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Waterway Management Consultants

TORQUAY SANDS DEVELOPMENT

TORQUAY, VICTORIA

SURFACE WATER MANAGEMENT SYSTEM

DRAFT FINAL REPORT

Concept for management of quality and quantity of surface waters for irrigation supply and feature lakes and wetlands

for: **MHY Handbury Pty Ltd**

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22 July 2001

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1. INTRODUCTION

The Torquay Sands Resort development involves construction of an 18 hole golf course resort as an integrated feature of a residential and commercial estate on a 124 hectare site to the east of Horseshoe Bend Road.

A key component of the development will be the provision of a cascade of amenity lakes through the resort, generally aligned east-west along the drainage line. The lakes will provide a focus for the resort village and residential areas, as well as playing integral roles in the harnessing of surface water for re-use as golf course irrigation water. Also there will be a series of interconnected smaller lakes and wetlands, designed for water quality treatment and irrigation supply, as well as aesthetic values. It is essential that the main amenity lakes (and other smaller water bodies located close to residential precincts), should maintain aesthetically pleasing aspects, and not suffer from water quality-related problems. Water quality conditions will also be a primary design consideration in the other lakes and open water segments of the wetlands.

Accordingly this report examines water quality and quantity constraints of the site and outlines a surface water design concept which maximises the likelihood of achieving desirable aesthetic conditions and maintaining acceptable water quality in the lakes, whilst satisfying golf course irrigation needs and offsite environmental protection requirements.

2. SITE DRAINAGE FEATURES

The subject property is located on the east side of Horseshoe Bend Road in Torquay. The gently undulating 124 hectare site is mostly cleared agricultural land used for grazing. Significant native vegetation remains along the southerly (dunal) fringes of the site which flank crown land as the coastal foreshore to Bass Strait.

The east end of the site flanks a vast coastal wetland area which is part of the (estuarine) floodplain of Thompsons Creek (Breamlea Creek). This area is subject to tidal backflow and is characterised by saltmarsh communities. There are two local surface drainage catchments which are referred to in this report as the Western and Southern Catchments.

2.1 Thompsons Creek floodplain

Enquiries at Council have revealed no information on past flooding occurrences except that sections of Breamlea Road are covered at times. The Rural Floodland Zoning on the Planning Scheme maps covers the marshland area and was done in conjunction with the Geelong Regional Commission following flood observations in 1978.

No formal assessment of flooding in this area has ever been carried out according to DNRE Floodplain Management Unit (Mr I Gauntlett) or the Corangamite CMA (Mr T

Jones). A formal request to the CCMA for advice on flood levels resulted in recommendation for the 100 year ARI flood level to be adopted as 2.20 m AHD at the east end of the resort site, with minimum freeboard of 300 mm to apply for floor levels of any building.

2.2 Western Catchment

The main surface drainage feature within the site is a seasonal watercourse which crosses the property from west to east. It is fed by intermittent surface runoff from an upstream (presently rural) catchment, and by drainage emanating from within the resort property. For convenience this catchment is referred to as the Western catchment. The watercourse itself is ill-defined and located within a broad gently sloping depression. The catchment area extends to west of the Surfcoast Highway and to the north of South Beach Road and totals about 524 ha at the saltmarsh. Substantial urban expansion is proposed according to the Torquay North Outline Development Plan, with the area south of South Beach Road to be fully developed for residential purposes in the future.

2.3 Southern Catchment

This area includes about 39 ha of existing urban development in the Golden Beach and South Beach Estates to the east of Horseshoe Bend Road, as well as 75 ha of undeveloped land to the west of Horseshoe Bend Road, 9 ha of resort land, and about 18 ha of foreshore reserve land along The Esplanade. All undeveloped rural land to the west of Horsshoe Bend Road is proposed for future residential development.

2.4 The Esplanade Wetland Pondage

The southern catchment drains to an artificial pondage excavated within a natural terminal depression at the east end of The Esplanade, adjacent to the south-westerly tip of the resort property. At present, drainage water entering this pondage is redirected south-westerly by pump and rising main to the intersection of Horseshoe Bend Road and The Esplanade, from whence it flows by gravity pipeline to Deep Creek. In times of flood, the pump system is unable to cope with the volumes entering the pondage and water levels can then rise significantly. In major floods the pondage can overflow direct to the ocean through the primary sand dune via erosion of Whites Cut. The most recent such occurrence was in April 2001 when significant damage occurred.

This pondage and diversion system has some key deficiencies at present:

- water quality treatment potential is severely limited by poor hydraulic design;
- the pumping significantly adds to municipal maintenance and operation costs;
- flood levels can threaten existing residential development;
- flood overflow through Whites Cut has caused significant erosion damage;
- the pondage has low environmental and aesthetic qualities, and often harbours

mosquitoes;

- the steep banks of the pondage are a safety threat to the growing surrounding residential area.

3. TORQUAY SANDS SURFACE WATER MANAGEMENT PROPOSALS

3.1 Performance Objectives

The surface water management scheme for the Torquay Sands development integrates water sourced from urban and rural stormwater and treated water from the Black Rock Sewerage Treatment Plant (BRSTP) in a multi-purpose network of amenity and irrigation supply lakes and wetlands.

Water quality results show that the BRSTP water is too salty to use without dilution and some disinfection may also be needed. BRSTP water will apparently cost up to $330/ML at the resort gate which is about 50% of mains water cost. Hence there are economic, irrigation and environmental imperatives to minimise use of BRSTP water.

There are no feasible groundwater supplies and mains water supply is not an acceptable option for recurrent irrigation and lake maintenance operations. Rural runoff is negligible in this region during the summer/autumn periods when irrigation demand is greatest. Hence provision of suitable storages for retention and reuse of stormwater generated from within the development and other existing urban areas is a key management need.

The scheme has been developed to meet the following performance objectives:

- To treat stormwater derived internally and from external catchments as a valuable resource rather than as a waste product;
- To maximise the potential for use of urban stormwater for irrigation of the golf course;
- To minimise use of treated effluent water for irrigation in the longer term;
- To mimic existing rural drainage runoff quality and quantity regimes as far as is practicable with the resort fully developed;
- To resolve existing water management problems associated with the existing pondage and pump system at the east end of The Esplanade;
- To provide a sustainable, attractive and safe water environment within the residential and golf course development;
- To provide for safe passage of floodwaters through the resort site in accordance with contemporary best practice management.

3.2 Proposed Water Storages

The surface water management system incorporates the following water storages and features:

- An expanded and modified Esplanade Wetland Basin (EWB);
- A cascade of 5 amenity lakes (AML) along the main drainage line, totalling about 6.1 ha in surface area and some 110 ML at Normal Top Water Level (NTWL). The majority of urban drainage flows are directed to these lakes after treatment in wetland systems;
- 5 irrigation lakes (IRL) within the site area, totalling about 1.2 ha surface area and 40 ML at NTWL, receiving all golf course drainage (after passage through wetland systems);
- a main irrigation lake (IRL) located on land immediately west of the resort site of about 90 ML storage volume;
- A network of other wetlands located along the urban drainage lines in the resort and on the golf course drainage lines. The golf course drainage system is independent of the urban drainage system and the amenity lakes.

Details of the various water features and storages and conduits are shown on the Waterway Concept Development Plan (GBLA Dwg. No. L1).

3.3 Proposed Surface Water Management

3.3.1 Southern Catchment Proposals

In the short term the only "freshwater" supplies available for amenity lake filling and irrigation are urban stormwaters. Stormwater will require treatment to pre-set levels to allow its use in the feature amenity lakes in the residential precincts.

At present, urban stormwater is only available from the existing Golden Beach and South Beach Estates in the Southern Catchment, which drains to the EWB. When development is complete in this catchment a total urban area of 123 ha will be available. The capacity of existing drainage pipes on the east side of Horseshoe Bend Road is 850 l/s. Hence future development upstream will require retarding storage to be provided to ensure peak 100 year ARI flow across Horseshoe Bend Road does not exceed 850 l/s.

To access the Southern Catchment waters, a 750 mm diameter pipeline will be provided to convey water by gravity from the EWB into AML4. To maximise availability of urban stormwater in the short term, the proposal also includes a low flow diversion pipeline to harness an additional 39 ha of existing urban catchment area west of Horseshoe Bend Road at Loch Ard Street. A diversion pit and 600 mm diameter pipeline will be built along the south frontage of The Esplanade, to convey all flows up to about 400 l/s at Loch Ard Street back to the EWB. To adequately treat all of this water prior to its entry to AML4, the EWB will be reconstructed to act as a treatment wetland.

Major benefits will accrue for Whites Cut and the Foreshore Reserve area as a planned outcome of the proposed resort development:

- all water entering this pondage will be redirected into the resort to assist with golf course irrigation and amenity lake water supply. Hence water quality in Deep Creek will improve;
- regular pump discharge of water to Deep Creek will cease, reducing municipal maintenance and operation costs;
- all floodwaters will be redirected through the resort so that no flood overflows will in future occur via Whites Cut. This recently damaged area can thus be allowed to fully regenerate and adjacent residential properties will be permanently protected from flooding;
- the pondage itself will be modified by earthworks and plantings to improve its water quality treatment capacity, resolve public safety threats, and enhance its landscape, recreation and environmental values.

Details of the proposed modifications to the EWB are shown on the Foreshore Entrance Reserve Plans (GBLA Dwg No's L0-L9).

3.3.2 Western Catchment upstream of Torquay Sands

Unlike the Southern Catchment, floodwaters discharging from this catchment will flow directly through the resort site.

The ~~only~~ works ~~forming part of the resort proposal are~~ construction of the main irrigation dam (60 ML minimum) and an associated wetland on land between the western boundary of Torquay Sands and Horseshoe Bend Road. The dam will cover an area of about 3 ha, eventually within a surrounding residential environment. As water levels in this dam may be drawn down markedly at times to satisfy irrigation demand in the golf course, a wetland system will be constructed around the dam to enhance its appearance and disguise its utilitarian function. This wetland system will cover an area of up to 2.5 ha at NTWL, and will be designed to provide some retardation storage capacity as well as treatment of urban stormwater discharged from future development of the property. Treated water discharging from the wetland will firstly be directed into the main irrigation dam. If the latter is full the water will be discharged to the cascade of amenity lakes through the resort proper. Water stored within IRL7 will only be able to discharged via irrigation. There will be no other outlet from IRL7.

3.3.3 The proposed amenity lakes

The design concept for these feature lakes has been developed through consideration of site topography, soil and groundwater constraints, water supply constraints, source water quality constraints and the desired beneficial uses of the lakes. The lake water quality will be managed for secondary contact recreation, as a minimum performance standard. The lakes will not be managed for swimming water quality.

Details of the various amenity lakes and edge treatments area shown on the Waterway Lake Edge Plan (GBLA Dwg No L1).

In summary a cascade of 5 amenity lakes is to be formed covering a total area of 6.1 ha with NTWL's ranging from 5.00 m AHD (AML1) to 2.00 m AHD (AML5). Each lake will have maximum depth of up to 2.5 m and all will be sealed using synthetic liners to prevent ingress of saline groundwater and seepage loss of stored fresh water. Lake edgings are designed to cope with seasonal evaporative drawdown of water level of up to 300 mm. All floodwaters emanating from the upstream catchment area will be passed through the amenity lake system. When in excess of irrigation storage needs, overflows will pass through to the saltmarsh.

The bulk of all urban stormwater from the resort will be passed through treatment wetlands and thence into the amenity lakes. No golf course drainage will be connected to this water system or to the amenity lakes.

3.3.4 The Irrigation System

The golf course irrigation system will utilise a shandy of BRSTP water and stormwater. As a consequence of its relatively high salinity, BRSTP will not be applied "neat" except during exceptional circumstances. At the downstream end of the resort site two irrigation dams (IRL5 and IRL6) will be built on either side of AML5. These two dams will be linked by a syphon pipeline so the two dams will act as a single storage with NTWL of 1.90 m AHD. All golf course drainage will pass to these two dams after first being treated in appropriate on-line wetland systems.

The airspace above NTWL in both AML4 and AML5 (to a height of 300 mm) will be used to temporarily store up to 15 ML of excess stormwater during runoff events. This will be achieved by the weir controls for both lakes being set 300 mm above NTWL. This water will be transferred by gravity at a controlled rate from AML4 into AML5 and thence into the flanking irrigation lakes IRL5 and IRL6, from where it will be delivered by pump and rising main to the main irrigation lake (IRL7) which is to be located upstream of the resort, or applied directly as irrigation as the case may be.

In recognition of their close proximity to residential allotments, IRL 5 and IRL6 will operate in the same way as AML4 and AML5; that is, the airspace above NTWL to a height of 300 mm will be used to temporarily pond water pending its transfer to the main irrigation dam. During normal irrigation periods, water will be returned from the main irrigation lake by pipeline back to IRL5/6 and thence applied to the course area. Water levels in IRL5/6 will not be drawn down below NTWL during irrigation, unless the water level can be restored at the same time by transfer from the main irrigation lake, IRL7.

Three smaller irrigation lakes (IRL2/3/4) will be constructed on the back nine (adjacent to the 16th Green/17th Tee). These lakes will be filled by a mix of urban stormwater from adjacent residential lots and golf course runoff, and will be topped up from the irrigation system, as needed to maintain supply levels. The airspace above NTWL in IRL3/4 will be used as temporary floodwater storage in the same manner as AML4/5, with such water transferred to IRL 5/6 by pipeline.

All golf course drainage water will be kept separate from the amenity lake system and hence from the outlet from AML5 to the saltmarsh. It will be possible for floodwaters flowing across the golf course to flow out to the saltmarsh during major flood events, but IRL5, IRL6 and IRL7 will be fully protected from such floodwaters and will be fitted with one-way flow valves to prevent loss of stored water out to the saltmarsh.

BRSTP water will be drawn by agreement from the large dam on the neighbouring Santospirito property to the north of the resort site. It will be delivered by pipeline to the wet well of the main golf course pump station (which is to be located adjacent to IRL6), but only as needed to makeup the supply sourced from the main irrigation system. Thus BRSTP water will not be injected into any of the proposed irrigation dams but will instead be applied directly as irrigation. If required, disinfection will occur at the upstream end of the supply pipeline in a suitable on-line structure so that contact time will be satisfied by the time it completes its passage to the pump station.

4. MANAGING OFFSITE HYDROLOGIC IMPACTS OF THE TORQUAY SANDS DEVELOPMENT

Surface water inflows to the saltmarsh wetlands to the east of the site have historically been winter/spring dominated with negligible runoff during summer/autumn periods. These wetlands can be expected to be sensitive to significant hydrologic changes brought about by increased volume and frequency of runoff events. Such changes are an inevitable consequence of increased surface imperviousness and drainage efficiency, but can be effectively mitigated through strategic design, as is proposed for the resort development.

4.1 Peak runoff rates-flood management

4.1.1 Requirements

The Torquay Sands development will increase surface imperviousness (thus generating more runoff per unit area), and modify drainage response by construction of new drains, lakes and wetlands.

The Torquay Sands development has no control over discharges emanating from lands external to its boundaries, but it is obligated to:

- control discharges from within its boundaries so that no detrimental impact accrues to properties downstream

- provide for passage of all waters from upstream catchments so that no detrimental impact accrues to properties upstream
- ensure internal development levels and drainage systems adequately protect the development itself from flooding
- ensure major floods are passed through the site in a safe manner.

To mitigate offsite impacts of increased stormwater runoff from the resort site, the drainage systems within the resort will provide for flood retardation storage in the airspace above AML5 and AML6 as well as in the minor lakes and wetlands.

4.1.2 Methodology

Surface runoff regimes in times of flood have been assessed using the industry-standard RORB hydrologic model.

The model structure incorporates the proposed Loch Ard Street and EWB diversion pipelines, the modified EWB, the future Southern Catchment retarding basin at Horseshoe Bend Road and the two main amenity lakes, AML4 and AML5. Three scenarios of catchment development were considered; existing conditions, existing conditions with Torquay Sands developed, and full catchment development. Average imperviousness of 45% has been assumed within existing residential areas in the upstream Western and Southern catchments. Within the resort site, average imperviousness of 60% within the residential development envelopes has been adopted. Future residential development areas in upstream catchments were assumed to have 50% average imperviousness, reflecting a likelihood of smaller lot sizes.

4.1.3 Stage-storage-discharge characteristics of modelled flood storages

The future Southern Catchment retarding basin at Horseshoe Bend Road does not form part of the Torquay Sands proposal works but was simulated as a nominal storage of 20,000 m3 with maximum outlet discharge of 850 l/s to match capacity of existing drainage through established residential properties downstream.

Modified Esplanade Wetland Basin			
Stage (m AHD)	**Storage (m3)**	**Discharge (m3/s)**	**Comments**
3	0	0	Base of wetland
4.70	9,000	0	NTWL of wetland. Outflow commences through orifice control pipe. Surface area about 1.4 ha.
5.0	13,370	0.025	Top of outlet pit. Approximate 1 year ARI water level and limit of fully effective water quality treatment zone. Major flood storage is above this level
5.50	24,425	0.72	
6.00	40,525	0.80	
6.25	51,330	0.82	Overland flows start to pass into golf course.

100 yr flood

Modified Esplanade Wetland Basin			
Stage (m AHD)	**Storage (m3)**	**Discharge (m3/s)**	**Comments**
6.40	57,900	1.25	

Amenity Lake AML1			
Stage (m AHD)	**Storage (m3)**	**Discharge (m3/s)**	**Comments**
3	0	0	Approximate base
5.00	8,000	0	NTWL of lake. Surface area about 0.48 ha. Crest of 20 m wide main weir. Limit of temporary irrigation storage capacity. Major flood storage is above this level
5.50	10,400	12.0	
6.00	12,800	34.0	

Amenity Lake AML2			
Stage (m AHD)	**Storage (m3)**	**Discharge (m3/s)**	**Comments**
2	0	0	Approximate base
4.00	10,000	0	NTWL of lake. Surface area about 0.58 ha. Crest of 20 m wide main weir. Limit of temporary irrigation storage capacity. Major flood storage is above this level
4.50	12,900	12.0	
5.00	15,800	34.0	

Amenity Lake AML3			
Stage (m AHD)	**Storage (m3)**	**Discharge (m3/s)**	**Comments**
1.50	0	0	Approximate base
3.50	7,000	0	NTWL of lake. Surface area about 0.45 ha. Crest of 20 m wide main weir. Limit of temporary irrigation storage capacity. Major flood storage is above this level
4.00	9,250	12.0	
4.50	11,500	34.0	

Amenity Lake AML4			
Stage (m AHD)	**Storage (m3)**	**Discharge (m3/s)**	**Comments**
1	0	0	Approximate base
3.00	52,000	0	NTWL of lake. Outflow commences through orifice control. Surface area about 2.6 ha. Temporary irrigation storage commences above this level
3.30	59,800	0.050	Crest of 20 m wide main weir. Limit of temporary irrigation storage capacity. Major flood storage is above this level
3.50	65,500	3.10	
4.00	80,000	20.00	

Amenity Lake AML5			
Stage (m AHD)	**Storage (m3)**	**Discharge (m3/s)**	**Comments**
0	0	0	Approximate base
2.00	40,000	0	NTWL of lake. Temporary irrigation storage commences above this level. Outflow commences through pit outlet to irrigation lakes IRL5 and IRL6. Surface area about 2.0 ha.
2.20			100 year ARI flood level in saltmarsh
2.30	46,000	0.050 (to irrigation storage)	Crest of overflow pit. Limit of temporary irrigation storage capacity. Major flood storage is above this level. All discharge below this level is to irrigation storage.
2.60	52,000	0.56	Crest of grassed overflow spillway across encircling embankment (50 m minimum length). Overflow goes to saltmarsh
2.90	70,000	16.0	

Wetland at Main Irrigation Lake			
Stage (m AHD)	**Storage (m3)**	**Discharge (m3/s)**	**Comments**
6.50	0	0	Approximate base of open water segment in wetland
7.50	8,000	0	Approximate levels of deep marsh area
8.00	18,000	0	NTWL of wetland. Outflow commences through orifice control to main irrigation lake IRL7 if capacity available. Other wise flow commences to amenity lakes downstream. Surface area about 2.5 ha.
8.50	28,000	0.30	Crest of 20 m wide overflow weir. Limit of fully effective wetland treatment zone
9.00	43,000	12.50	
9.50	58,000	35.00	
Note: All levels are referenced to an assumed NTWL of 8.00 m and may vary. Wetland and lake designs have yet to be finalised for IRL7.			

4.1.4 RORB Model Results

Model results are listed in Table 1 for the three development scenarios:

1. existing conditions,
2. existing conditions with Torquay Sands and
3. future catchment development conditions

The increase of 0.8 m3/s (10.5%) in peak 100 year ARI discharge to the saltmarsh with Torquay Sands developed, is entirely due to the 0.8 m/s transferred via the 750 mm diameter pipeline from The Esplanade Wetland Basin. This pipe is required to resolve the flooding problems in The Esplanade and the threat of erosion of the primary sand dune at Whites Cut.

After accounting for this inflow, the results show that retarding storage to be provided within the property is sufficient to ensure no increase in peak discharge to the saltmarsh, as a consequence of the development of Torquay Sands.

For long term ultimate catchment development the model predicts a near doubling of peak discharge to the saltmarsh. This result assumes that Council do not act to ensure future development upstream of Horseshoe Bend Road provides sufficient internal flood retarding storage to maintain rural discharge conditions. If Council do act to ensure the same conditions are placed on that development area as has been placed on Torquay Sands then no change in peak 100 year ARI discharge to the saltmarsh will occur. but the total volume of discharge will be greater (over a longer period)

The Torquay Sands lake and wetland system is able to reduce peak discharge at Horseshoe Bend Road by about 50% but cannot fully control all future catchment development outside its boundaries.

4.1.5 Recommended Flood Levels

As Torquay Sands has no control over any future Council decision in relation to allowable peak discharges from future Torquay North development to the west of Horseshoe Bend Road, it is necessary for flood management planning within the development to proceed on the basis that future flows will not be controlled to existing rural conditions.

Rounded to the nearest 50 mm the adopted flood levels through the various storages are as set out in Table 2. Allowances for additional head losses across proposed road crossings are also included.

Table 2 Recommended 100 year ARI Flood Levels in Torquay Sands

Water Body	Location	Adopted flood level (m AHD)
The Esplanade Wetland Basin area		6.40
AML1	Upstream proposed road	5.75
	Downstream proposed road	5.65
AML2	Upstream proposed road	4.75
	Downstream proposed road	4.65
AML3		4.15
AML4		3.85
AML5	Upstream proposed road	2.95
	Downstream proposed road	2.90
Saltmarsh Boundary		2.20

Floor levels of any dwellings must have at least 300 mm freeboard above 100 year ARI flood levels.

4.1.6 Floodway safety

Velocity and depth of floodwaters in all floodways will conform with contemporary standards for safety of pedestrians and vehicles as set out in Melbourne Water Corporations' Floodway Safety guidelines.

Table 1 RORB Model Results (100 year ARI floods)

Location	Existing conditions	Existing Catchment onditions with Torquay Sands developed			Future Conditions (full catchment development)		
	Peak Discharge (m3/s)	Peak Discharge (m3/s)	Peak Level (m AHD)	Peak Flood Storage (m3)	Peak Discharge (m3/s)	Peak Level (m AHD)	Peak Flood Storage (m3)
Western Catchment at Horseshoe Bend Road	5.0	5.0			28.3 **		
Western Catchment at inlet to Torquay Sands	5.1	5.1			16.4 ***		27,000
Southern Catchment at Horseshoe Bend Road	3.6	1.6			0.85 ****		23,100
Esplanade WB	>6.5	0.8	6.05	42,900	1.2	6.38	57,100
AML1		5.1	5.28	1,360	16.9	5.63	3,010
AML2		5.1	4.28	1,630	16.6	4.62	3,600
AML3		5.1	3.78	1,260	16.4	4.12	2,770
AML4		5.9	3.61	16,700	13.5	3.84	23,300
AML5		6.1	2.76	15,600	13.4	2.88	18,200
Saltmarsh	7.6	8.4 *			14.5		

* Increase in discharge compared to pre-Torquay Sands conditions is entirely due to diversion of flow from The Esplanade Wetland Basin

** Assumes no retarding storage provided upstream of Horseshoe Bend Road in the Western Catchment.

*** Assumes no retarding storage provided upstream of Horseshoe Bend Road in the Western Catchment. Flow reduction achieved through 27,000 m3 wetland storage on land between Horseshoe Bend Road and Torquay Sands

**** Assumes flow controlled to capacity of existing drainage pipes east of Horseshoe Bend Road via 23,100 m3 retarding basin

4.2 Water quantity regime considerations

4.2.1 An overview

Retarding basins only mitigate the effect of increased peak discharges. They cannot fully mitigate the impacts of urban development on seasonal runoff trends because they do not alter the volume or frequency of flow passing.

Under existing rural conditions, runoff rarely occurs to the saltmarsh in the dry seasons. With the onset of urbanisation in the Western Catchment, starting with Torquay Sands, there will be a marked change in dry season runoff characteristics. Impervious surfaces and efficient drainage systems will produce a runoff response from almost any rainfall event. Convectional rainfall events (the summer thunderstorms), will thus have the potential to impact on the saltmarsh, in the absence of adequate corrective measures.

Such problems can only be addressed by providing for excess surface runoff water to be stored on site so that it can be consumed directly (eg., by irrigation) or indirectly (eg., via increased evaporation or seepage to groundwater).

In the case of Torquay Sands the water will be used for golf course irrigation and lost to evaporation. All water storages will be sealed using synthetic liners to prevent ingress of saline groundwater. This automatically prevents any significant seepage losses from occurring so that no change to the local groundwater environment will occur.

All stormwater generated from development areas (roads, condominiums, houses, hotel) and the golf course, will be stored on site, treated in wetland systems and diverted to supply the main lakes and other minor feature lakes and ultimately the irrigation system. Water supply to maintain water quality standards and limit drawdowns in the lakes and to provide irrigation supply are issues of major importance to the Torquay Sands development.

Published figures indicate that mean annual runoff from the rural catchments in this locality approximates 50 mm. Thus under existing conditions the 124 ha site can be expected to yield about 60 ML of surface runoff to the saltmarsh wetlands. Mean annual rainfall is about 600 mm with mean annual evaporation of about 1100 mm (free surface evaporation losses will be about 770 mm). The total surface area of the main wetlands , amenity lakes and irrigation lakes associated with Torquay Sands is 14.2 ha. Thus mean annual evaporation losses from the water bodies will be of the order of 110 ML.

Residential/resort/roading development will occupy approximately 45 hectares (around 36%) of the site, of which average imperviousness will be about 60%. Assuming 85% runoff from impervious areas and 10% from golf course areas and other pervious parts of the development, the total mean annual inflow volume to the waterbodies from the

development will be of the order of 200 ML. This implies an average annual spill of about 90 ML from the water systems, excluding irrigation usage.
When golf course irrigation demand is taken into account (estimated to be 160 ML/year on average, rising to 245 ML in severe drought years):

- there can be little doubt that the development of the Torquay Sands property will maintain or reduce the mean annual volume of surface runoff entering the saltmarsh from the property, compared with existing conditions.

- as demand for irrigation water consumption will be highest in the dry seasons, there will be little prospect of surface water derived from the Torquay Sands development passing through to the saltmarsh at such times.

- the proposed surface water management system will effectively mimic the natural seasonal trend and volume of surface water input to the saltmarsh.

4.2.2 Water Balance Modelling Methodology

Water balance estimates have been carried out to assess:

- the required capacity of the main irrigation dam;
- supply and demand volumes of surface runoff and makeup irrigation supply from BRSTP;
- natural runoff regimes for the catchments to the saltmarsh;
- future runoff regimes to the saltmarsh with all development in place.

The first two items are inter-related.

The water balance model uses paired rainfall and evaporation records from nearby stations over a 10 year period, using 7 day timesteps.

4.2.3 The Main Irrigation Dam

A decision as to which dam size is appropriate will depend on several variables:

- what total area is to be irrigated,
- how much BRSTP water is to be used;
- how much land is available;
- what catchment development scenario is used.

In regard to area of irrigation, the design intent is for the course minimise water usage in recognition of the limited supply available in Torquay. This approach envisages use of significant areas of low water requirement indigenous sedge and grassland vegetation, with a total of about 31 ha to be irrigated, comprising about 10 ha of tees and greens and about 21 ha of fairways. This resulted in a mean annual irrigation demand of about 160 ML, rising to 245 ML in severe drought years.

There is a variety of catchment development scenarios which can be considered. For simplicity two scenarios have been selected as set out in Table 3.

Table 3 Catchment Development Scenarios

Scenario	Description	Comments
1	Esplanade Wetland catchment fully captured and diverted. Torquay Sands residential area 100% developed with golf course area completed. Upstream catchment remains rural.	180 ha catchment to the Esplanade Wetland of which 40 ha is impervious (EXISTING CONDITIONS). 155 ha catchment to the main amenity and irrigation lake systems in Torquay Sands of which 27 ha is impervious and 7.3 ha is water surface 238 ha rural catchment upstream of Main Irrigation Dam in White/Harding land
2	As for 1 but with balance of rural areas west of Horseshoe Bend Road and south of South Beach Road fully developed. "ULTIMATE CATCHMENT DEVELOPMENT"	180 ha catchment to the Esplanade Wetland of which 78 ha is impervious. 155 ha catchment to the main amenity and irrigation lake systems in the resort of which 27 ha is impervious and 7.3 ha is water surface 238 ha rural catchment upstream of Main Irrigation Dam in White/Harding land of which 119 ha is impervious

Table 4 outlines the water balance figures for the specified irrigation demand, a range of dam sizes between 30 ML and 120 ML, and the two catchment development scenarios. Mean annual irrigation for the 10 year period modelled was 160 ML/year with a maximum year total of 200 ML.

The water balance estimates are based on the following additional assumptions:

- Short term irrigation storage supply of 300 mm depth above NTWL in amenity lakes 4 and 5 and irrigation lakes 3/4, 5 and 6 of up to 16.2 ML (total 5.4 ha surface area).
- The short term irrigation storage volume of 16.2 ML can be delivered by pump to the main irrigation dam within 1 week (50-60 l/s maximum pumping rate).
- No leakage of the waterbodies
- All waterbodies are initially full
- No consumptive use of water in The Esplanade Wetland Basin below NTWL.

Table 4 Makeup Supply (Black Rock STP water) for mean annual irrigation demand of 160 ML/year

Development Scenario	Statistic	Main Irrigation Dam Size (ML)			
		30 ML	60 ML	90 ML	120 ML

Table 4 Makeup Supply (Black Rock STP water) for mean annual irrigation demand of 160 ML/year

1 Existing Conditions with Torquay Sands developed	Mean	72	56	37	25
	Maximum	103	90	90	90
2 Ultimate Catchment development	Mean	28	9	2	0
	Maximum	55	35	12	0

Thus to avoid use of BRSTP water in the long term it would be necessary to build a 120 ML dam.

In the shorter term until such time as development occurs in the Torquay North area, 25 ML/year of BRSTP water will still be needed on average with a 120 ML dam, with possible peaks up to 90 ML/year in dry years. With a maximum estimated drought year demand of 245 ML the likely maximum BRSTP makeup supply would rise to 135 ML. If dam size was reduced to 60 ML there would be no alteration to dry or drought year makeup supply needs.

From the long term perspective, there does not appear to be any solid justification for building a dam larger than 90 ML or even 60 ML. After all catchment development is complete in Torquay North the average annual cost of makeup supply for a 60 ML dam is $3,000. For a 90 ML dam the cost would be $660.

However without Torquay North being developed, the makeup supply costs in the short term would average $18,500/year and $12,000/year for the 60 and 90 ML dams respectively. There is no reliable timetable for the development of Torquay North.

It is considered that the best compromise solution would be to build a "turkey nest" dam with 60 ML capacity at external finished surface level, with additional pumped inlet capacity of 30 ML. The proposal has been finalised on the basis of this storage capacity.

4.2.4 Water Supply for Lakes and Irrigation in the Early Years

It is likely that for the first 12 months of golf course irrigation about 100-120 ML of BRSTP water could be needed to kickstart the storage system. Actual figures would be entirely dependant on recorded rainfall and progress on storage construction.

This BRSTP water cannot be added to any of the amenity lakes and nor should it be added directly to the irrigation lakes.

The water balance figures indicate that storage construction is a critical early need along with the diversion pipes into and out from the Esplanade Wetland. Ideally (from a water management viewpoint) the sequence of construction could be as follows:

1. Amenity Lake 4,

2. Esplanade Wetland outlet pipe to Amenity Lake 4,
3. Decommission existing pumped outlet from Esplanade Wetland,
4. Gravity diversion of Esplanade Wetland contents across to Amenity Lake 4 (with temporary bypass drain from inlet pipe to new outlet pipe),
5. Esplanade Wetland reconstruction,
6. Amenity Lake 5, plus irrigation lakes 3/4, 5 and 6,
7. Diversion system into Esplanade Wetland from Loch Ard Street,
8. Main Irrigation Dam and pumped inlet system from Irrigation Lakes 5/6.

At the very least, Steps 1-4 should be complete before significant irrigation demand arises in the golf course.

Water balance estimates indicate that under average annual rainfall conditions the Esplanade Wetland catchment will be able to deliver about 218 ML of water into Torquay Sands once the Loch Ard Street diversion is in place. However in dry years this could fall to 114 ML. Given the initial fill requirement of nearly 150 ML for all storages within Torquay Sands, and the irrigation demand, there will be little prospect of gaining significant water storage in the main irrigation dam for the first 2 years under average weather conditions.

Therefore, given the paucity of water in the early stages of the project, the main amenity lakes (AML4/5) and smaller irrigation lakes (IRL 5/6) will have to be used as true irrigation storages for one or two years in order to provide enough shandy water to allow ongoing application of the BRSTP to the golf course.

Use of these lakes as irrigation storages will ameliorate the start-up water supply problem, but will greatly reduce the aesthetic values of these lakes over the operating period. This is due to the greatly increased drawdown that would occur from irrigation abstraction. It would also prevent establishment of aquatic vegetation which is required for effective long term management of lake water quality. Therefore after all dams are finally filled and the system is fully operational, it will be necessary to draw down the AML4 and AML5 to plant and establish submerged aquatic vegetation. Barring wetter than normal weather conditions this will probably be about Year 2-3.

4.2.5 Surface water runoff to the saltmarsh

The water balance model was also used to check the volumes of surface water entering the saltmarsh for existing conditions, existing conditions with Torquay Sands fully developed, and ultimate catchment development conditions.

The results listed in Table 5 show that:

a. For existing catchment conditions with Torquay Sands and its surface water management strategy fully developed:

- the mean annual discharge of surface water to the saltmarsh from the study area will increase by about 87% compared to natural runoff conditions;

- this increase is entirely due to the diversion of the Southern Catchment across to the Western Catchment;

- the mean annual discharge of surface water from within the original boundaries of the Western Catchment to the saltmarsh will actually be reduced by 38% with full development of Torquay Sands.

It is considered that these outcomes are acceptable for the following reasons:

- dry season surface water inputs to the saltmarsh will still be negligible because this is when all water is diverted and consumed for irrigation;

- increases in annual discharge occur in the wet seasons when the bulk of freshwater inflows to the saltmarsh naturally occur.

The Esplanade Wetland flow diversion is required to address the flood management, sand dune erosion, and pump system operational issues in The Esplanade, as well as to facilitate consumptive use within Torquay Sands.

It would still be possible for Council to retain and continue to operate, at its cost, the pump system from The Esplanade Wetland across to Deep Creek if it was required to reduce the volume of surface water flowing to the saltmarsh. Torquay Sands could be developed with a smaller diversion pipe fitted with valve control to prevent diversion of water to the Western Catchment when the irrigation system was full. This would however still leave the problems of flood management and primary sand dune erosion at The Esplanade to be addressed by others.

b. For ultimate catchment development conditions:

- the mean annual discharge of surface water to the saltmarsh from the study area will increase by about 400%, compared with rural runoff conditions;

- this increase is due to the massive increase in surface runoff generated as a result of development west of Horseshoe Bend Road and the assumption of no consumptive use of this water being made.

This outcome was to be expected given the extent of future development proposed in the catchments. It is not the responsibility of Torquay Sands to mitigate such impacts which arise from areas external to its boundaries.

Table 5 Water Balance Results

Year	Rainfall (mm)	Evap'n (mm)	Surface Water Flow to Saltmarsh (ML)						
			Natural Conditions (393 ha c/m)	Existing Conditions with Torquay Sands developed (573 ha c/m)			Ultimate Catchment development (**) (573 ha c/m)		
			Outflow from Western Catchment	Inflow from Southern Catchment to Western Catchment	Outflow from Western Catchment (*)	Total outflow to Saltmarsh	Inflow from Southern Catchment	Flow from Western Catchment	Total to Saltmarsh
1979	511	1459	32	150	-32	118	284	390	674
1980	497	1487	0	133	-105	28	266	247	513
1981	567	1476	333	276	241	517	398	602	1000
1982	431	1509	0	114	-107	7	230	188	418
1983	605	1282	469	343	426	769	467	802	1269
1984	492	1290	55	152	-17	135	278	361	639
1985	650	1203	239	274	207	481	434	720	1154
1986	507	1224	145	192	86	278	315	462	777
1987	673	1257	311	308	269	577	469	782	1251
1988	634	1299	149	236	100	336	400	640	1040
Totals	5567	13486	1733	2178	1068	3246	3541	5194	8735
Means	548.11	1354.11	173.3	217.8	106.8	324.6	354.1	519.4	873.5
Maximum	673	1509	469	343	426	769	469	802	1269
Minimum	431	1203	0	114	-107	7	230	188	418

(*) negative values indicate water consumed within Western Catchment (irrigation and evaporation)
(**) Assumes no consumptive uses of surface water in Western Catchment upstream (west) of Horseshoe Bend Road

4.3 Water quality considerations

No free discharge of surface water will occur from any part of the Torquay Sands development, without such water firstly being processed through grass filtration and/or wetland treatment and lake storage systems.

Separate runoff management systems are proposed for rainfall runoff from irrigated areas of the golf course and for rainfall runoff from urban areas and the non-irrigated parts of the golf course. Owing to the clustering of Holes 8 and 9 around AML3 and AML4 it is necessary to irrigate these areas with freshwater from AML4. No BRSTP water will be applied to any part of Holes 8 and 9.

Based on the soils investigations completed to date:

- there is no evidence of acid-sulphate soils being present on the site in significant quantities
- the clayey soils are slightly to moderately dispersive and will require protection from water action

4.3.1 Treatment of urban stormwater and runoff from non-irrigated parts of the golf course

The urban water treatment wetlands (WL1-WL9) have been sized to treat all flows from the residential and commercial areas of the resort and from non-irrigated golf areas, up to at least the 1 in 1 year ARI peak flow storm event. They will achieve approximately 80% suspended solids removal and removal of 50% of the incoming total phosphorus and total nitrogen, as recommended in the Best Practice Environmental Management Guidelines for Urban Stormwater (EPA 1999).

To achieve these performance criteria, the total area of "treatment" wetlands provided has been set at a very conservative 1.5 % of the contributing developed catchment area. This will also satisfy a related criteria that the wetlands achieve a 95% hydrologic effectiveness and detain pollutants for up to 72 hours to provide the required treatment.

The inlet portions of each wetland serving urban areas will incorporate a zone for coarse particle sedimentation and appropriate litter trapping. Up to 80% of the surface area of the wetlands will be composed of a mix of ephemeral area and shallow to deep marsh areas up to 0.6 m deep, which will feature emergent aquatic vegetation. Open water zones within the wetland will be limited to about 20% of the surface area.

The design of edge treatment, choice of wetland plantings and recirculation measures will aim to mitigate the risk of nuisance conditions such as mosquitos or algal blooms.

4.3.2 Treatment of golf course runoff (areas irrigated in part with BRSTP water)

Treated water from Black Rock STP is proposed to be imported for golf course irrigation. Due to expected higher nutrient loadings by comparison with urban stormwater runoff, all rainfall runoff from irrigated areas of the golf course is kept separated from that arising from the non-irrigated areas and the urban stormwaters. This reduces the "load" on treatment capacity in the wetland systems protecting the amenity lakes.

Maximum opportunity for mechanical filtration and biological uptake through extended detention is an important key to effective treatment of the runoff from irrigated areas of the golf course. For this reason and to comply with runoff quantity management needs, all such rainfall runoff is contained on site in a series of ephemeral wetland depressions draining to terminal storage systems. As far as is practicable, these systems have been protected from entry of runoff from both non-irrigated areas on the course and external catchments. They are designed as ephemeral wetlands with small open water areas acting as landscape features and evaporation surfaces. In times of significant runoff the open water areas will increase until such time as preset overflow levels are exceeded and discharge will occur through to the terminal irrigation storages (IRL5 and IRL6), from whence the water will be returned to the main irrigation dam.

The design of the ephemeral wetlands aims for removal of up to 60% of total nitrogen and total phosphorus. To achieve these performance criteria, the total area of "treatment" wetlands provided is about 3% of the contributing irrigated catchment area in the golf course.

4.3.3 The amenity lakes and small irrigation lakes

In contrast to the wetlands, the lakes are primarily open water bodies with gently sloped verges and shallows for safety and also to suit establishment of a diverse community of fringing aquatic vegetation. Up to 85% of the surface area of the lakes is intended to be open water, free of significant stands of emergent aquatic vegetation. A further 35% of the lake area is intended to be colonised by submerged aquatic vegetation.

The lakes form an important component of the water quality treatment train, with long term settlement of fine particulates and ultraviolet disinfection being the primary processes at work.

The design concept aims to provide a range of environmental, social and economic values within the lakes and wetland system including:

- flood conveyance, storage and reduction of peak flows to protect the development and upstream and downstream areas;
- provision of substantial water quality treatment to residential area and golf course drainage water;

- irrigation supply for golf course watering;
- landscape, scenic and recreational values;
- habitat for aquatic flora and fauna;
- other aquatic ecosystem values, and community environmental education values.

The beneficial uses of each system component will vary to some extent depending on anticipated water quality. For example the sediment traps and wetlands will be of a relatively poorer quality than the lakes themselves. Clearly the human uses of the treatment wetlands are restricted, however the lakes could be used for limited recreational pursuits including yabbying or non motorised boating. There is no intention to maintain swimming quality standards in the lakes or to encourage any body contact recreation in the future.

The water quality in the lakes should satisfy the State Environment Policy (Waters of Victoria, 1988). In particular E.coli shall be less than 1000 organisms/100 ml, dissolved oxygen greater than 6 mg/l, pH from 6.0 to 6.9, and suspended solids less than 25 mg/l. In addition EPA preliminary nutrient guidelines of 0.05 mg/l of total phosphorus and 0.6 mg/l of total nitrogen are appropriate initial aims for the lakes. The downstream water quality should not deteriorate from pre-development levels.

The proposed lakes and associated wetlands will form a major landscape feature and theme of the overall development, and they provide an opportunity to demonstrate best management practice for urban stormwater management. A positive impression of this major landscape feature will leave potential residents with a positive impression of the development as a whole, and justify the attempt to integrate environmental values with commercial pursuits.

While it is important that the lakes and wetlands system should create a visually pleasing impression they should not create a potential for adverse impact on public amenity, health or safety.

The appearance of the lakes zone is a function of water quality, lake design and shape, growth of plants and algae, edge treatments and other landscape features, and the standards of future maintenance. The lake zone should be free of any visually obvious pollutants such as oils, scums, foam and litter. Algal growth should not be excessive, and blue green algal growths should be absent.

Future terrestrial and aquatic plantings around parts of the lakes zone will contribute significantly to the scenic and environmental values of the development.

Special shoreline treatments such as rock boulders, retaining walls, boardwalks, jetties and sand or gravel beaches will be incorporated to:

- suit a variety of landscape and recreational objectives

- suppress wind-driven wave action
- prevent uptake of fine particulates and clays through dispersion processes, and
- mitigate turbulent resuspension of settled materials.

Shoreline treatments are shown on the Waterway Lake Edge Plan (GBLA Dwg. No. L1). The ultimate water quality within the lakes will be dependent on a suite of factors ranging from input water quality, to effectiveness of wetland treatments, to internal lake processes.

Factors relating to input water quality have been discussed and it would seem that the quality of water sources is similar to other lake developments and should not be a constraint to maintenance of good lake conditions. The results of input water quality sampling conducted on 18/10/00 after a rainfall period give some confidence that good water quality conditions can be sustained in the amenity lakes and irrigation lakes.

Table 6 Water quality monitoring data

PARAMETER	Esplanade Pondage	Property Drain
Conductivity (uS/cm)	69	340
pH, (units)	7.6	7.7
Turbidity (NTU)	73	74
Nitrate+Nitrite N (mg/l)	0.26	0.040
Ammonia N (mg/l)	0.19	0.019
TKN (mg/l)	0.62	1.0
Total N (mg/l)	0.88	1.0
Ortho P (mg/L)	0.009	0.055
Total P (mg/L)	0.091	0.15
E.coli, (org/100ml)	890	

Detention of stormwater in the wetlands and lakes for extended periods with little inflow could lead to the following water quality responses:

- rise in water temperature
- increase in algal and plant growth
- decrease in turbidity and suspended solids
- increase in daytime oxygen levels and night time depletion
- decrease in levels of phosphorus and nitrogen in the water column

On balance the effects of the wetlands and lakes are to significantly improve downstream water quality because of the biological and physical processes within them. This treatment potential may be enhanced by:

- attention to design which maximises treatment

- encouragement of growth of aquatic plants especially at the shallow margins
- segmentation of wetlands into alternating deep and shallow marsh areas across the full width to promote good plant contact and even distribution of flow
- increasing the surface area of the wetlands
- artificial aeration, recirculation or other treatment

All of these measures are to be employed in Torquay Sands.

The water quality regime in the lakes will effect the visual and biological condition of the lakes including the frequency and severity of algal growth and aquatic plant growth.

Algal occurrence and growth is influenced by a number of factors including:

- levels of the nutrients (C, N, P) in the water and sediments
- ratio of N to P in the water
- other water quality characteristics such as salinity
- light and shading
- temperature
- water clarity
- suspended particles in water
- grazing by invertebrates especially cladocerans and ostracods
- physical characteristics of the lake system e.g. depth, surface area, circulation.

One of the primary factors effecting algal productivity is total phosphorus and total nitrogen concentrations. Worldwide studies in lake systems have shown the correlation that exists between algal concentrations (as measured by Chlorophyll *a* concentration) and the total phosphorus and nitrogen concentrations. The levels of these nutrients that would occur in the lake systems without prior treatment are in the range where blooms could potentially occur, however a large proportion of such nutrients will be removed in the treatment wetlands. It is estimated that prior to wetland treatment, TP levels in incoming stormwater will be about 0.2 mg/L and TN will be less than 2mg/L. After wetland treatment TP levels would be about 0.1mg/L and TN less than 1 mg/L. From these estimates it is further calculated that, in the shorter term, the likely water column TP in the larger of the amenity lakes (AML4 and AML5) will be about 0.07mg/L. While this is above the guideline level of 0.05mg/L it would not be sufficiently high to allow a significant algal bloom to develop. When the total catchment is ultimately developed input loads will increase but the impact of such increase will be counterbalanced by the higher flow volumes and hence the decrease in water residence times in each of the water bodies, making it less likely that bloom populations of algae could develop.

It is anticipated that some green algae will grow within the lake and wetland systems. The occurrence of limited growths of filamentous and unicellular green algae is natural and should not be of concern. It is probable that some attached algal species will grow on surfaces such as weirs or rock beaching.

Optimum growth conditions for blue green algae occur when, apart from abundant nutrients, there are long periods of sunlight and relatively calm and still conditions. The presence of low numbers of blue green algae in a waterbody is quite normal, it is bloom conditions that are of concern because of the aesthetic deterioration and the ability of some species to produce toxins. Attention to minimizing catchment inputs and wetland maintenance, as is proposed in Torquay Sands, will lessen the possibility of such blooms.

The most powerful control mechanisms are in fact biological controls. It is therefore important that the lakes and wetlands develop as viable aquatic ecosystems, which support invertebrates and fish.

Given adequate water supply and water quality any lake will develop to support a diverse range of aquatic plants, small aquatic animals and fish. This increase in diversity as a lake evolves will help ensure that no particular species (for example green filamentous algae or blue green algae) grows in excessive amounts.

The quality of the lakes will influence the degree of algal and plant growth. From a biological viewpoint the lakes will show a biological response to a range of physico-chemical factors including the water quality regime, the physical characteristics of the lake, and climatic conditions.

The species and numbers of organisms that can live in any aquatic system is dependent on many factors including flow regimes, water quality, food supply, riparian zone inputs, shading, competition and habitat. Habitat and habitat diversity will strongly determine the species and numbers of organisms found. In the absence of suitable habitat very few species will be found. Healthy populations of water and riparian plants should be encouraged to develop in and around lakes and wetlands as quite apart from their habitat value they:-

- take up nutrients from the lakes that would otherwise be available for algal productivity;
- can be a visually attractive and interesting part of the lake system;
- give the lakes a more natural, less artificial appearance;
- protect the edges from erosion, and make level fluctuations less obvious;
- provide shelter to grazing invertebrates that help control algal numbers.

Aquatic plant growth is dependent on the plants having a suitable rooting medium, therefore wherever plant growth is required in the lake, artificial liners will be covered with adequate depth of suitable soil. Of course there is always the possibility that one or more species could grow in nuisance proportions (especially Typha and Phragmites species), but attention to monitoring and maintenance, and early control will prevent such conditions from arising.

Other potential water quality problems in the lakes system are:

- Oxygen depletion, especially at night
- Microbiological contamination
- Pollution spills
- Development of mosquitoes in nuisance proportions

Oxygen depletion could well occur in dry weather periods with little inflow to the lakes, or at times of macrophyte or algal die off. This could result in odours, or the stress or death of fish and invertebrates. With adequate upstream treatment this would be rare however the possibility can easily be prevented by provision of mixing or re-circulation through the system. The irrigation system provides a ready means of recirculating water through the lakes and the wetlands in dry periods. The lake system has also been aligned to encourage wind-driven circulation, and the relatively shallow depths (<2.5 m) will inhibit the possibility of stratification problems developing.

The potential for mosquito hazards in the lakes can be minimised through adoption of appropriate design. It is important to ensure that the wetlands do not contain pockets isolated from predation by normal wetland biota such as fish and crustaceans. Such pockets include water trapped on poorly graded banks following elevated water levels in storm flows, or shallow water in association with debris. Design measures for minimising the possibility of mosquito nuisance have been incorporated including:

- grading banks to ensure free shedding of water following draw down of floodwaters;
- adoption of a waters-edge grading of slope 1 in 3 with an edge lip of at least 100 mm and a minimum water depth of 300 mm;
- shaping to provide efficient circulation of flow;
- providing sediment and trash interception at wetland entry points;
- selecting aquatic plants which do not have broad leaves above the surface to minimise substrate for mosquito breeding;
- providing artificial recirculation mechanisms.

5. FUTURE OPERATION, MAINTENANCE AND MONITORING REQUIREMENTS FOR LAKES AND WETLANDS

Operation and maintenance of the lakes and wetlands is crucial for problem free conditions to be maintained. Such maintenance will include:

- routine water quality monitoring according to a set program especially for dissolved oxygen levels and presence of blue green algal cells;
- clearing of grates or traps of litter;
- maintenance of pumps, weirs, grates and outlet structures;
- control and management of aquatic plant growth along lake and wetland margins;

- maintenance and reinstatement of edge erosion following large flows;
- maintenance of wetland re-circulation system;
- desilting of silt trap/ treatment wetlands;
- collection of litter on lake margins and from wetland traps;
- planting and vegetation management;
- monitoring of sediment accumulation rates in each wetland;
- provision of mains or bore water to compensate for evaporation losses;
- isolation of wetlands in the event of a pollution spill.

It is suggested that prior to commissioning, a maintenance and monitoring schedule be prepared and costed.

6. CONCLUSIONS

The detail investigations summarised in this report show that with the proposed Torquay Sands development proposal in place:

- major benefits will accrue in regard to flood protection along The Esplanade, prevention of erosion of Whites Cut, and the social, and environmental values of the existing Esplanade Wetland and its surrounds.

- the necessary volumes of floodwater can be contained within the site to ensure peak offsite discharges from the Torquay Sands development are maintained to present conditions.

- the water storage and water quality treatment systems within the resort boundaries have been designed to effectively mimic the existing seasonal regime of surface water discharged from the site area to the saltmarsh wetlands in the Thompsons Creek estuary/floodplain.

- The mean annual surface runoff volume discharged to the saltmarsh from the Torquay Sands site area will be reduced by 38% compared with existing conditions.

- The mean annual surface runoff volume discharged to the saltmarsh from the Western Catchment, after full diversion of the Southern Catchment from The Esplanade, will be increased by 87% compared with existing conditions.

- Despite the increase in mean annual discharge, little effect will occur to seasonality of flows entering the saltmarsh. Freshwater volumes will be virtually the same during the dry seasons of the year (ie., minimal or none), with virtually all of the increased discharge occurring in the wet seasons when natural freshwater inflow is significant in any case.

- After completion of urban development within the Torquay North area (ie., all land west of Horseshoe Bend Road), the mean annual surface runoff volume discharged to the saltmarsh from the Western Catchment, including full diversion of the Southern Catchment from The Esplanade, will be increased by 400% compared with existing conditions. This assumes no consumptive uses of surface water (such as is the case in Torquay Sands), are employed in these catchments.

- Such a massive increase in annual discharge will result in some changes to seasonality of inflow to the saltmarsh, with significant increases likely to occur due to impervious area runoff in convectional rainfall events (ie., the summer thunderstorms).

- The increased discharges will not be associated with, nor caused by the Torquay Sands development. Although the Torquay Sands irrigation system is able to handle some of the flows in the dry seasons the capacity of the storage systems and irrigation demand is insufficient to ameliorate the impacts.

- all external catchment floodwaters will be passed through the amenity lake systems and development areas along designated paths. Velocity and depth of floodwaters in all floodways will conform to contemporary standards for safety as set out in Melbourne Water Corporations' Floodway Safety guidelines and minimum freeboard of 300 mm will be applied to all residential areas.

- all stormwater generated from development areas (roads, condominiums, houses, hotel) will be stored on site, treated in wetland systems and diverted to supply the amenity lakes and other minor feature lakes and the golf course irrigation system. The water treatment wetlands will be designed and sized to treat all flows from the residential and commercial areas of the resort and from non-irrigated golf areas, in accordance with recommendations in the Best Practice Environmental Management Guidelines for Urban Stormwater (EPA 1999).

- leakage of surface water to groundwater from proposed waterbodies will be minimal owing to the use of synthetic liners.

- treated water from the Black Rock STP is proposed to be imported to assist with golf course irrigation in the driest times of the year. Due to expected higher nutrient loadings by comparison with urban stormwater runoff, all rainfall runoff from irrigated areas of the golf course will be kept separated from that arising from the non-irrigated areas and the urban stormwaters. All BRSTP water will be applied directly to the course after initial disinfection and shandying with stormwater. It will not be discharged directly into any of the lakes.

- all rainfall runoff water from irrigated parts of the golf course will be separated from the urban stormwaters and contained on site in a combined water quality/water quantity management system. This will take the form of a series of depressions draining to ephemeral wetlands offering maximum opportunity for mechanical filtration and biological uptake of pollutants through extended detention. Overflows from these wetlands will be directed to the irrigation lake system and reused on the golf course.

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