Appendix E Town of Claremont

APPENDIX E.1 HISTORIC AERIAL IMAGE COMPARISONS FOR TOC

Figure 12-67: SRCla01 Mrs Herberts Park Aerial Images 1953, 1965, 1983 and 2014

Figure 12-68: SRCla02 Jetty Rd Aerial Images 1953, 1965, 1983 and 2014

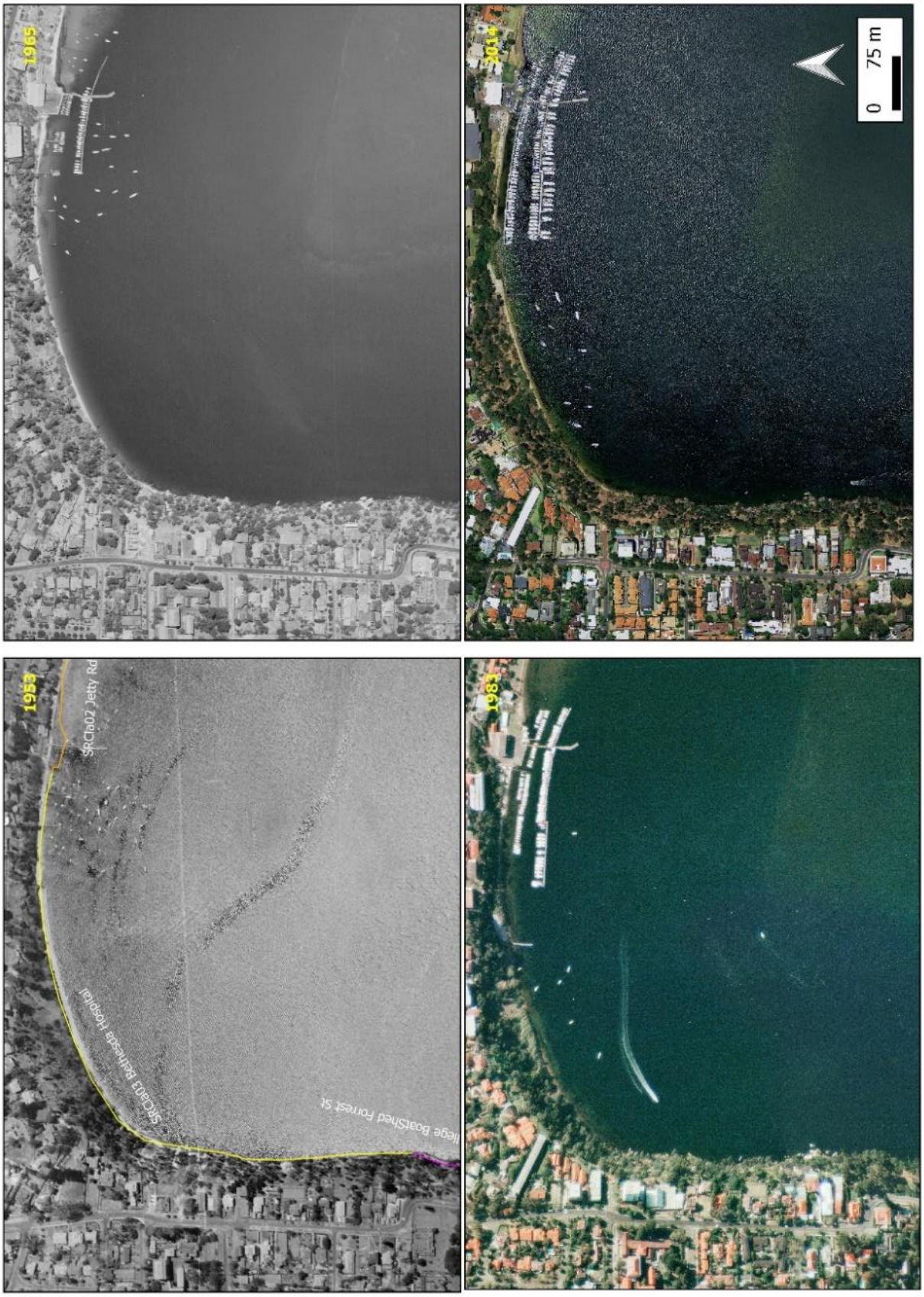

Figure 12-69: SRCla03 Bethesda Hospital Aerial Images 1953, 1965, 1983 and 2014

APPENDIX E.2 DETAILED ISSUES AND CONSTRAINTS FOR TOC

Table 12-34: Issues and Constraints for Town of Claremont Segments

		SRCla01 Mrs Herberts Park	SRCla02 Jetty Rd	SRCla03 Bethesda Hospital
	Asset_ID	RV_00082	RV_00098	RV_00083
	Length_m	408	427	1003
Governance	LGA	Town of Claremont	Town of Claremont	Town of Claremont
	Boundary with other LGA or stakeholder	Y (City of Nedlands)	Y (CYC)	Y (Shire of Peppermint Grove, CYC)
	HWM Private Property (or other private property land-use conflict)	Y	Y	Y
	Site access constraints for undertaking works	N	N (soft sediment possibly)	Y (cliffs, boatsheds, Christchurch Boat ramp)
Environmental /Heritage Significance	Bushforever/ ecological sites/ marine parks	N	N	Y (Threatened Ecological Community – Tuart Trees)
	Native title/aboriginal heritage (DAA Heritage Site search)	Y (Site Swan River 3536)	Y (Site Swan River 3536)	Y (Site Swan River 3536, Site Loreto Convent Claremont 3755)
	European heritage	Y (Claremont Baths)	Y (Claremont Jetty)	Y (Osborne Steps)
	Significant trees	3 (2 Mrs Herberts Park, 1 near drain)	1 (Norfolk Pine on Jetty Road)	N
	Views (and people likely to kill trees for it)	Y	Y	Y (only at top of cliffs)
Recreation infrastructure	Recreation reserves/ areas/ parks	Mrs Herberts Reserve (Reserve 885), Alex Prior Reserve (Reserve 2025), Reserve 35609 (reclaimed portion of 3 properties by WAPC subdivision), Reserve 24253	Reserve 24253, Reserve 39246 (WAPC reclaimed immediately downstream from toilet block for one property)	Reserve 24253
	Yacht club and goal to avoid sedimentation	N	Y (CYC)	Y (CYC)
	Boat moorings	Y (>50m from grassline)	Y (>50m from grassline)	Y (>40m from base of cliffs)
	Dinghy storage	N	Y	Y
	Kayak launching	Y	Y	Y

		SRCla01 Mrs Herberts Park	SRCla02 Jetty Rd	SRCla03 Bethesda Hospital
	Boat ramps	N	Y (Chester Road)	Y (CYC private ramp, Christchurch boatshed private ramp)
	Cycle path	N	N	N
	Toilet blocks	Y (set back beyond inundation zone)	Y (Jetty Road)	N
	Car parks	Y (Chester Road)	Y (Jetty Road, also CYC but not public)	N (CYC in part but not public)
	Infrastructure in inundation zone (100Yr ARI + SLR)	Y (carpark, rock revetment around carpark, boat ramp, Chester Road, drain, private property assets, seating, play equipment)	Y (Jetty Road carpark, Claremont Jetty, Jetty Road, toilets at Jetty Road, sewage pump station at Jetty Road, drains (groynes and flexmat in scour area), stairs, private property assets, seating, CYC infrastructure, flexmats adjacent to CYC)	Y (CYC infrastructure, Christchurch boatshed and boatramp (and broken jetty), Rock wall adjacent to Christchurch boatshed, private property assets (including boatsheds))
	Stairs	N	Y (two sets of floating stairs (attached to jetty))	Y (on hill extending from Christchurch to mid-slope - creating UA issues)
	Disabled access	N (Chester road car park on to grassed area possible)	Y (Jetty Road carpark only on to Jetty Road. Needs relocation due to overbank runoff)	N
	Seating	Y	Y	N
	Jetties (require navigability)	N	Y	Y (Private assets of CYC)
Response to modifications	Historic dredging <100m from shoreline	Y (not traditional dredging but rocks were excavated from the bed (pre-1931), Claremont baths may have been dredged)	Y (local excavation of material at CYC)	N
	Historic dredging >100m from shoreline	Maybe	Maybe	N
	Historic reclamation/ renourishment	Y (1920, 1931, additional dates unknown)	Y (1995, 1997, Unknown, 2004)	N
	Structure extending riverward providing artificial control	Y (Chester Road carpark revetment and boat ramp [>20m extension])	Y (Jetty Road abutment, groynes at drains [3m], CYC [30m since 1953])	Y (CYC [30m since 1953], Christchurch boat ramp [5m now])
	Previous structure extending riverward providing control, now removed	Y (Chester Road revetment pre-1931 alignment)	N	N

		SRCla01 Mrs Herberts Park	SRCla02 Jetty Rd	SRCla03 Bethesda Hospital
	Groynes	N	Y (2 small minor ones at Jetty Road drains)	N
	Structure impeding cross-shore transport	Y (Chester Road car park, private property walling)	Y (abutment at Jetty Road, walling at toilet block at Jetty Road, private property walling, CYC walling, flexmat east of CYC (now buried))	Y (CYC walling, Rock wall adjacent to Christchurch boat ramp, Christchurch boat ramp)
Runoff, stormwater and sewerage	Overbank runoff/ unmanaged runoff	N	Y (Jetty Road carpark including new disabled access point, private property riverwards, CYC runoff)	Y (CYC runoff, possible some from upper bank private properties from paved areas and flushing of swimming pools)
	Stormwater drainage	Y (low on bank with headwall with drain causing ponding)	Y (Jetty Road 2 main drains and 1 smaller carpark drain low invert levels)	N
	Delta/ accumulation associated with drainage	N (ponding)	Y (accumulation and scour with Jetty Road drains)	N
	Water Corp/ main roads drains	N	Y (Jetty Road)	N
	Sewerage or pump station	N	Y (Jetty Road, check CYC facilities)	N
Other, UA, wrack, scarps, ASS, sprinklers, bed level lowering, rotation	Uncontrolled access contributing to erosion	Y (immediately east of Chester Road carpark where people access beach and in gaps between sedge. Trampling of sedge)	Y(minor trampling adjacent to Jetty Road, trampling of sedge)	Y (particularly where bamboo removed west of Christchurch boatshed and where stairs (2011) only extend half-way downslope with trampling)
	Wrack accumulation	Y	Y	Y (only immediately adjacent to private leases of CYC and Christchurch grammar)
	Scarp formation (trip hazard)	Y (small)	Y (small)	N
	Terrestrial acid sulphate soil risk	Low to no risk of AASS and PASS occurring generally at depths of >3m	Low to no risk of AASS and PASS occurring generally at depths of >3m	Low to no risk of AASS and PASS occurring generally at depths of >3m
	Sprinklers adjacent to walling	N	N	N
	Bed level lowering	Maybe (possible adjacent to Chester Road carpark)	N	N

		SRCla01 Mrs Herberts Park	SRCla02 Jetty Rd	SRCla03 Bethesda Hospital
	Rotation	Y	Y	Y
Existing Plans	Existing Plans in place that may restrict works	No significant constraint (FMP (2002), Freshwater Bay Management Plan (1999))	CYC activities and approved extensions (also FMP (2002), Freshwater Bay Management Plan (1999))	Christchurch boat launch activities and CYC activities and approved extensions (FMP (2002), Freshwater Bay Management Plan (1999), bamboo clearing)

APPENDIX E.3 STRUCTURE CONDITION AND FUNCTION COMPARISON TOC

Damara WA/Seashore Engineering staff undertook a structure condition and function assessment in 2004 (Damara WA 2007a; SRT 2008 *FAMS*) and 2014 (Damara WA 2015) for most of the WESROC foreshore. A three-point ranking for structure condition and foreshore retention function was undertaken in both assessments and was available for comparison. The three-point rankings are explained in the table below. It should be noted that although this information was not reported in the 2014 assessment, it was still collected to provide comparison to the method used in 2003-2007 elsewhere on the river.

Assessment	Condition	Foreshore Retention Function
Good	The structure is well maintained and is not subject to damage from active processes.	There is no evidence of material loss from behind the structure. The structure performs its function under the full range of conditions experienced since construction or last major maintenance.
Fair	The structure has experienced some damage due to active processes. In general, this damage is minor and any repair would be considered routine maintenance.	There is good retention under moderate conditions, with some material loss during extreme or infrequent events. Minor loss of material affects less than 25% of the area immediately behind the structure.
Poor	Damage has occurred to the structure. The structure would require replacement, possibly with design modifications to accommodate the active processes.	The structure is performing unsatisfactorily as a retaining system. Significant sediment loss affects more than 25% of the area immediately behind the structure.

The comparison of structure condition is included in Figure 12-70 and the comparison of foreshore retention function in Figure 12-71, with the 2004 results in the left panel and the 2014 in the right panel.

Not all structures were assessed on both occassions, the spatial extent of the structures assessed sometimes varied and some structures did not exist in 2004. Notable modifications include:

- SRCla01.B01 - Revetment has been extended further upstream (east) since 2004.

Further visual comparison between photos of structures, along with three photos of each structure is provided in Appendix E.7. The 2014 photos of each structure are from Damara WA (2015), the 2003/2004 photos are from Damara WA (2003, 2007).

The 2014 assessment also noted any structures with areas of focal condition of 4 or 5 (out of a rank of 5, with 5 being the worst condition), which corresponds to focal areas of 'poor' condition according to the three-point ranking in the table above. Structures *not rated as poor*, with small areas of condition 4 or 5 included:

- Town of Claremont: SRCla01.B01

The information on where these focal areas of poor condition are located is included in Table 12-36.

A visual representation of the combined condition and consequence ranking for structures and drains in the WESROC area is provided. This rank is called the Asset Management System (AMS) Rank and it was used in the recent assessment of asset condition for Parks and Wildlife (Damara WA 2015, after MP Rogers & Associates 2013). This combined ranking is according to Table 12-35 with condition provided as a rank of 1 (good) to 5 (poor) and consequence provided as a rank of 1 (low) to 5 (high). The combined ranks are colour-coded into six ranks of management priority with red highest priority through to dark green as lowest priority. A limitation of this approach is the rank was applied for the whole foreshore subsegment and it does not incorporate small locations of failure.

Table 12-35: Asset Management System (AMS) Rank

		Condition				
		1	**2**	**3**	**4**	**5**
Consequence	5	5	10	15	23	25
	4	4	9	14	20	24
	3	3	8	13	19	22
	2	2	7	12	18	21
	1	1	6	11	16	17

The number of structures and drains (left panel), along with their AMS rank (right panel), are shown in Figure 12-72 and Figure 12-73. Further explanation of the condition, consequences and management requirements are provided in Table 12-36 and Table 12-37. Not all assets were assessed. For example, drains ending in code .D0x were not assessed.

Figure 12-70: Town of Claremont Structure Condition 2004 and 2014

Figure 12-71: Town of Claremont Structure Function 2004 and 2014

Figure 12-72: Town of Claremont AMS January 2015 Rank for Structures

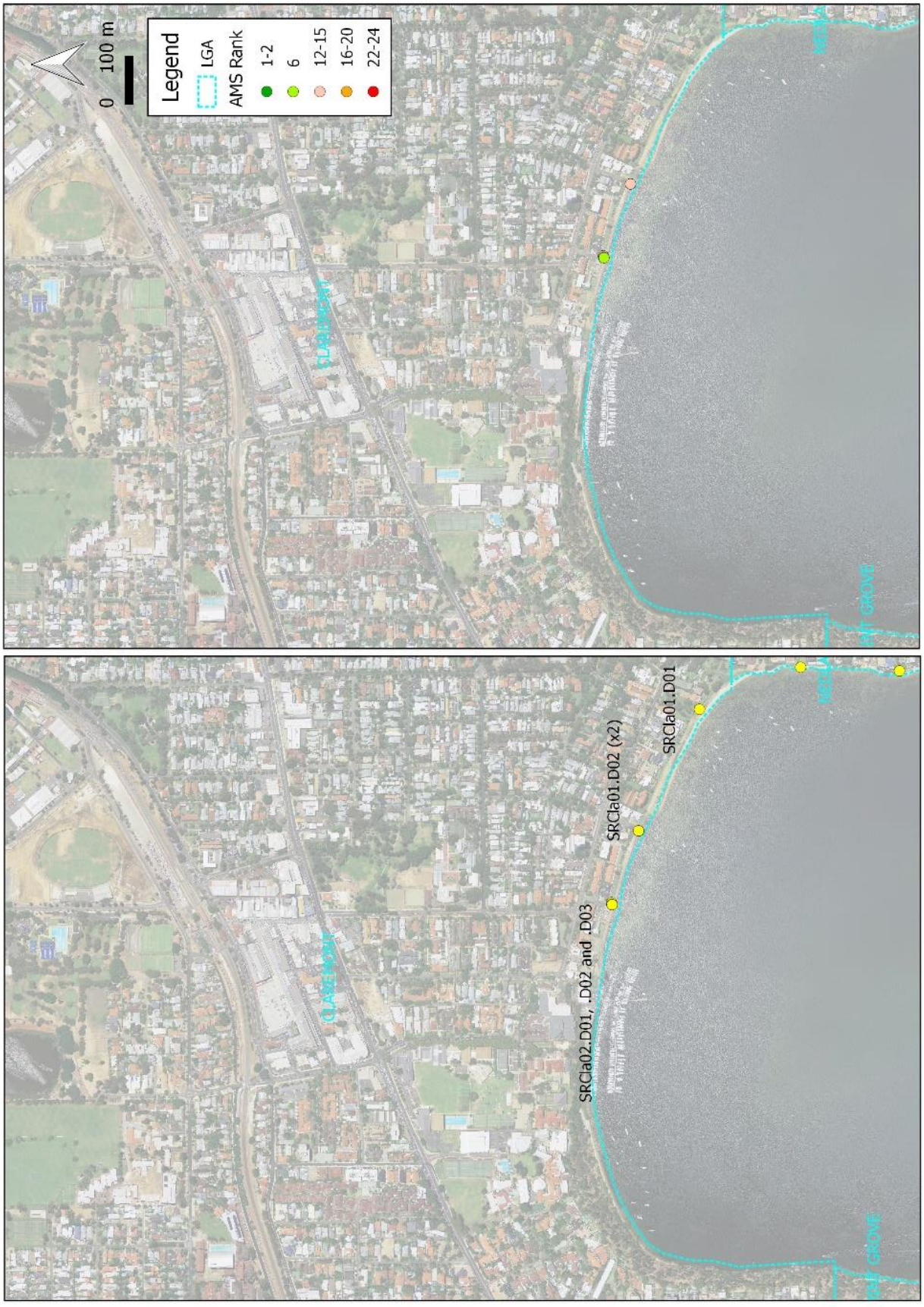

Figure 12-73: Town of Claremont AMS January 2015 Rank for Drains

APPENDIX E.4 DAMARA WA (2015) STRUCTURE AND DRAIN ASSESSMENTS FOR TOC

Table 12-36: Town of Claremont - AMS structure condition and maintenance (Damara WA 2015)

ID	L. (m)	H (m)	Cond.	Cons.	Rank	Condition comment	Maintenance comment	Rater comments
SRCla01 Mrs Herberts Park.B01 (Rock Revetment/ Rock Rip Rap)	72	0.86	3	3	13	Limestone rock with some building rubble; Revetment immediately abuts car park (with small section of woodchips, sedge and kerbing between crest and carpark) which extends locally into the river compared to adjacent banks. Revetment has been extended upstream to retain grass area as a tie-in with flanking erosion (scarp in grass) and wrack accumulation. At upstream end some extra rock acts as a small groyne. At the downstream end there are local drains, a boat ramp and then private property. In the revetment there is armour unit breakage, toe flattening, loss of crest elevation, exposure (and loss) of core, loss of armour contact, slope steepening, drifters, no evidence of filter cloth, poor drainage management to landward, some voids and undersize rock (particularly at crest). There are a couple of sections that are condition 4. A lot of past patching is evidence, particularly in some areas with undersize rock. Erosion over and through the structure. Some areas of partial collapse. No obvious gradation in rock sizes to the core. Some steep face areas. Localised areas of runoff over the carpark from water accumulated in the carpark (385069 6460057) running off the steep hill. Car park itself has broken kerbing, movement of bitumen and areas with unmanaged runoff. At toe of revetment there are drifters and old core, with groundwater seepage. Evidence of overtopping.	Immediate maintenance and Remove/rebuild; Immediate maintenance includes avoiding using undersize rock in future, replace drifters into revetment, create a more gradual sloped toe and raise level of the revetment in collapsed areas. Maintain two PVC drains to ensure siltation is minimal and consider adding another drain for local runoff at 385069 6460057 at end of car park (note this will be a point of focal failure under wave conditions and require frequent [6-monthly maximum] maintenance). Renourishment required at upstream extent to manage updrift erosion. Overall the main recommendation is to Rebuild/remove. Shift the front area of the carpark landward and extend further upstream to ensure the same number of bays, but without extending as far riverward. The norfolk pine tree would be maintained, but the pepper tree would be lost, which would require community consultation. If carpark moved the revetment should be reconstructed as a layered revetment with reduced slope, filter cloth, core and good interlocking.	Purpose is shore realignment (it is effectively realigning the shore for adjacent foreshores and holding the line for the carpark), structure protection (car park, boat launching ramp). Historic purpose was Claremont baths; Consequence (3) because of asset value of carpark, reconstruction of revetment and complaints by public

Table 12-37: Town of Claremont - AMS drains condition and maintenance (Damara WA 2015)

ID	Int Diam (mm)	Invert (m)	Cond.	Cons.	Rank	Condition comment	Maintenance comment	Rater comments
SRCla01 Mrs Herberts Park.D01	225; 225	0.594; 0.417	3	2	12	PVC; 2 small pipes that locally drain car park adjacent to steep Chester Road. Some siltation of the two drains with leaf litter likely to often obscure drains. Discharge to within large revetment. Not lowest point in carpark so not all runoff flows to this drain. Flows off at low point in car park/revetment as identified in B01	No urgent works required; Ongoing (6-weekly) clearing of vegetation and leaf litter on landward and riverward sides of drains.	Consequence (2) if drain is blocked, water from steep Chester Road accumulates in car park and flows off at low point in car park/revetment.
SRCla02 Jetty Rd.D01	900	-0.02	3	4	14	Concrete; gross pollutant trap (GPT). Water Corporation - Large round drain and in conjunction with a large rectangular drain (D02) discharges into the same area, creating the same problems. Discharges into an area with decking above, channelled between two training walls (grouted limestone blocks), with insufficient grout. Adjacent to decking is the Claremont Jetty. Sand bar forms between two training walls blocking stormwater flow from the drains and the draining of water from high water level events in the river. At the time of assessment a scour channel had formed in the bar to allow the release of water. Trapped water could also have trapped seagrass emanating a sulfurous smell (concern for local residents). Area is susceptible to scour during large flow events, with a scour hole >0.5m deep on the terrace, full of wrack during the December 2014 assessment. Landward of the scour hole is a 150mm x 150mm flexmat (flexible concrete block mattress), with scour riverward.	Immediate maintenance; Re-grout limestone block groynes. Do not install any larger scour management plans for these drains (no larger scour apron). If smell is a concern - dig out sand bar and allow to flush when required or dig out decomposing wrack and seagrass. Remove decomposing wrack and seagrass also from scour hole to reduce smell.	Consequence (4) because of the local scour and blocking caused by movement of the beach and interaction with the flow from the large Water Corporation drains. When drain is blocked there can be a bad odour from decomposing wrack generating a lot of complaints. Local loss of beach also a concern. Scour hole a safety hazard.

ID	Int Diam (mm)	Invert (m)	Cond.	Cons.	Rank	Condition comment	Maintenance comment	Rater comments
SRCla02 Jetty Rd.D02	600x1250	0.02	3	4	14	Concrete; gross pollutant trap (GPT). Water Corporation - Large rectangle and in conjunction with a large round drain (D01) discharges into the same area, creating the same problems. Discharges into an area with decking above, channelled between two training walls (grouted limestone blocks), with insufficient grout. Adjacent to decking is the Claremont Jetty. Sand bar forms between two training walls blocking stormwater flow from the drains and the draining of water from high water level events in the river. At the time of assessment a scour channel had formed in the bar to allow the release of water. Trapped water could also have trapped seagrass emanating a sulfurous smell (concern for local residents). Area is susceptible to scour during large flow events, with a scour hole >0.5m deep on the terrace, full of wrack during the December 2014 assessment. Landward of the scour hole is a 150mm x 150mm flexmat (flexible concrete block mattress), with scour riverward.	Immediate maintenance; Re-grout limestone block groynes. Do not install any larger scour management plans for these drains (no larger scour apron). If smell is a concern - dig out sand bar and allow to flush when required or dig out decomposing wrack and seagrass. Remove decomposing wrack and seagrass also from scour hole to reduce smell.	Consequence (4) because of the local scour and blocking caused by movement of the beach and interaction with the flow from the large Water Corporation drains. When drain is blocked there can be a bad odour from decomposing wrack generating a lot of complaints. Local loss of beach also a concern. Scour hole a safety hazard.
SRCla02 Jetty Rd.D03	300	CNYA	2	1	6	Concrete; Local car park drain located high in the headwall. Exact invert level could not be assessed due to access constraints. Condition good and locally drains even if other two drains are silted over.	No urgent works required; Consider if drain is adequate if runoff to car park is altered.	Consequence (1). Local car park drain that is high up and unlikely to be silted over, and therefore car park unlikely to block up. Impact of drains largely attributed to D01 and D02

APPENDIX E.5 BMP (SRT 2009) APPLICATION FOR TOC

The decision-support framework was applied, according to the method described in Section 3.2 of SRT (2009), to refine which stabilisation techniques should be considered further. The application of the decision-support framework requires the consideration of nine factors which influence whether a technique is appropriate for the site of interest (Table 3.1 of SRT 2009). The nine criteria applied in the 2009 assessment for three areas of foreshore in the Town of Claremont are included in Table 12-38.

A list of potential techniques for each length of foreshore is provided using the decision-support framework based on the application of the nine factors (Table 12-38). The degree of appropriateness (in respect of the nine factors only) is interpreted according to the cell shading:

- Dark blue—A potentially appropriate technique based on the nine factors and should be the first techniques considered further;
- Blue—More factors are rated as good than fair for the nine factors; and
- Light blue—More factors are rated as fair than good for the nine factors and should be the last techniques considered further.
- No shading—Identified as 'poor' or 'not applicable' across at least one of the nine factors.

Table 12-38: Potential Techniques for Further Investigation for Town of Claremont

= Potentially appropriate technique = More factors rated as good than fair = More factors rated as fair than good = Rated as poor or not applicable		Claremont Baths	Colleges	Osborne Parade
Dominant Process		Wave-dominated		
Physical scale		Extended		
Restricted Space		None	Water restriction	Water restriction
Cost		Low maint. cost	Low capital cost	Low capital cost
River location		Estuarine		
Finance value x likelihood		Low	Low	Low
Safety value x likelihood		Low	Low	Low
Amenity value x likelihood		Moderate	Low	Low
Environment value x likelihood		Low	Moderate	Moderate
Approach	**Technique**			
Retreat	Managed retreat			
Revegetation	Sedges			
	Trees/large shrubs			
	Ground covers			
	Combined multistorey vegetation			
Bio-engineering (with revegetation)	Coir logs			
	Jute matting			
	Brushing/Bundling			
	Soil replacement (gravel/sand mix)			
	Brush mattressing			
Gabions	Stepped			
	Mattress			
Revetments	Rock toe with resloping			
	Tipped rock			
	Interlocked rock			
	Layered			
	Cellular system			
	Block revetment			

= Potentially appropriate technique = More factors rated as good than fair = More factors rated as fair than good = Rated as poor or not applicable		Claremont Baths	Colleges	Osborne Parade
	Flexmat			
	Sand bag			
	Geotextile			
Seawalls	Baffles			
	Timber walling			
	Sand bag walls			
	Limestone block (gravity)			
	Piled walls			
	Concrete panel			
	Sheet-piling			
Renourishment	Without associated structures			
	Combined with hard structures			
	With sacrificial/temp. structures			
	Construction of secondary features			
Groynes	Single short-groyne			
	Single long-groyne			
	Headland field			
	Short groyne field			
	Long groyne field			
	Geotextile			
Flow modification	Riffles			
	Flow baffles			
	Channel excavation			
	River training			
	Spurs			
	Large woody debris			

The output is not intended as a relative ranking of the techniques for the site of interest, as only nine factors have been considered. Before the selection of a specific technique for a site other factors that influence, such as bank height, structure movement, cost and aesthetics should also be considered (see Section 3.2.2 of the BMP). Potential projected changes in processes, such as potential shifts in mean sea level, and drainage management should also be considered. For the foreshore length considered that represent the main section of sandy foreshore used for recreation between Watkins Road and CYC (Claremont Baths) there are no options that rank in the highest category. The highest ranked options are retreat, revegetation, bio-engineering (coir logs or brush mattressing), geotextile revetments, renourishment with hard structures/sacrificial structures and some flow modification. Bio-engineering is not encouraged at this site due to the seasonal variation in sediment transport, frequent inundation and vertical migration of the hydraulic zone resulting in rapid damage and failure of the bio-engineering. Geotextile revetments may be considered as an emergency structure at the back of the beach, but with high cost and difficulty to tie-in to the underlying rock.

A combination of retreat, revegetation and renourishment with hard structures is considered appropriate for the foreshore between Watkins Road and CYC.

Managed retreat is likely to be the method recommended for the steeper areas downstream of CYC.

APPENDIX E.6 DETAILED TABLES ON WORKS FOR EACH SEGMENT FOR TOC

Table 12-39: Segment SRCla01 Mrs Herberts Park

Short-term (risk management) for 0-5 years		
Goal	**Capital works and costs**	**Maintenance works & costs**
Improve resilience for interannual variations in MSL and winds.	**Modify car park revetment** for gradual tie-in to the east, increasing the curve to landwards and a more smooth transition. *Cost*: *$10-15k (price increase may occur if pre-1931 reclaimed area requires excavation). Reuse existing rock.* **Create small drain** or drainage chute (grouted rock channel with low point to channel flow) at the low point in the car park. *Cost: $2-3k*	Manually breach the **sand bar at the Alex Prior drain** (≈monthly towards neap tides). Sediment can infill the scour hole under the drain (reduce ponding) or go on adjacent beach. *Cost: In-kind labour* Maintain **sedge**. *Cost: $2k pa + in-kind labour* **Minor renourishment** adjacent to Chester Rd car park using 100 m^3 sand from CYC. Annual or 2-yearly with dependent on wind patterns (or linked to other sand harvesting). *Cost: $3.5k. Sand from CYC (2-yearly)* Backfill between **revetment crest** and car park. Create a wider splash zone at the crest between the top of revetment and car park kerbing. *Cost for backfill with coarse gravel: $2k pa + in-kind labour*
Monitoring (all timeframes)	Tabulate records of rates and timing of revegetation, backpassing, renourishment, drain storm bar breaching (Alex Prior Park) and repairs to the rock revetment and car park. Annual and post-event revetment inspection. Annual photos at 50m intervals. Monthly photos of beach widths at fixed locations.	
Issues to be resolved (all timeframes)	Identify when car park surface renewal is planned, and when renewal of Alex Prior Park drain is planned. Long-term plans of narrowing car park require a groyne to be constructed at CYC (see SRCla02 Table 12-40). Private property owners to be informed of future requirements for works to mitigate erosion/inundation hazard. An agreed plan required with CoN for management at Watkins Road to minimise transfer of erosion hazard to ToC. Community awareness about the natural processes that govern seagrass wrack accumulation on the beach. Whadjuk approval for excavation of the car park and revetment, and construction of the groyne (long-term). Cease WAPC resumption of land during subdivision process.	

Works to be avoided for future management (Section 8.2.1)	Works that reduce hydraulic smoothness. Works that restrict bidirectional sediment transport. Works that limit the future upward movement of a storm bar. Fixed hard path along the beach. Expenditure on reconstructing the revetment in its present location.	
Medium-term (planning) for 5-25 years		
Goal	**Capital works and costs**	**Maintenance works & costs**
Improve resilience for scenario of increased mean sea level and variability, by promoting sand to transfer onshore.	**Raise storm bar** by 0.75m (≈4m wide, ≈750m^3) with swale to landward. Migration of the beach landward, removal of grass and planting/transplanting sedge with access pathways (no sedge at Mrs Herberts). *Trigger*: +0.3m MSL for 3 years and loss of most sedge. *Cost*: *$85k* **Renourish** ≈5-yearly with external sourced sand from a quarry (250m^3, vol. may be less, only at E and W extents). *Trigger*: erosion adjacent to revetment >5m for 15m to the east and no sand available at CYC. *Cost*: *$25k (5-yearly)* **Revetment crest readjustment** when next undertaking car park resurfacing. Reduce car park surface by ≈1.5m, create a rock splash zone landward of the revetment. Some reworking of crest. *Cost*: *$20-25k* **Drain at Alex Prior Park** to have discharge location shifted up the park so invert level is higher on the slope. Create a living stream lined with sedge or allow water to flow over grass/gravel to dissipate flow and scour capacity before the beach. Will still require breaching of the sandbar. Tie-in with renewal of drain or development of park. *Cost*: *≈$10k*	Manually breach the **sand bar at the Alex Prior Park drain** (≈monthly towards neap tides). Sediment can be used to infill the scour hole under the drain (reduce ponding) or transferred to the adjacent beach. *Cost: In-kind labour* Maintain **drain discharge area at Alex Prior Park**. *Cost: In-kind labour* Maintain **sedge**. *Cost: $2k pa + in-kind labour* **Minor renourishment** focused adjacent to Chester Road car park using material sourced from the accumulation at CYC. Annual or 2-yearly with timing dependent on wind patterns (or linked to other sand harvesting). *Cost: $3.5k for 100 m^3 sand from CYC (2-yearly)* **Rework** sediment on beach into **storm bar** at ≈3-5 year intervals in breach points. *Cost: 3k + revegetation costs (after storm bar works)* **Maintain revetment** and wider splash zone (assumes revetment is modified) *Cost: $2-4k pa + in-kind labour (excludes car park surface maintenance)*
25-year cost	≈$350k. A further investment of $150k required to migrate car park and revetment landward with modification to beach. Costs are not indexed.	

Long-term (strategy) for >25 years		
Goal	**Capital works and costs**	**Maintenance works & costs**
Progressive retreat to allow for mean sea level increase.	Once beach has narrowed the **car park will be narrowed and extended east** to have similar capacity for car-parking (and access to private property) with reduced control on adjacent foreshores. Excavation of remnant rocks from revetment and reclaimed area will be required and available for use. Requires groyne at CYC first. Approximately 255m^3 material excavated (car park and revetment) and 52.5m^3 bitumen disposed. 60m x 10m car park construction with drainage and a 72m rock revetment 1.25m height, with broad splash zone. *Trigger*: maintenance costs for revetment and car park exceed 10% capital costs over 5 years (ie $15k) and annual renourishment required from external sources. *Cost*: *$125k (exc. Groyne – see Table 12-40) + $10k for regrading/revegetation of beach east of new car park.* **Renourish** ≈3-5-yearly with external sourced sand from quarry (250m^3). *Trigger*: erosion adjacent to revetment >5m for 15m to the east and no sand available at CYC. *Cost*: *$25k (3- to 5-yearly)* **Drain at Alex Prior Park** could be consolidated into groundwater recharge within the park. Avoid increasing flow if land is developed. *Not costed*	As beach responds to new car park alignment continue to **regrade beach areas into a storm bar** and swale. *Cost: $5k pa for first few years after car park construction* Maintain **sedge**. *Cost: $3k pa + in-kind labour* **Minor renourishment** focused adjacent to Chester Road car park using material sourced from the accumulation at CYC (likely groyne). Annual or 2-yearly with timing dependent on wind patterns (or linked to other sand harvesting). *Cost: $3.5k for 100 m^3 sand from CYC* **Rework** sediment on beach into **storm bar** at ≈3-5 year intervals in breach points. *Cost: 3k + revegetation costs* **Maintain revetment** and wider splash zone. *Cost: $3k pa + in-kind labour* **Raise storm bar again** *Trigger*: if sustained >+0.5m MSL occurs. *Not costed*

Table 12-40: Segment SRCla02 Jetty Rd

Short-term (risk management) for 0-5 years		
Goal	**Capital works and costs**	**Maintenance works & costs**
Improve resilience for existing MSL/wind variance, and increased recreation.	Now: Immediately **shift** disabled access **cut in kerb at Jetty Road** to the other side of the drain pits to avoid runoff and scour of sediment from the foreshore. *Cost*: *$1k + in-kind labour* Ongoing: **Education program** regarding seagrass wrack. Web based. *Cost*: *$5k*	**Clear sand bar at Jetty Rd** drains (≈monthly near neap tides). Transfer to beach to E. *Cost: in-kind Water Corporation* **Re-grout** groynes at Jetty Road. *Cost: $2k (now and 5-yearly)* **Minor renourishment** focused at Jetty Road area using material from CYC. Annual/2-yearly dependent on winds *Cost: $2k for 100 m^3 sand from CYC (2-yearly) using a dozer along beach.* Maintain **sedge**. *Cost: $3k pa + in-kind labour* Maintain **grass (**after minor renourishment) near Jetty Rd to reduce erosion due to trampling. *Cost: $0.5k pa + in-kind labour* **Clear wrack** from the beach when agreed between ToC and Rivers and Estuaries Riverpark Unit. Either re-use in river elsewhere or bypass to W side of CYC. *Cost: in-kind Parks and Wildlife (ex-SRT)* **Harvest sediment** from CYC. Wrack to be harvested first. Should coincide with minor renourishment to minimise cost. *Cost: included in minor renourishment and SRCla01 (Table 12-39).* *After storm bar capital works: **Rework** sand on beach into **storm bar** at ≈3-5 year intervals in breach points. *Cost: 3k + revegetation costs*
Monitoring (all timeframes)	Tabulate records of rates and timing of revegetation, backpassing, renourishment, drain storm bar excavation (Water Corp.), excavation of sediment adjacent to CYC, blowback at Jetty Road drains. Tabulate patterns of wrack accumulation and metocean conditions, along with dates Parks and Wildlife cleared the wrack. Annual photos at 50m intervals. Monthly photos of beach widths at fixed locations to identify adaptation requirements.	

Issues to be resolved (all timeframes)	Identify when Water Corporation are planning on renewing the Jetty Road drains, plans for the sewage pump station and sewage overflow tanks. Restrict any CYC expansion riverward or to the east. ToC to depend on sand at E of the parking area for other areas (Chester & Jetty Rds) during periods of net W transport. Walling at eastern extent of car park may require strengthening (CYC), with CYC responsible for maintenance and renewal of their structures. Sand harvesting area underlay by flexmats ca 1997. CYC to manage runoff from hard areas away from sand harvesting area. Water Corp. commitment to monthly clearing of sand bar at Jetty Rd drains. Parks and Wildlife commitment to clearing seagrass wrack and maintaining in the system. The requirement will increase once the groyne is installed. Arrangement with CYC, Parks and Wildlife and ToC for wrack clearing near CYC, harvesting sand at CYC and backpassing here and SRCla01 (Table 12-39). Inform private property owners of requirements to mitigate erosion/ inundation hazard. Community awareness about the natural processes of wrack accumulation. Ensure groyne is constructed before large renourishment programs and car park revetment retreat (SRCla01 Table 12-39). Whadjuk approval for construction of the groyne (long-term). Resolve any potential issues with ponding or increased inundation hazard on low-lying private properties due to raising the foreshore area (long-term). Cease WAPC resumption of land during subdivision process.	
Works to be avoided for future management (Section 8.2.1)	Large renourishment before CYC groyne construction to avoid sedimentation of CYC. Minor renourishment at focal locations (e.g. Jetty Rd) are fine. Reducing hydraulic smoothness (e.g. impervious structures under the jetty). Works that restrict bidirectional sediment transport. Works that limit upward storm bar movement & raising the foreshore level. Fixed hard path along the beach. Works that restrict harvesting of sand adjacent to CYC. High capital investment at landward extent of the jetty. Damage to Norfolk pine at Jetty Road. Harvesting sand for external use, other than renourishment of ToC beaches. Removing seagrass wrack from Swan-Canning System (biological impacts). New and expensive infrastructure in the inundation hazard zone.	
Medium-term (planning) for 5-25 years		
Goal	**Capital works and costs**	**Maintenance works & costs**
Extend existing foreshore use for as long as possible.	**Raise storm bar** by 0.75m (≈4m wide, ≈825m^3) with landward swale. Landward beach migration, removal of grass, plant sedge with access paths (no sedge in high use areas). Raise foreshore level (long-term) sooner if a cheap supply of sand is available. *Trigger*: +0.3m MSL for 3 years & loss of most sedge. *Cost*: *$100k*	See 0-5 year column.

25-year cost	≈$240k. A further investment of $150k to construct groyne, raise foreshore level and one external renourishment campaign. Costs are not indexed.	
Long-term (strategy) for >25 years		
Goal	**Capital works and costs**	**Maintenance works & costs**
Improve resilience of the foreshore to increased mean sea level through modifying structures, raising foreshore levels, renourishment and some retreat	**Raise invert level of two Water Corporation drains at Jetty Rd**. Link to renewal. Requires raising the jetty at landward end, decking and disabled access. Avoid damage to Norfolk pine. *Trigger:* Blowback, to avoid choking and flooding. *Cost: Expense of Water Corp., with negotiation for decking and jetty.* **Small curved groyne at CYC E** to trap sand transported west along the beach. *Trigger:* External renourishment (3 years). Pre-car park retreat (Table 12-39) *Cost: $70k* **Renourish** ≈3-5-yearly with sand from quarry (250m^3). Requires groyne first. *Trigger*: erosion to infrastructure at Jetty Rd (<0.5m buffer) and no sand at CYC. *Cost*: *$25k (3- to 5-yearly)* **Relocate sewage pump station at Jetty Road** to landward, linked to renewal. *Cost: Expense of Water Corporation.* **Toilet block at Jetty Rd** to be moved, raised or protected/ plumbing modified to avoid leaks. Link to renewal. ToC decision. *Cost: not costed.* **Raise broader foreshore level** landward of the swale due to the narrow foreshore, includes grass replacement. ToC decision. *Cost: ~$50k*	**Clear sand bar at Jetty Rd** drains (≈monthly near neaps). Transfer to beach to E. Pre-storm clearance may be needed. See capital works for long-term plan. *Cost: in-kind Water Corporation* **Minor renourishment** focused at Jetty Road area and at boat ramp using material sourced from CYC (likely with groyne constructed). Annual/2-yearly with timing dependent on wind patterns (or linked to other sand harvesting). *Cost: $2k for 100 m^3 sand from CYC (2-yearly) using a dozer along the beach.* Maintain **sedge**. *Cost: $4k pa + in-kind labour* Maintain **grass** near Jetty Road to reduce erosion through pedestrian trampling. After minor renourishment. *Cost: $0.5k pa + in-kind labour* **Rework** sand on beach into **storm bar** at ≈3-5 year intervals in breach points. *Cost: 3k + revegetation costs* **Clear wrack** from the beach when agreed between ToC and Rivers and Estuaries Riverpark Unit. Accumulation to increase at groyne. Either re-use in river or bypass to W side of CYC. *Cost: in-kind Parks and Wildlife* As beach responds to new car park alignment (see SRCla01 Table 12-39) continue to **regrade beach areas into a storm bar** and swale. *Cost: $5k pa for first few years after car park construction* **Raise storm bar again** *Trigger*: if sustained >+0.5m MSL occurs. *Not costed*

Table 12-41: Segment SRCla03 Bethesda Hospital

<table>
<tr><th colspan="3">Short-term (risk management) for 0-5 years</th></tr>
<tr><th>Goal</th><th>Capital works and costs</th><th>Maintenance works & costs</th></tr>
<tr><td>Allow lower foreshore to erode to provide a source of sediment, while managing trampling</td><td>Christchurch to extend stairs from school to the boat shed (extends half-way down the slope) to minimise erosion from pedestrians. Fence other pathways to minimise trampling and revegetate.
Cost: Christchurch Grammar School
Develop guidelines and memoranda of understanding regarding requirements for private property owners and leaseholders (see Issues to be resolved below).
Cost: Unknown.</td><td>Maintain stairs and fencing to guide pedestrian access between Christchurch school and the boat shed. Annual and post-event checks with maintenance to be undertaken as needed.
Cost: Christchurch Grammar School
Encourage any areas with bamboo removal to be revegetated with other plants to slow erosion, if erosion is threatening any existing facilities.
Cost: Unknown, to be confirmed with private property owners and Parks and Wildlife (ex-SRT)</td></tr>
<tr><td>Monitoring
(all timeframes)</td><td colspan="2">Tabulate records of any known works undertaken by private property owners along this section of foreshore.
Annual photos at 50m intervals to monitor rates of lower foreshore retreat and to check works by private property owners.
5- to 10-yearly geotechnical assessment of toe of steep banks to determine hazards related to slip failure or bank collapse.</td></tr>
<tr><td>Issues to be resolved
(all timeframes)</td><td colspan="2">Clear documentation outlining the responsibility of CYC, Bethesda Hospital, Christchurch School and private property owners in terms of:
maintaining their own erosion mitigation structures and facilities (no financial assistance provided by government). This also requires maintenance of access to their lower foreshore areas for heavy vehicles, or arrangements with adjacent owners for access or the understanding that a barge may be required.
minimising the transfer of erosion risk to adjacent properties and the potential to have to provide financial compensation if any works undertaken transfer erosion.
works should not reduce hydraulic smoothness or restrict bidirectional transport.
contributing to weed management and fire load reduction for fire management (details TBC). This includes no dumping of garden waste.
surface runoff management and pool discharge for properties at the top of cliffs and steep slopes.
any works to require Whadjuk approval.</td></tr>
</table>

Issues to be resolved (cont.)	Develop a Memorandum of Understanding with CYC to ensure CYC are responsible for maintenance of their walling and facilities, with no further extensions of their car parking or hardstand areas to the east or riverward. Also if any excavation of boat pens is undertaken, and material is clean, it should be maintained in the system in the lower foreshore area. Encourage Christchurch School to modify their stair access directly to their boatshed and ensure ongoing maintenance is undertaken. Advise Christchurch to reduce riverward extension of their boat ramp facilities. Cease WAPC resumption of lower foreshore during subdivision process.	
Works to be avoided for future management (Section 8.2.1)	Works that reduce hydraulic smoothness. Works that restrict bidirectional sediment transport. Works that could result in slips of the steep slopes, which could cause damage to private property above. Reinstatement of Osborne steps, or equivalent access to lower foreshore, because of high capital and maintenance costs and the inability to guarantee safe pedestrian access between Christchurch boat ramp and CYC. Harvesting any sediment from this section for use elsewhere on the river as it will enhance the rate of erosion of the steep banks. Works that transfer erosion hazard to adjacent properties. Plans for pedestrian access along this section of foreshore. Renourishment of the lower foreshore because of contribution to sedimentation of CYC pens, unless the material is harvested from the pens.	
Medium-term (planning) for 5-25 years		
Goal	**Capital works and costs**	**Maintenance works & costs**
Allow lower foreshore to erode to provide a source of sediment and ensure private property owners do not transfer erosion stress without compensation	**Install fencing** to restrict lower foreshore access once erosion is causing a safety hazard. *Trigger:* Geotechnical assessment that slip failure or bank collapse could occur. *Cost: ≈$40k (unknown as depends on fence locations).*	**Maintain stairs and fencing** to guide pedestrian access between Christchurch school and the boat shed. Annual and post-event checks with maintenance to be undertaken as needed. *Cost: Christchurch Grammar School* **Maintain fencing** restricting lower foreshore access, with likely damage due to corrosion, wave damage and vandals. *Cost: $3k pa* **Review guidelines and memoranda of understanding** with private property owners and leaseholders on a 5- to 10-yearly basis. *Cost: Unknown.* Encourage any areas with bamboo removal to be **revegetated** to slow erosion, if erosion is threatening any existing facilities. *Cost: Unknown, to be confirmed with private property owners & Parks and Wildlife (ex-SRT)*

25-year cost	Difficult to estimate with this foreshore as it depends on the agreements established with private property owners and leaseholders. In-kind and lawyer costs likely required to establish responsibilities.	
Long-term (strategy) for >25 years		
Goal	**Capital works and costs**	**Maintenance works & costs**
Encourage managed retreat, or adaptation, for the lower foreshore for some private property owners.	**Recommend lease-holders and private property owners seek guidance** on pathways for managed retreat on the lower foreshore or how to adapt their facilities for ongoing erosion and potential increase in mean sea level rise. *Cost: Unknown and to be shared between private property owners and leaseholders.*	**Maintain stairs and fencing** to guide pedestrian access between Christchurch school and the boat shed. Annual and post-event checks with maintenance to be undertaken as needed. *Cost: Christchurch Grammar School* **Maintain fencing** restricting lower foreshore access, with likely damage due to corrosion, wave damage and vandals. *Cost: $3k pa* **Review guidelines and memoranda of understanding** with private property owners and leaseholders on a 5- to 10-yearly basis. *Cost: Unknown.* Encourage areas with bamboo removal to be **revegetated** with other plants to slow erosion, if erosion is threatening any existing facilities. *Cost: Unknown, to be confirmed with private property owners and Parks and Wildlife (ex-SRT)*

APPENDIX E.7 FORESHORE STRUCTURE PHOTOS AND COMPARISONS FOR TOC

Figure 12-74: Photos SRCla01 Mrs Herberts Park.B01 8 December 2014

Figure 12-75: Photo comparison SRCla01 Mrs Herberts Park.B01 2004 and 2014