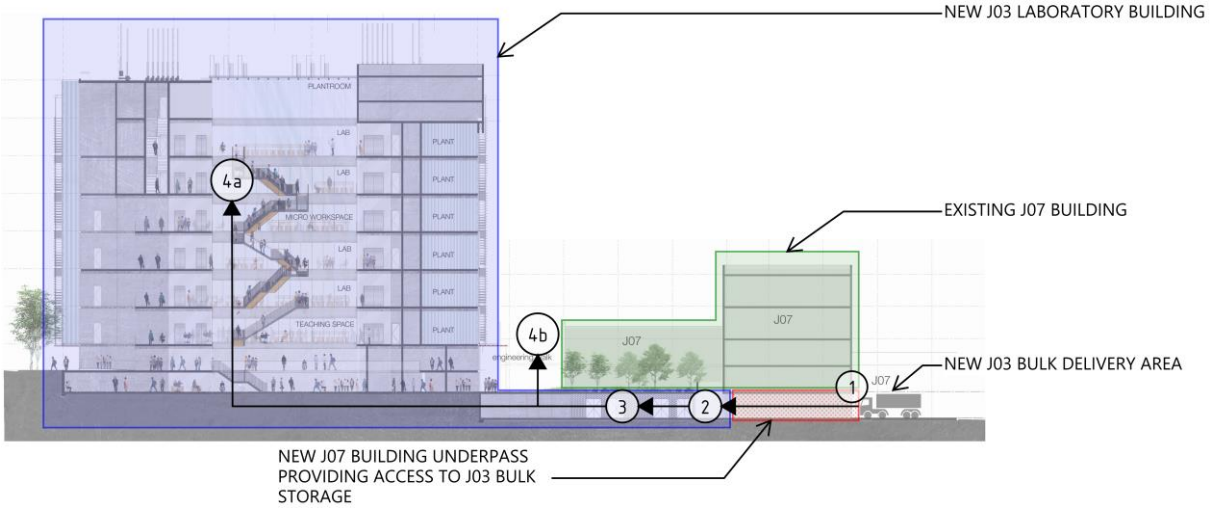

Figure 2 - Proposed J03 Building Delivery, Storage and Distribution Process Flow.

The bulk dangerous goods storage area within level 1 of the new J03 building will form one of three major dangerous goods storage and distribution locations within the University of Sydney ETP. The process presented in Figure 2 provides a high level schematic depiction of the dangerous goods handling process through the J03 bulk storage area. The process nominally comprises: -

1. Deliveries are received at the new J03 dedicated bulk delivery area located adjacent the eastern entry of J07 between J07 and J13.

2. All deliveries will be handled at J03 level 1 for processing and storage. The new J03 level 1 area will incorporate dedicated bulk chemical storage and decanting areas with the potential of utilising internal gas storage.
3. Bulk chemicals will be decanted and packaged for distribution to laboratory intermediate cabinet storage.
4. J03 level 1 will form a major dangerous goods terminal for ETP chemicals and gasses will derive distribution to the intermediate laboratory stores in building J03 (4a) or to other buildings within the ETP (4b).

In addition to the process presented in Figure 2, the process for distribution and handling of dewars is proposed to be generally consistent to other dangerous goods such that; bulk storage is decanted into small manageable dewar for storage and processing in J03 level 1.

The proposed new development will incorporate cryogenic gas dewar activities external to the loading dock, with a minor store located within the loading dock, wherein no activities other than storage are permitted.

4. SCHEDULE OF MATERIALS

4.1 PROPOSED INCLUDED CLASSES

The Australian Code for the Transport of Dangerous Goods by Road & Rail (ADG, Australian Dangerous Goods Code) separates dangerous goods into classes. For packing and storage purposes, select dangerous goods classes are allocated Packing Group (PG) sub-categories. The PG sub-categories are assigned to specific dangerous goods classes to communicate the different hazard levels of materials within the class, with PG (I) representing the highest hazard (danger) and PG III representing the lowest hazard (danger). The classes of dangerous goods proposed for storage and handling at the new ETP Stage and forming part of this assessment comprise: -

- Class 2 Gases.
  - 2.1 Flammable.
  - 2.2 Non-Flammable, Non-Toxic.
  - 2.3 Toxic.
- Class 3 Flammable Liquids. (including PG I, PG II, PG III)
- Class 4 Flammable Solids.
  - 4.1 Flammable Solids. (including PG I, PG II, PG III)
  - 4.2 Liable to spontaneous combustion. (PG II)
  - 4.3 Emits flammable gasses when in contact with water. (PG I)
- Class 5 Oxidising and Organic Substances.
  - 5.1 Oxidising Substances. (including PG I, PG II, PG III)
  - 5.2 Organic Peroxides. (PG II)
- Class 6.1 Toxic Substances. (including PG I, PG II, PG III)
- Class 7 Radioactive Material.
- Class 8 Corrosive substances. (including PG I, PG II, PG III)
- Class 9 Miscellaneous Dangerous Substances. (including PG I, PG II, PG III)

4.2 PROPOSED EXCLUDED CLASSES

The classes of dangerous excluded from this assessment comprise: -

- Class 1 Explosives:
  - 1.1 Mass Explosion Hazard.
  - 1.2 Projection Hazard but No Mass Explosion Hazard.
  - 1.3 Fire Hazard and either Minor Blast or Minor Projection Hazard but No Mass Explosion Hazard.
  - 1.4 No Significant Hazard.
  - 1.5 Very Insensitive Substances, No Mass Explosion Hazard.
  - 1.6 Extremely Insensitive Substances, No Mass Explosion Hazard.
- Class 6.2 Infectious Substances.

It is understood that laboratories within the J03 building may require infrequent use of the dangerous goods excluded from this assessment. Prior to introducing one of the excluded dangerous goods into the J03 building, the laboratory and dangerous goods manager shall be responsible for completing a detailed risk assessment to ensure that introduction of the material does not introduce an increased risk to the building occupants.

5. STANDARD REQUIREMENTS

5.1 GAS STORAGE

5.1.1. GENERAL

Australian Standard *AS 4332 The Storage and Handling of Gases in Cylinders* is the reference standard for storage and handling of gases in cylinders. Australian Standards that contribute to the engineering assessment process for storing and handling of gases in cylinders comprises: -

- Storage and handling of cryogenic gases in dewars and other containers shall be in accordance with Australian Standard AS 1894.
- Storage and handling of anhydrous ammonia shall be in accordance with AS 2022.
- AS 60079.10.1 Explosive atmospheres Classification of areas – Explosive gas atmospheres for gas warning sensors and compliant electrical fittings

Empty gas cylinders are treated as a full container for assessment of storage volumes and clearance requirements.

5.1.2. MINOR STORAGE

Gaseous dangerous goods are stored in "Minor" or "Bulk" quantities. A description of the requirements of minor gas storage in accordance with AS4332 is provided. A minor store is a dedicated storage location with quantity limits presented in Table 2.

Gas Classification	Maximum Aggregate Water Capacity, L
2.1	500
2.2	2,000
2.2 (5.1 Subsidiary Risk)	1,000
2.3	50
Total Mixed Aggregate	2000

Table 2 – Maximum Quantities of Gas Permissible for Classification as Minor Storage, AS4332, Table 2.1

Minor stores are considered to introduce reduced consequences to the overall building fire load and are generally unlikely to reduce the safety of the surrounding area.

All minor stores require the following: -

- Gas cylinders shall be stored no less than 3 meters from artificial heat sources, combustible materials and vegetation to prevent ignition.
- The storage location shall provide adequate ventilation at high and low level in accordance with AS 1668.2.
- Gas cylinders shall be segregated by a distance not less than that presented in Table 3.
- The floor construction of the storage area shall be solid and draining away from cylinders.
- Outdoor stores of Class 2 gases shall be separated from other dangerous goods stores by a minimum 3 meters, not less than 1 meter away from any air intakes including doors, windows, air vents and ducts.

Minor stores located internally require the following: -

- Total capacity shall not exceed 2,000 Litres mixed aggregate storage for cylinders in use, spare cylinders not in use and cylinders awaiting removal.
- No more than one minor storage area for every 200m^2 of floor area. Undue concentration of cylinders should be avoided.
- Must be separated from other minor stores of gases and other dangerous goods stores by a minimum of 5 meters
- No minor storage in basement levels, with the exception of Class 2.2 gases with no subsidiary risks.

5.1.3. SEGREGATION WITHIN A STORE

Class/Sub-Risk	Class 2.1	Class 2.2	Class 2.2/5.1	Class 2.3 or 2.3/8
2.1	-	0	3	3
2.2	0	-	0	0
2.2/5.1	3	0	-	3
2.3 or 2.3/8	3	0	3	-

Table 3 - Segregation of Gases within a Store. AS4332, Table 4.2

A screening wall as presented in Figure 3 may be utilised for realising the required minimum separation distances.

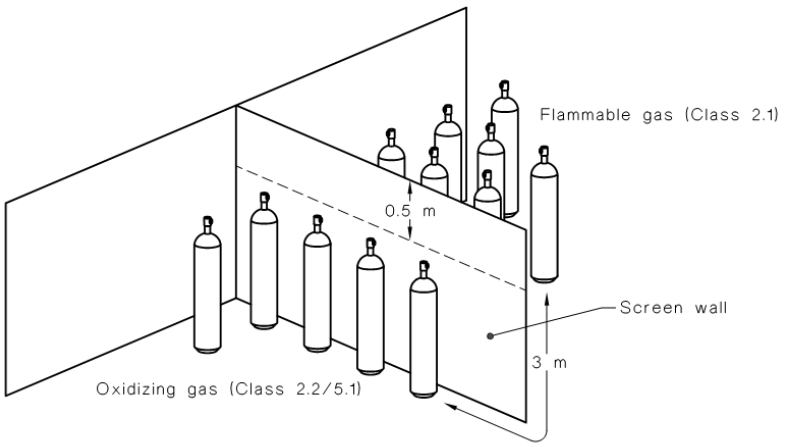

Figure 3 - Example Fire Rated Segregation within Store. AS 4332, Figure 4.3

5.1.4. LABORATORY STORAGE

Storage of gases in laboratories is governed by AS 2243.10, which requires that cylinders are stored in a laboratory for connection and usage. Storage of gases in laboratories for convenience, that are not in use should be avoided to prevent inadvertent release of gases.

Consideration should be given to the potential hazardous effects of the gases stored.

Individual containers (in use, not stored) within the laboratory should not exceed a quantity of 70 Litres in volume.

5.1.5. BULK STORAGE

Gases may be stored, internally or externally, in volumes exceeding minor storage allowances. Storage quantities exceeding minor storage quantities presented in Table 2, requires a room construction and the segregation requirements presented in Section 5.1.6 of this report.

5.1.6. STORAGE CONSTRUCTION

The Australian Standard AS4332 does not recommend the storage of Class 2 dangerous gasses internal to an occupied building. The internal storage of gases introduces additional hazards with respect to managing the potentially toxic or flammable atmosphere. Where an internal store is adopted the floor of the store shall be configured to ensure that in the event of a cylinder being compromised and discharged material is moved away from the other cylinders. The drainage slope should not be such that it effects the stability of the stored cylinders.

Any store for gases in cylinders that is attached to or located within a building shall be located on ground level and separated by one or more walls each with a Fire Resistance Level (FRL) of at least 240/240/240. The roof of the store shall also achieve an FRL of 180/180/180.

All doors that provide access to an internal bulk gas store shall be outward swinging unless the door comprises a ventilated roller door that permits internal operation.

A combination of high and low-level ventilation should be provided with the design conditions in accordance with the type gas stored, such as gases with densities greater than/less than air. Ventilation shall generally be realised using mechanical systems. Natural ventilation can be considered providing sufficient dilution of any vapour or gas away from building entrances, doors, window, air conditioning intakes, sources of ignition or areas where people are likely to congregate is realised.

Ventilation systems serving an internal gas store shall be capable of maintaining the internal store atmosphere within a safe exposure limit during possible and credible storage scenarios. As the densities of stored gasses is variable, the store shall be provided with high and low level ventilation. AS4332 provides prescriptive design criteria for natural and mechanical ventilation systems serving gas storage areas.

Gas stores are considered separate stores when separated from a protected place by a distance of at least 3m, or as presented in Table 4. The store should have an FRL of:

- 240/240/240 for the walls and
- 240/240/240 for the roof if the protected place is taller otherwise:
- 120/120/120 for the roof of the store (if any)

Australian Standards provide further separation distances for bulk gas storage based on the dangerous goods classification and the type (item(s)) of separation.

Item No.	Item(s) from which separation is required.	Aggregate water capacity of store	Minimum Distances. m			
			Class			
			2.1	2.2	2.2/5.1	2.3
1	Protected place	≤500	0	0	0	3
		>500 ≤1,000	3	0	0	5
		>1,000 ≤2,000	3	0	3	8
		>2,000	6	5	5	15
2	On site protected place	≤500	0	0	0	3

		>500	≤1,000	3	0	0	3
		>1,000	≤2,000	3	0	3	5
		>2,000		3	3	3	8
3	Stores for other dangerous goods, combustible liquids or combustible materials		≤500	3	3	3	3
		>500	≤1,000	3	3	3	5
		>1,000	≤2,000	3	3	3	8
		>2,000		5	3	5	15
4	Filling/decanting points for packages of dangerous goods or combustible liquids, or dangerous goods or combustible liquids in bulk.		≤500	3	3	3	3
		>500	≤1,000	3	3	3	5
		>1,000	≤2,000	3	3	3	8
		>2,000		5	3	5	15

Table 4 - Minimum Separation Distances for Gas Cylinder Stores (adapted from AS4332, Table 4.1)

5.2 CHEMICAL STORAGE

5.2.1. GENERAL

The Australian Standard AS2243 Safety in Laboratories – Part 10 Storage of Chemicals, is the reference standard for determining the dangerous goods storage limitations and the minimum construction requirements. This section has been prepared to summarise the minimum requirements for the proposed new J03 laboratories.

5.2.2. LABORATORY STORAGE (OTHER THAN DEDICATED CABINETS)

The intermediate storage of dangerous goods within a laboratory compartment is permitted in small quantities, with the exception Class 2 Gasses and Cryogenic Liquids. AS2243.10 provides a prescriptive summary for the maximum intermediate storage quantities permitted within the laboratory compartment. The maximum storage quantities are summarised in Table 5.

Type of Substance / Class of Dangerous Goods	Maximum per 50m² (L/kg)	Maximum pack size (L/kg)
Class 3	10	5
Combustible Liquid	50	20
Classes 4.1-4.3, 5.1 and 5.2	20 but less than 10 of any one class	10
Class 6.1	PG 1 – 10 Other - 50	PG 1 – 10 Other - 50
Class 8	Liquids – 20 Solids - 50	20
Class 9 and aerosols	Liquids – 50 Solids - 100	Liquids – 5 Solids - 20
Maximum Aggregate Quantity	**200**	**-**

Hazardous Substances	-	Liquids – 5 Solids - 20

Table 5 - Summary of AS2243.10 Maximum In-Laboratory Storage Quantities.

The standard advises that all chemicals should be returned to their primary storage (i.e. dedicated cabinet or bulk store) to ensure an acceptable level of safety for laboratory users and other personnel. On this basis, the consideration for dangerous goods storage is based on the allowable storage quantities defined for dedicated stores or cabinets.

5.2.3. DEDICATED CHEMICAL STORAGE CABINETS

Chemical storage cabinets provide a dedicated location to store chemicals within a laboratory. The cabinets are available to provide different volumes for storage and are generally designed to form part of a laboratory compartment. Chemical storage cabinets provided in accordance with AS2243.10 are required comply with the following: -

- Maximum aggregate storage volume of 250L or 250kg.
- Maximum aggregate storage volume of Class 4.1, 4.2, 4.3, 5.1 and 5.2 shall not exceed 50L or 50kg.
- Minimum 10m segregation from any one of the cabinets forming part of the aggregated storage quantity.
- Cabinets to be located minimum 3m from escape doors

The cabinet storage requirements shall be coordinated with the proposed laboratory arrangement during detailed design.

5.2.4. BULK STORAGE QUANTITIES

Australian Standard AS2243.10 provides prescriptive limitations for bulk storage of chemicals in a dedicated store. The standard stipulates the storage limitations based on the goods classification and associated packing group. Table 6 provides a summary of the maximum storage limitations defined in AS2243.10.

Type of Substance / Class of Dangerous Goods	**Maximum Storage (L or kg)**		
	PG 1	**PG2 and PG3**	**Other**
Class 3	200, not more than 100 in any one cabinet	1,000	N/A
Combustible Liquid (C1/C2)	N/A	N/A	1,000
Classes 4.1-4.3, 5.1 and 5.2	200 (aggregate)	1,000 (aggregate) Max 50 of Class 5.2 in any one cabinet.	N/A
Class 6.1 Class 8 Class 9	500 (aggregate) Max 100 of Classes 6.1 and 8 in any one cabinet.	1,000 (aggregate)	N/A
Hazardous Substances	N/A	N/A	2000
Maximum Aggregate Quantity	**500**	**2,000**	**2,000**

Table 6 - AS2243.10 Maximum Bulk Storage Quantities

Preliminary dangerous goods storage quantities for the new J03 bulk store have been calculated applying the storage limitations presented in Table 6 and available manifest quantities. The values have been utilised to develop preliminary storage spatial arrangements and are presented in Table 7.

Dangerous Goods Classification	Optimised Bulk Storage Volume kg/L			Total Aggregate Storage kg/L
	PG I	PG II	PG III	
Class 3 – Flammable Liquids	200.00	906.18	93.82	1200.00
Class 4.1 – Flammable Solids	0.00	6.16	6.64	12.80
Class 4.2 – Liable to spontaneous combustion	0.00	10.98	0.00	10.98
Class 4.3 – Emits flammable gasses when in contact with water	12.34	0.00	0.00	12.34
Class 5.1 – Oxidising Substances	184.55	79.41	113.56	377.52
Class 5.2 – Organic Peroxides	0.00	0.30	0.00	0.30
Class 6.1 – Toxic Substances	48.95	56.73	108.52	214.20
Class 8 – Corrosives	54.16	412.05	140.56	606.78
Class 9 – Miscellaneous	0.00	4.35	60.74	65.08

Table 7 - Summary of Calculated Maximum Storage Values in accordance with AS2243.10.

Calculation of storage quantities in accordance with AS2243.10 provides a baseline for determining of the internal spatial requirements of storage area. The calculation has also been completed to ensure a uniform and consistent design standard is adopted throughout the building.

It is understood that the J03 bulk store will form one of three main receipt and distribution centres for dangerous goods throughout the ETP. As outlined in the User Group Meeting dated 19th February 2018, the storage quantities presented in Table 7 may become restrictive the anticipated building and proposed centralised distribution arrangement, particularly the storage and handling of Class 3 Flammable Liquids.

The University of Sydney's CIS has confirmed that they would like to exceed the optimises quantities above, exceeding the allowable quantities for Class 3 Flammable liquids. Refer to Appendix D for the revised chemical storage quantities.

The construction requirements for proposed quantities to be stored that exceed the allowable limits is provided in the NCC Australian Standard AS1940:2017 The Storage and Handling of Flammable and Combustible Liquid. This standard provides alternative methodology for the calculation of the maximum storage quantities. The standard alternative approach defines the minimum room requirements for storage of a chemical volume outlining prescriptive maximum individual and aggregate storage quantities.

Room requirements include:

- General Construction.
- Fire Protection Services.
- Bunding and Spill Containment.
- Ventilation.

The spatial and geometric constraints must be considered to ensure the safe handling of materials within the storage area.

It is noted that AS2243.10 does not recommend the use of multiple design standards for designing bulk storage systems, and alternative calculation methods should only be applied following completion of a detailed risk assessment.

To facilitate storage of the dangerous goods storage quantities presented in Appendix D, detailed design in accordance with AS1940 and risk assessment in accordance with ISO 31000 is required.

5.2.5. BULK STORAGE ROOM CONSTRUCTION

Rooms designed for the bulk storage of dangerous goods and hazardous materials in accordance with AS2243.10 require the minimum fire resisting construction requirements stipulated in AS1940. Refer to 5.3.6 of this report for construction requirements.

Rooms used for the storage of dangerous good shall also be independently ventilated and provided with spill containment in accordance with AS1940 & AS3780.

5.3 BULK STORAGE OF FLAMMABLE LIQUIDS

5.3.1. GENERAL

AS1940 provides minimum acceptable safety requirements for storage facilities and provides guidance in storage and handling of flammables and combustible liquids in accordance with legislation that underpins the document. This Standard will be used in lieu of AS 2243.10 for Class 3 substances only, subject to the final hazard analysis in Appendix E of this report.

5.3.2. MINOR STORAGE

Bulk storage of flammable and combustible liquids is governed by the requirements of AS 1940. The storage quantities proposed or J03 exceeds the limitations of AS 2243.10, therefore storage of Class 3 flammable goods shall be in accordance with AS 1940.

The proposed bulk storage volumes of Class 3 flammable liquids exceed the threshold for classification as minor storage, as shown in Figure 4. Therefore, the classification does not apply to the Class 3 Dangerous Goods bulk store but will apply to minor stores of Class 3 goods on laboratory levels.

TABLE 2.1
MINOR STORAGE

Location	Flammable liquids		Combustible liquids	Manufactured products
	PG I or PG II	PG III	C1, C2	
Residential buildings of any type				
Within a residence	5 L	25 L	50 L total C1 and C2	50 L
In a garage attached to a residence with a 60/60/60 FRL separating wall	25 L	50 L	100 L total C1 and C2	250 L
Outdoors, or in a shed or garage, separated from the residence or any other building by 1 m space	100 L	250 L	500 L total C1 and C2	250 L
Outdoors, uncovered, or in a shed or garage, separated from the residence or any structure or boundary by either 3 m of space or a wall having an FRL of 180/180/180	250 L	250 L	500 L total C1 and C2	250 L
A supply tank for domestic oil-fired appliances (see AS 1691) is excluded from any calculation of the quantity stored on the premises				
Educational establishments (excluding laboratories)	5 L per 50 m^2 of floor space	10 L per 50 m^2 of floor space	500 L total C1 and C2 per 50 m^2 of floor space	
For storage outdoors, or in sheds or attachments, the limits for the corresponding entry in residential buildings shall apply				
Laboratories (see Notes 1, 2 and 5)	50 L per 50 m^2 of floor space, or 50 L in a room of up to 50 m^2 of floor space	100 L per 50 m^2 of floor space	200 L total C1 and C2	The limit for any manufactured product is the same as for a liquid of the same Packing Group

Figure 4: Table 2.1 from AS 1940 with threshold quantities for definition as minor storage.

5.3.3. GENERAL REQUIREMENTS

Installations intended for the storage of and handling of flammable liquids shall be constructed so that it is safe and suitable for the conditions of use. Factors of consideration include site conditions, design of plant, equipment and operating procedures to minimise fire risk, design for specific emergencies, safe

access and egress, avoidance of ignition sources, ventilation, points of vapour relief and spill control. The storage shall not be used for the storage of dangerous goods other than Class 3 dangerous goods.

5.3.4. STORE TYPE

The proposed level 1 loading dock internal store located wholly within the building is acceptable by AS1940, provided that a fire door is provided between the store and the associated building. See Figure 5 for example of an acceptable layout with fire door, ignition source exclusion zone, bunding, fire walls, or fire rated roof, and mechanical ventilation.

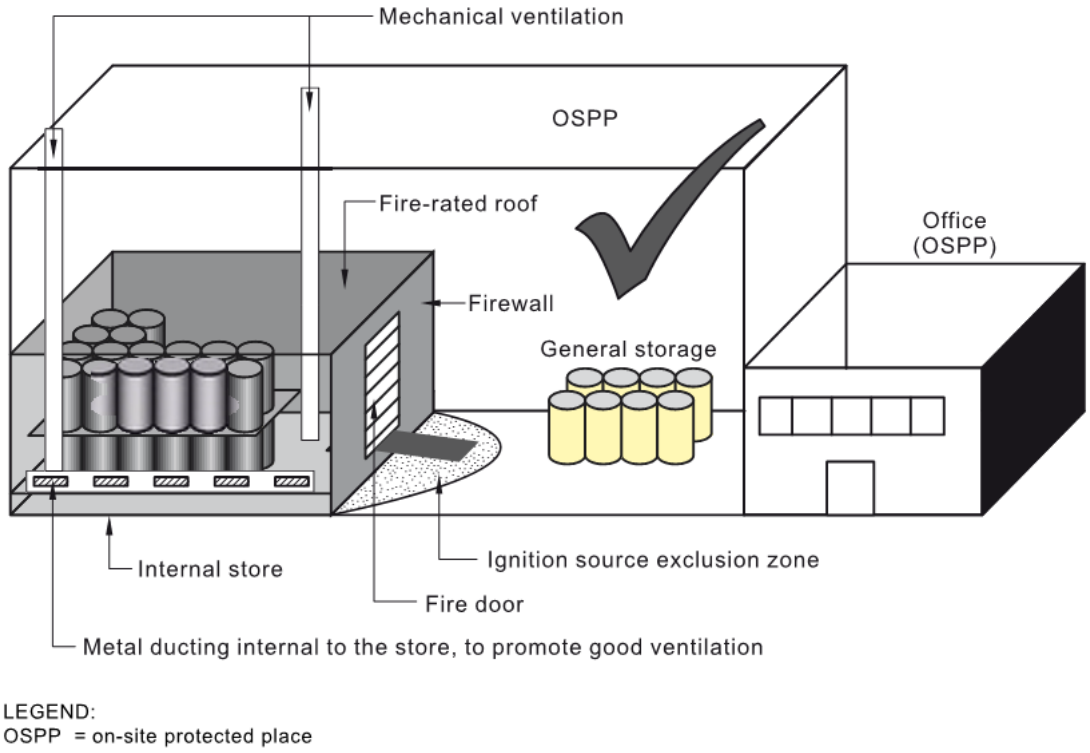

Figure 5: Package store with mechanical ventilation and fire walls from AS 1940.

Activities involving mixing, blending, degreasing, decanting, etc. are not to be conducted within the store unless due diligence in risk assessment and risk management planning has been conducted. Decanting may be conducted within the dedicated decanting room.

5.3.5. VENTILATION

Vapour hazards shall be minimised with ventilation, extraction or dispersal to maintain low exposure levels wherever a flammable liquid is being used or transferred or decanted.

Natural ventilation is not suitable for the proposed internal store and decanting room, and the store should be adequately ventilated with a mechanical ventilation system in accordance with AS 1940.

5.3.6. CONSTRUCTION REQUIREMENTS

Other than where a fire-structure is required, any wall or roof is to be masonry, concrete, or structure sheeted with a non-combustible material. Floors shall be impervious or liable to incendive sparking, such as concrete or sealed masonry.

Fire-rated structures are to comply Table 8:

Table 8: AS1940 Construction requirements for internal or attached package stores.

Fire-Rated Structure	Fire Resistance Level /Material
Separating walls (Failure of any component with FRL of less than this shall not compromise the stability of any firewall.)	240/240/240
Floor	Reinforced concrete with FRL of 180/180/180
Roof	180/180/180
Duct passing through store	-/180/180
Occupancy above	180/180/180
Doors (Must be outward opening, sliding, auto-close fire door fitted with thermal-release device)	-/120/30

5.3.7. SPILL CONTAINMENT

In accordance with AS1940 Class 3 Flammable liquids stores shall be provided with a dedicated bund. The bunded volume is required to be 100% of the largest vessel, 25% of the total stored volume (for storage under 10,000L) and the sprinkler discharge capacity.

If the proposed total storage volume is 1,500L with a 200L drum being the largest storage container, the bund is required to have a minimum capacity of 4.2m^3 (4,200L). The requirements for AS3833 – Mixed Class Storage are consistent with AS1940, as such bunding is to be provided for both the Class 3 and Mixed Dangerous Goods stores.

5.3.8. FIRE FIGHTING EQUIPMENT

Any building or site exceeding the minor storage shall be provided with fire protection in accordance with AS1940, Section 11. Materials used for fire a protection system may be suitable for the conditions of use and compatible with the liquids being stored. All firefighting media, appliances, equipment, components, hoses, connectors, booster connection and the like shall be compatible with that of Fire and Rescue New South Wales (FRNSW) at all essential interfaces.

In addition, any firefighting equipment shall be located so as to be reasonably adjacent to the risk being protected and accessible without danger in an emergency. The fire protection facilities shall either be an independent system or integrated with other fire protection systems. Any firefighting equipment that is susceptible to corrosion or degradation by weather, the environment, ultraviolet light, fumes and the like, shall be protected by a sheltered location or a protective enclosure, with the contents suitably labelled in accordance with the relevant Australian Standard.

A layout plan detailing the locations of all tanks, shut off valves pipelines, hydrants, and firefighting systems shall be provided and kept available for ready reference. Adequate wall-charts should be displayed in strategic control locations. Furthermore, all equipment, piping and valves shall be adequately supported and protected, taking into consideration the potential for traffic damage and projectile impact during fire. The fire protection and equipment shall be maintained in accordance with the relevant section of AS1851. Any fire extinguisher shall be located and mounted in accordance with AS2444.

Any fixed fire protection or detection system shall be designed and installed in accordance with the reference standard presented in the National Construction Code. Where any requirement in AS1940 is more onerous than the requirement of the appropriate Standard, then the requirement of AS1940 shall take preference.

Any fire alarm system shall comply with AS 1670 and AS 1603.5, together with the following requirements:

- An automatic system shall be capable of being manually activated at clearly identified positions
- The warning signal of the alarm system shall be sufficiently distinguishable from other signals to permit ready recognition, and shall be clearly audible throughout the whole installation, unless it can be demonstrated that audibility over a limited area is justified.
  NOTE: In addition a visual alarm system should be considered in areas of excessive noise.
- The power supply for any alarm system shall be independent of the main electricity isolating switch for the area.
- Any mandatory fire alarm systems shall be connected to a fire station nominated by FRNSW or 24 h monitoring service. The latter shall immediately notify the nominated fire station in the event the fire alarm being activated.
- Manual alarm call points shall be located at convenient and safe locations near work stations.

Fire hose reels shall be installed where specified in AS1940, Section 11. Fire hose reels shall comply with AS/NZS 1221 and AS 2441. Foam hose reels shall be fitted with suitable foam making equipment capable of producing at least 27 L/min of foam solution at minimum of 220 kPa for 30 minutes.

Foam water sprinkler system, if provided, shall comply with AS2118.1 and their installation shall comply with NFPA 16. Refer also to AS 2118.3 for foam water deluge systems. Furthermore, each indoor storage cabinet having a capacity of 250 L or less, at least one powder type extinguisher shall be provided. For indoor storage cabinets of more than 250 L capacity, an extra extinguisher or foam hose reel shall be provided. All extinguisher shall be located not less than 3 m or more than 10 m from the cabinet.

In areas where packages are filled, with or without an associated storage, extinguishers shall be provided as follows:

- For every filling point for flammable liquids, or for any two such filling points that can circumscribed by a 5 m diameter, one powder-type extinguisher plus foam extinguisher shall be provided. A foam-equipped hose reel may be substituted for any foam extinguisher within reach of the hose.
- For every filling point for combustible liquids or group of filling points within a 5 m diameter circle, one powder-type extinguisher within 10 m of the filling point.

5.3.9. ADDITIONAL REQUIREMENTS

The following items should be provided within 2-10m to the proposed store:

- Eye wash
- Handbasin for handwashing
- Safety shower complaint with AS 4775
- Purpose built racking and/or suitable restraint where package on pallets are intended to be stored more than three high, or IBC's two high.

5.4 STORAGE OF RADIOACTIVE SUBSTANCES

5.4.1. GENERAL

The storage of radioactive substances is to be in accordance with AS 2243 Part 4 Ionising Radiations. This standard is intended to be used when operating with radioactive substances in amounts less than licensable quantities as required by the NSW Government.

This standard stipulates that radioactive substances are to be used and stored such that they do not present a hazard to persons in the vicinity, stored separately to non-radioactive substances where practicable. Radioactive substances including waste should be labelled adequately.

In addition to AS 2443.4, Class 7 Radioactive substances are to be stored in accordance with statutory requirements pursuant to the Radiation Control Act 1990, and Regulations and guidance materials as advised in the EPA submission. The Act provides further guidance on storage and licencing should these thresholds be exceeded.

Expected quantities and types of Class 7 Substances could not be resolved in the user group engagement, therefore advice in this report is based on minimum requirements of AS 2243.4. The user group has provided advice that only minor quantities of stable isotopes, or substances with long half-lives such as deuterium or Carbon-13 are to be stored in the J03 loading dock.

The proposed development is considered low-level in teaching, medical and research laboratories in universities with a typical usage of 20MBq of radiotoxicity hazard group 2, up to 2 GBq of group 3, and up to 200 GBq of radiotoxicity hazard group 4. It is assumed that these levels will not be exceeded. Further advice is to be sought if these levels are expected to be exceeded.

Radioactive substances are to be stored in a locked store with the following criteria to be met:

5.4.2. FLOOD MITIGATION

The store shall be situated to minimize the risk of flooding and other natural or man-made hazards. If there is any possibility of accidental flooding then provision shall be made for all substances to be stored above floor level, and for water to be drained.

If approved by the sewerage authority Sydney Water and Fair Trade NSW, low specific activity liquid waste that is miscible with water may be discharged via sinks connected to the sewerage system. Aqueous radioactive shall be diluted by quantities of water so that the regulatory authority requirements are met, this will be assisted using a flushing sink. Drains used for the disposal of aqueous radioactive waste shall be clearly and permanently labelled and segregated from other drainage systems within the building that dispose of non-radioactive waste. The above requires a trade waste approval from Sydney Water. The alternative disposal method is to use an approved waste contractor for the removal of radioactive waste.

5.4.3. FIRE RESISTANCE & DECONTAMINATION

The store shall be constructed of durable, fire-resistant materials. The store's interior surfaces shall be constructed of materials which can be decontaminated easily.

Design and construction requirements for radiation, radioisotope and radiological laboratories should also comply with AS 2982.1.

5.4.4. SHIELDING

The store shall be adequately shielded to ensure that radiation levels outside the store, at locations that are

(i) accessible to occupationally exposed persons, shall not exceed 200 μSv in one hour; and

(ii) (ii) accessible to non-occupationally exposed persons, and members of the public, shall not exceed 20 μSv per hour when averaged over one week.

5.4.5. SIGNAGE

A radiation warning sign shall be displayed at the entrance to the store.

5.4.6. BUNDING

The store shall be provided with spillage trays on which the containers of liquid radioactive substances shall be placed. Each tray shall have sufficient volume to retain the whole of the contents of the containers on the tray with 10% additional capacity and to enable their recovery.

5.4.7. VENTILATION

The store shall be provided with an air extraction system if any radioactive gases or vapours are emitted from the substances held in the store. The extraction system shall be actuated before any person enters

the store. If radium, thorium or uranium compounds are stored, the air shall be extracted close to floor level. The discharge point for the air extraction system shall be sited away from any occupied area and shall comply with the requirement of AS 1668.2 for obnoxious discharges.

5.4.8. SECURITY

The store shall be kept locked except when radioactive substances are being transferred into or out of the store. Radiation warning signs are to be displayed at the entrance to each designated radiation area.

5.4.9. DISPOSAL

Australian Standard AS2243.4 Section 8 provides guidance for disposal of radioactive waste. Disposal shall be completed by suitably licenced contractors.

Where more than tracer quantities of unsealed radioactive substances are in constant use in laboratories, discharge authorizations for solid, airborne and liquid effluents shall be those agreed by the appropriate regulatory authorities.

5.4.10. CLEANING

Suitable storage space shall be provided reserved for radioisotope laboratories on advice from ARPANSA.

5.4.11. PERSONAL PROTECTIVE EQUIPMENT

Wrap-over type laboratory coasts with fastenings using hook and loop fastening fabric should be provided, coats to be colour identified for radioisotope work. Laboratory to be dedicated to radioisotope work only. Additional PPE may be provided by the university once proposed substances to be store are identified.

5.4.12. FITTINGS AND FINISHES

Fittings and finished to be chosen such that they can be readily cleaned for decontamination.

Seamless PVC flooring is recommended. Joints are to be sealed and made waterproof, located away from contamination sources such as sinks and under-edges of benches. Floor penetrations to be minimised where possible.

Walls to be washable high-gloss or semi-gloss paint, reasonable free of exposed electrical conduits and water/gas pipework.

Benchtops to be smooth, waterproof and chemical resistant as well as easy to clean such as melamine, seamless vinyl, cast epoxy resin or stainless steel. Flushing sink and handbasin to be provided (knee/foot operated or automatic actuator) for disposal of aqueous liquid waste. Eyewash to be provided at handbasin to assist decontamination of personnel if required. Refer Section 5.4.2.

6. HAZARDOUS AREA ZONING

Australian Standard AS/NZS60079.10.1:2009 Explosive Atmospheres – Classification of areas – Explosive gas atmospheres is the standard for zone classifications within laboratory and storage areas. The hazardous zone classification is dependent on the potential for flammable gas or vapours to be contained or released. The standard is an adaptation of ICE60079.10.1, Ed.1.0 (2008) and supersedes previous Australian Standards including AS2430.3.3 and AS2430.3.6.

Hazardous zone classifications comprise: -

- Zone 0: An area in which an explosive gas atmosphere is present continuously for long periods or frequently.
- Zone 1: An area in which an explosive gas atmosphere is likely to occur in normal operation occasionally.
- Zone 2: An area in which an explosive gas atmosphere is not likely to occur in normal operation but, if it does occur, it will exist for short periods only.
- Non-Hazardous (NH): An area in which an explosive gas atmosphere is not expected to be present in quantities to require special precautions for the construction, installation or use of equipment.

AS/NZS 60079.10.10 Appendix ZA provides example hazardous area classifications. The example classifications have been utilised for the preliminary assessment. Detailed hazardous zoning assessment to be completed by others.

6.1 LABORATORY STORAGE

It is understood that generally the laboratory areas are proposed to store flammable dangerous goods. In accordance with AS/NZS 60079.10.1, 0.3m above the laboratories finished floor level is to be classified as Zone 2, refer Figure 6 for hazardous area zoning for a typical laboratory.

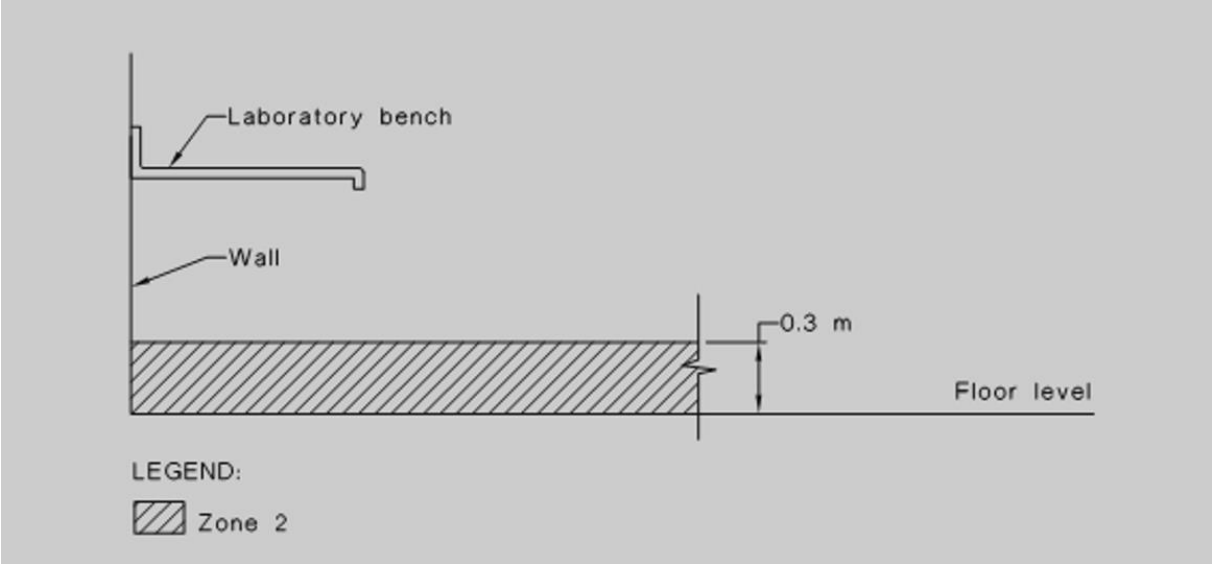

Figure 6 - Laboratory Hazardous Zoning (adopted from AS/NZS 60079.10.1, Figure ZA.47)

6.2 BULK CHEMICAL STORAGE HAZARDOUS ZONING

AS/NZS 60079.10.1 provides example hazardous zoning classifications for Package (Bulk) Storage areas. Table 9 provides an overview of the example hazardous zoning classifications for bulk package storage areas. The zones presented within this table assume all areas are well-ventilated and in accordance with AS1668.2.

Hazardous Zone	Classification Area	
	Vertical	**Horizontal**
Areas used for packaging and filling		
Zone 1	Ground level to 1.5m above the fill opening	3m in all directions from fill opening
Zone 2	Ground level to 1.5m above fill or vent opening	8m in all directions from fill or vent opening
Where packages are opened occasionally for decanting, sampling or testing		
Zone 1	Ground level to 1m above the top of package	3m in all directions
Zone 2	Ground level to 1.5m above the top of package	5m in all directions
Where packages remain closed and exceed AS1940 Minor Storage quantities		
Zone 2	Ground level to 1m above the top of package	3m in all directions
Storage cabinets as defined by AS1940		
Zone 1	Interior of cabinet	
Zone 2	Ground level to 1m above the top of the cabinet and vent (if provided)	3m in all directions
Minor storage areas, in accordance with AS1940, where packages remain closed		
Zone 2	0.3m from packages or allotted storage area.	
NH	All other areas	

Table 9 - Example Hazardous Zoning Classifications for Bulk Storage Areas in accordance with AS/NZS 60079.10.1.

The example hazardous zones presented in Table 9 are defined for the areas surrounding the stored package. The zoning classification area for packaging located adjacent a door opening shall extend beyond the door opening area.

The hazardous zoning and clearance requirements of gas storage is dependent on the type of gas and the volume of the storage cylinder.

6.3 FLAMMABLE GOODS STORE

The hazardous area zone for the Flammable goods store extends from the fire door, sump, vent, etc. to any ignition source is to comply with AS/NZS 60079.10.1.

7. PROPOSED DANGEROUS GOODS STORAGE

7.1 PRELIMINARY DANGEROUS GOODS QUANTITIES

Preliminary dangerous goods quantities were based on a compilation of chemical inventories for each lab based on existing usage through the engineering precinct. Refer to excel document 14119-007 Chemical Inventory and Summation provided by Lucid.

This document provides a full list of dangerous goods classes, quantities and locations of existing dangerous goods expected to be moved to the proposed new development. This advised the preliminary dangerous goods quantities as proposed in Appendix A.

7.2 REFINED DANGEROUS GOODS QUANTITIES

The next iteration of dangerous goods quantities was based on information provided via the user group and University hazardous materials specialists. It was advised that the bulk store for J03 would become one of three hubs for storage and handling of dangerous goods within the precinct. Lucid has been provided with a goods register that outlines the total quantities of classes of each dangerous goods class to be stored within the precinct. This advice indicated that approximately one third of the total dangerous goods quantities is intended to be stored in the proposed new J03 bulk store.

For the refined dangerous goods quantities, refer to 14119-013 for Revised Chemical Inventory & Summation in Appendix D of this report. This document provides revised total quantities adopted in this report.

7.3 BULK STORAGE ARRANGEMENT

Bulk Storage of dangerous goods is proposed to be located within the Level 1 loading dock with direct access at ground level. The final bulk storage area has been developed with the User Group to ensure the room arrangements accommodate the requirements of the user groups and comply with Australian Standards. Figure 7 presents the preferred loading dock option as of 7th November 2018.

Based on preliminary calculations of Dangerous Goods storage quantities and in accordance with AS2243.10 and AS1940, the Architectural arrangement has provided dedicated Dangerous Goods stores to accommodate the proposed Dangerous Goods storage quantities.

The proposed room allocations comprise: -

- Decant Class 3 Room 111 - (approx. 20m^2) AS 1940
- DG Store Mixed Waste Room 110 - (approx. 22m^2) to AS 2243.2
- DG Store Mixed Room 112 – (approx. 18m^2) containing Class 4 Flammable Solids and Class 6 Toxic Substances to AS 2243.10
- DG Store Class 3 Room 113 – (approx. 22m^2) to AS 1940
- DG Store Class 5 Room 115 – (approx. 20m^2) to AS 2243.10 (*It was noted that this could in future become a Class 6 store, University of Sydney CIS to confirm, and requirements can be reviewed.)*
- DG Store Class 8 Room 116– (approx. 20m$^{2)}$ to AS 2243.10
- Radioactive Store 114 – (approx. 10m^2) to AS 2243.4
- Dispensary 120A within Bulk store (general consumables only)
- Dewar store room 117 to AS1894
- Flammable Gases Room 130 Class 2.1 Store to AS 4332 & AS 2243.10
- Toxic Gases Room 131 Class 2.3 Store AS 4332 & AS 2243.10
- Inert Gases Room 132 Class 2.2 & Class 2.2(5.1) Store AS to 4332 & AS 2243.10
- Oxidising Gases 133 (Sub-risk 5.1) Store to AS2243.10, & AS4332

At this point there is no dedicated de-boxing area within the current building arrangement. This is anticipated to be resolved in the dangerous goods handling brief to be provided by Cox Architecture.

Room arrangements have been coordinated with the technical design team and User Group representatives to ensure laboratory requirements are satisfied. The Level 1 room arrangements shall provide consistent provisions for the storage chemical dangerous goods.

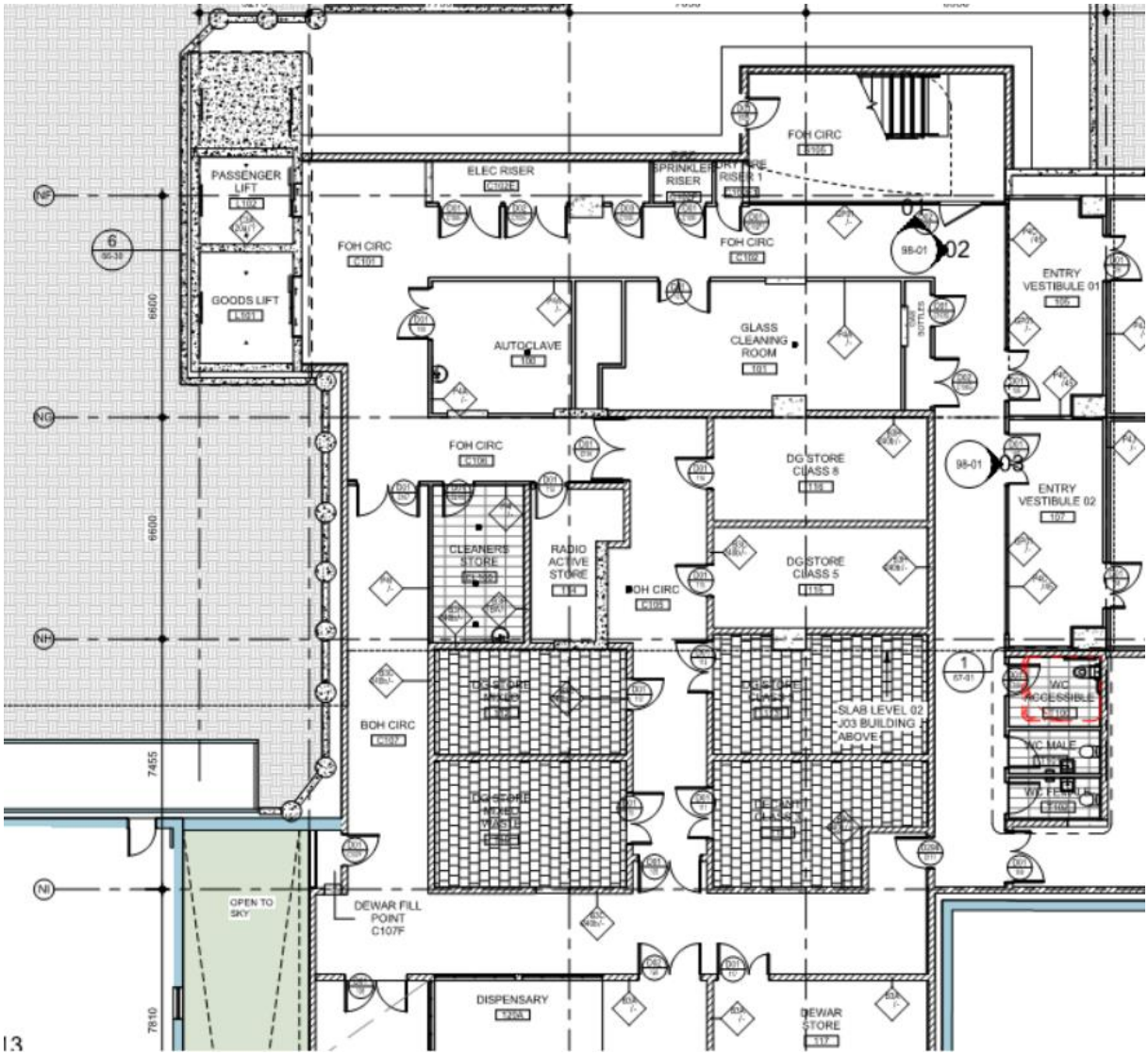

Figure 7 – Level 01 Bulk Dangerous Goods Store, Cox 70% Design Documentation, with Open Void, external VIE storage and internal Gas Storage (COX Architecture, K33-COX-ARC-DRG-21-01(O)).

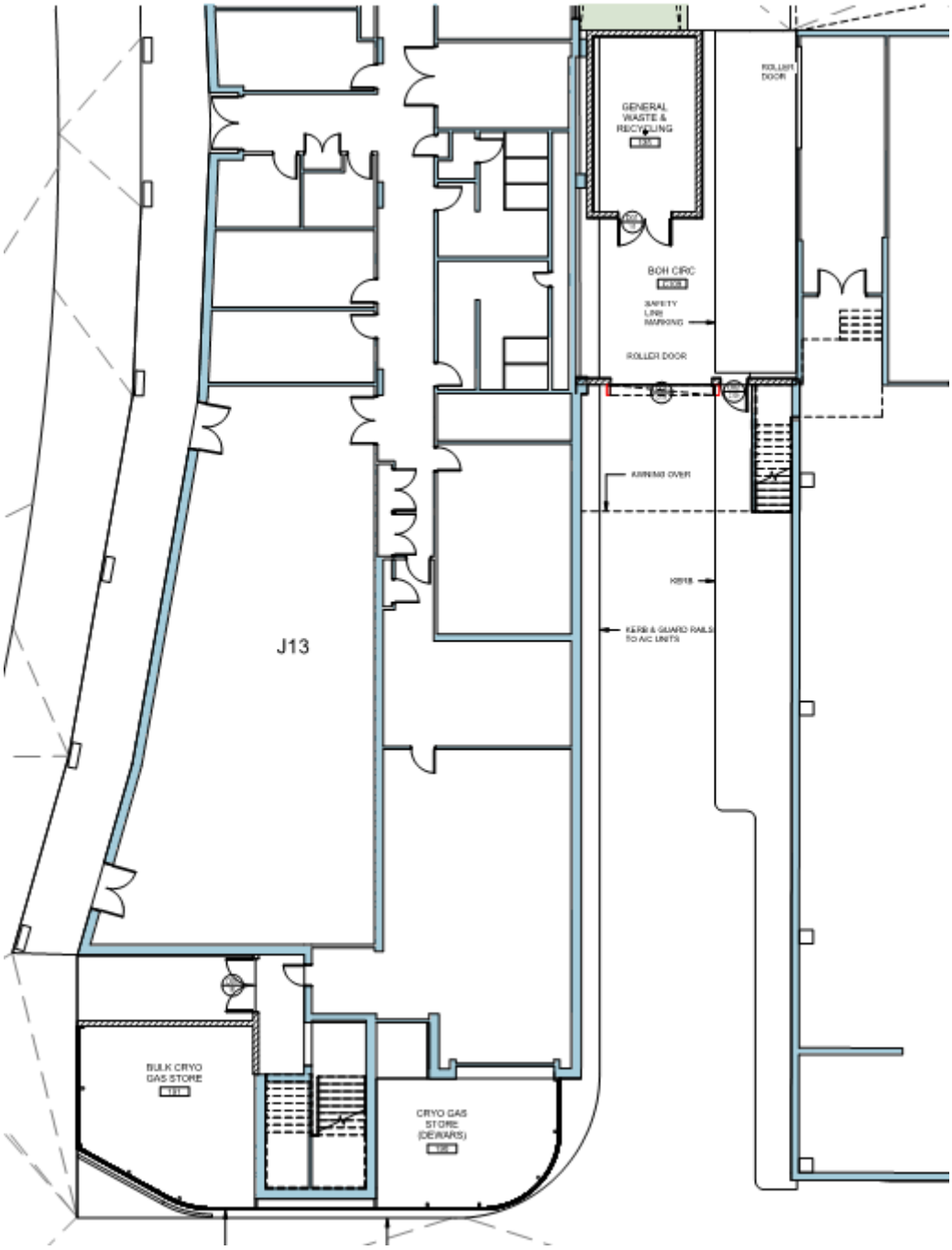

Figure 8: External Cryogenic gas stores, (COX Architecture, K33-COX-ARC-DRG-21-00(M)).

7.4 INTERMEDIATE STORAGE

Intermediate storage the temporary storage of dangerous goods before use in a laboratory. Shelves, laboratory benches, laboratory stores and the like may be used for intermediate storage. AS 2243.10 defines allowable limits (in addition to bulk storage and dedicated cabinets) for laboratory storage based on room and package size. The ETP Stage 1 project proposes multiple types, quantities and usage of dangerous goods.

Australian Standard AS2243.10 outlines that all chemicals should be returned to their primary storage (i.e. dedicated cabinet or bulk store) to realise an acceptable level of safety for laboratory users and other personnel. Therefore, the laboratory total dangerous goods storage quantities shall be based on the dedicated cabinet storage limitations.

7.5 DEDICATED CHEMICAL CABINETS

Dedicated chemical cabinets are the recommended storage method for in-laboratory use of dangerous goods. Chemical cabinet types and locations will be based on spatial and compatibility requirements defined in AS 2243.10 and presented in Section 5.2.3 of this report. Detailed design and final type and location of fixed furniture and equipment is to be guided by the Goods Handling Brief and Cox documentation, based on user group engagement and spatial requirements.

Figure 9: Example 30 L Flammable Liquids Storage Cabinet (Pratt Safety Systems)

7.6 GAS STORAGE OUTSIDE OF LOADING DOCK

The storage and handling of gases is to be in accordance with AS 4332. The building is proposed to contain minor stores only as per Cox documentation.

Lucid has provided advice on gas cylinder storage within the loading dock only. Storage on all other levels has been guided by Hoslab. Hoslab to confirm type and quantity of gas cylinders throughout proposed building.

8. RISK ANALYSIS AND HAZARD ANALYSIS

8.1 GENERAL

Australian Standards AS2243.10 and AS4332 are considered to provide the best practice design requirements for the storage and handling of chemical and gaseous dangerous goods within a laboratory environment. When the dangerous goods storage and handling requirements are provided in accordance design requirements presented in these Australian Standards is considered that an acceptable level of risk to occupants will be realised. However, the prescriptive requirements of these standards may not capture the unique risks and hazards presented by site specific building arrangements and handling operations, as well as the increased risk from deviating from AS 2243.10 with AS 1940 for increased storage quantities of Flammable Liquids.

8.2 PRELIMINARY AND FINAL HAZARD ANALYSIS

CETEC Professional Scientific Solutions' report entitled "Preliminary Hazard Analysis of the Proposed New Engineering Precinct Building Following SEPP 33 Protocols' dated 30 November 2017 presents the hazards and risks associated with the proposed development of Building J03. The report defines the development as a '*potentially offensive industry,*' on the basis that the proposed development is expected to exceed allowable vehicle movements and allowable volumes kept on site defined within SEPP 33. In accordance with SEPP3 requirements and The Department of Planning's HIPAP No. 6, a Preliminary Hazard Analysis for the pre-approval phase has been undertaken.

The hazard analysis to be undertaken in the Post-approval phase is the Final Hazard Analysis as shown in Figure 10.

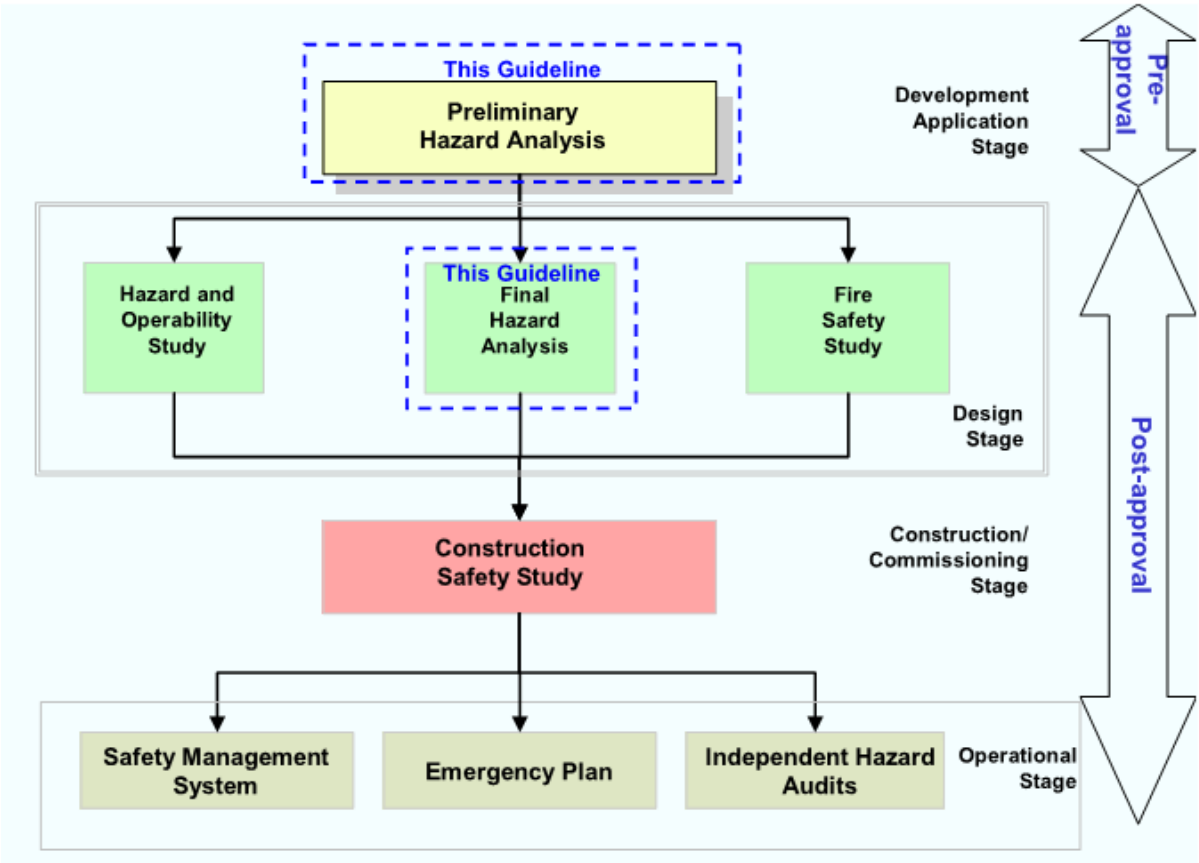

Figure 10: The Hazards-Related Assessment Process (Figure 1, HIPAP No. 6)

8.3 IDENTIFYING HAZARDS

Risk identification involves establishing a detailed register of hazards and the associated risks throughout a site that are introduced as a result of the inherent risks of storing dangerous goods. A hazard is defined as anything that may cause harm, and risk is the chance that the hazard will result in harm.

8.4 ASSESSING, CALCULATING, AND PRIORITISING HAZARDS

To assign priority to each hazard, the risk must be assessed. Two aspects are considered when assessing risk, and these are the likelihood of exposure, i.e. how often the hazard likely to occur, and the potential consequence, i.e. the degree of severity of the injury that may result. These two aspects are quantified using the indicators shown in Figure 11: The University of Sydney Risk Matrix.

			Potential Consequences				
			L6	L5	L4	L3	L2
			Minor injuries or discomfort. No medical treatment or measureable physical effects.	Injuries or illness requiring medical treatment. Temporary impairment.	Injuries or illness requiring hospital admission.	Injury or illness resulting in permanent impairment.	Fatality
			Not Significant	**Minor**	**Moderate**	**Major**	**Severe**
Likelihood	Expected to occur regularly under normal circumstances	**Almost Certain**	**Medium**	**High**	**Very High**	**Very High**	**Very High**
	Expected to occur at some time	**Likely**	**Medium**	**High**	**High**	**Very High**	**Very High**
	May occur at some time	**Possible**	**Low**	**Medium**	**High**	**High**	**Very High**
	Not likely to occur in normal circumstances	**Unlikely**	**Low**	**Low**	**Medium**	**Medium**	**High**
	Could happen, but probably never will	**Rare**	**Low**	**Low**	**Low**	**Low**	**Medium**

Figure 11: The University of Sydney Risk Matrix

8.5 CONTROLLING HAZARDS

Suitable risk control measures can be established once hazards have been identified and assigned a risk level and priority. The selected control measure should be applied as soon as practicable and assigned to the party best suited to control the hazard. Chapter 8 of the NSW Storage and Handling of Dangerous Goods Code of Practice provides more information on determining control measures and applying the hierarchy of control, this will be incorporated in the detailed assessment.

8.6 RISK MANAGEMENT

The risk and hazard analysis shall be documented in accordance with the University of Sydney Risk Assessment Register. The risk assessment form attached in Appendix C documents the University of Sydney policy, provides direction hazard evaluations and documents controls for assessing residual risk. Serious or ongoing hazards should be reported using RiskWare to ensure that appropriate corrective actions are tracked and completed. Risk assessments should be reviewed and updated regularly for identifying new risks, introduction of new dangerous goods, incident occurrence, dangerous goods relocations or any other similar event.

Dangerous goods storage in volumes that exceed quantities defined by the Storage and Handling of Dangerous Goods Code of Practice require notification to the relevant authority in accordance with legislation requirements.

Material Safety Data Sheet (MSDS) shall be located within the vicinity of dangerous goods storage for applying appropriate caution and enabling corrective actions for response to near miss or incident.

The SEPP 33 report provides preliminary hazard and risk assessments for the proposed new laboratory. The assessments were completed as part of the preliminary hazard analysis nominated in Figure 10.

The hazard analysis presented in the SEPP 33 report stipulates that the storage and handling of dangerous goods within the new laboratory building shall be in accordance with the Australian Standard AS2243.10. Material specific design standards are also included (i.e. AS1940 for Class 3 Flammable Liquids).

Building activity	Associated chemical and/or hazard class	Comments on requirements and storage restrictions
Natural gas: supply, storage & handling	Natural gas (a Class 2.1 gas)	If required for a laboratory application, natural gas will be reticulated from the gas supplier's lines into the building and distributed to the required location. Pipe dimensions and pressures as per applicable Australian Standards.
Compressed gases in laboratory spaces: supply, storage & handling	Classes 2.1, 2.2, and 2.3 (note: Class 2.2 includes gases with sub. class 5.1)	Storage and handling on site will be dictated by the requirements of AS 2243.10 and AS 4332 (most requirements are in AS 4332).
Flammable liquids: supply, storage & handling	Class 3 liquids	Storage and handling on site will be dictated by the requirements of AS 2243.10 and AS 1940.
Class 4 substances: supply, storage & handling	Class 4 substances comprise: 4.1: Flammable solids 4.2: Substances liable to spontaneous combustion 4.3: Substances which emit flammable gases when in contact with water.	Storage and handling on site will be dictated by the requirements of AS 2243.10 and AS 5026. Note: Class 4.1, 4.2 and 4.3 form three very distinct classes and should be considered individually. The GHS classifies them separately.
Oxidising substances: supply, storage & handling	Class 5.1 substances	Storage and handling on site will be dictated by the requirements of AS 2243.10 and AS 4326.
Organic peroxides: supply, storage & handling	Class 5.2 substances	Storage and handling on site will be dictated by the requirements of AS 2243.10 and AS 2714.
Toxic substances: supply, storage & handling	Class 6.1 substances	Storage and handling on site will be dictated by the requirements of AS 2243.10 and AS 4452, and with various state and federal regulations.
Radioactive materials: supply, storage & handling	Class 7 substances	Storage and handling on site will be dictated by the requirements of Australian Radiation Protection and Nuclear Safety Agency, with consideration of AS 2243.4.

Building activity	Associated chemical and/or hazard class	Comments on requirements and storage restrictions
Corrosive substances: supply, storage & handling	Class 8 substances	Storage and handling on site will be dictated by the requirements of AS 2243.10 and AS 3780.
Miscellaneous dangerous goods: supply, storage & handling	Class 9 substances	Storage and handling on site will be dictated by the requirements of AS 2243.10 and AS 4681.
Cryogenic liquids: supply, storage and handling.	Examples: liquid helium, liquid nitrogen.	Storage and handling on site will be dictated by the requirements of AS2243.10 and AS1894. Flammable or toxic cryogenic liquids will require special provisions.

Table 10 – CETEC, SEPP 33 Report Preliminary Hazard Analysis.

The storage and handling requirements presented in this report generally align with the SEPP 33 preliminary hazard analysis. It is not proposed to update or modify the preliminary hazard analysis as part of further reporting.

The preliminary risk assessment completed as part of the SEPP 33 is separated into six independent categories, comprising: -

- Gas Reticulation and Storage: flammable and toxic.
- Cryogenic Liquids Usage /Storage.
- Chemical Storage and Laboratory Areas / Usage (Classes 3 to 9, excluding 6.2 and 7, including sub. Classes).
- Storage or usage of Class 7.
- Transportation of Dangerous Goods to and from the building.
- Transportation of Dangerous Goods within the building.

The outcomes presented from the final hazard assessment to provide further generic design guidance for probable risk events. The outcomes from this assessment have been provided in Appendix E. This is intended to be implemented in addition to the risk management controls proposed by the SEPP 33 report provided by CETEC.

As Class 7 radioactive dangerous goods were not previously expected to be stored and utilised within the proposed new laboratory building, further risk assessment under this sub-category has been provided.

9. SUMMARY OF OUTCOMES

This report has been developed to provide an overview of the proposed strategy for the storage and handling of dangerous goods within the new J03 laboratory building.

Section 5 of this report provides an overview of the Australian Standard requirements for the storage of gaseous and chemical dangerous goods in accordance with AS4332 and AS2243.10 respectively. The bulk chemical storage quantities have been provided by the senior project manager for the University of Sydney's HazMat project. Table 10 provides a summary of the proposed aggregate storage quantities and storage areas allocations.

Storage Location	Storage Type	Dangerous Goods Class	Proposed Aggregate Storage (L/kg)	Room/Store Allocation	Proposed Floor Area/Clearance
Level 1 Loading Dock	Bulk	2	2,000 L 2.1 -500 L max 2.2 -2,000 L max 2.3 -50 L max	Flammable gases store, toxic gas store & Inert Gas store	Class 2.1: Room Floor Area 17m^2 Class 2.2: Room Floor Area 12m^2 Class 2.3: Room Floor Area 5m^2
		3	1,500	DG Store Class 3	Room Floor Area 25m^2
		4.1	12.80	DG Store Mixed	Room Floor Area 25m^2
		4.2	10.98		
		4.3	12.34		
		5.1	377.52	DG Store Class 5	Room Floor Area 20m^2
		5.2	0.30		
		6.1	214.20	DG Store Mixed	Room Floor Area 25m^2
		7	**Not received, assumed below licensable threshold**	Radioactive Store	Room Floor Area 9m^2
		8	606.78	DG Store Class 8	Room Floor Area 20m^2
		9	65.08	DG Store Mixed	Room Floor Area 25m^2
Laboratories	Dedicated Storage Cabinets	2	Nil Storage, in-use only	N/A	Gas storage cylinders to have capacity not greater than 70 L within labs.
		3	Minimum 10m radial clearance	Cabinet A (Dedicated)	

Storage Location	Storage Type	Dangerous Goods Class	Proposed Aggregate Storage (L/kg)	Room/Store Allocation	Proposed Floor Area/Clearance
		4.1	from other dedicated storage cabinets with an aggregate maximum storage volume of 250L/kg. No cabinet to be located within 3m of required exit.	Cabinet B (Dedicated)	
		4.2		Cabinet B (Dedicated) Segregated from Classes 3 & 5.1	
		4.3		Cabinet B (Dedicated) Segregated from Classes 3, 5.1 & Water	
		5.1		Cabinet C (Dedicated, noting incompatibilities documented in MSDS)	
		5.2		Cabinet C (Dedicated)	
		6.1		Cabinet D	
		8		Cabinet E (Dedicated) Segregated from Class 4.3, 3, 5.1 & Other incompatible substances	
		9		Cabinet D	

Table 11 - Summary of Proposed Dangerous Goods Storage Quantities and Room Allocations.

Limitations of the storage quantities presented in Table 11 comprise: -

- Storage quantities presented for Class 2 dangerous goods are based on the maximum storage quantities permitted for a minor store. Additional gas storage quantities may be permitted if the separation distances presented in Table 4 of this report.
- Maximum storage quantity of Class 8 Corrosives has been calculated in accordance with AS2243.10. Additional storage volume may be accommodated when calculated in accordance with AS3780.
- Dedicated cabinet storage quantities presented are the maximum permitted for each classification. The maximum aggregated storage volume of all dangerous goods within a dedicated cabinet or collection of cabinets shall not exceed 250L/kg.
- No allowance has been made for the storage of dangerous goods on shelves with the laboratories.

Calculation of maximum storage quantities for Class 3 and Class 8 dangerous goods requires consideration of the proposed storage areas geometric constraints and services provisions. Coordination with the architectural and engineering design team and further design development is required to enable further storage quantity assessment.

Table 12 provides an overview of the construction and firefighting service requirements for the different types of dangerous goods storage areas proposed for the new J03 building.

Store Type	Fire Resistance Levels (FRL's)			Ventilation	Fire Fighting Equipment (FFE)
	Walls	Floor/Roof	Doors		
Gas Store	240/240/240	240/240/240 or 120/120/120	Nil Specified	High and Low-level ventilation. Natural or Mechanical ventilation acceptable	For <1,000 L Fire Hose Reel coverage. For 1,000-2,000 L Fire Hose Reel coverage. Dry Chemical Portable Fire Extinguisher
Dedicated Chemical Cabinet	Chemical storage cabinet construction to be in accordance with AS 2243.10			Ventilation only required following detailed risk assessment of	Nil Specific, building FFE to be utilised.
Bulk Chemical Store	240/240/240	180/180/180	-/120/30	Natural or Mechanical ventilation is acceptable. Independent ventilation systems are required for each dangerous goods store. Mechanical ventilation systems shall provide 0.3m^3/min per square meter of room floor area.	Automatic fire extinguishing or detection system. Dry Chemical Portable Fire Extinguisher
Radioactive Substances Store	240/240/240	180/180/180	-/120/30	Advice required from ARPANSA. Low-level laboratories may require a recirculating fume	Nil Specific, building FFE to be utilised.

				cupboard in accordance with AS2982.1 & AS/NZS 2243.8.	

Table 12 - Store Construction Requirements.

APPENDIX A - ENGINEERING CALCULATION PRELIMINARY BULK STORAGE QUANTITY

PROJECT NUMBER:	14119	**REVISION:**	A
PROJECT TITLE:	University of Sydney – ETP Stage 1 Laboratory	**CALC NO:**	DG001
		DATE:	06 FEB 18

CALCULATION TITLE:	Preliminary Bulk Storage Quantity

CALCULATION DESCRIPTION:	This calculation has been completed to determine the indicative bulk storage quantities for the new J03 Laboratory forming part of the ETP Stage 1 works. These storage quantities will be used to determine spatial requirements for Level 1 store. The Dangerous Goods storage within the proposed new J03 Laboratory building is required to comply with the upper limits presented in AS2243.10:2004. The following calculation utilises the current storage volumes to proportion the aggregated maximum storage volume. Details for separation and room storage requirements are not presented in this calculation.

DESIGN BASIS & REFERENCES:	This calculation has been completed using the University User Group supplied inventory information. Australian Standard AS 2243.10:2004 – Safety in Laboratories – Part 10: Storage of Chemicals, Table 2 – Maximum Storage Quantities. Extract provided in Appendix A.

	NAME	**POSITION**	**SIGNATURE**	**DATE**
CALCULATED BY:	Anderson Claxton	Fire and Life Safety Engineer		06 February 2018
VERIFIED BY:	Huon Payne	Mechanical Engineer		06 February 2018

FIND

Maximum Bulk Storage of Class 3, 4, 5, 6, 8 and 9 Dangerous Goods.

GIVEN/KNOWN

- Maximum aggregated quantity in accordance with AS2243.10:2004.
- Current storage volumes from building where operations will be relocated from and are user defined. Minor revisions to the storage quantities may be accommodated in the storage quantities presented in this assessment.

ASSUMPTIONS/QUALIFICATIONS

- J07A and J07B external bulk storage inventory has been excluded from the assessment in accordance with the Laing O'Rourke – Scope of Works – Engineering Transformation Project – Stage 1 – 20 Dec 17 – For Distribution, Section 1.16.
- Storage quantities do not include Laboratory shelf or chemical cabinet storage. Separate calculations to be completed for these storage areas.
- It is understood that Class 1 – Explosives and Class 7 – Radioactive Dangerous Goods will not be stored within the new Laboratory building. These may be utilised on a case-by-case basis with storage and handling dictated by a standalone, bespoke risk assessment.
- Class 2 – Gasses are understood to be required for the new laboratory building, however, bulk storage will be external to the level 1 bulk store and therefore separate from this assessment.

ANALYSIS

Table 13 provides an overview of the current J01 Bulk Storage quantities. It is understood that these storage quantities may be different for the new J03 Laboratory Building. These have been used as a baseline for proportioning storage only.

Dangerous Goods Classification	**Storage Volume kg/L**		
	PG I	**PG II**	**PG III**
Class 3 – Flammable Liquids	13.95	702.41	72.73
Class 4.1 – Flammable Solids	0	2.55	2.76
Class 4.2 – Liable to spontaneous combustion	-	4.55	-
Class 4.3 – Emits flammable gasses when in contact with water	0.31	-	-
Class 5.1 – Oxidising Substances	4.60	32.90	47.04
Class 5.2 – Organic Peroxides	-	0.13	-
Class 6.1 – Toxic Substances	1.22	23.50	44.95
Class 8 – Corrosives	1.35	170.69	58.23
Class 9 – Miscellaneous	-	1.80	25.16

Table 13 - Summary of J01 Bulk Chemical Storage

From the information presented in Table 13 a percentage total storage was calculated for each class. The percentage total storage for Packing Group I was calculated using the following equations: -

$$Percentage\ Total\ Storage\ of\ Class\ (n) = \frac{V_{PGI,Class\ n}}{\sum(V_{PGI,Class\ 3}, V_{PGI,Class\ 4} \dots V_{PGI,Class\ 9})}$$

As the aggregated maximum storage capacities of Packing Groups II and III are combined in accordance with AS2243.10:2004, the percentage maximum storage capacities were combined and calculated using the following equation: -

$$Percentage\ Total\ Storage\ of\ Class\ (n) = \frac{V_{PGII,Class\ n} + V_{PGIII,Class\ n}}{\sum(V_{PGII,Class\ 3}, V_{PGIII,Class\ 3} \dots V_{PGII,Class\ 9}, V_{PGIII,Class\ 9})}$$

Where V is the storage volume presented in Table 13. Percentage total storage volumes are presented in Table 14 .

Dangerous Goods Classification	**Percentage Total Storage**		
	PG I	**PG II**	**PG III**
Class 3 – Flammable Liquids	65.10%	65.17%	
Class 4.1 – Flammable Solids	0.00%	0.45%	
Class 4.2 – Liable to spontaneous combustion	0.00%	0.38%	
Class 4.3 – Emits flammable gasses when in contact with water	1.44%	0.00%	
Class 5.1 – Oxidising Substances	21.47%	6.72%	
Class 5.2 – Organic Peroxides	0.00%	0.01%	
Class 6.1 – Toxic Substances	5.69%	5.76%	
Class 8 – Corrosives	6.30%	19.25%	
Class 9 – Miscellaneous	0.00%	2.27%	

Table 14 - Summary of the Percent Total Storage for Each Dangerous Good on a Packing Group Basis

Utilising the maximum aggregate storage quantities as presented in AS2243.10:2004, Table 2 (refer Appendix B) and the percentage total storage, the preliminary bulk quantities were calculated and are presented in Table 15: -

DG Classification	**3**		**4.1, 4.2, 4.3, 5.1, 5.2**		**6.1, 8, 9**		**Aggregate**	
Calculated Storage	**L**	**Pass /Fail**	**kg/L**	**Pass /Fail**	**kg/L**	**Pass /Fail**	**kg/L**	**Pass /Fail**
PG I	325.52	Fail	114.51	Pass	59.97	Pass	500	Pass
PG II & PG III	1303.43	Fail	151.19	Pass	545.38	Pass	2000	Pass

Table 15 - Calculated Maximum Bulk Storage Capacity

From the information presented in Table 15, the calculated maximum storage of Class 3 Flammable Liquids exceeds the maximum permitted by AS2243.10:2004.

To optimise the bulk storage capacity, the storage of Class 3 Flammable Liquids was capped at the maximum permitted by AS2243.10:2004. The remaining available Dangerous Goods storage was proportioned between the remaining two storage groups using the inventory values as a baseline. Results from the optimised calculation are presented in

Dangerous Goods Classification	**3**		**4.1, 4.2, 4.3, 5.1, 5.2**		**6.1, 8, 9**		**Aggregate**	
Optimised Storage	**L**	**Pass /Fail**	**kg/L**	**Pass /Fail**	**kg/L**	**Pass /Fail**	**kg/L**	**Pass /Fail**
PG I	200.00	Pass	196.89	Pass	103.11	Pass	500	Pass
PG II & PG III	1000.00	Pass	217.05	Pass	782.95	Pass	2000	Pass

Table 16 - Optimised Bulk Storage Quantities

SUMMARY

To enable preparation of preliminary room arrangements, it is proposed that the storage quantities presented in Table 17 are utilised.

Dangerous Goods Classification	**Optimised Bulk Storage Volume kg/L**			**Total Aggregate Storage kg/L**
	PG I	**PG II**	**PG III**	
Class 3 – Flammable Liquids	200.00	906.18	93.82	1200.00
Class 4.1 – Flammable Solids	0.00	6.16	6.64	12.80
Class 4.2 – Liable to spontaneous combustion	0.00	10.98	0.00	10.98
Class 4.3 – Emits flammable gasses when in contact with water	12.34	0.00	0.00	12.34
Class 5.1 – Oxidising Substances	184.55	79.41	113.56	377.52
Class 5.2 – Organic Peroxides	0.00	0.30	0.00	0.30
Class 6.1 – Toxic Substances	48.95	56.73	108.52	214.20
Class 8 – Corrosives	54.16	412.05	140.56	606.78
Class 9 – Miscellaneous	0.00	4.35	60.74	65.08

Table 17 - Summary of Preliminary Bulk Storage Quantities

Details for separation and room storage requirements are not presented in this calculation.

APPENDIX B – AS2243.10: 2004 – Table 3 – Maximum Storage Quantities

TABLE 2

MAXIMUM STORAGE QUANTITIES (Note 1)

kilograms for solids and aerosols, litres for liquids

Type of goods	PG I	PG II and PG III	Other
Goods too dangerous to be transported	Not applicable (Note 3)	Not applicable (Note 3)	Risk assessment required
Class 2 aerosols (UN 1950)	Not applicable (Note 3)	100	Not applicable
Class 3 primary or subsidiary risk (except UN 3256)	200 but no more than 100 in any one cabinet	1000	Not applicable
Combustible liquids C1/C2	Not applicable (Note 3)	Not applicable (Note 3)	1000
Class 4.1 Class 4.2 Class 4.3 Class 5.1 Class 5.2	200 aggregate (includes Class 4.1 UN 3221 to 3240, Class 5.2 UN 3101, 3102 and 3111 to 3120 as well)	1000 aggregate No more than 50 of Class 5.2 in any one cabinet	Not applicable
Class 6.1 Class 8 Class 9 (except elevated temperature goods UN 3257 and 3258 and dry ice UN 1845)	500 aggregate No more than 100 of Classes 6.1 and 8 in any one cabinet	1000 aggregate Class 6.1 and Class 8 liquids in breakable containers of no greater than 1 L capacity, liquids in non-breakable containers of no greater than 5 L capacity, solids in packages of no greater than 10 kg and non-combustible articles such as batteries may be stored outside cabinets.	Not applicable
UN 3256 to 3258 UN 1845	Not applicable (Note 3)	See Note 4	Not applicable
Hazardous substances not otherwise classified as dangerous goods	Not applicable (Note 3)	Not applicable (Note 3)	2000 for hazardous substances not otherwise classified as dangerous goods
Aggregate maxima	500	2000	2000 (Note 2)

NOTES:

1 For the purpose of risk management, some dangerous goods of Class 4.1 and 5.2 have been added to Packing Group I, varying from the groupings used for ADG Code and MSDS purposes.

2 Where other chemicals for laboratory use are stored, they shall be excluded from the total amount unless they are incompatible with other store contents.

3 No goods are assigned to this Packing Group.

4 A risk assessment is required to determine the storage conditions, storage quantities and whether the goods can be stored with other goods. For dry ice (UN 1845), particular account shall be taken of the room size, room temperature and ventilation rates when assessing the quantity to be stored.

APPENDIX C - THE UNIVERSITY OF SYDNEY RISK ASSESSMENT FORM

THE UNIVERSITY OF SYDNEY

RISK ASSESSMENT FORM

Use this form to assist you to complete risk assessments for hazardous activities and processes. Any serious or ongoing hazards should be reported via RiskWare to ensure that appropriate corrective actions are tracked and completed.

Faculty/School:		**Initial Issue Date:**
		Next Review Date:
Risk Assessment Reference Number:		
Risk Assessment Name:		
Prepared by:		
Responsible supervisor/s:		

Identify the activity and the location	**Identify who may be at risk** This may include fellow workers, students, visitors, contractors and the public
Activity or process:	**Persons at risk**:
Location:	**Risk assessment team (Who was consulted?):**

List of Legislation, Code of Practice, Australian Standards, Guidance Materials used to determine control measures

Risk Assessment Methodology

Assessing the risk is a brainstorming exercise, which is most effectively carried out in a team environment with the people required to complete the activity or process. Most activities or processes are broken down into a variety of separate tasks. For each task, consider the hazards, the potential harm or negative outcomes and the conditions required for those negative outcomes to occur.

Whenever assessing the health and safety risks associated with a task, always consider the following primary risk factors.

- The **physical activities** required to complete the task e.g. repetitive movement, high force, physical exertion, awkward posture
- The **work environment** e.g. lighting, work layout, traffic, thermal comfort, working in isolation
- The **nature of the hazard itself** e.g. working with chemicals, microorganisms, radiation, machinery, potentially violent clients
- The **individual workers involved**, e.g. level of training, skills, experience, health, age, physical capacity

The information gathered from the **risk assessment** process must be used to develop a **Safe Work Procedure (SWP).**

THE UNIVERSITY OF SYDNEY

RISK ASSESSMENT FORM

Task or scenario	**Hazard/s**	**Associated harm,** e.g. what could go wrong?	**Existing Risk Controls**	**Current risk rating** Use the Risk Matrix	**Any additional controls are required?**[1]	**Residual risk rating** Use the Risk Matrix

[1] Always consider whether or not it is possible to eliminated the hazard or hazardous task altogether. If this is not possible, refer to the hierarchy of risk controls.

THE UNIVERSITY OF SYDNEY

RISK ASSESSMENT FORM

Implementation of Additional Risk Controls				
Additional controls needed	**Resources required**	**Responsible person**	**Date of implementation**	**RiskWare Reference**
Write the Safe Work Procedure (SWP)	Time (approx 1 hour)	Supervisor		N/A
Train workers to complete process in accordance with SWP	Time – supervisor and workers	Supervisor		N/A

List emergency controls for how to deal with fires, spills or exposure to hazardous substances and/or emergency shutdown procedures

REVIEW			
Scheduled review date	**1 year**	**2 years**	**3 years**
Are control measures in place (YES/NO)			
Are controls eliminating or minimizing the risk (YES/NO)			
Are there any new problems with the risk (YES/NO)			
Reviewed by:			
Actual Review date:			

THE UNIVERSITY OF SYDNEY

RISK ASSESSMENT FORM

Risk Matrix.

			Potential Consequences				
			L6	L5	L4	L3	L2
			Minor injuries or discomfort. No medical treatment or measureable physical effects.	Injuries or illness requiring medical treatment. Temporary impairment.	Injuries or illness requiring hospital admission.	Injury or illness resulting in permanent impairment.	Fatality
			Not Significant	Minor	Moderate	Major	Severe
Likelihood	Expected to occur regularly under normal circumstances	Almost Certain	Medium	High	Very High	Very High	Very High
	Expected to occur at some time	Likely	Medium	High	High	Very High	Very High
	May occur at some time	Possible	Low	Medium	High	High	Very High
	Not likely to occur in normal circumstances	Unlikely	Low	Low	Medium	Medium	High
	Could happen, but probably never will	Rare	Low	Low	Low	Low	Medium

Event	Consequence Rating	Likelihood Rating	Overall Risk	Required Mitigating Strategies
Gas Reticulation and Storage: flammable and toxic gases				
Leakage of gas to the atmosphere from reticulated pipelines outside of the building.	Moderate	Unlikely	Moderate	▪ For enclosed areas (i.e. gas stores), design enclosure as per the requirements of AS 4332. ▪ Use fully welded pipework. ▪ Locate over-pressure release valves at appropriate locations to minimise the release of gases into an enclosed location, i.e. vent to atmosphere. ▪ Identify hazard zones (as per AS 60079.10.1) and install appropriate electrical fittings complying with the enclosure's classification, i.e. zone type, Gas Group, Temperature Class. ▪ Install collision bollards to protect the cylinders or piping locations. ▪ Conduct plume modelling to confirm safe dispersion of contaminants.
Flammable gas: Operational error by user resulting in over-pressuring of gas line or accidental dislodging of cylinders, possibly resulting in cylinder valve shearing off or opening and sudden gas release. no ignition	Moderate	Moderate	High	▪ For enclosed areas (i.e. gas stores), design enclosure as per the requirements of AS 4332. ▪ Use fully welded pipework. ▪ Locate over-pressure release valves at appropriate locations to minimise the release of gases into an enclosed location, i.e. vent to atmosphere. ▪ Locate structurally sound cylinder holders within the enclosure with ample space for cylinder movements between cylinder exchanges.
As above, but gas ignites	Catastrophic	Rare	High	As above, but additionally: ▪ Identify hazard zones (as per AS 60079.10.1) and install appropriate electrical fittings complying with the enclosure's classification, i.e. zone type, Gas Group, Temperature Class. ▪ Install gas sensors to monitor for explosive levels of the gas being reticulated, with automatic shut-off valves connected to the gas sensor.

Event	Consequence Rating	Likelihood Rating	Overall Risk	Required Mitigating Strategies
Highly toxic gas: Operational error by user resulting in over-pressuring of gas line or accidental dislodging of cylinders, possibly resulting in cylinder head shearing off and sudden toxic gas release.	Catastrophic	Rare	High	▪ For enclosed areas (i.e. gas stores), design enclosure as per the requirements of AS 4332. ▪ Use fully welded pipework. ▪ Locate over-pressure release valves at appropriate locations to minimise the release of gases into an enclosed location, i.e. vent to atmosphere. ▪ Locate structurally sound cylinder holders within the enclosure with ample space for cylinder movements between cylinder exchanges. ▪ Install specific gas warning sensors that are coupled to the pressure regulator and will shut off the gas supply a specified concentration of the toxic gas.
Flammable gas: Venting of gas (whether intentional or unintentional), resulting in significant release of gas, gas ignites	Major	Rare	High	▪ For enclosed areas (i.e. gas stores), design enclosure as per the requirements of AS 4332. ▪ Use fully welded pipework. ▪ Locate over-pressure release valves at appropriate locations to minimise the release of gases into an enclosed location, i.e. vent to atmosphere. ▪ Locate structurally sound cylinder holders within the enclosure with ample space for cylinder movements between cylinder exchanges. ▪ Identify hazard zones (as per AS 60079.10.1) and install appropriate electrical fittings complying with the enclosure's classification, i.e. zone type, Gas Group, Temperature Class. ▪ Install gas sensors to monitor for explosive levels of the gas being reticulated, with automatic shut-off valves connected to the gas sensor.
All gases: Gas release within laboratories, leading to hazardous oxygen depletion, no ignition	Major	Rare	High	▪ For enclosed areas (i.e. gas stores), design enclosure as per the requirements of AS 4332. ▪ Use fully welded pipework.

Event	Consequence Rating	Likelihood Rating	Overall Risk	Required Mitigating Strategies
				▪ Locate over-pressure release valves at appropriate locations to minimise the release of gases into an enclosed location, i.e. vent to atmosphere. ▪ Install oxygen depletion sensors to monitor for explosive levels of the gas being reticulated, with automatic shut-off valves connected.
Flammable gas: Gas release within laboratories, gas ignites	Catastrophic	Rare	High	▪ For enclosed areas (i.e. gas stores), design enclosure as per the requirements of AS 4332. ▪ Use fully welded pipework. ▪ Locate over-pressure release valves at appropriate locations to minimise the release of gases into an enclosed location, i.e. vent to atmosphere. ▪ Locate structurally sound cylinder holders within the enclosure with ample space for cylinder movements between cylinder exchanges. ▪ Identify hazard zones (as per AS 60079.10.1) and install appropriate electrical fittings complying with the enclosure's classification, i.e. zone type, Gas Group, Temperature Class. ▪ Install gas sensors to monitor for explosive levels of the gas being reticulated, with automatic shut-off valves connected to the gas sensor.
Oxidising gas: Gas release within laboratories, spontaneous ignition of combustible materials	Major	Rare	High	▪ For enclosed areas (i.e. gas stores), design enclosure as per the requirements of AS 4332. ▪ Use fully welded pipework. ▪ Locate over-pressure release valves at appropriate locations to minimise the release of gases into an enclosed location, i.e. vent to atmosphere. Locate structurally sound cylinder holders within the enclosure with ample space for cylinder movements between cylinder exchanges.

Event	Consequence Rating	Likelihood Rating	Overall Risk	Required Mitigating Strategies
				▪ Restrict as far as possible the quantity of any material that may be combustible. ▪ Install oxygen sensors (or specific sensor for oxidising gas or gases) to monitor for elevated levels of the gas being reticulated, with automatic shut-off valves connected to the gas sensor.
Highly toxic gas: Gas release within laboratories, causing death or serious injury	Catastrophic	Rare	High	▪ For enclosed areas (i.e. gas stores), design enclosure as per the requirements of AS 4332. ▪ Use fully welded pipework. ▪ Locate over-pressure release valves at appropriate locations to minimise the release of gases into an enclosed location, i.e. vent to atmosphere. ▪ Locate structurally sound cylinder holders within the enclosure with ample space for cylinder movements between cylinder exchanges. ▪ Install specific gas warning sensors that are coupled to the pressure regulator and will shut off the gas supply a specified concentration of the toxic gas.
Cryogenic Liquid Usage / Storage				
Non-toxic cryogenics: Vessel rupture within indoor setting or sudden loss of containment, resulting in fatality	Catastrophic	Rare	High	▪ Locate vessel as per the requirements of AS 1894. ▪ Ensure pressure release valve is appropriate and working correctly for vessel requirements. ▪ Ensure all separation distances, as per AS 1894, are met. ▪ Direct pressure release valves to areas away from public spaces. Ensure release valve meets separation requirements as per AS 1894.
Cryogenic liquids in general: Spillage of vessel contents within	Moderate	Unlikely	Moderate	▪ For closed vessels which are transporting cryogenic liquids

Event	Consequence Rating	Likelihood Rating	Overall Risk	Required Mitigating Strategies
indoor setting, leading to burns & moderate health effects				internally, ensure dewars with a maximum volume of 250 L are used. ▪ For open vessels, ensure maximum dewar volume is based on risk assessment taking into consideration room volume, fresh air ventilation and volume of cryogenic liquid.
Chemical Storage and Laboratory Areas/ Usage (Classes 3 to 9, excluding 6.2 & 7, including sub. Classes)				
Class 3 or Class 4.3: Accidental spillage or breakage of containers, resulting in fire or explosion with fatality	Catastrophic	Rare	High	▪ Design chemical storage areas as per the requirements of AS 2243.10, incorporating further requirements from AS 1940, i.e. fire separation, ventilation requirements, etc. ▪ Incorporate minimum firefighting requirements as per AS 1940. ▪ Ensure flammable liquids store has containment area that's designed as per the requirements of AS 1940, thus supplying minimum bunding requirements so that all foreseeable spills are contained ▪ For areas where flammable vapours may result, ensure hazard zoning as per the requirements of AS 60079.10.1 are incorporated clearly documenting zone type, Gas Group, Temperature Class. ▪ Ensure that all flammable liquids are suitably stored, even those which are only subsidiary Class 3
All classes, but particularly Class 5.1 and Class 8: Accidental breakages resulting in spillage and mixing of 2 or more incompatible chemicals within chemical storage area. serious injuries	Major	Rare	High	▪ Design chemical storage areas incorporating segregation and separation to minimise unwanted chemical mixing, i.e. Class 3 chemicals to be separated from Class 8 and 6.1. Class 6.1 chemicals to be segregated from Class 8 chemicals. ▪ Ensure that all potential incompatibilities are checked when assigning storage locations, including acids/alkalis, acids/cyanides, hypochlorites/acids and Class 4.3/water.

Event	Consequence Rating	Likelihood Rating	Overall Risk	Required Mitigating Strategies
As above, but with consequences outside of building complaints from personnel in surrounding buildings	Moderate	Rare	Moderate	As above, but additionally: ▪ Ensure exhaust from chemical storage areas exhaust at an appropriate location, ideal locations may require investigation through aermod, ausplume or physical modelling of wind and building infrastructure.
Class 6.1 and Class 8: Accidental spillage or breakage of containers, leads to injuries requiring hospitalisation	Moderate	Unlikely	Moderate	▪ Careful assessment of each course of action and use of appropriate PPE to minimise probability of a spillage of toxic and corrosive chemicals
Class 5.1: Accidental spillage of chemical within laboratories, liquid contacts organic material such as fabric or an oxidisable substance, resulting in injury requiring hospitalisation	Moderate	Rare	Moderate	▪ Training of all personnel to increase awareness of the potential of oxidising agents to lead to fires, with reference to AS 4326.
Class 5.1, 6.1 or 8: Accidental breakage of glass container within laboratories, with injury to person and contact with substance that's corrosive to skin,	Moderate	Rare	Moderate	▪ Careful assessment of each course of action and use of appropriate PPE to minimise probability of the breakage of a glass vessel containing of toxic, oxidising or corrosive chemicals
Multiple classes: Two chemicals are deliberately mixed, leading to unintended and violent reaction, resulting in injury requiring hospitalisation & property damage	Moderate	Unlikely	Moderate	▪ Careful assessment of risk of uncontrolled reaction prior to mixing chemicals; of appropriate PPE to minimise probability of injury
As above, but with consequences outside of building complaints from personnel in surrounding buildings	Moderate	Rare	Moderate	As above, but additionally: ▪ Ensure exhaust from chemical storage areas exhaust at an appropriate location, ideal locations may require investigation through aermod, ausplume or physical

Event	Consequence Rating	Likelihood Rating	Overall Risk	Required Mitigating Strategies
				modelling of wind and building infrastructure
Storage or usage of Class 7				
Accidental spillage or breakage of containers within storage areas.	Moderate	Unlikely	Moderate	▪ Design the entire radiochemistry laboratory and associated storage areas as per the requirements of AS 2243.4, ensuring that no other activities are carried out within that area ▪ Ensure that full training is provided to all personnel working with radioactive materials. ▪ Ensure that disposal of radioactive materials is carried out with the requirements of AS 2243.4 and within the applicable legislation
Transportation of Dangerous Goods to and from the building				
Loss of containment of dangerous goods onsite while goods are being delivered to site	Major	Unlikely	High	▪ Ensure that all deliveries to site are conducted by approved suppliers which hold all relevant licensing as per the Australian Dangerous Goods Code, Dangerous Goods (Road and Rail Transport) Act 2008 and Dangerous Goods (Road and Rail Transport) Regulation 2014. ▪ Ensure appropriate spill kits are available and that all university staff who may be in attendance are trained in their use, and in how to react to a loss of containment. ▪ Ensure the design of the loading dock provides ample space for ease of truck movements. ▪ Ensure that spilt material is not allowed to enter waterways and that it's not somehow flushed or moved into a public place where members of the public may be exposed to it. ▪ Ensure that the company delivering the dangerous goods has a safety management system that includes procedures for clean-ups and incident management; where spills occur on university premises, the

Event	Consequence Rating	Likelihood Rating	Overall Risk	Required Mitigating Strategies
				university staff should be in control of the clean-up process.
Transportation of Dangerous Goods within the building				
Transportation of gases or cryogenic liquids between building levels resulting contents spillage.	Major	Unlikely	High	▪ Prevent personnel from occupying lifts while they are being used to transport cryogenic liquids between floors. ▪ Implement lift controls for unattended lift usage. ▪ Transport goods on purpose-designed trolleys to minimise the possibility of spillage of dangerous goods.

APPENDIX D – REVISED CHEMICAL INVENTORY & SUMMATION

Engineering Precinct - Current Holdings

*Indicates Grand total assumed to be equally distributed across all three hubs

DG Class	PK Group	Units	J01	J02	J03	J05	J06	J07	J11	Grand Total	New J03 *	Complies with AS2243.10?	Proposed Quantities for Loading Dock (kg/L)
2.1 - Flammable Gasses	(blank)	Cylinder (Various sizes)	10				3	52		**65**	22	Unable to determine, Usyd to confirm size and number of cylinders	500
		KG (Equivalent)	89171		27	59	6	37	2	**89302**	29767		
		Other (/Unit)						95		**95**	32		
	II	Cylinder (Various sizes)	1					3		**4**	1		
		KG (Equivalent)	1		7			1		**8**	3		
	III	Cylinder (Various sizes)	1							**1**	0		
		KG (Equivalent)	1			23	2	3		**28**	9		
2.2 - Non-Flammable, non-Toxic Gases	(blank)	Cylinder (Various sizes)	4							**4**	1	As above	1450
		Cylinder (Various sizes)	68			4	7	39	6	**124**	41		
		KG (Equivalent)	182369		2			159		**182530**	60843		
2.3 - Toxic Gases	(blank)	Cylinder (Various sizes)	1							**1**	0	As above	50
		KG (Equivalent)	7500							**7500**	2500		
		Other (/Unit)	90							**90**	30		
	III	KG (Equivalent)	1							**1**	0		
3 - Flammable Liquids	(blank)	KG (Equivalent)	13		119	141	5	1210	43	**1530**	510	No	N/A
		Other (/Unit)					20			**20**	7		
	I	KG (Equivalent)	26					9		**35**	12		100
	II	KG (Equivalent)	1254		35	161	11	1094	38	**2592**	864		900
		Other (/Unit)						3		**3**	1		
	III	KG (Equivalent)	91		58	105	39	202		**495**	165		500
4.1 - Flammable Solids	(blank)	KG (Equivalent)	6			1		1		**7**	2	Yes	N/A
	I	KG (Equivalent)						0		**0**	0		0
	II	KG (Equivalent)	4			1		1		**6**	2		6
	III	KG (Equivalent)	19			6		4		**29**	10		7
4.2 - Substances Liable to Spontaneous Combustion	I	KG (Equivalent)				0				**0**	0	Yes	0
	II	KG (Equivalent)	1					1		**1**	0		11
	III	KG (Equivalent)	3							**3**	1		0
4.3 - Dangerous when Wet	I	KG (Equivalent)	2					0		**2**	1	Yes	12
	II	KG (Equivalent)	1			0		1		**2**	1		0
	III	KG (Equivalent)						0		**0**	0		0
5.1 - Oxidising Substances	(blank)	Cylinder (Various sizes)	13				5	2		**20**	7	Yes	Confirm Number and size of cylinders
		KG (Equivalent)						0		**0**	0		
	I	KG (Equivalent)	10			1				**11**	4		185
	II	KG (Equivalent)	49			1		8		**58**	19		80
		Other (/Unit)	2							**2**	1		
	III	KG (Equivalent)	149		0	5		10		**164**	55		113
5.2 - Organic Peroxides	II	KG (Equivalent)	0			1		1		**2**	1	Yes	0.3
6.1 - Toxic Substances	(blank)	KG (Equivalent)	1							**1**	0	Yes	N/A
		KG (Equivalent)	6		11	2	0	22	9	**50**	17		
		Other (/Unit)	3							**3**	1		
	I	KG (Equivalent)	2					7		**9**	3		49
	II	KG (Equivalent)	12			0		3		**15**	5		56
	III	KG (Equivalent)	72					24		**95**	32		109
		Other (/Unit)	75							**75**	25		
6.2 - Infectious Substances	(blank)	KG (Equivalent)	0					0		**0**	0	Yes	0
7 - Radioactive Substances	III	KG (Equivalent)						20		**20**	7	N/A	More info required

8 - Corrosive Substances	(blank)	KG (Equivalent)	2							**2**	1		
		Other (/Unit)	25							**25**	8		N/A
		KG (Equivalent)	40		45	23	2	21	4	**135**	45		
		Other (/Unit)	4					12		**16**	5	Yes	
	I	KG (Equivalent)	5					2		**7**	2		54
	II	KG (Equivalent)	473		1	19		55		**547**	182		412
		Other (/Unit)	6							**6**	2		
	III	KG (Equivalent)	265		1	24	3	51		**344**	115		140
9 - Miscellaneous Dangerous Goods and Articles													N/A
	(blank)	KG (Equivalent)	0							**0**	0		
		KG (Equivalent)	3		7	56		90	5	**162**	54	Yes	
		Other (/Unit)	1		1			4		**6**	2		
	II	KG (Equivalent)	0							**0**	0		4
	III	KG (Equivalent)	90			10		48		**148**	49		61
		Other (/Unit)	1							**1**	0		
Blank -No DG CLASS / OTHER	(blank)	KG (Equivalent)	52			2		0		**54**	18		
		Other (/Unit)	44							**44**	15		
		Cylinder (Various sizes)	14		1	9	2	9	1	**36**	12	Unknown	N/A
	(blank)	KG (Equivalent)	1805806	0	280	1552	1110	3445	35	**1812227**	604076		
		Other (/Unit)	1905		10	101		170		**2186**	729		
Grand Total			**2089767**	**0**	**606**	**2306**	**1215**	**6916**	**141**	**2100951**	700317	2166	2399

Aggregate storage >2,000 for PG II & III

Aggregate storage <500 for PG I

APPENDIX E – FINAL HAZARD ANALYSIS