



Protecting Water Quality in Golf Courses in Singapore

Catchment and Waterways Department
PUB

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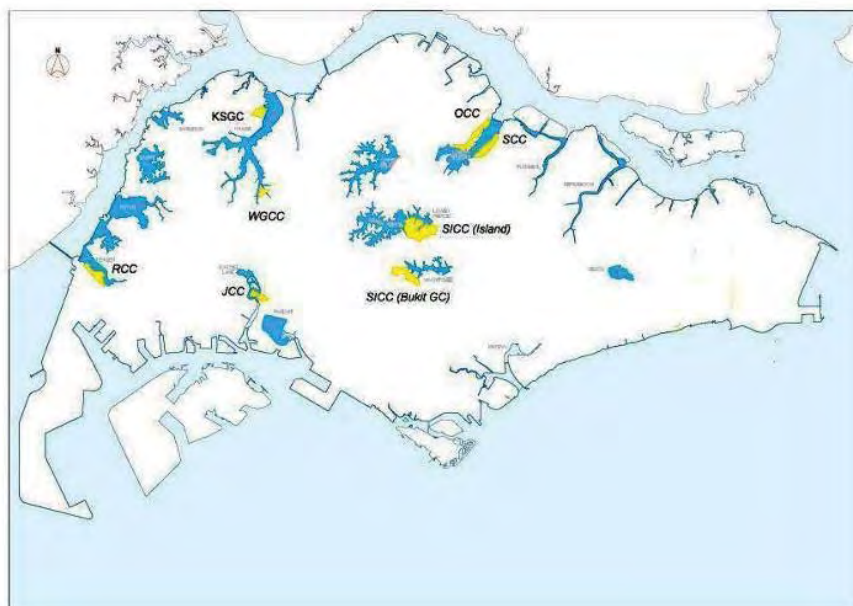
- List of golf courses bordering reservoirs
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List of golf courses bordering reservoirs

- Singapore Island Country Club in MacRitchie catchment,
- Singapore Island Country Club in Lower Peirce catchment,
- Orchid Country Club and Seletar Country Club in Lower Seletar Catchment,
- Jurong Country Club in Jurong Lake catchment,
- Warren Golf Club in Kranji Catchment,
- Kranji Sanctuary Golf Club in Kranji Catchment,
- Raffles Country Club in Tengeh Reservoir catchment,
- Marina East Golf Course in Marina catchment

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Location of golf courses in water catchment



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How golf courses impact the reservoir water quality

- Some golf course ponds are linked to reservoirs through overflow pipes or weirs
- Pond waters overflow into reservoirs during rain events.
- Sand-based golf courses lacking function in soil filtration

Ranges of golf course pond water quality

Water quality data since 2003.

- pH 6.2 – 8.0
- Conductivity 30-420 μ mhos/cm
- Total alkalinity 5 – 170 mg/L
- Nitrate 0.2 – 0.8 mg/L
- Ammonia 0.03 – 0.16 mg/L
- Total Nitrogen 0.6 – 1.3 mg/L
- Orthophosphate 0.03 – 0.065 mg/L
- Total Phosphorus 0.09 – 0.22 mg/L
- Chlorophyll-a 40-60 μ g/L
- TOC 5 – 14 mg/L

Water quality concerns

- Generally the concern is the high nutrient levels will result in “eutrophication” (algae bloom, low DO, bad odour)
- Most golf courses are in eutrophic or hypereutrophic condition

Trophic state	Total N (mg/L)	Total P (mg/L)	Chlorophyll-a (µg/L)	Secchi disc (m)
Oligotrophic	< 0.4	< 0.015	< 4	< 4
Mesotrophic	0.4 - 0.6	0.015 – 0.025	3 – 7	2.5 – 4.0
Eutrophic	0.6 – 1.5	0.025 – 0.1	7 - 40	1.0 – 2.5
Hypereutrophic	> 1.5	> 0.1	> 40	< 1.0

Reference: Classification of lakes (Forsber & Ryding, 1987)

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Best Management Practices (water quality improvement)

- Retention ponds for storage of runoff, prevent large influx to reservoirs
 - Direct drainage through constructed bioswales and vegetated cover into storage ponds
 - Edge planting in storage ponds
 - Maintain riparian buffer stripes to intercept runoff
 - Allowing filtering of nutrient through plants, soil and microorganisms
- Construct or modify ponds with gentler slope gradient to encourage natural establishment of wetlands along pond shoreline.
- To construct ponds in a series to treat runoff, to catch first flush and continue filtering
- To introduce new buffer vegetation in highly fertilised area or high runoff area

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Recommendations

- Wetland planting to improve water quality

- Reduce thinning or pulling out of cattails and to maintain a thicker belt of marsh plants along the perimeter of the ponds
- To expand area of wetland planting (area away from golfers)
- To plant the cattails into the pond water
- To introduce shorter wetland plant species



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Examples from Marina East Golf Course



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Examples from Kranji Sanctuary Golf Course



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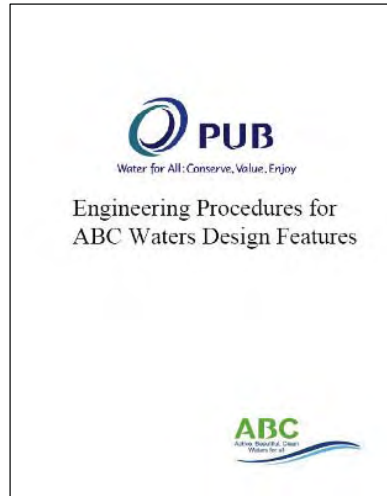
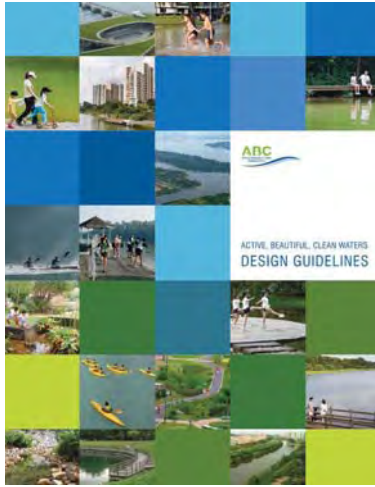
Best Management Practices (Maintenance)

- Prevent grass cuttings/leaves from dropping into the ponds (increase TOC)
- Remove any surface scum and algae
- Control weed manually (to prevent the use of herbicides)
 - Prevent entry and continue with the removal of invasive floating aquatic plants e.g. duckweed and water lettuce
 - Prevent entry and continue with the removal of invasive submerged aquatic plants e.g. hydrilla



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Active, Beautiful, Clean Waters Design Guidelines



Download

http://www.pub.gov.sg/abcwaters/abcwatersdesignguidelines/Documents/ABC_Guidelines_090616

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Examples of ABC water features in golf courses

- To install ABC Waters Design features (e.g. rain garden, bioretention swales) to remove nutrients from runoff
- Examples
 - Bioretention swales in KSGC
 - Wetland planting at SICC



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Examples of ABC Waters features

- Rain gardens / Biotopes / Bio-retention system
- Floating wetlands
- Treatment wetlands



Rain Garden @ Balam Estate



Bioretention swales @ Sengkang West Way



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Examples of treatment wetlands by PUB



Pilot treatment wetland in Kranji catchment

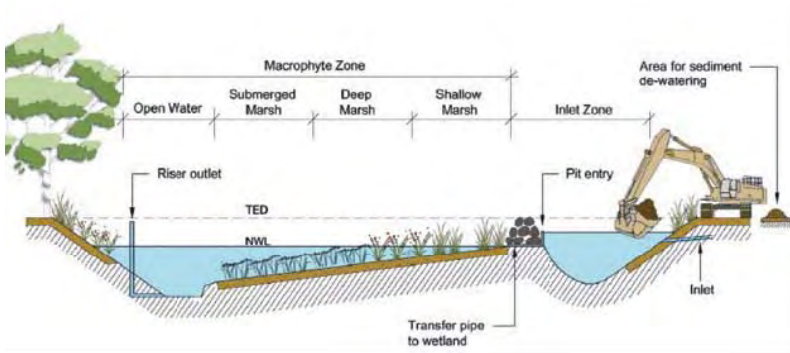


Pilot floating island in Lower Seletar reservoir

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Design of constructed wetlands - different water depths for wetland planting

1. Shallow marsh zone (up to 0.2 m deep)
2. Marsh & Deep Marsh (0.3 – 0.6 m)
3. Open water (>0.6 m deep)

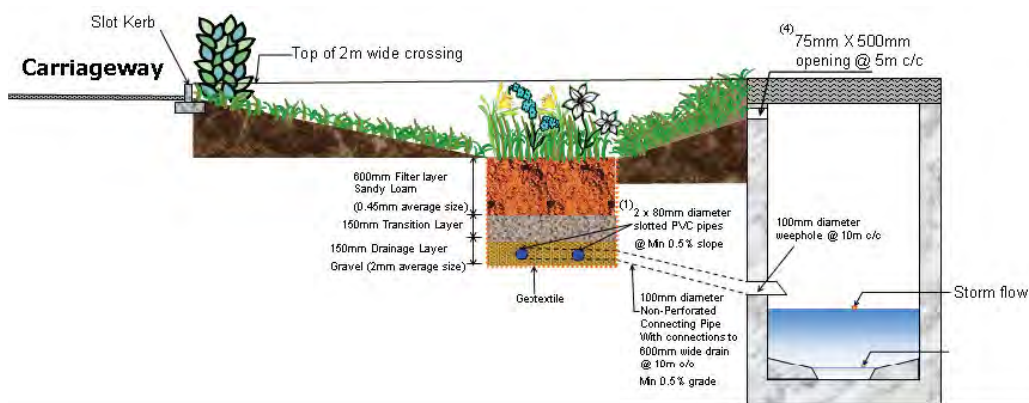


Cattail *Typha angustifolia*

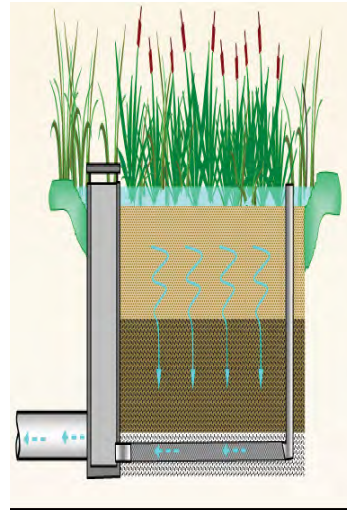


Spike rush *Eleocharis dulcis*

Bioretention swales



Rain gardens



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Benefits from improved pond water quality

- Better reservoir water quality for drinking water supply
- Better water quality for biodiversity conservation
- Aesthetically pleasing
- World class golf course with BMP
- A “Green” golf course

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Recommendations

- To establish water quality monitoring programme by Golf Clubs
- To install aeration and re-circulation system in deeper water area with low DO or area with algae problem
- To initiate wetland planting or maintain vegetated area for nutrient removal and algae control
- To install treatment wetland and bioretention systems for treatment of surface runoff

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Thank You

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