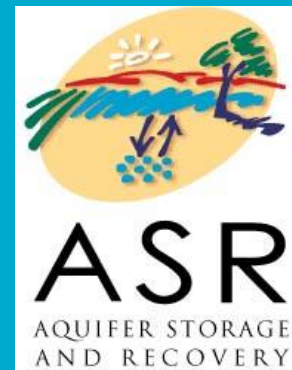




Bolivar recycled water ASR

Risk management

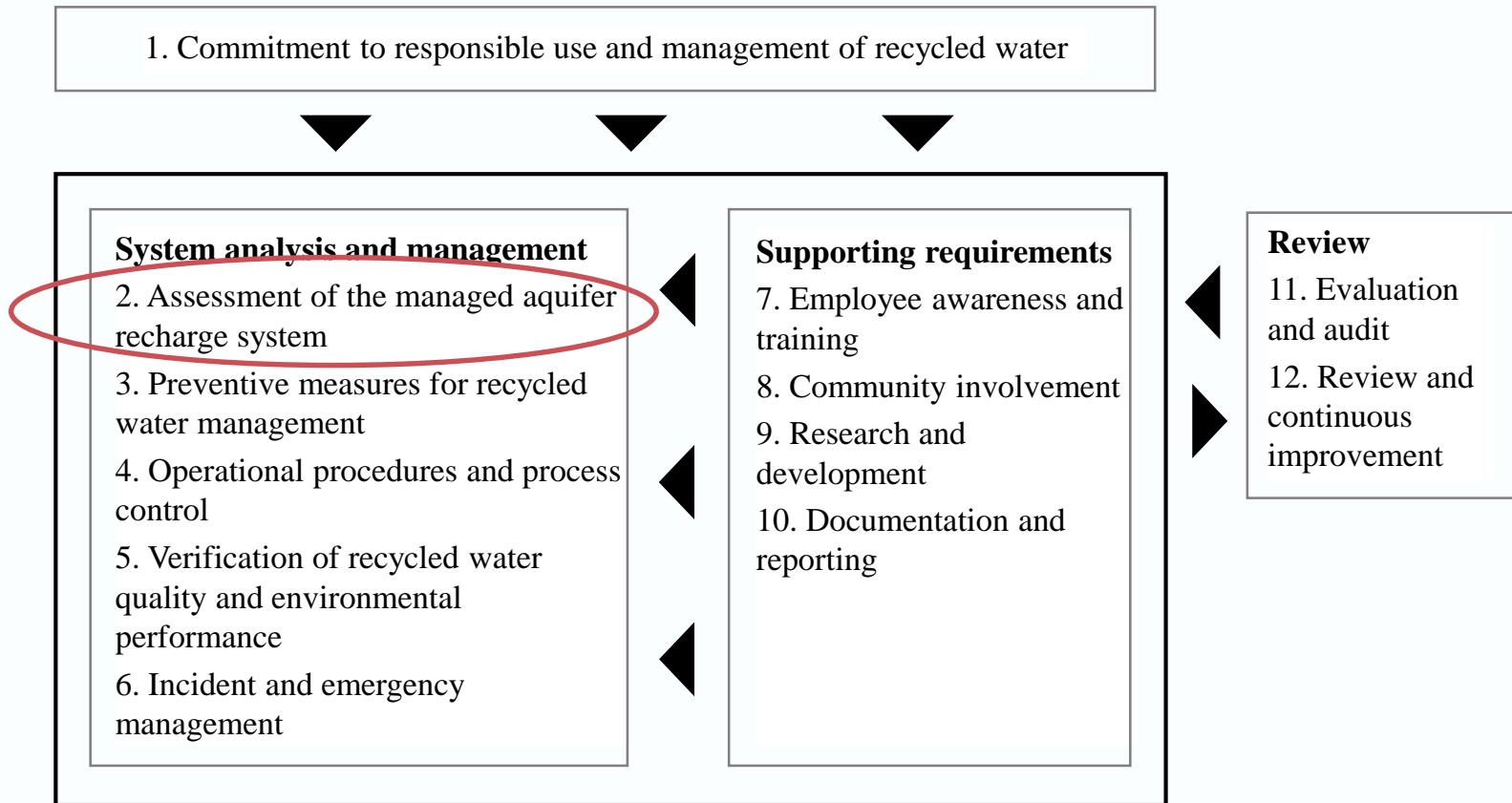
Declan Page | Group Leader, Liveable Sustainable and Resilient Cities
27 January 2016



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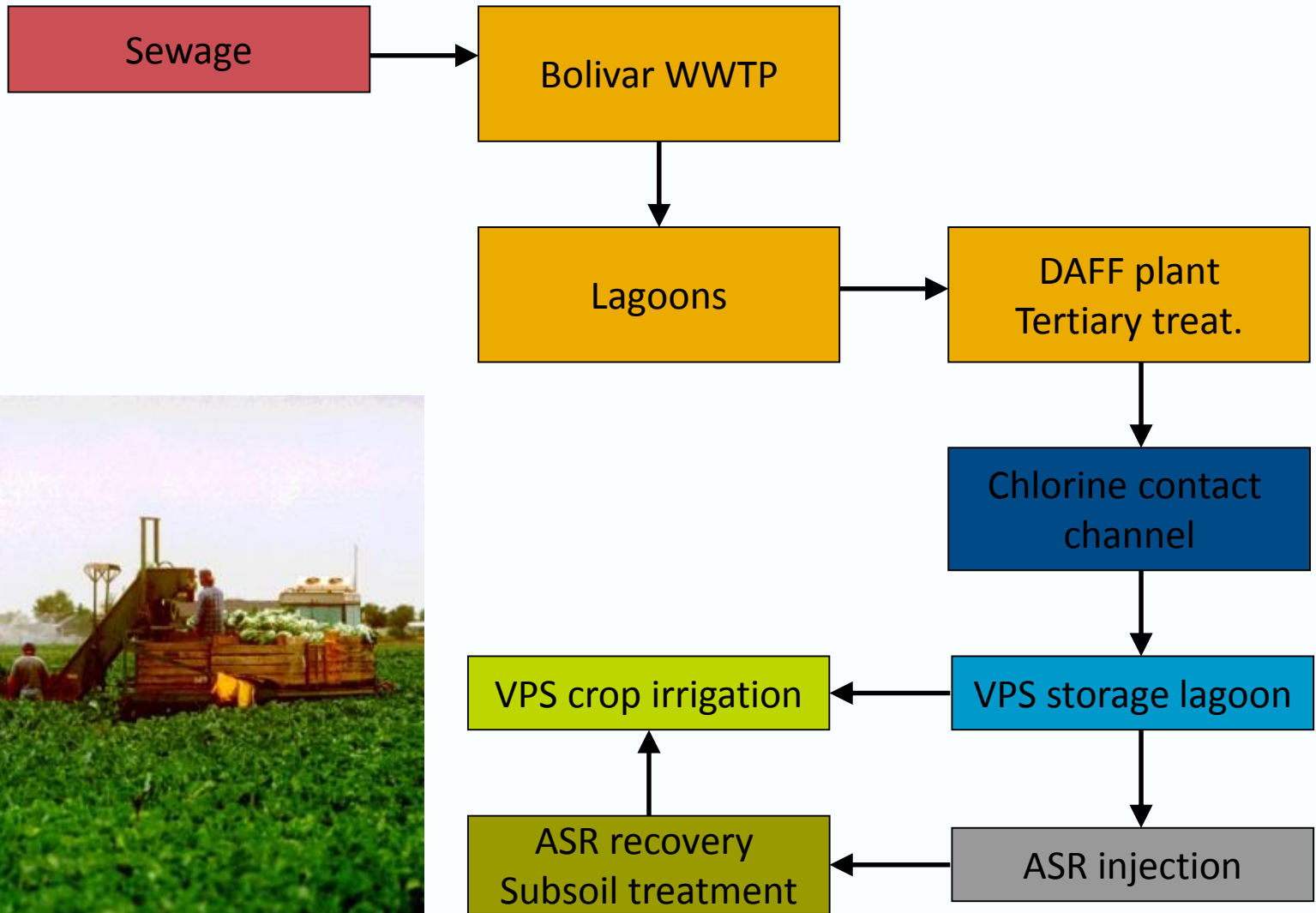
Framework for managing aquifer recharge



Assessment of the Bolivar ASR system

- The risk assessment has been performed considering the Australian Guidelines for Water Recycling (AGWR) and the Managed Aquifer Recharge Guidelines
- Scope of the risk assessment
 - Source of recycled water, intended uses, receiving environments and routes of exposure
 - Recycled water system analysis
 - Assessment of water quality data
 - Hazard identification

Recycled water system analysis



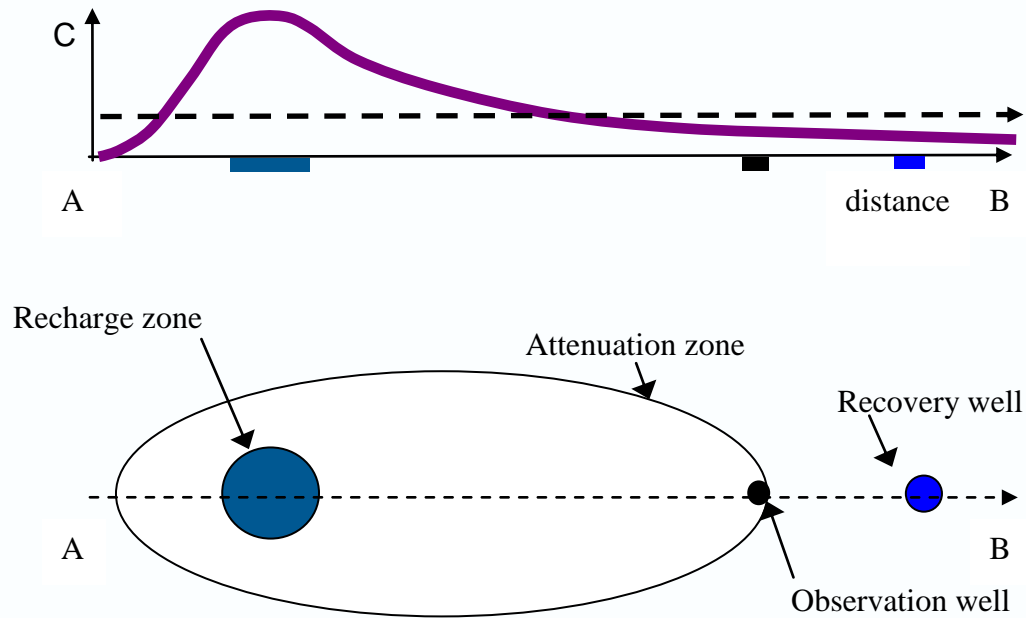
Source of recycled water, intended uses, receiving environments and routes of exposure

- Source water: raw water treated in Bolivar WWTP and DAFF plant
- Intended uses: crop irrigation
- Receiving environments: aquifer, soil
- Routes of exposure:
 - Human end points: 3 scenarios selected (according to WHO Water Reuse for Irrigation guidelines):
 - Crop consumption
 - Accidental water ingestion (aerosols) by growers/irrigators
 - Accidental water ingestion (aerosols) by local communities
 - Environmental end points: 3 end points selected:
 - Crop
 - Soil
 - Aquifer

Hazard identification

- Hazards identified in the MAR Guidelines:
 - Pathogens
 - Inorganic chemicals
 - Salinity and sodicity
 - Nutrients
 - Organic chemicals
 - Turbidity and particulates
 - Radionuclides
 - Pressure, flow rates, volumes and levels
 - Contaminant migration in fractured rock and karstic aquifers
 - Aquifer dissolution and aquitard and well stability
 - Impacts on groundwater-dependent ecosystems
 - Greenhouse gases

Attenuation zone



Provides adequate residence time of recharged water for natural attenuation of all hazards to meet environmental values

Maximal risk assessment

MAR Hazards Human and Environment routes of exposure and end points	Human		Environment		
	Crops consumption	Irrigators / growers Local communities	Crops	Soil	Aquifer
1. Pathogens	High risk	High risk	High risk	Low risk	Low risk
2. Inorganic chemicals	High risk	High risk	High risk	High risk	High risk
3. Salinity and sodicity	Low risk	Low risk	High risk	High risk	Low risk
4. Nutrients: nitrogen, phosphorous and organic carbon	Low risk	Low risk	High risk	High risk	High risk
5. Organic chemicals	Low risk	High risk	High risk	High risk	High risk
6. Turbidity and particulates	Low risk	High risk	Low risk	Low risk	High risk
7. Radionuclides	High risk	High risk	Low risk	Low risk	Low risk
8. Pressure, flow rates, volumes and groundwater levels					High risk
9. Contaminant migration in fractured rock and karstic aquifers					High risk
10. Aquifer dissolution and stability of well and aquitard					High risk
11. Aquifer and groundwater-dependent ecosystems					High risk
12. Energy and greenhouse gas considerations					High risk

VPS risk assessment

MAR Hazards Human and Environment routes of exposure and end points	Human		Environment		
	Crops consumption	Irrigators / growers Local communities	Crops	Soil	Aquifer
1. Pathogens	Low risk	Low risk	Low risk	Low risk	Low risk
2. Inorganic chemicals	Unknown risk	Unknown risk	Unknown risk	Unknown risk	High risk
3. Salinity and sodicity	Low risk	Low risk	Unknown risk	Unknown risk	Low risk
4. Nutrients: nitrogen, phosphorous and organic carbon	Low risk	Low risk	Low risk	Low risk	High risk
5. Organic chemicals	Low risk	Low risk	Low risk	Low risk	High risk
6. Turbidity and particulates	Low risk	Low risk	Low risk	Low risk	Low risk
7. Radionuclides	Unknown risk	Unknown risk	Low risk	Low risk	Unknown risk
8. Pressure, flow rates, volumes and groundwater levels					High risk
9. Contaminant migration in fractured rock and karstic aquifers					Unknown risk
10. Aquifer dissolution and stability of well and aquitard					High risk
11. Aquifer and groundwater-dependent ecosystems					Unknown risk
12. Energy and greenhouse gas considerations					Unknown risk

Residual risk assessment

MAR Hazards Human and Environment routes of exposure and end points	Human		Environment		
	Crops consumption	Irrigators / growers Local communities	Crops	Soil	Aquifer
1. Pathogens	Low risk	Low risk	Low risk	Low risk	Low risk
2. Inorganic chemicals	Low risk	Low risk	Low risk	Low risk	Low risk
3. Salinity and sodicity	Low risk	Low risk	Unknown risk	Unknown risk	Low risk
4. Nutrients: nitrogen, phosphorous and organic carbon	Low risk	Low risk	Low risk	Low risk	Low risk
5. Organic chemicals	Low risk	Low risk	Low risk	Low risk	Low risk
6. Turbidity and particulates	Low risk	Low risk	Low risk	Low risk	Low risk
7. Radionuclides	Low risk	Low risk	Low risk	Low risk	Low risk
8. Pressure, flow rates, volumes and groundwater levels	Low risk	Low risk	Low risk	Low risk	Low risk
9. Contaminant migration in fractured rock and karstic aquifers	Low risk	Low risk	Low risk	Low risk	Low risk
10. Aquifer dissolution and stability of well and aquitard	Low risk	Low risk	Low risk	Low risk	Low risk
11. Aquifer and groundwater-dependent ecosystems	Low risk	Low risk	Low risk	Low risk	Low risk
12. Energy and greenhouse gas considerations	Low risk	Low risk	Low risk	Low risk	Low risk

Critical control points and critical limits applied to Bolivar ASR

Critical control point	Critical limit	Target criteria
DAFF treatment: quality of the injectant	pH > 6.5 During 1 st cycle it was observed that below this pH there was calcite dissolution	pH > 7 Ensuring a pH at least neutral prevents an excessive calcite dissolution
	TDS < 1500 mg/L Contractual limit for VPS	TDS < 1300 mg/L If this limit is increased, after mixing with the groundwater the recovered water can have a too high TDS
	Daily average TDS < 900 mg/L Maximum TDS < 1200 mg/L	Daily average TDS < 900 mg/L Maximum TDS < 1200 mg/L
Quality of recycled water blend suitable irrigation		

Conclusions

- An assessment of the managed aquifer recharge system has been performed, highlighting:
 - The effectiveness of the treatment barriers
 - Appropriateness of the whole recycling system for producing water for crop irrigation
- Hazards to be considered in the DAFF treated + chlorinated water to be used for ASR injection and crop irrigation are:
 - Pathogens: Rotavirus meet the limits set for crops consumption set in the AGWR. Storage in the aquifer also further reduces the risk to acceptable levels
 - Salinity: Although the produced water is under the contractual value between VPS, the cultivation of crops tolerant to the salinity and the long-term effects to the soil should be considered. Salinity can be managed by dilution (e.g. with harvested stormwater), treatment (e.g. reverse osmosis) or crop irrigation management.
- Aquifer treatment is an additional barrier that improves the microbiological quality of the recovered water

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