APPENDIX J: WASTE STORAGE AND DISPOSAL—ANALYSIS OF VIABILITY AND ECONOMIC IMPACTS

1. ANALYSIS OF VIABILITY—COMMISSIONED STUDY

This study, undertaken by Jacobs and MCM, assessed the business case and provides quantitative analyses for establishing facilities in South Australia for the storage and disposal of radioactive waste.

The study estimated the whole of life costs of four conceptual waste storage and disposal facilities in a combination of generic stand-alone and collocated scenarios. It assessed the potential returns on investment of establishing those facilities and supporting infrastructure in South Australia.

ASSUMPTIONS AND INPUTS

The assumptions and inputs set out below formed the baseline scenario of the viability analysis.

FACILITY CONFIGURATION SCENARIOS

The study analysed the viability of four facilities in a range of different configurations: see Table J.1. The four facilities were:

- an interim storage facility for above-ground dry cask storage of used nuclear reactor fuel and for storage of intermediate level waste
- a geological disposal facility for disposal of international used fuel
- an intermediate depth repository for international intermediate level waste
- a near-surface low level waste repository for the disposal of low level waste arising from the operation and decommissioning of the interim storage facility, intermediate depth repository and geological disposal facility.

Under the baseline scenario (CS 4 in Table J.1), the intermediate depth repository and geological disposal facility were collocated.

Table J.1: Configuration scenarios modelled

Configuration scenarios (CS)	Coastal location	Inland location	Inland location	Inland location
CS 1: stand-alone facilities	ISF	LLWR	IDR	GDF
CS 2: no ISF		LLWR	IDR	GDF
CS 3: no ISF, collocate GDF & IDR		LLWR	GDF & IDR	
Baseline scenario CS 4: collocate GDF & IDR	ISF	LLWR	GDF & IDR	
CS 5: all facilities at coastal site	All four facilities			
CS 6: collocate IDR and LLWR	ISF	LLWR & IDR		GDF
CS 7: ISF & LLWR collocated, GDF & IDR collocated, 'optimised' case	LLWR & IDR		GDF & IDR	
CS 8: LLWR collocated with GDF & IDR	ISF		GDF, IDR & LLWR	
CS 9: all facilities at inland site			All four facilities	

Notes: GDF = geological disposal facility, IDR = intermediate depth repository, ISF = interim storage facility, LLWR = low level waste repository.
Source: Jacobs & MCM

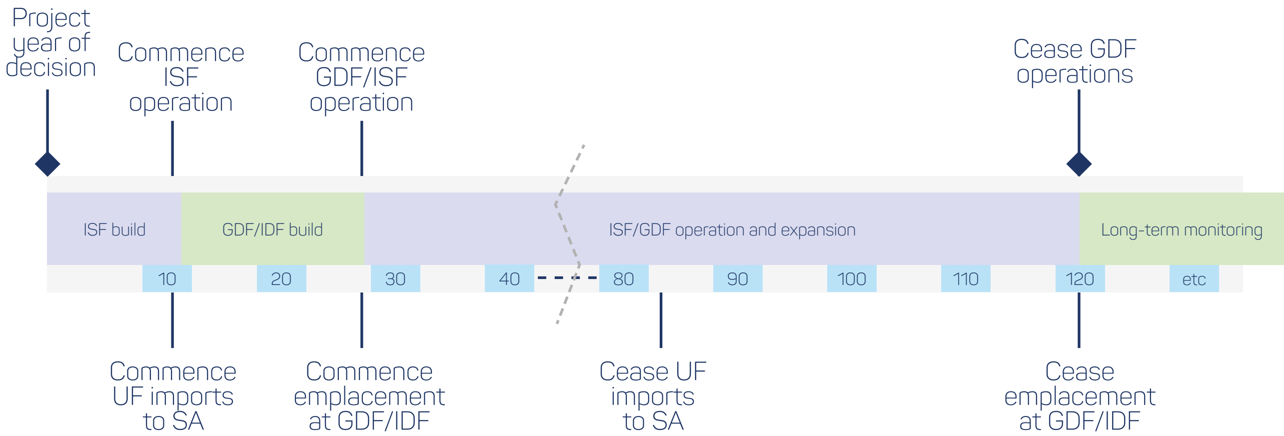

Figure J.1: Assumed facility development and operation timeline (baseline scenario)

Notes: GDF = geological disposal facility, IDR = intermediate depth repository, ISF = interim storage facility, UF = used fuel.
Source: Jacobs & MCM

TIMELINE

The baseline scenario assumes that the interim storage facility would receive used fuel and intermediate level waste in project year 11, after the decision to proceed, siting, licensing and construction were completed. Receipt of used fuel and intermediate level waste would continue at the interim storage facility until project year 83.

Used fuel would be transferred to the geological disposal facility for disposal in project year 28 and continue for 92 years. Intermediate level waste transfers would start in project year 26 and continue for 49 years. The difference in times is primarily due to the need to store used fuel for 40 years before permanent disposal. The timeline for development and operation of the facilities under the baseline scenario is summarised in Figure J.1.

MARKET

The baseline scenario included a conservative assumption about the portion of the total global waste inventory that would constitute an accessible market for South Australian waste storage and disposal services. This required assessment and estimates about historic, current and planned nuclear power programs in countries around the world, and their current strategies and future plans to manage the associated radioactive waste.[1]

There are substantial inventories of used fuel accumulating in countries with nuclear power programs around the world, many of which currently lack solutions for long term management.[2] The total global quantity of used fuel is . currently estimated to be approximately 390 000 tonnes of heavy metal (tHM), and by 2090 this is anticipated to grow to over 1 million tHM.[3]

The assumption about the accessible market excluded countries that are committed to domestic solutions for waste management and disposal, including the USA, France, the UK, Canada, China and India, as well as waste from countries with laws or policies prohibiting export of their waste.[4]

The estimated quantities include waste from existing reactors and those in advanced stages of development that are expected to be operational by 2030, but exclude waste from reactors that become operational after 2030.[5] They also exclude potential waste produced locally if Australia were to develop a civil nuclear power program, although any impact such quantities could have on the baseline scenario is expected to be marginal.[6] Vitrified high level waste as a result of reprocessing spent fuel has been included in this assessment, but forms a small proportion of the total estimated quantities.

The estimated quantities from countries with no domestic solution that could be potential clients for waste storage and disposal services are set out in Table J.2.

The aggregate current and forecast quantities of waste from major potential client countries with no domestic solutions that would comprise the accessible market for South Australia appear in Table J.3.

Table J.2: Current and forecast stockpiles of used fuel and intermediate level waste from existing, operational nuclear reactor fleet

	Used fuel (tHM)		Intermediate level waste (m³)	
Countries	Current	Cumulative forecast (2080)[a]	Current	Cumulative forecast (2080)[a]
Japan	23 126	53 463	85 175	18 0975
Korea	14 199	50 532	25 119	101 732
Germany	15 119	21 786	46 378	67 431
Ukraine	6 205	17 404	24 889	60 246
Spain	5224	9373	15 745	28 849
Belgium	4413	7458	12 749	22 364
Taiwan	3517	8565	10 605	28 490
Argentina	3458	8197	2348	6404
Switzerland	2679	4200	7744	12 547
Romania	2096	10 756	1143	5080

Source: Jacobs & MCM

[a] Based on operation of existing reactor fleet over 60 years

Table J.3: Total current and forecast used fuel and intermediate level waste stockpiles from existing, operational nuclear reactor fleet from nations not committed to a national solution

Total	Current	Forecast (2090)
Used fuel (tHM)	89 979	276 000
Intermediate level waste (m³)	269 471	782 430

The accessible market estimated for used fuel in Table J.3 represents 26 per cent of the total quantity forecast to have accrued globally by 2090.[7] The estimate for intermediate level waste represents approximately 3 per cent of the total quantity forecast to have accrued globally by 2090.[8]

The proportions of used fuel attributable to current and future nuclear power programs are illustrated in Figure J.2.

Taking into account the possibility that not all countries comprising the potentially accessible market would necessarily use the South Australian storage and disposal services, the baseline scenario assumes that 50 per cent of the accessible quantities of used fuel and intermediate level waste will be stored and disposed of in South Australian facilities: see Table J.4 and Figure J.3. The baseline market capture assumption is compared with higher and lower cases in Table J.4.

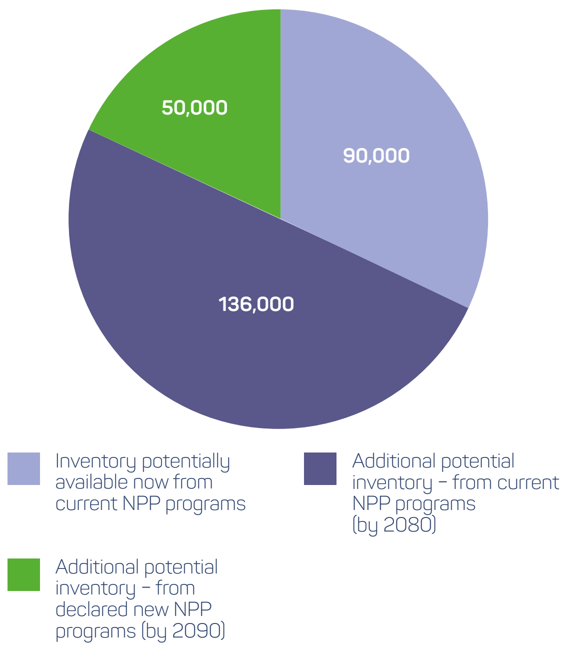

Figure J.2: Potential used fuel inventory (tHM) available to South Australia by 2090

Note: Total 276,000 tHM

Image courtesy of Jacobs and MCM

Table J.4: Potential shares of the accessible market for used fuel and intermediate level waste

Scenario	Used fuel inventory (by 2090)	Intermediate level waste inventory (by 2090)
Upper case (75% of accessible)	207 000 tHM	585 000 m^3
Baseline (50% of accessible)	138 000 tHM	390 000 m^3
Lower case (25% of accessible)	69 000 tHM	195 000 m^3

Note: tHM = tonnes of heavy metal
Source: Jacobs & MCM

Table J.5: Whole of life costs for used fuel disposal in countries with advanced projects

Country	Whole of life disposal costs (A$ million per tHM)
Finland	$0.65
Sweden	$1.13
Switzerland	$2.43

Source: Jacobs & MCM

WILLINGNESS TO PAY AND PRICE TO CHARGE

The estimation of revenues that prospective integrated waste storage and disposal facilities developed in South Australia could secure required the determination of a range of prices that client countries might be willing to pay for the services. The price to charge in the baseline scenario was selected on the basis of a conservative assessment of the range of potential prices identified.

The willingness to pay and price analysis predominantly focused on used fuel, given that it is the most expensive and politically problematic waste type to manage and has the potential to significantly affect the overall viability analysis.[9]

In the absence of a market for international waste storage and disposal services, a potential customer's willingness to pay was inferred from a range of sources including[10]:

- the cost of developing and operating national disposal facilities
- national waste disposal funds
- the cost of reprocessing services

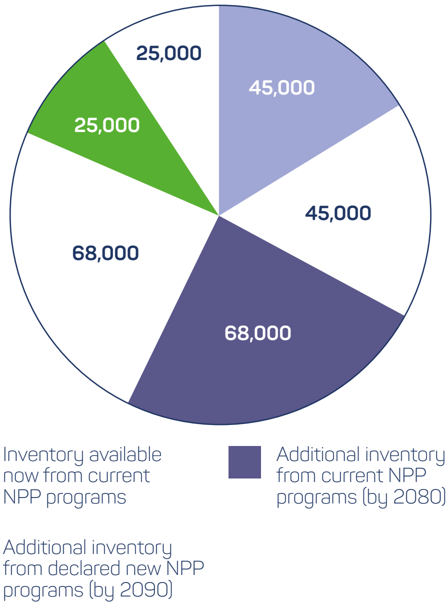

Figure J.3: Baseline assumption–market share of accessible used fuel (tHM) for management and disposal to 2090

Notes: Total 138 000 (50 per cent of Table J.2 total), NPP = nuclear power plant
Image courtesy of Jacobs and MCM

- reductions in the cost of capital from a guaranteed solution for the disposal of waste
- distress payments for plant shutdowns.

A significant aspect of this analysis related to the costs associated with storage and management of used fuel that countries with domestic nuclear power programs might avoid by utilising South Australian services.

Published data and estimates about the costs (per tHM of used fuel) of planning, constructing, operating and closing geological disposal facilities from countries with such facilities in advanced stages of development provided an indication of costs countries might seek to avoid, thus informing willingness to pay (Table J.5). The average cost of A$1.2m per tHM of used fuel provides an illustrative benchmark for costs which might be avoided by utilising South Australia's services.[11]

The cost associated with storage and disposal of used fuel incurred by utilities, which can in turn inform potential willingness to pay, can also be derived from the average levelised cost of electricity (LCOE) of nuclear power plants. From the LCOE, it is possible to identify the proportion that can be attributed to used fuel storage and disposal. This analysis indicated that the cost of storage, transport and disposal of used fuel amounts to about US$1m per tHM or A$1.39m per tHM.[12]

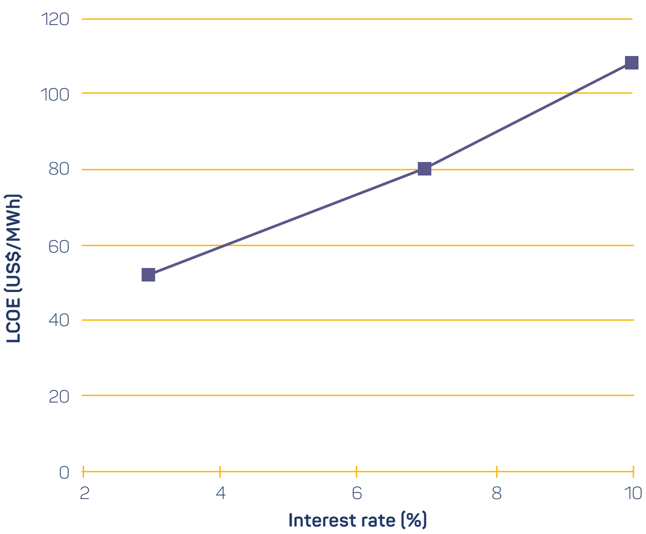

Figure J.4: Variation in nuclear power LCOE with cost of capital

Note: LCOE = levelised cost of electricity
Image courtesy of Jacobs and MCM

The cost of an alternative to storage and final disposal—namely, reprocessing—can indicate willingness to pay. A recent estimate of costs for proposed reprocessing of used fuel from Taiwan suggested a willingness to pay for that service of over US$1m, or A$1.54m per tHM. Given that Taiwan would still receive back after reprocessing vitrified high level waste, which requires further expenditure on a disposal solution, it can be inferred that willingness to pay for combined storage and final disposal services as an alternative to reprocessing might be even higher.[13]

Willingness to pay can also be inferred from potential reductions in the cost of capital for new nuclear power plants that can secure guaranteed back-end solutions. For nuclear power projects with fixed-cost arrangements in place for the used fuel management liability, the project risk is likely to be perceived to be lower, which would assist in securing a lower interest rate on finance. A reduction of 0.5 per cent in the interest rate, attributable to lower project risk, would equate to A$1.9m to A$2.6m per tHM of used fuel. The significant impact of the interest rate on the LCOE of a nuclear power plant is illustrated in Figure J.4.[14]

A further indication of willingness to pay can be drawn from examining the costs that plant operators would incur from unscheduled plant shutdowns due to lack of used fuel storage and the payments they may make to avoid such costs. Table J.6 shows the loss in US dollars that utilities could avoid by utilising an international storage disposal solution.

A baseline willingness to pay estimate (US$1.5m) was derived by taking the mid-point between:

- the average estimated costs of used fuel disposal from countries with geological disposal facilities in advanced stages of development (US$1m), and
- the minimum estimated willingness to pay in countries without a local disposal solution (US$2m).

After subtracting pre-delivery costs incurred by clients in preparing and transporting the waste to South Australia (estimated at US$0.15m per tHM),[15] the baseline scenario assumes a conservative price to charge international clients of A$1.75m per tHM for storage and permanent disposal of used fuel, as shown in Figure J.5. There may be potential to negotiate higher prices under some circumstances.[16]

The potential revenue achieved through storage of intermediate level waste is much lower than for used fuel due to the lower willingness to pay from client countries.[17] Intermediate level waste is considerably less problematic for countries to accrue and store than used fuel. This component of project revenue will have less of an impact on overall viability of the integrated facilities. The baseline scenario assumes a conservative price of A$40 000 per m^3 of intermediate level waste. This figure is based on a proposed appropriate levy on nuclear power plant operators for eventual intermediate level waste disposal in a recent report from the UK Department of Energy and Climate Change. It suggested that a cost of £25 900 per m^3 reflected the anticipated cost of its management, equating to about A$66 000 per m^3.[18]

Table J.6: Loss avoided by availability of international spent fuel transport, storage and disposal

Loss avoided by the availability of fuel storage and transport (US$ per MWh)	Burn-up (GWd/teU)	Thermal efficiency (%)	Output (MWh/teU)	Expected used fuel cost per teU (US$ millions)
80	50	34	408 000	32.64

Notes: GWd = gigawatt day, MWh = megawatt hour, teU = tonne enriched uranium
Source: Jacobs & MCM

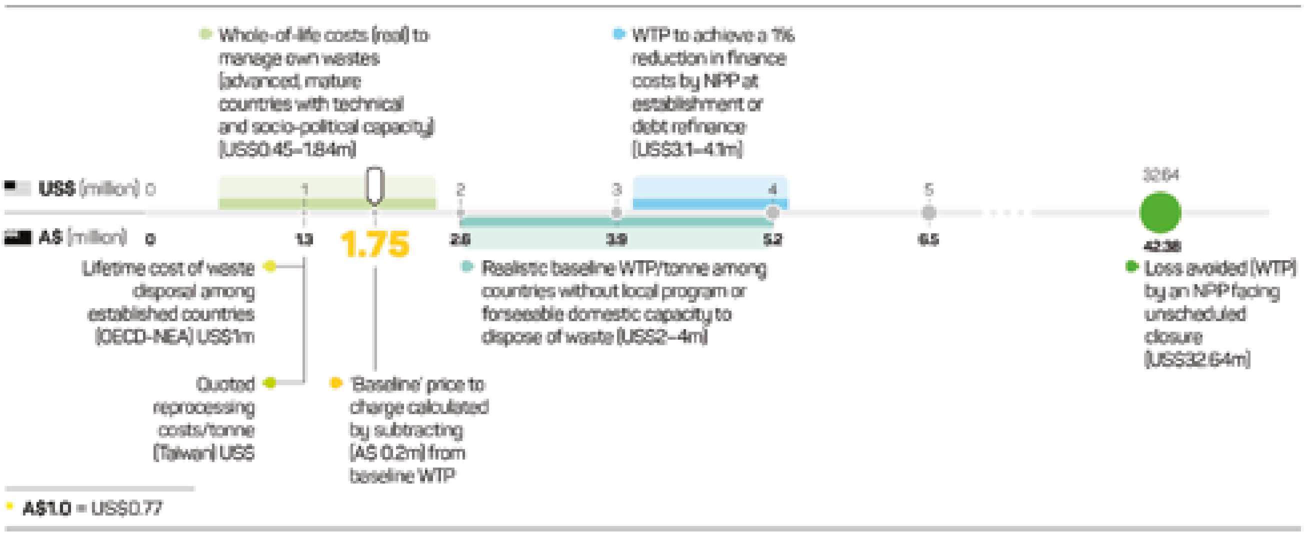

Figure J.5: Summary willingness to pay (US$m and A$m per tHM) based on published data and enhancements

Image adapted from Jacobs & MCM

FACILITY CAPACITIES

The capacities of each facility in the baseline scenario are based on the market capture assumptions discussed above. Under the baseline scenario, the facilities are assumed to have corresponding capacities of:

- 138 000 tHM of used fuel in the geological disposal facility
- 390 000 m^3 of intermediate level waste in the intermediate depth repository (collocated with the geological disposal facility)
- 81 088 m^3 of low level waste in the near surface low level waste repository initially, with the option to expand that capacity on an as-needs basis[19]
- 72 000 tHM of used fuel in above-ground dry casks and 175 000 m^3 of intermediate level waste in the interim storage facility.[20]

CAPITAL AND OPERATING COSTS

Capital and operating cost estimates are based on costs observed and forecast for similar overseas facilities currently in advanced stages of development, converted to Australian dollars and scaled to the projected South Australian scenarios. Cost estimates for supporting infrastructure are based on Australian experience from analogous examples in the resources and other sectors.[21]

The total capital cost for the construction, decommissioning and closure of the baseline facilities is estimated to be about A$41.0 billion, which includes a 25 per cent growth allowance and scope contingency. This sum is inclusive of the costs of developing new port, road, rail, airport and supporting electricity and water infrastructure.[22] Table J.7 shows the capital costs savings achieved by collocating the geological disposal facility and the intermediate depth disposal facility under the baseline scenario due to shared transportation, utility and surface infrastructure costs.[23]

Table J.8 shows the actual or estimated capital costs associated with similar projects overseas.

Total operating costs for the baseline scenario, including labour, contracted services, facility maintenance, equipment lease costs, industrial consumables and utilities, are estimated to be A$877.7 million per annum in the first 40 years, and A$765.2 million after year 40, to take into account the decrease in annual packaging costs at the interim storage facility as packages become available to be reused rather than purchased.[24]

The total combined capital and operating costs are estimated to be A$145.3 billion over the 120-year life of the project.[25] That total includes a significant portion of expenditure allocated to ensuring the safe construction, operation and closure of the facilities, as set out in Table J.9.

Table J.7: Estimated capital costs for the four facilities under the baseline scenario

Facility configuration	Total cost (A$ 2015 m, undiscounted and rounded)	Nominal size of facility (total waste capacity)	Normalised cost per unit (A$ 2015 thousands)
Low level waste disposal facility	820	81 088 m^3	10.1 per m^3
Interim storage facility	2200	72 000 tHM	30.63 per tHM
Intermediate depth disposal facility	14 300	390 000 m^3	36.67 per m^3
Geological disposal facility	33 400	138 000 tHM	242.02 per tHM
Collocated geological disposal facility and Intermediate depth disposal facility	38 000	138 000 tHM, 390 000 m^3	–
Baseline scenario: Low level waste disposal facility, interim storage facility plus collocated geological disposal facility and intermediate depth disposal facility	41 020	N/A	N/A

Source: Jacobs & MCM

Table J.8: Comparison of estimated costs to reference facility costs

Facility	Reference facility/cost database	Cost per stored unit (A$ thousands)	Commission estimated cost as percentage of reference facility
Low level waste disposal facility	El Cabril, ENRESA (2015)	8.9	113%
Interim storage facility	US EPRI, 2009	28	107%
	US DoE, 2013	34	89%
Intermediate depth disposal facility	Forsmark, Sweden (SKB, 2003)	13	277%
	Swiss (NAGRA)	26	139%
Geological disposal facility	Olkiluoto Finland Posiva (2003, 2005, 2012)	176	137%
	Forsmark, Sweden (SKB, 2014)	430	56%
	Swiss Nuclear, 2011	1 300	19%

Source: Jacobs & MCM

Table J.9: Allocated costs for site characterisation, safety case development and geological disposal facility (GDF) design refinement

Phase	Activities relating to demonstrating facility safety	Expenditure allocated (A$ 2015)	Time frame
Siting	1. Undertake initial siting process (including development of any exclusionary criteria and a process to call for and evaluate volunteer sites) 2. Secure permissions for surface-based intrusive site investigations (including deep and shallow drilling, sampling, surface and groundwater studies, in-situ stress measurements at depth, environmental impact studies) 3. Finalise detailed surface investigations, including specific characterization of major site features that will have an impact on GDF design 4. Develop initial safety case—based on naturally isolating characteristics of the host geology and performance targets —in conjunction with initial design of GDF	$938m for GDF $125m for interim storage facility $38m for low level waste repository	Years 1–13
URL-led design refinements	1. Construct access tunnels/shaft and underground research laboratory, including test emplacement gallery 2. Conduct test emplacements and monitor in-situ conditions 3. Refine assumptions underlying performance targets, GDF design and associated safety case to secure licence for construction of disposal galleries for used fuel emplacement	$578m Initial gallery and emplacement cost $250m/a during testing and commissioning phase	Years 19–28
GDF construction	1. Expansion of underground research laboratory: construction of disposal galleries and any additional access tunnels and shafts 2. Conduct additional in-situ testing and monitoring and use data to refine assumptions underlying performance targets, GDF repository design and associated safety case to verify targets in operational license can be met	$250m/a with links to GDF operation phase	Ongoing until no further waste to emplace (see below)
GDF operation	1. Emplace waste (possibly with a pilot phase to begin) 2. Conduct additional in-situ testing and monitoring and use data to validate assumptions to secure licence to close the facility	$205m/a $565m/a if encapsulation costs are included	Years 28–120
Closure and Decommissioning	1. Backfill and plug access tunnel and shafts to put site in a passive state and restore initial conditions—no further safety actions are required 2. Decommission above-ground buildings, interim storage facility and supporting infrastructure	$1150m	Years 83–125
Post-closure	1. Conduct additional surface-based testing and monitoring as per closure licence—this is confirmatory data, not a safety function 2. After the period of testing and monitoring, retain passive institutional controls (such as zoning restrictions as per closure licence) 3. After passive institutional controls are complete, the site is free-released	$0.55–$5.5m/a serviced from income on the reserve fund remaining at the time of closure	Years 125–1125 – ongoing

Notes: GDF = geological disposal facility, URL = underground research laboratory
Source: Jacobs & MCM

RESULTS OF VIABILITY ANALYSIS

The outputs of the analysis demonstrate that the baseline scenario is viable and would generate significant profits for South Australia. The analysis also showed that the development of an interim storage facility along with a geological disposal facility was critical to viability.

The total revenue generated under the baseline scenario would be approximately $257 billion (A$ 2015 real undiscounted) over the 120 year life of the project, with total expenditures of approximately $145 billion (including construction, operating, decommissioning and closure costs, but excluding royalties) over the same period.[26]

Applying a discount rate of 4 per cent, the net present value of profits to the state over the life of the project would amount to $40.4 billion.[27] Applying a commercial pre-tax discount rate of 10 per cent, the net present value of profits to the state would amount to $11.5 billion. These figures exclude the net present value of royalty payments made to the State Wealth Fund.[28]

EMPLOYMENT

The estimates about direct employment were based on an allocation of a reasonable proportion of construction costs to labour requirements. Approximately 1550 direct full-time jobs would be required in South Australia during the 25-year construction phase of the project, with a peak of about 4500 full-time jobs during the geological disposal facility construction phase (in years 21 to 25 of the project). A total ongoing operational workforce in South Australia of approximately 600 full-time direct jobs is anticipated once all facilities are completed.[40]

SENSITIVITY ANALYSIS

Analyses were also undertaken of the impacts on the viability of the baseline scenario if a smaller proportion of the used fuel and intermediate level waste market was captured, if lower prices were charged for services, if there was a delay in the receipt of used fuel and intermediate level waste, and if there were cost overruns. Under these scenarios, the project achieved lower profits than the baseline scenario, but remained highly viable.

MARKET CAPTURE

The impact of higher (75 per cent) and lower (25 per cent) capture of the accessible market of used fuel was analysed and the results illustrated in Figure J.6. That analysis indicates that the project remains viable even where only a quarter of the accessible used fuel market (69 000 tHM) is captured. Figure J.6 also demonstrates the viability of the project in the event of a lower market share at a range of prices below that of A$1.75m per tHM in the baseline scenario.

PRICE

The sensitivity of the baseline scenario's viability to a range of different prices charged for the services, assuming 50 per cent of the accessible market is captured, was analysed, as shown in Figure J.7. The project remains viable at the lowest analysed price of $750 000 tHM. Potential revenues increased significantly depending on the price charged, with higher prices for used fuel having the greater positive impact on profitability than increases in prices for intermediate level waste disposal.[29]

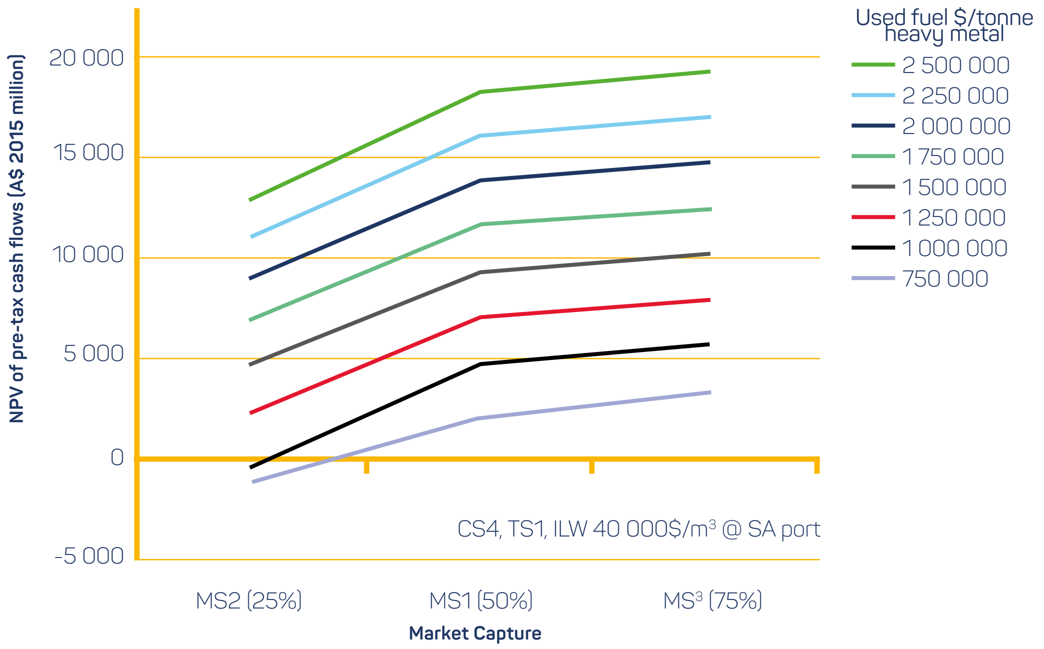

Figure J.6: Sensitivity of baseline scenario viability to lower and higher accessible market capture scenarios (see Table J.4 for details) and to lower and higher prices charged per unit used fuel

Note: CS = configuration scenario, ILW= intermediate level waste, MS = market scenario, NPV = net present value, TS = timing scenario
Source: Jacobs & MCM

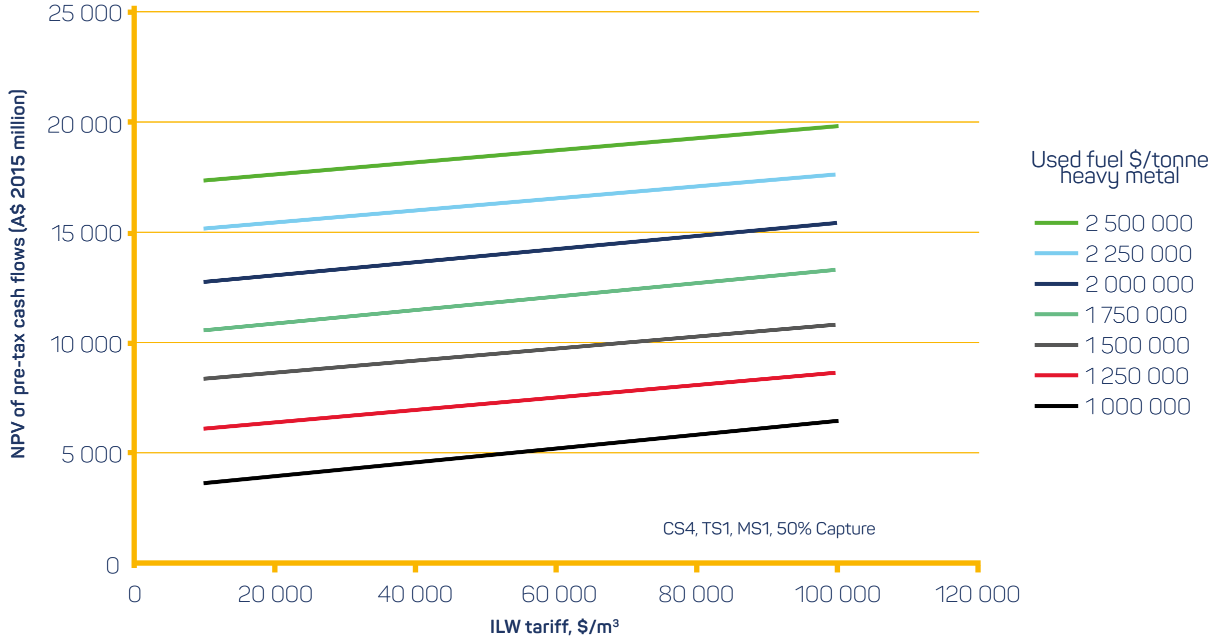

Figure J.7: Sensitivity of baseline scenario viability to price charged per unit of used fuel and intermediate level waste

Note: CS = configuration scenario, ILW= intermediate level waste, MS = market scenario, NPV = net present value, TS = timing scenario
Source: Jacobs & MCM

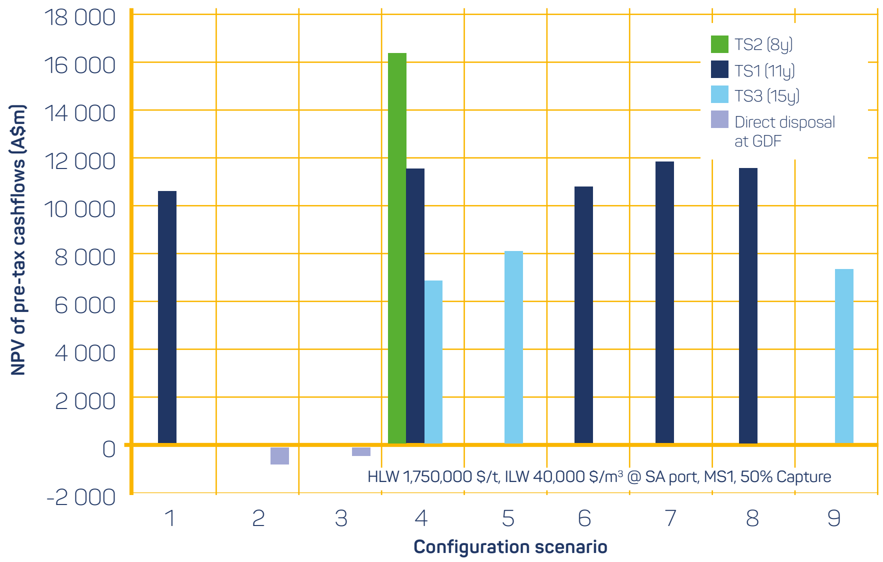

Figure J.8: Comparison of net present value (NPV) in Australian dollars of each of the configuration scenarios (see Table J.1 for details of configuration scenarios)

Notes: HLW = high level waste ILW = intermediate level waste, MS = market scenario, NPV = net present value, TS = timing scenario, GDF = geological disposal facility
Image courtesy of Jacobs & MCM

TIMING OF RECEIPT OF WASTE AND REVENUES

The sensitivity of the baseline scenario's viability to variations in the timeline for receipt of waste from clients was analysed. Figure J.8 illustrates the net present value (at a 10 per cent discount rate) of the baseline configuration scenario (described in Table J.1), when different time scenarios for importation of waste (at 8 years, 11 years and 15 years) are applied. The results indicate that the longer the receipt of waste (and associated revenues) is delayed, the lower the net present value of the project.[30]

Figure J.8 also demonstrates that a facility configuration scenario is viable only with the establishment of a surface interim storage facility capable of accepting used fuel prior to construction of geological disposal facilities.[31] Configurations 3 and 4, which did not include interim storage facilities (see Table J.1), did not generate profits because of the delay in receiving waste and associated revenues. Without a South Australian interim storage facility in which waste is allowed to cool prior to disposal, only used fuel that has already been allowed to cool in its country of origin could be received in South Australia for direct disposal, causing a delay of around 15 years before revenue is generated.

COST OVERRUNS

Analysis of the impact of both capital and operating cost overruns on the baseline scenario demonstrates that the project remains viable, despite a reduction in the overall net present value of the project.[32] Where both capital and operating cost overruns of 50 per cent were applied, the project net present value (at a 10 per cent discount rate) was reduced to A$8.9 billion, compared with A$11.5 billion under the baseline scenario with no such cost overruns applied: see Table J.10.

Table J.10: Sensitivity of project viability to overruns in capital and operating costs, excluding State Wealth Fund net present value

Scenario	Project net present value at 10% discount rate (A$ 2015 billion)
Baseline	11.5
Capital costs + 50%	9.9
Operating costs + 50%	10.5
(Capital and operating costs) + 50%	8.9

Source: Jacobs & MCM

RESERVE FUND

The modelling assumed the establishment of a reserve fund to provide for the costs of decommissioning, remediation of surface facilities, closure, backfill of underground facilities and the ongoing, post-closure monitoring phase.[33]

Given the reserve fund was assumed to be established to meet known liabilities, it was assumed that it would grow over time with a real rate of return equal to 2.4 per cent. This reflects investment of those funds in low risk assets such as government bonds. It is lower than the 4 per cent return assumed for the State Wealth Fund, which is based on more diversified investments.[34]

The modelling for the growth of that fund was undertaken to reflect two alternative approaches, and to provide for their comparison. Both scenarios fully fund all future liabilities.

A baseline scenario assumed that the reserve fund was constituted by drawing funds from operating revenues such that the profitability of the facility was maximised.

In the baseline scenario, the reserve fund was estimated to accumulate funds of A$32 billion (in current dollars), by year 83 of the project. This is sufficient to meet all future liabilities. The profit maximising criteria mean that it would only start to accumulate funds 45 years after the decision to proceed with the project is taken.[35] After year 83, it was assumed that it would be drawn down to meet decommissioning, closure and post-closure expenditures.

An alternative scenario was also considered on a more conservative basis, in which 10 per cent of annual operating profits would be directed to the reserve fund from the first year that used fuel and associated revenues were received. This commences in project year 11.[36] In addition, it did not discount the value of liabilities in the post-closure phase (beyond year 125) and instead assumed they grew at a real rate of one per cent annually.[37]

These assumptions lead to the accumulation of more than A$46 billion in the reserve fund by project year 60–an amount significantly in excess of the estimated decommissioning and closure costs. The effect of such conservative assumptions is that the amount of interest earned on the reserve fund at the time of closure is greater than the annual monitoring costs, i.e. there will be capital available in perpetuity.[38]

This scenario means that the project's overall profitability is reduced by A$1.7 billion to A$9.8 billion on a discount rate of 10 per cent.[39]

2. ANALYSIS OF ECONOMIC IMPACTS—COMMISSIONED STUDY

Economic modelling using a general equilibrium model was undertaken by Ernst & Young to assess the potential effect on the wider South Australian economy of investments being made in an interactive radioactive waste storage and disposal facility in South Australia. It estimated changes in key measures of economic activity such as gross state income, gross state product, wages and employment.

The modelling undertaken used the transparent, peer-reviewed model maintained by the Victoria University Centre of Policy Studies known as the Victoria University Regional Model (VURM).[41] This model has been used widely in Australia to assess the effects of investments made in one part of the economy on economic activity more broadly.

ASSUMPTIONS AND INPUTS

The potential macroeconomic impacts of investing in integrated waste storage and disposal facilities were assessed. The modelling only evaluated the economic impacts of investment in waste storage facilities in the period to 2050, notwithstanding revenues and costs associated with this investment taking place over a much longer timeframe.[42]

In the modelling, it was assumed that a government entity that owns, manages and operates the waste facilities transfers royalty payments and profits derived from revenues to a State Wealth Fund (Figure J.9). The State Wealth Fund was assumed to make investments that enable a real rate of return of 4 per cent per annum based on long term return in similar funds operating in Australia and overseas. It was assumed that half of these returns are transferred annually to the State Government to fund government services.

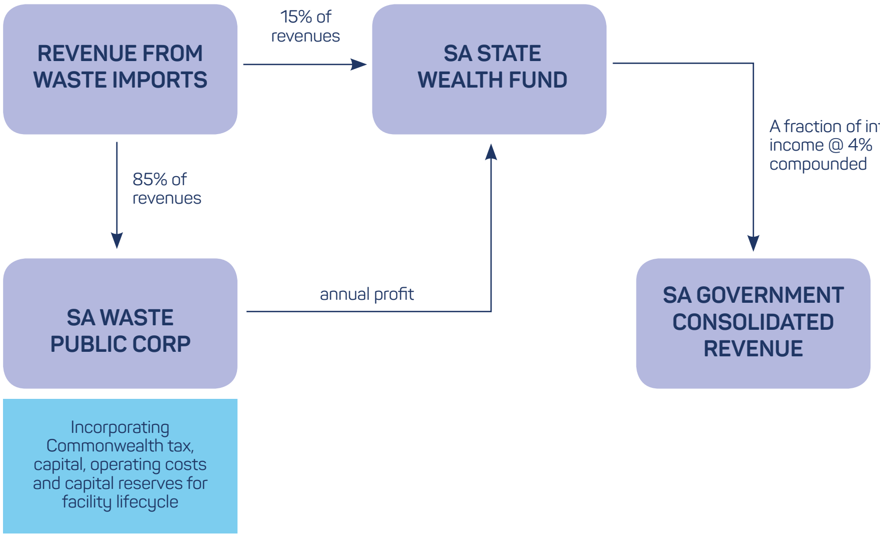

Figure J.9: Assumed revenue transfer model for the integrated waste storage and disposal concept

Image courtesy of Ernst & Young

The modelling also evaluated the economic impact of a combined investment in both the waste storage and disposal facility concept and further processing facilities owned and operated by a private entity providing conversion and enrichment services. The combined investment concept was developed to represent the possible economic outcomes that may emerge under a 'fuel leasing' arrangement.

The model calculated the economic benefits that flow to the state from:

- the combination of investments made in establishing the facilities that comprise the integrated concept
- investments that are made by the State Wealth Fund
- additional expenditure made by the state government.[43]

For the fuel leasing concept, the estimated economic impacts also include the influence of a private, independent investment in a conversion and enrichment facility.

RESULTS OF ECONOMIC IMPACT ANALYSIS

As illustrated in Table J.11, investment in waste storage and disposal facilities alone is expected to improve gross state income and gross state product by about 5 per cent in 2030 and about 3.6 per cent in 2050. It is also expected to generate direct and indirect employment of 9600 in 2030, and 7500 full time positions in 2050.[44]

Table J.11: Impact of investment in integrated waste storage and disposal facilities on the South Australian economy in 2030 and 2050 in a carbon constrained world[45]

Integrated waste storage and disposal facilities	2029–30	2049–50
Gross state income	$6837m (5.0%)	$7290m (3.6%)
Gross state product	$6699m (4.7%)	$7367m (3.6%)
Wages	0.4%	0.1%
Total employment	9603	7544

Source: Ernst & Young

A combined investment in a fuel leasing concept leads to a modest additional improvement to gross state income and gross state product of 0.5 per cent: see Table J.12. However, the present assessment does not consider the potential value of other synergies between the two parts of the fuel cycle discussed in Chapter 5 of the report.

Table J.12: Impact of investment in a fuel leasing arrangement comprised of conversion, enrichment and integrated waste storage and disposal facilities on the South Australian economy in 2030 and 2050

Fuel leasing	2029–30	2049–50
Gross state income (A$)	$7745m (5.6%)	$8106m (4.0%)
Gross state product (A$)	$7370m (5.2%)	$8274m (4.1%)
Wages	0.4%	0.1%
Total employment	11 400	9364

Source: Ernst & Young

SENSITIVITY

Modelling also evaluated the potential impact of revenues generated in South Australia by an integrated waste storage and disposal facility on transfer payments, namely, revenues from the Goods and Services Tax (GST), made by the Australian Government to the South Australian Government.

The states receive a portion of GST revenue from the Australian Government as recommended by the Commonwealth Grants Commission in accordance with instructions provided by the Commonwealth Treasurer. These recommendations are made two to three years in advance. Under these arrangements, while account is taken of other factors, the greater the level of economic activity and associated revenues in a state, the lower that state's share of GST revenue would be expected to be. The determinations about GST revenue are complex and dependent on the arrangements in place at the time between the Australian Government and states (including the agreement on the GST). For that reason, there is no guidance available to project any state's share of GST in the long term.[46]

The modelling undertaken for the Commission assumed that:

- there was no change in the revenue generating capability of any other state
- the current basis for distributing GST revenue would apply
- the revenue generated by the South Australian Government from the development of waste storage and disposal facilities in the years to 2050 was assumed to be the only determinant of South Australia's GST share.

The modelling shows that South Australia's anticipated share of GST revenue (about $1.25 for every dollar of GST revenue generated in the state) would, as a result of the revenues from integrated waste facilities, return to the state's long term average share of GST in 2050. That is because in the next three years, South Australia's share of GST revenue is expected to increase sharply (to about $1.45) as a result of the further decline of manufacturing. The investments and revenues associated with the integrated waste facilities, which on the basis of the financial analysis will commence in about 2030, mean that the state's share of GST revenue will decline again to about their present levels: see Figure J.10.[47]

South Australia's share of GST revenue could be lower still, if industries ancillary to the integrated storage and disposal facilities developed and further enhanced the state's revenue generating capability. However, those effects can be expected to be small. Conversely, South Australia's share could be higher in the event of decline of other industries or if the revenue-generating capabilities of other states improved significantly.

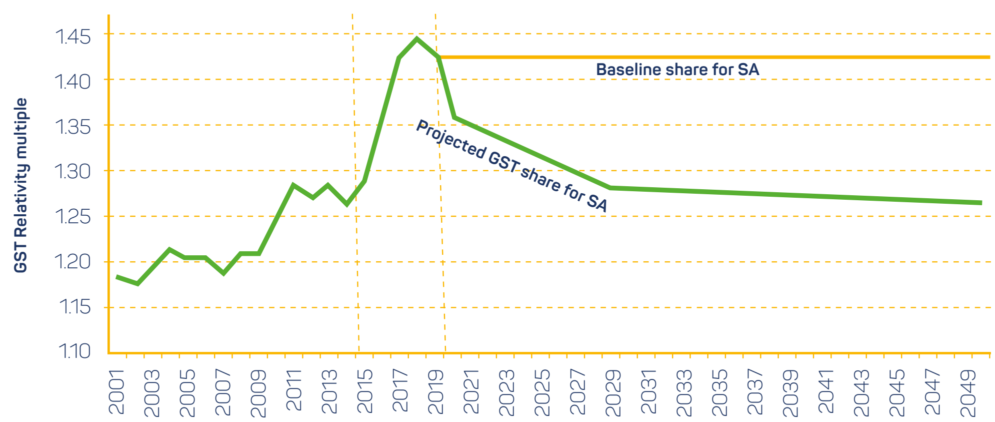

Figure J.10: Projected variation in share of GST revenue received by South Australia from 2019 to 2050 (as a multiple of GST generated in South Australia)

Source: Ernst & Young

NOTES

1 Jacobs & MCM, *Radioactive waste storage and disposal facilities in SA: Quantitative analysis and business case*, report prepared for the Nuclear Fuel Cycle Royal Commission, Adelaide, February 2016, paper 2, section 1, http://nuclearrc.sa.gov.au/

2 ibid., p. 3; paper 2, section 2.

3 ibid., p. 3; paper 2, section 2.3.4.

4 ibid., paper 2, section 2.1.

5 ibid., p. 3; paper 2, section 2.3.3.

6 ibid., paper 2, section 2.1.

7 ibid., pp. 3–4.

8 ibid., p. 4.

9 ibid., section 3.

10 ibid., paper 2, section 3.

11 ibid., paper 2, section 3.1.

12 ibid., paper 2, section 3.2.

13 ibid., paper 2, section 3.3.

14 ibid., paper 2, section 3.4.1.

15 ibid., paper 2, section 3.7.1.

16 ibid., paper 2, sections 3.7.1, 3.10.

17 ibid., paper 2, section 3.9.

18 ibid.

19 ibid., paper 3, section 7.

20 ibid., paper 4, sections 2.7.1–2.7.2.

21 ibid., pp. 3–4, paper 3, sections 2.11, 2.13 and 8.

22 ibid., paper 3, section 2.2, section 4.

23 ibid., paper 3, section 7.

24 ibid., paper 4, sections 2.2.0. 2.21, Table 2.14.

25 ibid., p. 1.

26 ibid., paper 5, section 4.1.

27 ibid., paper 5, section 4.10.

28 ibid.

29 ibid., paper 5, section 4.1.

30 ibid.

31 ibid.

32 ibid., paper 5, section 4.3.

33 ibid., paper 5, section 2.4.

34 ibid., paper 5, section 4.7.

35 ibid., paper 5, section 4.6.

36 ibid., paper 5, section 4.7.

37 ibid.

38 ibid., paper 5, section 4.8.

39 ibid., paper 5, section 4.7.

40 ibid., p. 1, paper 3, section 5.12.

41 Ernst & Young, *Computational general equilibrium modelling assessment*, report prepared for the Nuclear Fuel Cycle Royal Commission, Adelaide, February 2016, p. 5, sections 2.3, 2.4, http://nuclearrc.sa.gov.au

42 ibid., section 6.3.

43 ibid., section 4.3.4.

44 ibid., section 6.3.1.

45 ibid., sections 6.3, 6.4.

46 ibid., appendix E, box E.1.

47 ibid., section 6.3.4.

Transcripts and submissions can be found at the Nuclear Fuel Cycle Royal Commission's website: www.nuclearrc.sa.gov.au/transcripts and www.nuclearrc.sa.gov.au/submissions