Community Wastewater Reuse

Adoption of High Rate Algal Ponds for Rural Wastewater Treatment in South Australia

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Local Government Association of South Australia

District Council of Loxton Waikerie

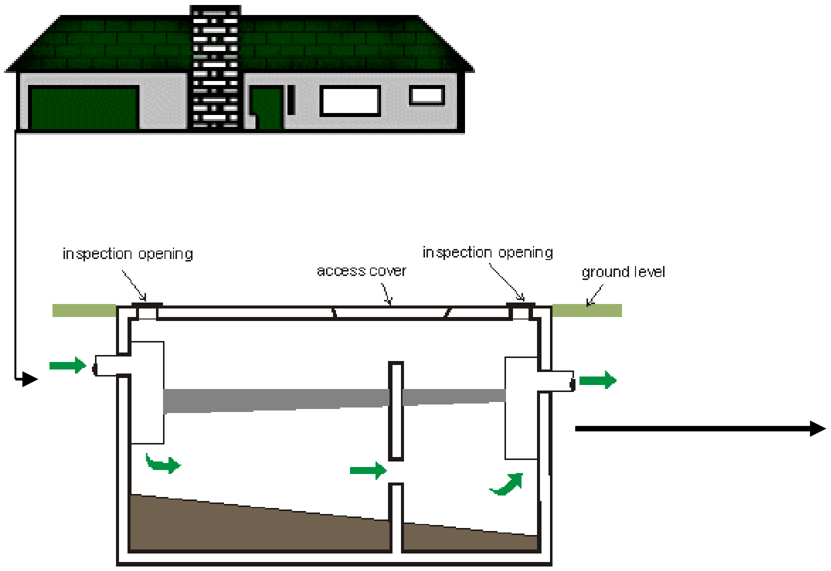
High Rate Algal Ponds for Rural Wastewater Treatment

- The problem
- The old solutions
  - Issues and limitations
- The new solution
  - Benefits

The Problem

- Wastewater treatment in rural communities.
- No wastewater treatment infrastructure support from major utilities.

Solution (1): On site wastewater treatment



On-site disposal – 'soakage trench'

Normally 3,000L;
24h detention,
60-70% SS &
30% BOD_5 removed

Problems with on-site disposal of treated effluent

- Disposal of treated effluent via sub-surface drainage or a ‘soakage trench’ can be problematic.
  - clay soils with low permeability
  - pooling of treated effluent resulting in
  - greater exposure of resident adults, children and pets to potential pathogens;
  - sandy soils – groundwater contamination
- Surface watercourses may also be contaminated from run-off during periods of heavy rainfall.

http://www.waternsw.com.au/__data/assets/pdf_file/0003/59853/Section-10-Absorption-Trenches-and-Beds.pdf

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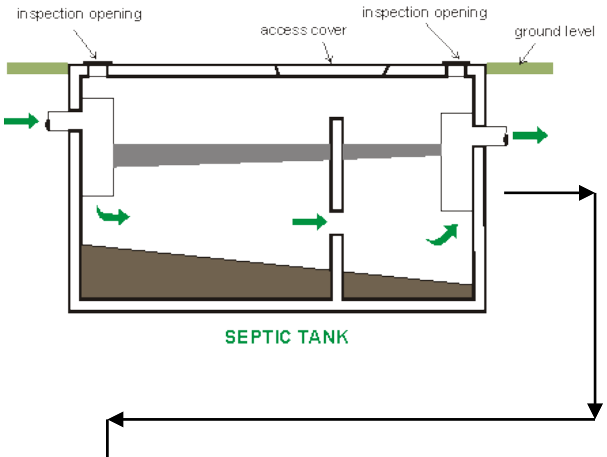
Potential River Murray Contamination

Solution (2)

Community wastewater management schemes (CWMS)

SA: Community wastewater management schemes

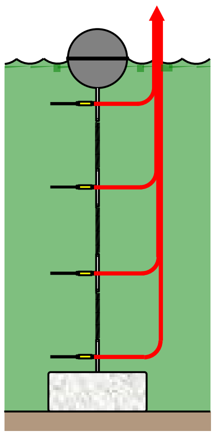


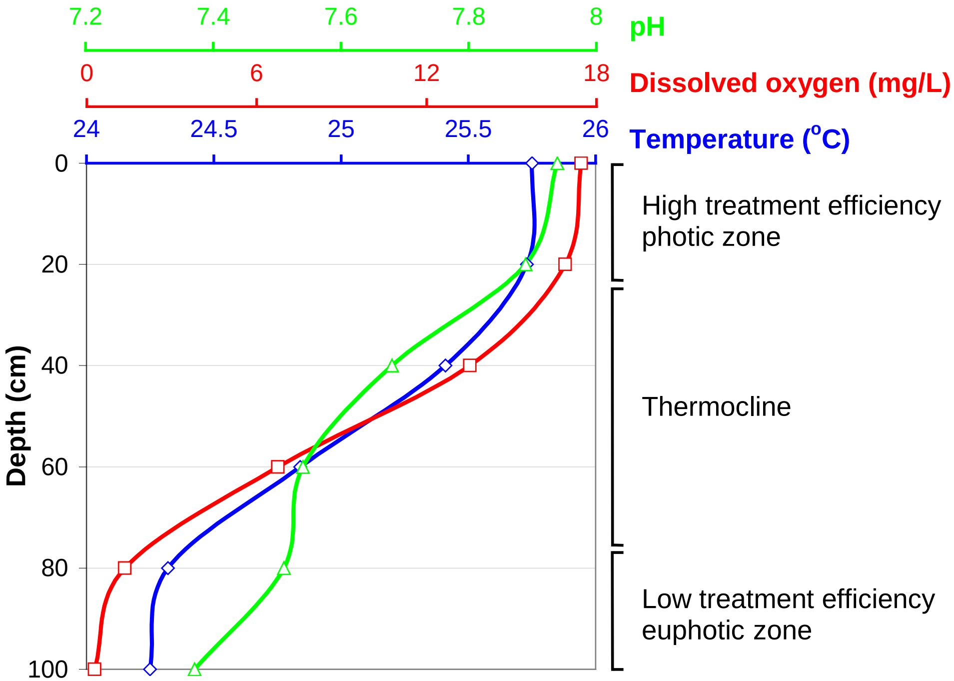
66 day retention time

Septic tanks on site:

- Anaerobic digestion of organic carbon.
- Solids retained in tank, permits use of small diameter pipework & infrastructure (lowering cost)
- Local Council maintains septic tanks.
- Very consistent effluent composition from system.
- Liquid phase delivered to treatment lagoons with long retention times (66d) = large surface area.

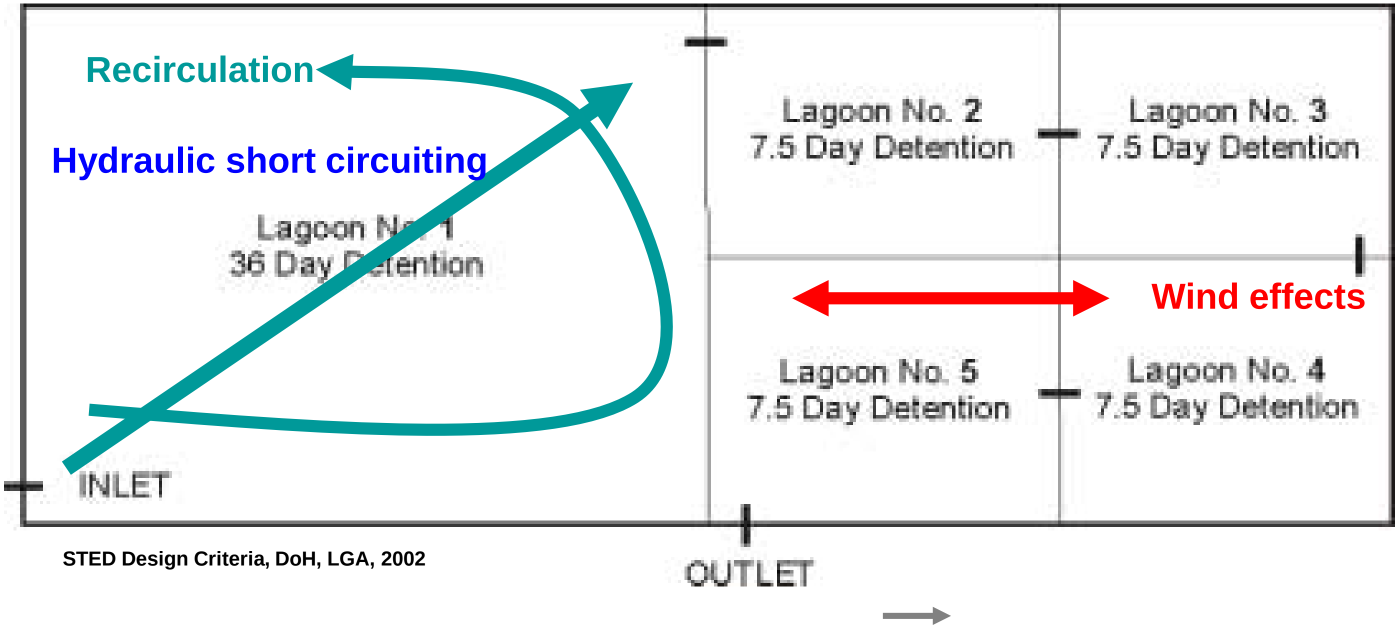
Problems with large deep (1.4m) lagoons Stratification: Dissolved oxygen, temperature and pH





Sweeney, DG, Nixon, JB, Cromar, NJ & Fallowfield, HJ. (2005)
Water Science and Technology, 51, 163-172.

Problems with *unmixed* lagoons (waste stabilization ponds)

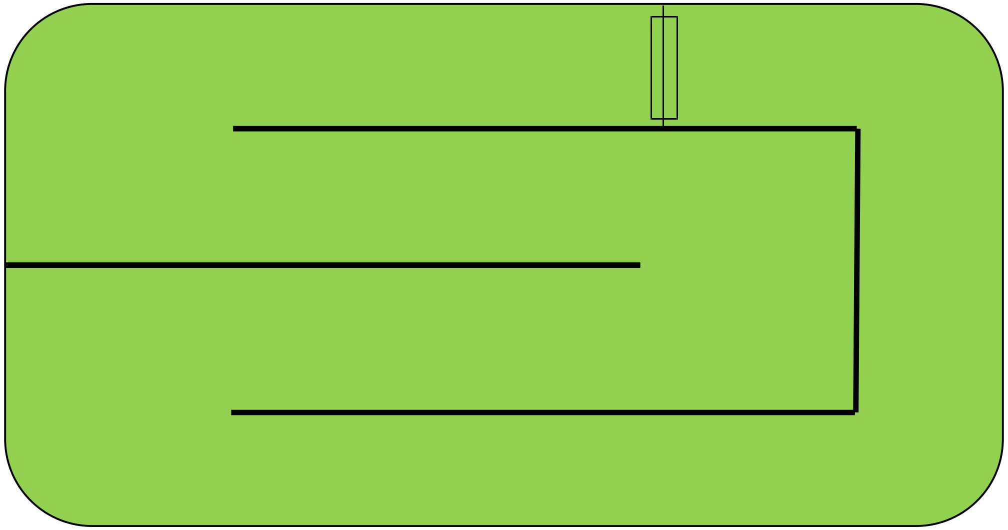


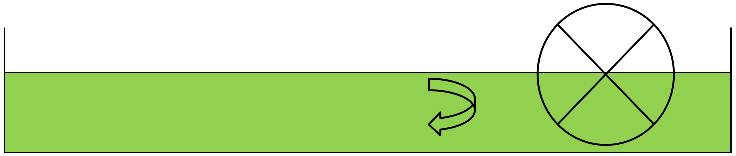
STED Design Criteria, DoH, LGA, 2002

Opportunity for High Rate Algal Ponds ?

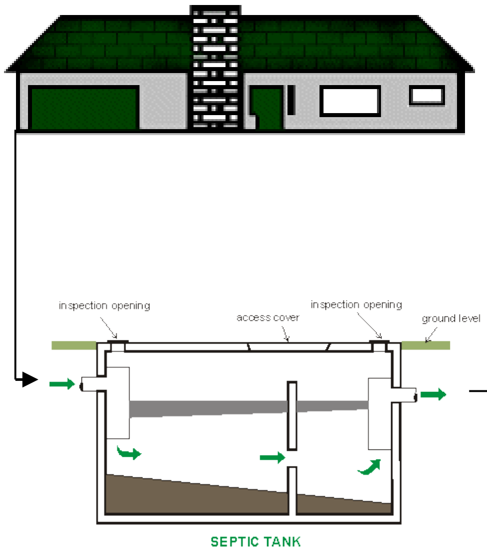
The new solution

High rate algal ponds





South Australia: High rate algal ponds for CWMS)



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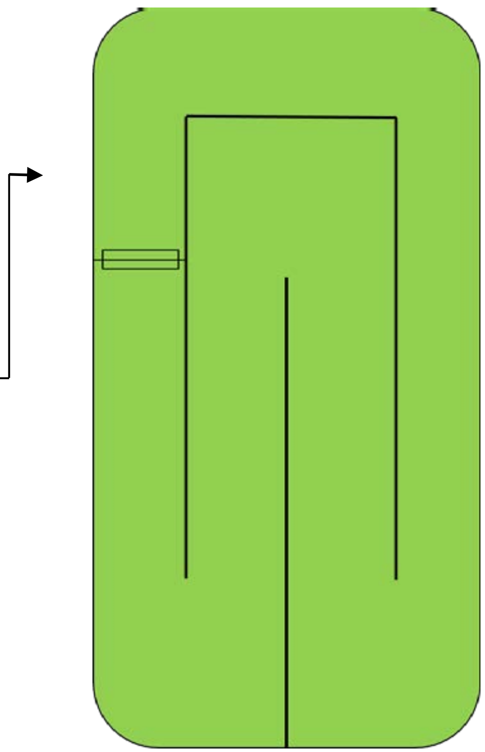

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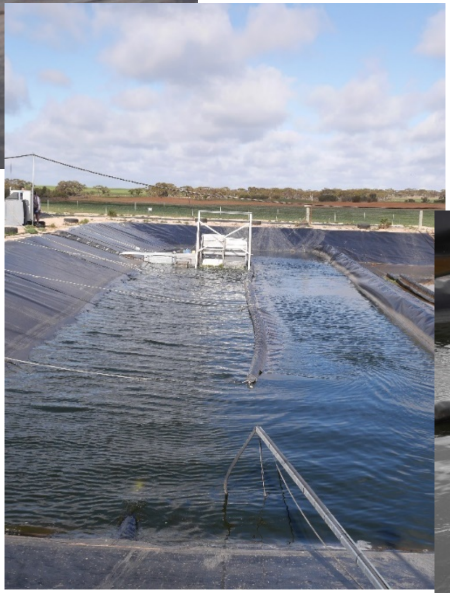
Lake Gairdner
Flinders Ranges
Spencer Gulf
Gulf St Vincent
Lyndoch
Kingston on Murray
Adelaide
Investigator Strait
Encounter Bay
Victoria
Image Landsat
© 2016 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth
US Dept of State Geographer
Tasman Sea
Solomon Sea
Savu Sea
Vanuatu
Noumea
Flying Fish

Kingston on Murray project:
Proposed - 2005
Construction - 2008



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Kingston on Murray HRAP

- 250 m^2 HRAP in a geotextile & HDPE lined, earthen walled basin.
- Channels were formed using HDPE, floating curtain walls.
- Operational depth (0.2 – 0.55m) was controlled by a vertical overflow pipe.
- The wastewater was circulated at 0.2m s^{-1} using an 8 bladed, paddlewheel
- **Hydraulic residence time 5-8 days**
- In 2012, a second identical HRAP was constructed within the basin to evaluate in series operation of HRAPs.

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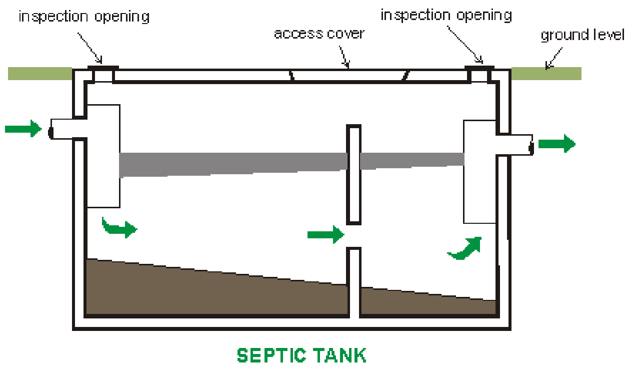
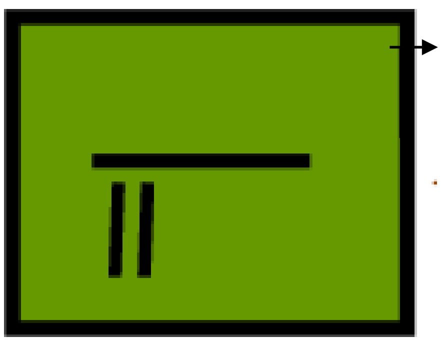
Comparative study

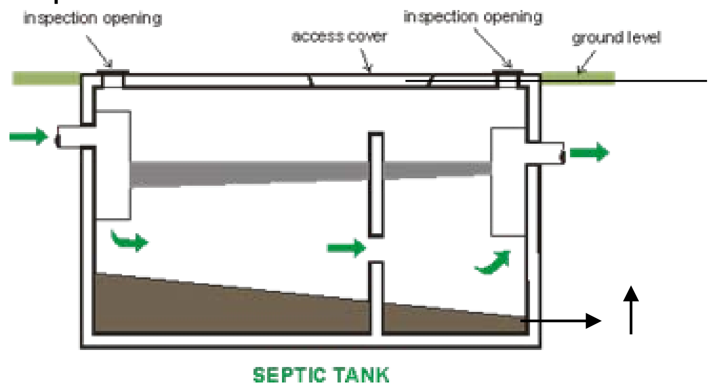
Comparative study: HRAP v WSP
(2009 – 2012)

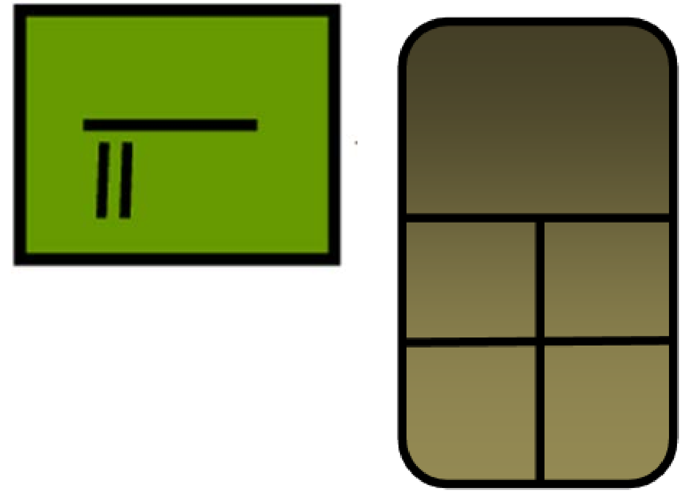
HRAP as facultative pond replacement





HRAP as maturation pond replacement





Lyndoch CWMS

Lyndoch CWMS

- Constructed in 1979
- Population serviced of approximately 1,750
- Influent flow125 and 165m^3/d
- Comprises of a facultative pond (6,300m^2, depth 1.2m effective volume of 5,000m^3 and THRT 30 days)
- followed by 2 in series maturation ponds each 2400m^2
- First maturation pond (depth 0.8m) effective volume was 1920m^3 with THRT of 11.6 days (flow rate 165m^3/d
- Second maturation pond has an effective volume 1800 m^3 (depth 0.75m) and a of THRT 10.9 days
- The combined THRT was 52.5 days

Table 1. Composition (median values) of inlet wastewater, ***pre-treated in on-site septic tanks,*** to the Community Wastewater Management Schemes at Kingston on Murray (KoM) and Lyndoch. (n = number of samples analysed)

	BOD_5 (mg/L)	NH_4-N (mg/L)	NO_2-N+ NO_3-N (mg/L)	PO_4-P (mg/L)	Log_{10} *E.coli* /100mL
KoM	200	87.8	0.2	13.9	6.384
n	124	121	121	119	124
Lyndoch	220	77.0	0.00	12.1	6.279
n	73	78	62	78	82

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Table 2. Percentage removal of BOD_5, total inorganic nitrogen (TIN) and soluble reactive phosphate (PO_4-P) and the log_{10} reduction value (LRV) of *E.coli* from effluent ***pre- treated in septic tanks*** followed by treatment in the HRAP at Kingston on Murray (KoM) and from the facultative pond at Lyndoch. n = number of samples analysed

Removal	BOD_5 %	TIN %	PO_4-P %	*E.coli* LRV
KoM HRT 5d	92.3	60.5	14.9	1.6
n	124	75	11.8	124
Lyndoch HRT 30d	93.2	45.7	13.4	2.1
n	74	62	78	82

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Table 3. Percentage removal of BOD_5, total inorganic nitrogen and soluble reactive phosphate and the log_{10} reduction value (LRV) of *E.coli* from ***facultative pond effluent*** following treatment in the HRAP at Kingston on Murray (KoM) and the maturation ponds at Lyndoch.

Removal	BOD_5 %	TIN %	PO_4-P %	*E.coli* LRV
KoM **HRT 5d**	59.1	57.8	[illegible]	2.7
n	75	[illegible]	75	75
Lyndoch **HRT 22.5d**	33.3	[illegible]	16.1	2.0
n	[illegible]	62	78	82

Independent review accepted Flinders data;
proceeded to independent validation 2012

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Independent Validation

- Designed in consultation with SA Dept Health & Ageing (Dr David Cunliffe, contributor to Australian & WHO reuse guidelines)
- Log_{10} reduction values (LRV) of indictor organisms of pathogenic bacteria, viruses and protozoa.
- 5^{th} percentile value was used for determining the validated LRV
- 20 samples, 1 ‘errant’ result = 5^{th} percentile

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Suitable indicators for LRV determination

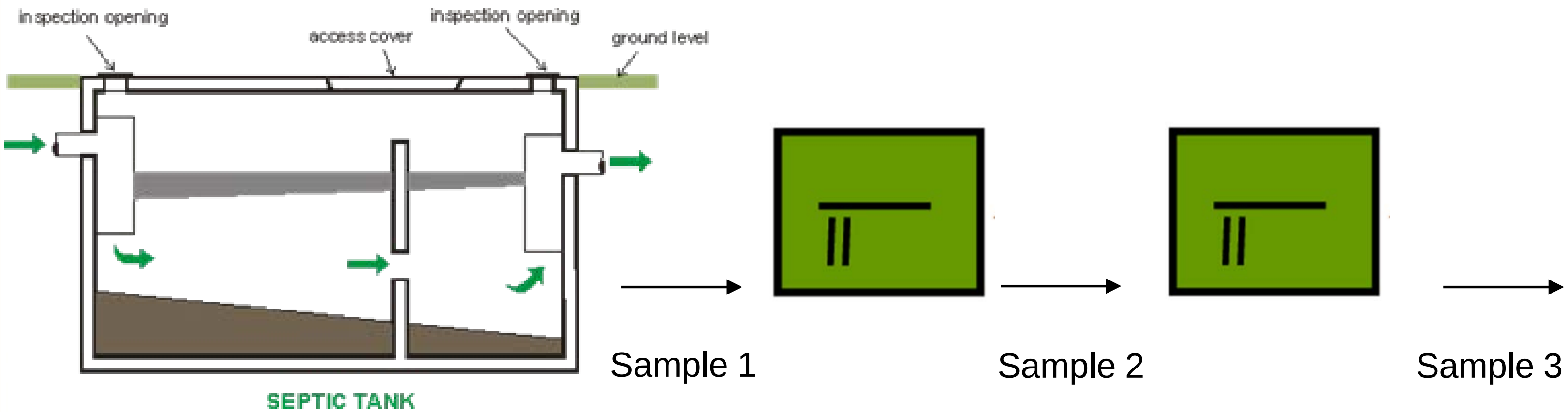
- Choice of indicators:
  - *E.coli* - pathogenic bacteria
  - F-RNA - 'phage pathogenic viruses
  - ?? – pathogenic protozoa

- Small population at KoM
  - Low excretion rates (incorporate into QMRA?)
  - ? Spiking with pathogenic protozoa - ~$145k

- Resolved to use aerobic spore forming bacteria as surrogates for pathogenic protozoa

Independent Validation

- HRAP configuration
  - 2, ~200m^2, 0.3m deep, 5d THRT HRAPs operated in series



S1-S2 = LRV HRAP1 S2 – S3 = LRV HRAP2

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Independent validation of $\log_{10}$ reduction values

250km

Sampled in Winter (worse case scenario); Monday & Thursday; 10 weeks; 20 inlet and 20 outlet samples

Independent microbiological analysis by National Association of Testing Authorities (NATA) accredited laboratory (AWQC)

Outcome

HRAPs validated and accepted by Department of Health and Ageing and by LGA SA as an alternate treatment system for Community Wastewater Management Schemes

Local Government Association of South Australia

DESIGN GUIDELINE for a

HIGH RATE ALGAL POND (HRAP)

as an element in

WASTEWATER TREATMENT

"each design must be engineered to suit the particular application, and each completed design is subject to approval by the Department for Health and Ageing".

Professor Ho … ssor Nancy Cromar

Buchanan

Scho… of the Environment

Flinders University

Adelaide, South Australia

2010 to 2015

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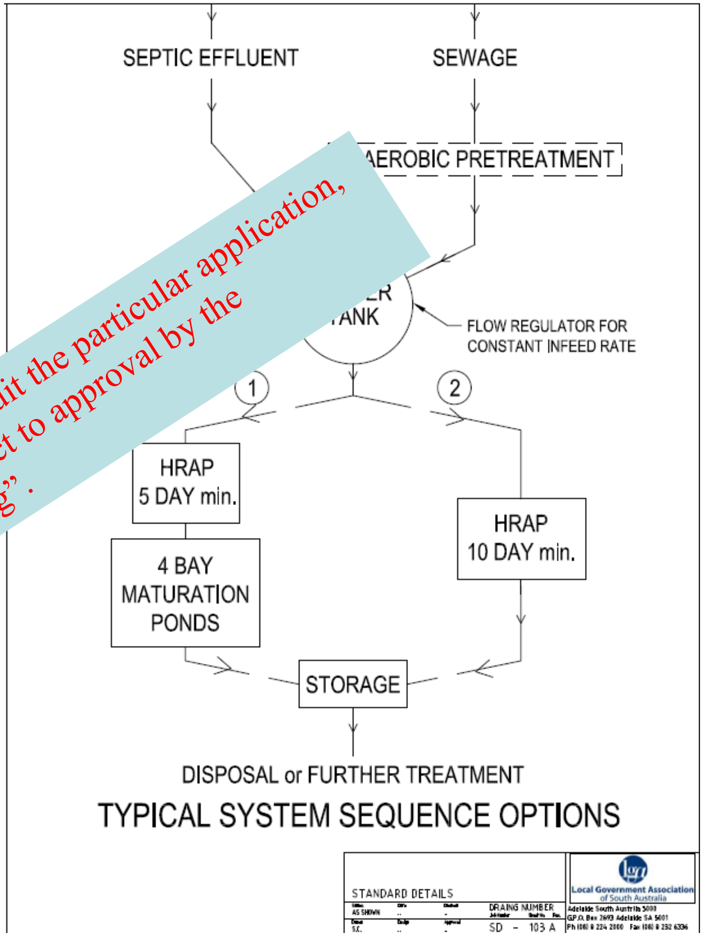

Chronology to acceptance

- 2005 project proposed
- 2008 HRAP construction at Kingston on Murray completed
- 2009 – 2012 HRAP/WSP comparative performance study completed
- 2012 HRAP configured for in series operation
- 2012 Independent review of Flinders data
- 2013 independent validation conducted (winter)
- 2016 Validation accepted HRAPs as approved alternate system for CWMS.

Beneficial outcomes of using HRAPs for rural SA communities

Consequences of the reduced area requirement and shorter hydraulic retention times of HRAPs:

- use 40 – 50% less surface area than the ‘traditional’ 5 cell WSP
  - the technology can be employed in locations were insufficient land is available for larger WSP systems.
  - alternative to energy intensive electro-mechanical wastewater treatment systems which are often considered for application where there is insufficient land for traditional WSP.

Beneficial outcomes of using HRAPs for rural SA communities

- Reduced construction costs
  - use 40 – 50% less surface area than the ‘traditional’ 5 cell WSP
  - with only 11- 30% of the earthworks required compared to a ‘traditional’ CWMS lagoon system
  - construction cost of the HRAP system is estimated to be 40 to 55% that of a conventional CWMS lagoon system.

Beneficial outcomes of using HRAPs for rural SA communities

- Reduced evaporative loses
  - significantly reduces evaporative losses, 12-17% loss compared with 30% for CWMS lagoon system,
  - more wastewater available for beneficial reuse within the rural community.

Final disposal of treated effluent

- Treated wastewater used for irrigation:
  - –Woodlots
  - –Grape vines
  - –Recreational spaces – ovals, parks
  - –Mining – dust suppression
  - –Firefighting

Future beneficial uses of biomass from wastewater HRAPs

- HRAPs produce significant quantities of biomass (70T/ha/yr)
- Biomass rich in nutrients and organic carbon – soil conditioner
- Potential source of renewable energy via anaerobic digestion
- Irrigation of forage and renewable energy crops

ACKNOWLEDGEMENTS

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- Loxton-Waikerie District Council for access to the wastewater treatment plant,
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- Our ‘project champion’ Richard Gayler of Gayler Professional Services & CWMS LGA SA Manager.

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