Managed Aquifer Recharge in Windhoek
Evaluation and Future Challenges

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Acknowledgements

City of Windhoek: Project and supply of data
Introduction: Windhoek Aquifer

- Fractured schists and quartzites
- Main supply until 1960s
- Emergency source up to 2000s
- 2004 MAR proposed
  - Water banking
  - First applied in 2008
- Aquifer still used as emergency source
MAR Philosophy

- Goal: High quality recharge water
  - Avoid damaging aquifer as a valuable source
  - Minimise post-treatment
- Recharge WQ stricter or equal to potable WQ standards
- EC, chloride, sulphate, DOC / AOC key parameters
Windhoek’s Water Supply

- Current demand: ~25 Mm³/a
- Diverse sources - SW, GW, Direct-Reuse
- Role players: Bulk supplier and municipality
- NamWater - bulk supplier
  - 3 Dam System (typical)
  - Northern GW sources (emergency)
- CoW - municipality
  - Direct potable reuse (typical)
  - Windhoek aquifer (emergency)
- Recharge water
  - SW and/or reuse water
MAR Challenges: Quantity

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Additional BHs</th>
<th>Max Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage (Mm$^3$)</td>
<td>60</td>
<td>90</td>
<td>110</td>
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<thead>
<tr>
<th></th>
<th>Recent</th>
<th>Potential</th>
<th>Likely Max</th>
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<tbody>
<tr>
<td>Abs Rate (Mm$^3$/a)</td>
<td>~9</td>
<td>11</td>
<td>16-19</td>
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<tbody>
<tr>
<td>Recharge (Mm$^3$/a)</td>
<td>5.4</td>
<td>8</td>
<td>2</td>
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</table>
MAR Challenges: Quality

Major Dams

Windhoek Aquifer: Borehole RWLs

TDS at Sources

DOC at Sources
MAR Challenges: Quality

Water Quality Time Availability for Artificial Recharge
Blend Ratio NW/DPR: 100%

Blend Ratio NW/DPR: 90%

Blend Ratio NW/DPR: 80%

Blend Ratio NW/DPR: 75%
MAR Challenges: WQ

Water Quality Time Availability for Artificial Recharge

<table>
<thead>
<tr>
<th>Blend Ratio</th>
<th>100%</th>
<th>90%</th>
<th>85%</th>
<th>80%</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>% AR Opportunity</td>
<td>36%</td>
<td>42%</td>
<td>42%</td>
<td>38%</td>
<td>28%</td>
</tr>
<tr>
<td>Years for AR (n=11 years)</td>
<td>3.9</td>
<td>4.7</td>
<td>4.6</td>
<td>4.2</td>
<td>3.1</td>
</tr>
</tbody>
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Thoughts and Conclusions

- Window of opportunity for MAR
  - Volume and WQ
  - Infrastructure sizing aspects
- Institutional arrangements not yet finalised
  - No supply agreement NW~CoW
- Future water source and utilization uncertainty
- Much more R&D needed for MAR maturity
THANK YOU