DAM RISK ASSESSMENT (Partially Based on Maroon Dam)

RISK REGISTER FOR THE PURPOSES OF THIS STUDY ONLY

Identifier	Risk Area	Risk Element	Risk Description	Untreated (Raw) Risk			Typical or Expected Treatment	Residual (After Treatment)Risk		
				Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
	ORIGINAL DAM (NO HARD COVER)									
	Dam Structure	Embankment Failure	Piping Type Failure	Possible	Major	VH	Provision of Filters and Seepage Drains	Unlikely	Major	H
			Flood Failure	Possible	Extreme	VH	Review and Increase Spillway Capacity	Rare	Extreme	H
			Operator Failure (gate issues etc)	Likely	Major	VH	Backup Power Supplies and Operating Systems, Auxiliary Spillway	Unlikely	Major	H
			Earthquake causing cracking	Rare	Moderate	L	Provision of Filters and Seepage Drains	Rare	Moderate	L
			Embankment Overtopping	Possible	Moderate	H	Upgrade Spillway Capacity	Rare	Moderate	L
		Outlet Failure	Blockage of Outlet	Unlikely	Moderate	M	Installation of Trash Racks and Trash Removal System	Unlikely	Minor	M
			Blockage of Control Valves	Rare	Moderate	L	Installation of Trash Racks	Rare	Moderate	L
			Damage to Control Valve Seals and Seats	Unlikely	Moderate	M	Installation of Trash Racks, Provison of external baulks over outlets	Unlikely	Minor	M
			Failure of Outlet Control Valves	Possible	Moderate	H	Upstream Baulk to enable isolation of valve	Possible	Minor	M
			Blocking of Trashrack	Possible	Minor	M	Provision of Trash Rack Cleaning Mechanism	Possible	Insignificant	L
			Outlet Tower Failure (Earthquake)	Unlikely	Major	H	Review and Strengthen as required	Rare	Major	M
		Spillway	Failure of the Spillway	Unlikely	Moderate	M	Spillway Upgrade	Rare	Moderate	L
			Blockage of the Spillway	Unlikely	Moderate	M	Spillway Upgrade and improvement works	Rare	Moderate	L
			Downstream Erosion of Spillway	Possible	Minor	M	Implement erosion control works	Unlikely	Minor	M
			Blockage pattern similar to ice build up	Possible	Moderate	H	Clear Vegetation, Spillway Upgrade	Unlikely	Moderate	M
		Fish Passage	Failure of the Fish Passage System	Possible	Minor	M	Increased level of inspection & maintenance	Unlikely	Minor	M
			Blockage of the Fish Passage System	Possible	Minor	M	Monitor and Clear as necessary	Possible	Minor	M
	Dam Operation	Water Rise & Fall	Inflow of Debris from floods	Almost Certain	Minor	H	Spillway Designed to pass Debris	Almost Certain	Insignificant	M
			Erosion of exposed banks as water level falls	Likely	Minor	M	Monitor and rectify if significant	Likely	Minor	M
			increased turbidity during high inflow periods	Likely	Minor	M	Catchment management issue	Likely	Minor	M
			Increased turbidity from erosion of internal banks	Unlikely	Insignificant	L	Monitor and undertake works if required	Unlikely	Insignificant	L
		Outlet Tower	Unable to Maintain trash racks and baulks	Possible	Minor	M	Upgrade to allow for removal / maintenance	Rare	Minor	L
			Unable to access the outlet tower at all times	Possible	Moderate	H	Upgrade to ensure access is possible	Unlikely	Moderate	M
			Unable to operate outlet and control valves	Possible	Moderate	H	Implement a regular maintenance program	Unlikely	Moderate	M
			Unable to remove or maintain valves	Possible	Major	VH	Undertake works to address issue	Unlikely	Major	H
		Seepage	Blockage of Filters	Unlikely	Moderate	M	Careul design and selection of filter material	Rare	Moderate	L
			failure of seepage monitoring	Unlikely	Minor	M	Inspection and maintenance program	Rare	Minor	L
		Ungated Spillway	Reduction in spillway capacity (change in hydraulic characteristics)	Possible	Moderate	H	Undertake Spillway Upgrade / auxiliary spillway	Rare	Moderate	L

Identifier	Risk Area	Risk Element	Risk Description	Untreated (Raw) Risk Likelihood	Consequence	Risk Rating	Typical or Expected Treatment	Residual (After Treatment)Risk Likelihood	Consequence	Risk Rating
		Gated Spillway	Failure of Spillway Gates to open under floods	Possible	Major	VH	Provision of backup systems	Unlikely	Major	H
			Spillway gates fail to close (after flood event)	Possible	Minor	M	Implement / increase maintenance regime	Unlikely	Minor	M
			Blockage of spillway (debris etc)	Possible	Major	VH	Provide Upstream Barrier / Catch nets	Unlikely	Major	H
		Fuseplug Spillway - erosion type	Fuseplug fails to operate under flood loading	Rare	Major	M	Regular review and inspection of fuse plug	Rare	Major	M
			Premature triggering of Fuse Plug	Unlikely	Moderate	M	Regular inspection and maintenance of fuse plug	Rare	Moderate	L
		Fuseplug Spillway - "Hydroplus"	Failure to operate under flood conditions	Unlikely	Moderate	M	Regular review and inspection of fuse plug	Rare	Moderate	L
			Premature triggering of Fuse Plug	Possible	Major	VH	Regular review and inspection of fuse plug	Unlikely	Major	H
		Stop Log Spillway	Unable to remove stop logs	Possible	Minor	M	Regular inspection and maintenance	Unlikely	Minor	M
			Blockage of spillway slots	Possible	Minor	M	Provide Upstream barrier / screen	Unlikely	Minor	M
		Impact on Water level monitoring systems	Failure of Water Monitoring Gauge (electronic)	Almost Certain	Insignificant	M	Regular Maintenance. Replace when required	Possible	Insignificant	L
			Guage not reading correctly	Likely	Insignificant	M	Regular checking and maintenance	Possible	Insignificant	L
	Water Quality	Temperature	Release of cold water downstream	Likely	Insignificant	M	Floating arm offtake or other outlet changes	Unlikely	Insignificant	L
			Dam rolling over (inversion of thermocline)	Likely	Minor	M	Stratification controls	Unlikely	Insignificant	L
		Algae	Development of Algae (blue green type)	Likely	Moderate	H	Warning signs, aeration systems etc	Possible	Moderate	H
			Swimmers and Recreation users becoming ill	Possible	Moderate	H	Warning signs, restrictions on boating & swimming	Possible	Moderate	H
		Sampling Locations	Require a boat to access - boating & drowning hazard	Possible	Extreme	VH	Flotation Vests, training	Unlikely	Extreme	VH
	Environmental	Thermocline	Development of Thermocline	Almost Certain	Minor	M	Implement controls if an issue	Almost Certain	Minor	M
		Impact on Aquatic Animals		Unlikely	Minor	M	Provide habitat (logs, structures etc)	Unlikely	Insignificant	L
		Impact on Microbes		Unlikely	Minor	M	Monitor	Unlikely	Insignificant	L
	Recreation Use	General Boating	Public Risk using boat ramp and facilities	Likely	Minor	M	Warning signs, ensure facilities meet standards etc	Likely	Minor	M
			Drowning or other accident / incident	Likely	Extreme	E	warning signs, boating speed limits etc	Possible	Extreme	VH
		High Speed Boating	Boating accident	Possible	Major	VH	warning signs, boating speed limits etc	Possible	Major	VH
		Fishing	Boating Accident / drowning	Possible	Extreme	VH	warning signs, boating speed limits etc	Possible	Extreme	VH
		Swimming	Drowning	Possible	Extreme	VH	Restricted swimmng areas, warning signs	Possible	Extreme	VH
			Other Injury	Possible	Minor	M	Warning signs	Possible	Minor	M
		Picnicing / sightseeing etc	Drowning	Possible	Extreme	VH	Warning signs and fences	Possible	Extreme	VH
			Other Injury	Possible	Minor	M	Warning signs, facilities that meet standards	Possible	Minor	M

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	ORIGINAL DAM - HARD COVER FITTED (changes from "No Cover" noted in red)									
	Dam Structure	Embankment Failure	Piping Type Failure	Possible	Major	VH	Provision of Filters and Seepage Drains	Unlikely	Major	H
			Flood Failure	Possible	Extreme	VH	Review and Increase Spillway Capacity	Rare	Extreme	H
			Operator Failure (gate issues etc)	Likely	Major	VH	Backup Power Supplies and Operating Systems, Auxiliary Spillway	Unlikely	Major	H
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			Embankment Overtopping	Possible	Moderate	H	Upgrade Spillway Capacity	Rare	Moderate	L
		Outlet Failure	Blockage of Outlet	Possible	Moderate	H	Installation of Trash Racks and Trash Removal System. Install Exclusion Screen around outlet	Unlikely	Minor	M
			Blockage of Control Valves	Unlikely	Moderate	M	Installation of Trash Racks	Rare	Moderate	L
			Damage to Control Valve Seals and Seats	Unlikely	Moderate	M	Installation of Trash Racks, Provison of external baulks over outlets	Unlikely	Minor	M
			Failure of Outlet Control Valves	Possible	Moderate	H	Upstream Baulk to enable isolation of valve	Possible	Minor	M
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		Gated Spillway	Failure of Spillway Gates to open under floods	Possible	Major	VH	Provision of backup systems	Unlikely	Major	H
			Spillway gates fail to close (after flood event)	Possible	Minor	M	Implement / increase maintenance regime	Unlikely	Minor	M
			Blockage of spillway (debris etc)	Possible	Major	VH	Provide Upstream Barrier / Catch nets	Unlikely	Major	H
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		Algae	Development of Algae (blue green type)	Likely	Moderate	H	Warning signs, aeration systems etc	Possible	Moderate	H
			Swimmers and Recreation users becoming ill	Possible	Moderate	H	Warning signs, restrictions on boating & swimming	Possible	Moderate	H
		Sampling Locations	Require a boat to access - boating & drowning hazard	Possible	Extreme	VH	Flotation Vests, training	Unlikely	Extreme	VH
	Environmental	Thermocline	Development of Thermocline	Almost Certain	Minor	M	Implement controls if an issue	Almost Certain	Minor	M
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		Impact on Microbes		Unlikely	Minor	M	Monitor	Unlikely	Insignificant	L
	Recreation Use	General Boating	Public Risk using boat ramp and facilities	Likely	Minor	M	Warning signs, ensure facilities meet standards etc	Likely	Minor	M
			Drowning or other accident / incident	Likely	Extreme	E	warning signs, boating speed limits etc	Possible	Extreme	VH
		High Speed Boating	Boating accident	Possible	Major	VH	warning signs, boating speed limits etc	Possible	Major	VH
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		Swimming	Drowning	Possible	Extreme	VH	Restricted swimmng areas, warning signs	Possible	Extreme	VH
			Other Injury	Possible	Minor	M	Warning signs	Possible	Minor	M
		Picnicing / sightseeing etc	Drowning	Possible	Extreme	VH	Warning signs and fences	Possible	Extreme	VH
			Other Injury	Possible	Minor	M	Warning signs, facilities that meet standards	Possible	Minor	M
	DAM WITH HARD COVER INSTALLED (ADDITIONAL RISKS)									
	Dam Operator	Increased Workload	Another issue to consider in a "crisis" situation	Likely	Minor	M	Well considered and designed cover	Unlikely	Minor	M

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				Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
		Moving the Cover	Moving cover on Dry Land (manual handling)	Likely	Minor	M	Provide handling equipment (loader etc)	Unlikely	Minor	M
			Moving cover on water (drowning, manual handling)	Possible	Extreme	VH	Life Jackets, training, handling equipment	Unlikely	Extreme	VH
		Operator OH&S	Cuts etc (from broken cover)	Likely	Minor	M	Use of Gloves and handling equipment	Possible	Minor	M
			Calm Weather conditions required to access cover (restricts period of access)	Likely	Minor	M	Plan to undertake work during early morning (low wind conditions)	Unlikely	Minor	M
			Heavy installed weight (depends on cover design) - leads to manual handling injury	Likely	Minor	M	Lifting mechanism to lift cover from the water	Unlikely	Minor	M
		Maintenance of Boom	Maintenance requires dam operators to access by boat and work over water. Risk of drowning. Handling of bulky (and heavy components)	Possible	Extreme	VH	Use of barge equipped with lifting equipment and provision of lift jackets and training	Unlikely	Extreme	VH
		Acceptance by the Operator	Operator(s) reluctant to take on additional "perceived" workload. Lack of ownership	Likely	Minor	M	Operator involvement in design and selection process (consulation with the operator)	Possible	Minor	M
		Collection & Disposal of Damaged Units	Need for frequent collection of damaged units. Requires use of boat. Risk of drowning.	Possible	Extreme	VH	Properly designed maintenance craft with lifting facilities, use of life jackets and training	Unlikely	Extreme	VH
		Increased level of signage	Installation & maintenance of additional warning signs	Likely	Minor	M	Regularly review and inspect signs	Likely	Minor	M
		Control of boating and related infringements	Increased level of control over boating activities. Damage to cover by recreation craft	Likely	Moderate	H	Increase area of boating exclusion zone, warning signs	Possible	Minor	M
		Cover units blowing onto face of Rock Fill Dams	Cover escapes from impoundment area and is blown up on the bank - difficult to access	Possible	Minor	M	Well designed containment boom and boom maintenance progra,	Unlikely	Minor	M
		Covers stacking on top of each other	Wind and wave action causes covers to stack on top of each other - requiring operators to separate. Manual handling and risk of drowning.	Possible	Major	H	Design of the covers to resist stacking or under normal wave action will separate.	Unlikely	Minor	M
		Increases Work Load under Dam Safety Emergency	Under dam safety events the cover will be neglected to deal with more important tasks, unless it impacts on dam safety	Almost Certain	Moderate	H	Robust design of cover and containment boom, back up boom	Possible	Moderate	H
	Public Safety	Increased Glare (Boating, public complaints)	Boating hazard (due to reflection off the covers and public complaints)	Possible	Minor	M	Change the colour of the cover and finish with a low reflective surface.	Unlikely	Minor	M
		Increased Glare (Aviation)	Aviation hazard due to the reflection off the covers	Unlikely	Minor	M	Change the colour of the cover and finish with a low reflective surface.	Rare	Minor	L
	Natural Event Risks	Wind Action	Strong wind causes covers to stack in one area	Possible	Moderate	H	Design covers to resist stacking or to easily slide apart when wind abates	Unlikely	Minor	M
		Wave Action	Wave action causes covers to stack together or contact between units causes damage	Possible	Moderate	H	Design covers to resist stacking and reinforce all contact points	Unlikely	Minor	M
		Flood Action	Floods lift the covers over the top of the containment boom(s) (Insufficient length in mooring system)	Possible	Moderate	H	Containment boom designed for large variation in water level including floods	Rare	Minor	L
		Drought Event (Major)	Cover(s) become stranded on exposed bed of dam. Damage to covers, blowing away in high winds etc	Possible	Moderate	H	The cover is partly removed and stored as the surface area reduces.	Rare	Minor	L
		Catching debris if located at head of Res.	Debris entering the dam causes damage to the cover or builds up and causes cover to sink.	Possible	Moderate	H	Cleaning and maintenance program	Unlikely	Minor	M
	Access	Operator Access	Dam operator unable to access cover to check its condition (unable to pass through containment boom)	Possible	Moderate	H	Provision of access panels and other facilities	Unlikely	Minor	M

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		Access to centre of mass to check	Unable to access centre of the area of cover to carry out inspections or remove damaged covers	Possible	Moderate	H	Reduce the number of covers in an area to enable a boat to move covers aside.	Unlikely	Minor	M
	Public	Accessible by public when washed up	Cover is accessed by the public during low water periods. Susceptable to vandalism and theft	Likely	Minor	M	Remove cover units as water levels fall	Possible	Minor	M
		Banning Recreation Use (or limiting)	Installation of hard cover will limit or reduce the water surface available for recreation. Adverse public reaction could result	Likely	Moderate	H	Promote public discussion / information during development / design phase	Possible	Minor	M
		Closing Rec Access if cover gets loose	If the containment boom fails, it may be necessary to close dam to recreation use. Adverse public reaction	Likely	Moderate	H	Develop a management plan for this situation. Design containment for a high loading and low probability of failure. Include a second outer containment boom	Unlikely	Minor	M
		Acceptance by Public	New technology could attract a wide range of comment including cost benefit of system	Likely	Moderate	H	Promote public discussion / information during development / design phase	Possible	Minor	M
	Aesthetics	Partial Coverage	Cover only covers a part of the dam - reduces visual aesthetics of the dam	Likely	Insignificant	M	No Action proposed	Likely	Insignificant	M
		Full Coverage	Full coverage of dam is likely to attract a lot of comment	Likely	Insignificant	M	No Action proposed	Likely	Insignificant	M
		Aesthetics Litter Problem	If the containment boom fails the cover will spread out and create a litter type issue	Likely	Moderate	H	Provide a second outer back up containment boom	Unlikely	Moderate	M
		Long term change in colour	Covers colour will change over time (fade and show algae growth)	Likely	Insignificant	M	No Action proposed	Likely	Insignificant	M
		Use of White Colour	White colour is highly reflective and therefore produces a high rate of "glare"	Likely	Insignificant	M	adopt an off shade of white and a non reflective surface	Unlikely	Insignificant	L
	Downstream Risks	Litter Problem (cover washing downstream)	If the containment boom(s) fail during a flood, cover units will be washed downstream, littering the stream.	Likely	Major	VH	Provide a second outer containment boom. Design of boom(s) to reduce risk.	Unlikely	Major	H
	Inherent Design Risks	Algae Growth	Growth of Algae on the covers impacting on the cover's performance	Almost Certain	Minor	H	Include an inhibitor in the fabrication material	Likely	Minor	M
		Stability	Cover is unstable when anyone attempts to stand on it (whilst in the water). Risk of injury or drowning.	Almost Certain	Major	E	Fence off area along bank, warning signs, boating exclusion zone around cover, outer second containment boom.	Possible	Major	VH
		Public Trapped under cover	Public accessing the cover are trapped under the cover	Possible	Major	VH	Fence off area along bank, warning signs, boating exclusion zone around cover, outer second containment boom.	Possible	Major	VH
		Public Walking on Cover	Public trying to walk on the cover, and falling through and unable to get out.	Possible	Major	VH	Fence off area along bank, warning signs, boating exclusion zone around cover, outer second containment boom.	Possible	Major	VH
		Containment Boom	Containment Boom Failing	Possible	Major	VH	Provide a second outer containment boom	Unlikely	Major	H
		Vandalism	Public vandalises the cover or containment boom	Possible	Major	VH	Fence off area along bank, warning signs, boating exclusion zone around cover, outer second containment boom.	Unlikely	Major	H
		Inquisitiveness (check out)	Public getting into difficulty from being inquistive (wanting to look at the cover)	Possible	Major	VH	Fence off area along bank, warning signs, boating exclusion zone around cover, outer second containment boom.	Unlikely	Major	H
		Efficiency Issue for Partial Coverage	Cover not performing as expected due to partial coverage of dam only	Possible	Minor	M	Conduct large scale testing in the field	Unlikely	Minor	M
		clearing of the dam of trees etc	Any trees or marine structure could damage the cover at low water levels	Possible	Minor	M	Clear and remove all structures from base of dam (could be difficult if dam water level is not low)	Unlikely	Minor	M

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		How tightly they pack (access etc)	Risk of cover units not packing together in a large mass as designed (and holding this pattern)	Unlikely	Insignificant	L	No Action proposed	Unlikely	Insignificant	L
		Wear between units (wave action)	Excessive wear due to constant wave action	Possible	Minor	M	Reinforce contact areas	Possible	Insignificant	L
		Keeping 2nd boom separated from main area	Maintaining the second outer containment boom with a sufficient gap to discourage the public from accessing the cover. Gap closes	Possible	Minor	M	Careful design and placement of boom mooring system	Unlikely	Minor	M
		adjusting boom mooring for vertical rise and floor	Boom mooring system unable to cope with large variation in water levels	Possible	Minor	M	Careful design and placement of boom mooring system	Unlikely	Minor	M
		Catching Debris	Cover and containment booms catching and holding debris floating in the dam	Possible	Minor	M	Design to minimise potential for catching and holding debris	Possible	Minor	M
		Long Term Exposure to Sunlight	Long term exposure to sunlight causes cover to prematurely break down and become brittle	Possible	Major	VH	Careful selection of colour and inclusion of UV stabiliser in manufacturing material	Unlikely	Minor	M
		Long term operation if whole of storage cover	creation of a permanent debris pack on the storage	Possible	Minor	M	No Action proposed	Possible	Minor	M
		Hail Damage	Damage to cover from a severe hail storm (very large hail)	Possible	Major	VH	Increase thickness of cover material	Possible	Minor	M
		Lightning Damage	Damage to cover if struck by lightning	Possible	Minor	M	No Action Proposed	Possible	Minor	M
		Fire	(Bush Fire or intentional damage)	Possible	Minor	M	Provide a fire retardant in the material of manufacture	Unlikely	Minor	M

Risk Register - Elements & Rating Criteria

REVISION: 0
REVISION DATE: 1/04/10
FILE PATH: H:\My Documents\Griffith University\[Maroon Dam Risk Assessment.xls]Existing Dam Risk Register

Likelihood Criteria

Likelihood of occurence	
Almost Certain	90 - 100%
Likely	51 - 90%
Possible	5 - 50%
Unlikely	0.5 - 5%
Rare	0 - 0.5%

Consequence Criteria:

Consequence	Classification						
	Cost	**Time to Repiair or Reinstate**	**Water Quality**	**Water Delivery**	**Community**	**Public & Workforce Safety**	**Environment**
Extreme	> $10 million	>10 weeks	Failing to meet spec. Unusable Risk to public health Not suitable for irrigation	> 80% shortfall	Extreme negative media coverage / State Government intervention	Death or permanent incapacition	Catastrophic site impact / high local impact / moderate external impact / serious long-term cumulative effect
Major	$5.0 million to $10 million	2 - 10 weeks		50% to 80% shortfall	Significant negative media coverage / Formal council intervention	Major injury / illness	High site impact / moderate local impact / minimal external impact / minor long-term cumulative effect
Moderate	$1.0 to $5.0 million	5 days - 2week	Useable but significant Water Quality issues	25% to 50% shortfall	Critical media coverage / formal council request for information	LTI	Moderate site impact / Minimal local impact / possible long-term cumulative effect
Minor	$200k to $1.0m	2 to 5days		5% to 25% shortfall	No. of community complaints above expected average	Minor injury / illness	Minimal site impact / easily controlled
Insignificant	Less than $200k	< 2day	Breach of one or two minor parameters No impact on Irrigation or Recreation users	< 5% shortfall	No. of community complaints at expected average	No injury / illness	No impact

Risk Rating:

Likelihood	Consequence				
	Insignificant	**Minor**	**Moderate**	**Major**	**Extreme**
Almost Certain	M	H	H	E	E
Likely	M	M	H	VH	E
Possible	L	M	H	VH	VH
Unlikely	L	M	M	H	VH
Rare	L	L	L	M	H