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Stage II Development of the Nelune Comprehensive Cancer Centre and Australian Advanced Treatment Centre (NCCC & AATC) -

Background & Introduction

Many medical apparatus use ionising radiation (including, but not limited to, x-rays) for diagnostic or therapeutic purposes. However, exposure to ionising radiation has been linked to a number of negative health effects. Different types of ionising radiation (such as X-Rays, Neutrons and Heavy particles) produce these health effects to differing degrees for a given dose received (amount of energy deposited). A system of weighting factors is used to account for the different rates of biological damage caused by the different types of radiation, allowing an 'equivalent dose' to be calculated. The SI-derived unit of equivalent dose is the Sievert (Sv), and it is equivalent dose that regulatory authorities use when specifying dose-limits, in order to limit the potential negative effects of the use of such equipment.

The relevant regulatory authorities specify the maximum equivalent dose that individuals can receive per year from artificial sources of radiation, excluding medically justified procedures. Particularly relevant to this project are the dose-rate limitations set by the Office of Environment and Heritage (NSW EPA) which includes the equivalent dose limit for members of the public of 1mSv/yr. To put this in perspective, the typical Australian receives an equivalent dose of approximately 1 to 2 mSv per year from naturally occurring 'background' radiation. The shielding for radiation facilities is designed to ensure no member of the public will receive an annual equivalent dose in excess of this limit.

As the equivalent dose-rate limitations are for people, rather than for areas, it is accepted practice when designing radiation shielding to take into account the expected 'occupancy' of the area. This is defined as the fraction of the workload of the radiation room that the person who is likely to receive the greatest dose likely to occupy that area. In this way, an area can be constantly occupied, but if no one individual spends a large amount of time in that area, the area can be considered to have a low 'occupancy factor', as no individual is likely to receive a dose that approaches the prescribed dose limit. An area with a low occupancy factor will not require the same level of shielding as an area that has a high occupancy factor. Assumptions of occupancy factors are generally made very conservatively, and should take into consideration future uses of the surrounding areas.

Project Details

The areas of NCCC & AARC Stage 2 which will require radiation shielding assessment include:

- HDR/Brachytherapy Room
- CT/Simulator Suite

Please Note: The CT/Simulator suite contains an artificial x-ray source, and only generates ionising radiation (x-rays) while in operation. The HDR Brachytherapy apparatus utilises a sealed radioisotope source.

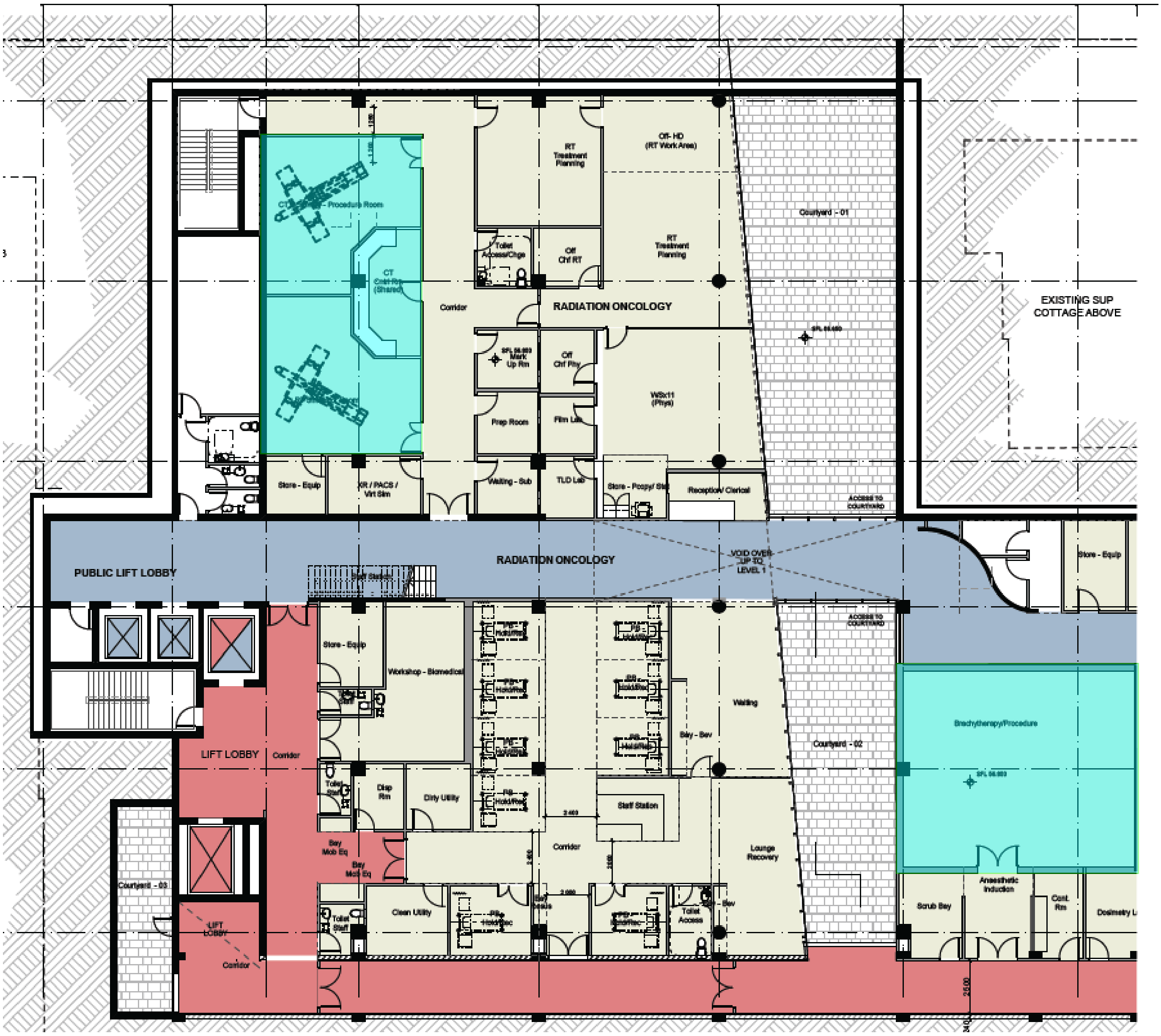

Figure 1- Shaded blue areas show the locations of the shielded room within stage II.

PO Box 504 Seven Hills NSW 2147 Ph: (02) 9838 9591 Fax: (02) 9838 9950

Email: info@radiationservices.net Web: www.radiationservices.net

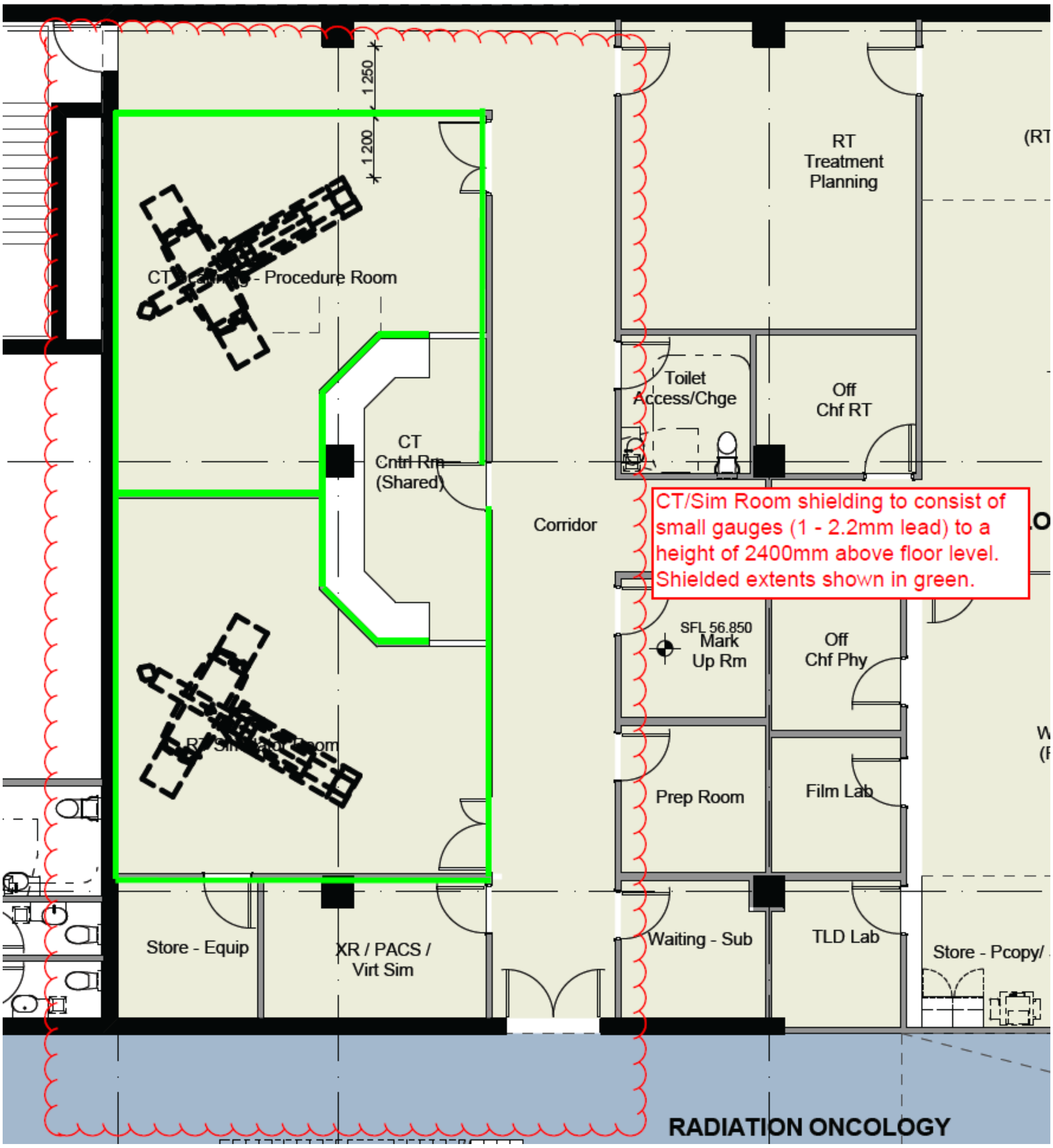

Figure 2:Shielding Extents for CT/Sim Suite

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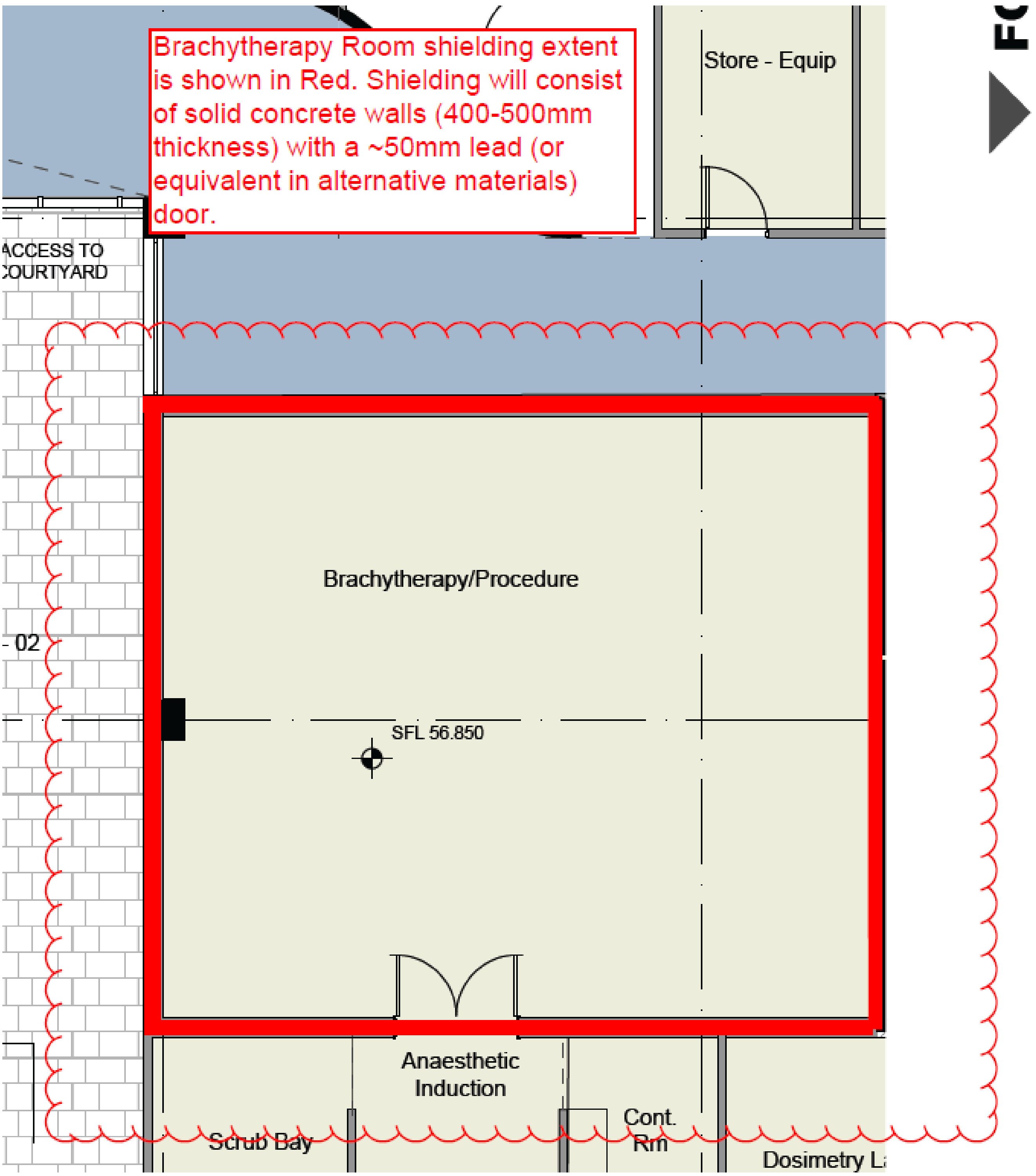

Figure 3: Shielding Extents - Brachytherapy Room

Radiation Shielding Design Methodology

HDR - Brachytherapy Room

The unshielded dose-rate at the distance of an occupant behind each barrier is calculated for the given workload. A Tenth-Value-Layer of 147mm for Ir-192 gammas in concrete is then used to determine the barrier requirement. Similarly, a Tenth-Value-Layer of 20mm lead is used to calculated the door requirement.

CT/Simulator Suite

Both rooms of this suite will be designed to house CT-simulators, as the additional shielding required is minimal, and will allow for the conventional simulator room to house a CT simulator in the future.

The unshielded dose-rate at the distance of an occupant behind each barrier is calculated for the given workload. The shielding requirement is then calculated using a method that is essentially that of *Archer et al*. "Diagnostic X-ray shielding design based on an empirical model of photon attenuation" Health Phys. 44:507-517; 1983, with parameters from *Simpkin* "Transmission of scatter radiation from computed tomography scanners determined by a Monte Carlo calculation" Health Phys. 58:363-367; 1990.

Radiation Shielding Design Assumptions for this Project -

Design Goals (Dose-Limits)

The requirements of the Office of Environment and Heritage will be met by the radiation shielding design for the project. The shielding design for barriers to uncontrolled areas is based on an occupancy-adjusted design goal of 10 µSv/wk (equivalent to 0.5 mSv/yr). This is half the allowable dose-rate for members of the public* – This allows for construction tolerances, as well as adding a general level of conservatism to the design. The shielding design for barriers to controlled areas (if the designation of areas as controlled is agreed to by the client)) is based on a design goal of 40 µSv/wk (equivalent to 2 mSv/yr), and assume full occupancy. This value is significantly less than the 100µSv/wk from all sources for occupationally exposed individuals*, again allowing for construction tolerances, but also allowing for dose to be received from other sources. No '*controlled'* areas, other than the radiation rooms themselves, have been designated for Stage II.

Design Workload

HDR Brachytherapy Room

- Workload is set at 250 Gy/wk @ 1cm from the source.
- The source is Ir-192.

CT/Simulator Suite

- Workload is set at 40,500 mAmin/wk.
- Scatter dose-rate at 1m is assumed to be 0.0038 mGy/mAmin.

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Storage of Radioactive Materials

Storage of radioactive materials will occur in the Hot Lab and adjacent hot storage area. *See Stage I for details.*

The radioisotope source for HDR brachytherapy retracts into a shielded container when not in use, and will be stored under the conditions imposed by *ARPANSA Radiation Protection Series No. 11, Code of Practice – Security of Radioactive Sources.*

Impact of the Development on the Surrounding Areas, including on future developments

All areas are adequately shielded for their intended uses. The following paragraphs concern future developments in the vicinity of Stage II.

- As the surrounding earth is used to provide most of the shielding requirement of the ceiling of the Stage II brachytherapy room, development below ground within the site boundaries may require supplementary shielding, particularly if the development is directly above the brachytherapy room.
- At the public boundary of the site (footpath and road), the dose-rates received will be sufficiently low that full occupancy by a member of the public would be acceptable. Therefore, the radiation from the facility will not limit any future development of these areas

References

*Dose-Limits are from *Radiation Guideline 7 – Radiation Shielding Design Assessment and Verification Requirements, (published by the Office of Environment and Heritage), Section 1.5*